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(12) **Reissued Patent**

Katzman et al.

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(45) **Date of Reissued Patent: Jan. 15, 2019**

(54) **SPRINKLER**

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(72) Inventors: **Oded Katzman**, Haifa (IL); **Zohar Katzman**, Haifa (IL)

(73) Assignee: **NAANDANJAIN IRRIGATION LTD.**, Kibbutz Na'an (IL)

(21) Appl. No.: **15/391,281**

(22) Filed: **Dec. 27, 2016**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **8,998,109**
Issued: **Apr. 7, 2015**
Appl. No.: **13/001,832**
PCT Filed: **Jun. 30, 2009**
PCT No.: **PCT/IL2009/000653**
§ 371 (c)(1),
(2) Date: **Dec. 29, 2010**
PCT Pub. No.: **WO2010/001392**
PCT Pub. Date: **Jan. 7, 2010**

U.S. Applications:

(60) Provisional application No. 61/129,471, filed on Jun. 30, 2008, provisional application No. 61/193,803, filed on Dec. 24, 2008.

(51) **Int. Cl.**

B05B 3/02	(2006.01)
B05B 3/04	(2006.01)
B05B 3/06	(2006.01)
F23D 11/04	(2006.01)
B05B 3/00	(2006.01)

(52) **U.S. Cl.**

CPC ***B05B 3/0486*** (2013.01); ***B05B 3/005*** (2013.01); ***B05B 3/006*** (2013.01); *Y10S 239/11* (2013.01)

(58) **Field of Classification Search**

CPC B05B 3/0486; B05B 3/005; B05B 3/006; Y10S 239/11

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,453,673 A	6/1984	Icenbice	
4,660,766 A	4/1987	Nelson et al.	
5,236,126 A	8/1993	Sawade et al.	
5,597,119 A *	1/1997	Gorney et al.	239/241

(Continued)

FOREIGN PATENT DOCUMENTS

CN	2584883 Y	11/2003
WO	2007109298 A2	9/2007
WO	2010/016053	2/2010

OTHER PUBLICATIONS

An English translation of an Office Action dated Oct. 17, 2017 which issued during the prosecution of Brazilian Patent Application No. PI09175067.

(Continued)

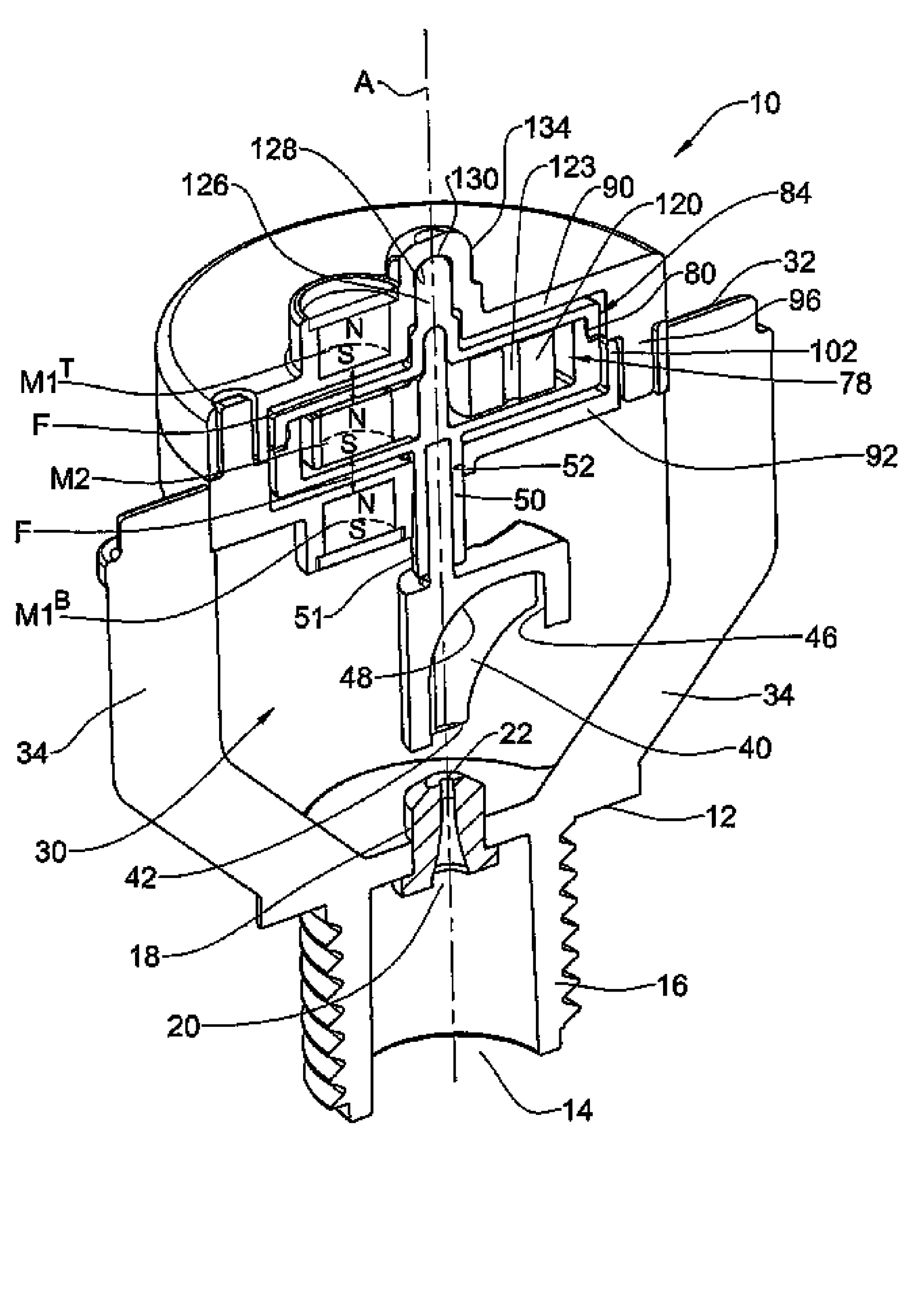
Primary Examiner — Joseph A Kaufman

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

Provided is a rotary sprinkler that includes a housing, a rotatable irrigation head associated with a first magnet assembly, and a second magnet assembly associated with the housing and fitted with a rotary dampening mechanism. The first magnet assembly and the second magnet assembly are arranged with like poles facing each other so as to generate a repulsion force therebetween.

19 Claims, 42 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,671,886	A *	9/1997	Sesser	B05B 3/005 239/222.21
5,730,365	A *	3/1998	Messinger	B05B 3/0486 239/222.17
7,111,796	B2 *	9/2006	Olson	239/452
7,287,710	B1	10/2007	Nelson et al.	
8,998,109	B2	4/2015	Katzman et al.	
2004/0232701	A1	11/2004	DeFrank	
2006/0065759	A1	3/2006	Olson	
2006/0091232	A1 *	5/2006	Grant	239/19
2010/0065656	A1 *	3/2010	Grant	239/222.11
2011/0114755	A1	5/2011	Katzman et al.	

OTHER PUBLICATIONS

An English translation of an Office Action dated Oct. 4, 2016, which issued during the prosecution of Indian Patent Application No. 2789/MUMNP/2010.

The International Search Report for PCT/IL2009/000653, completed on Nov. 26, 2009 and mailed on Dec. 3, 2009; and the Written Opinion for PCT/IL2009/000653; 11 pages total.

* cited by examiner

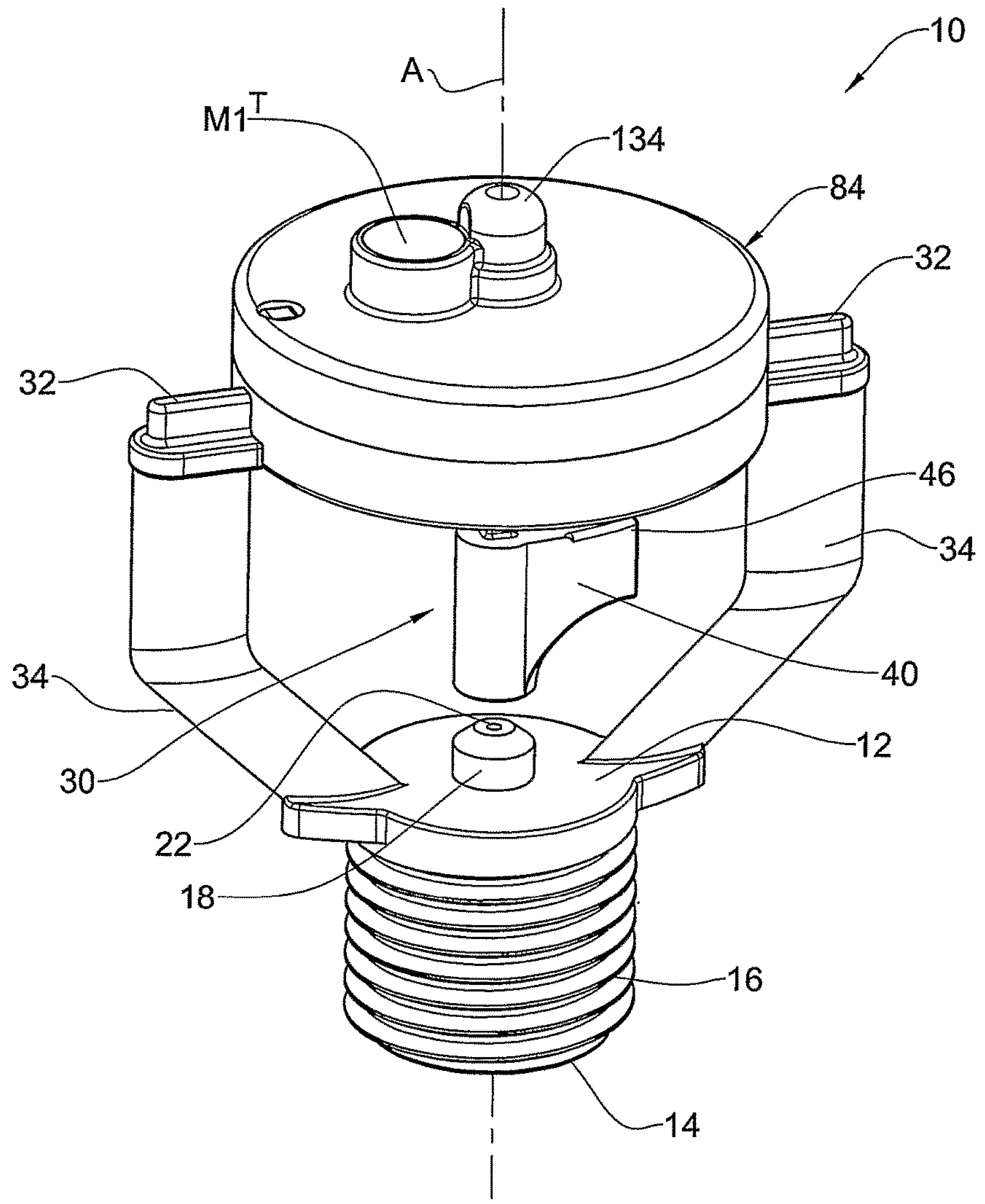


FIG. 1A

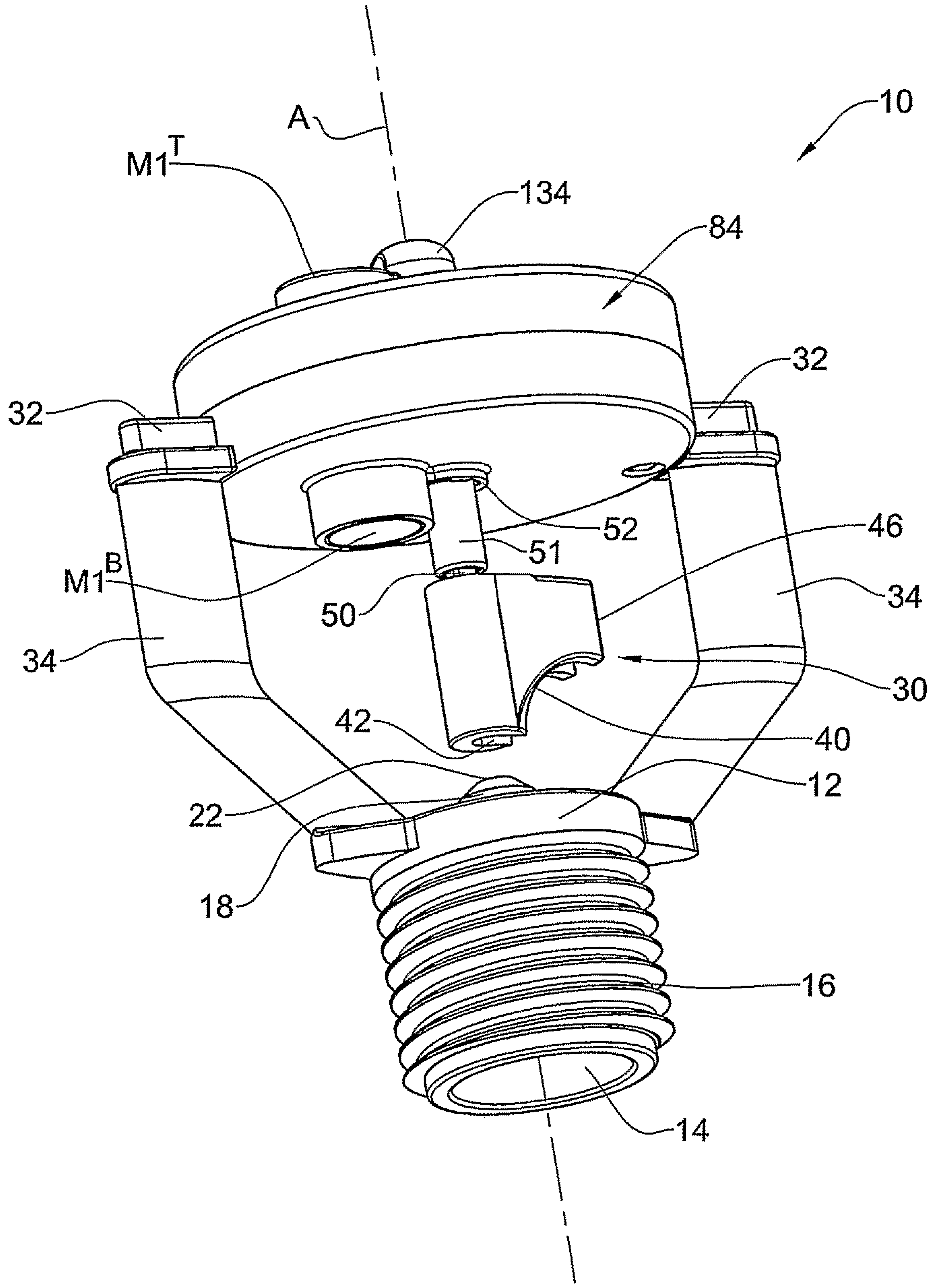
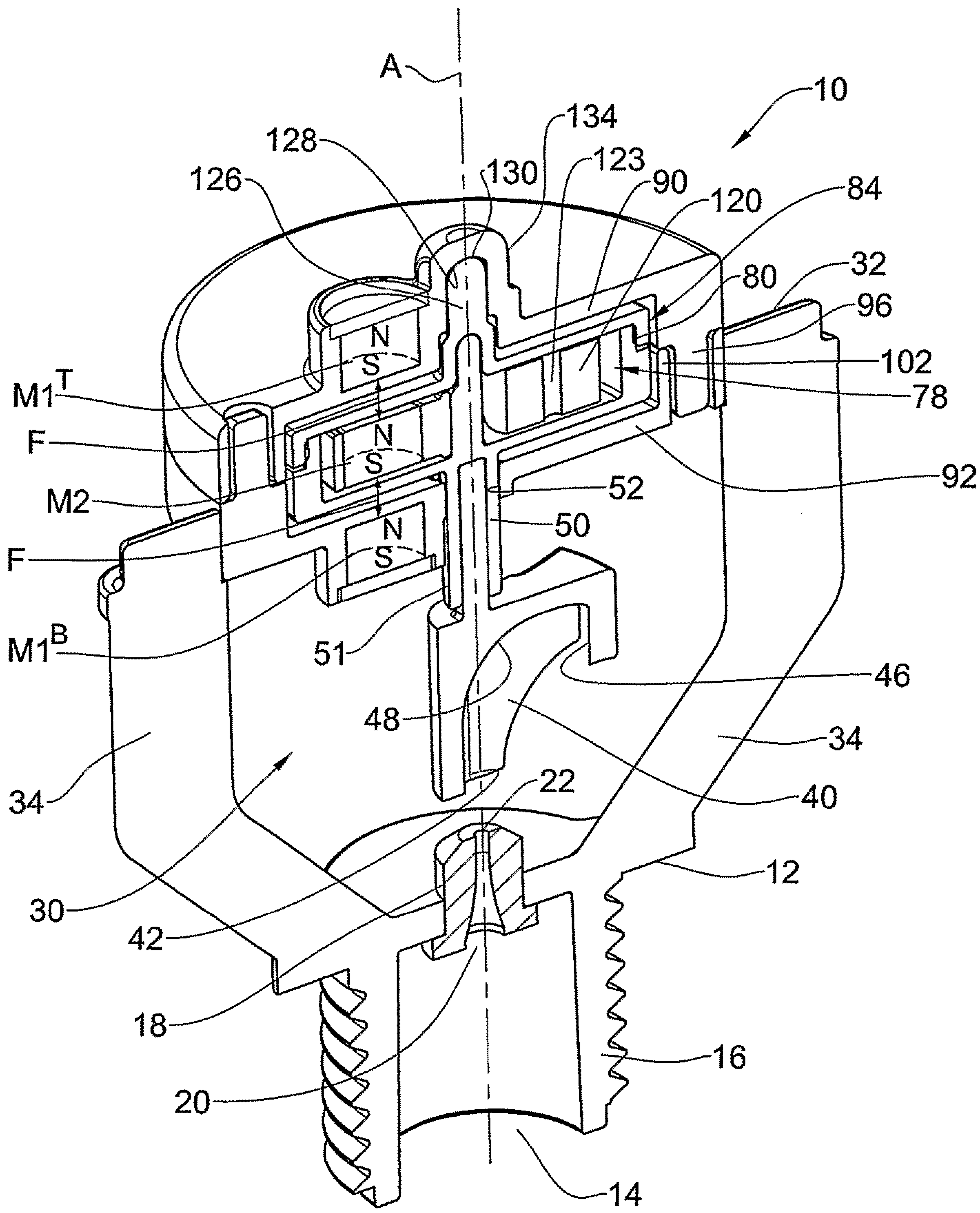


FIG. 1B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M2
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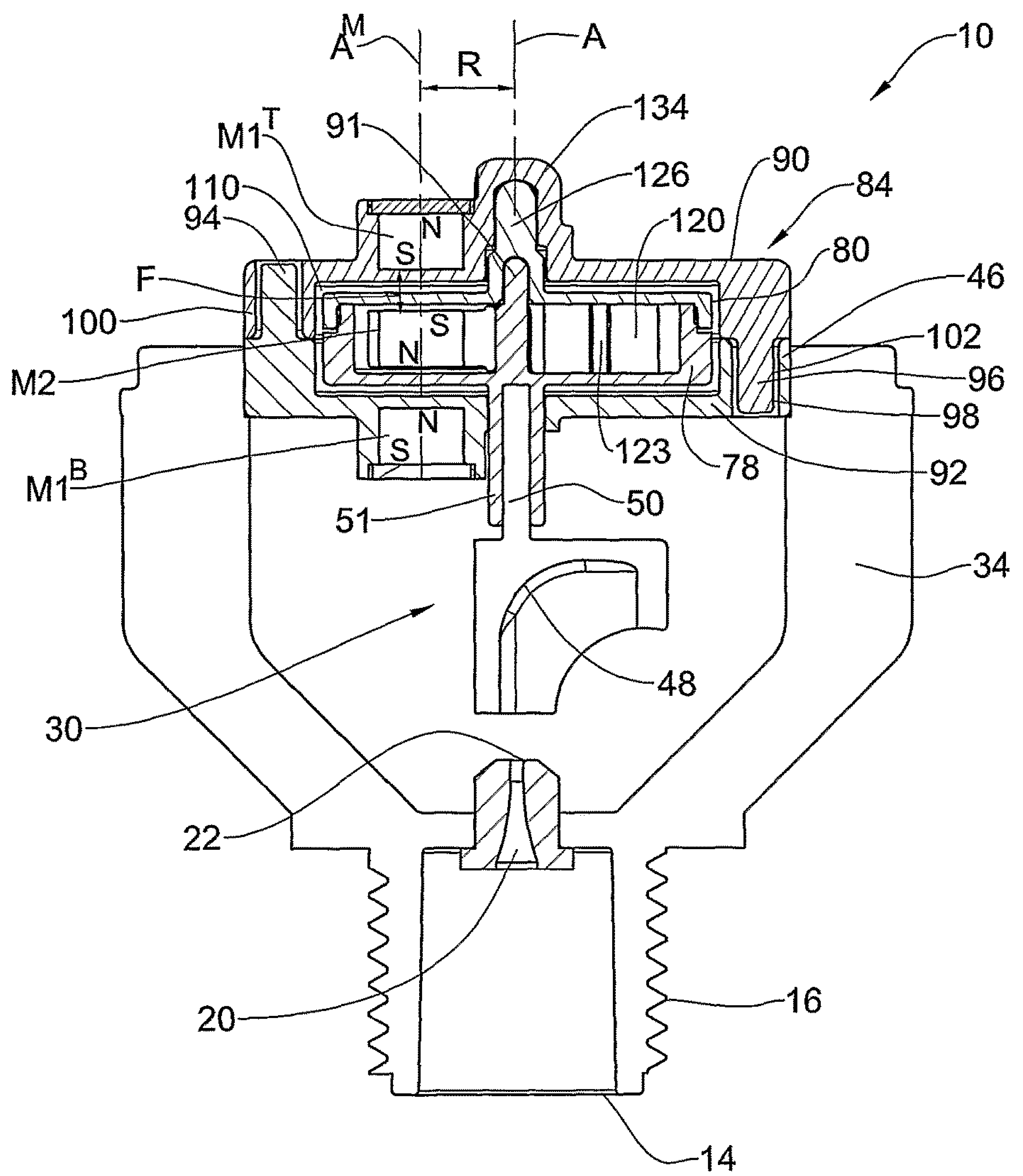
FIG. 2



A^M
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$M1^T$
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126
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110
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94
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S
100
102
N
M2
96
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FIG. 3

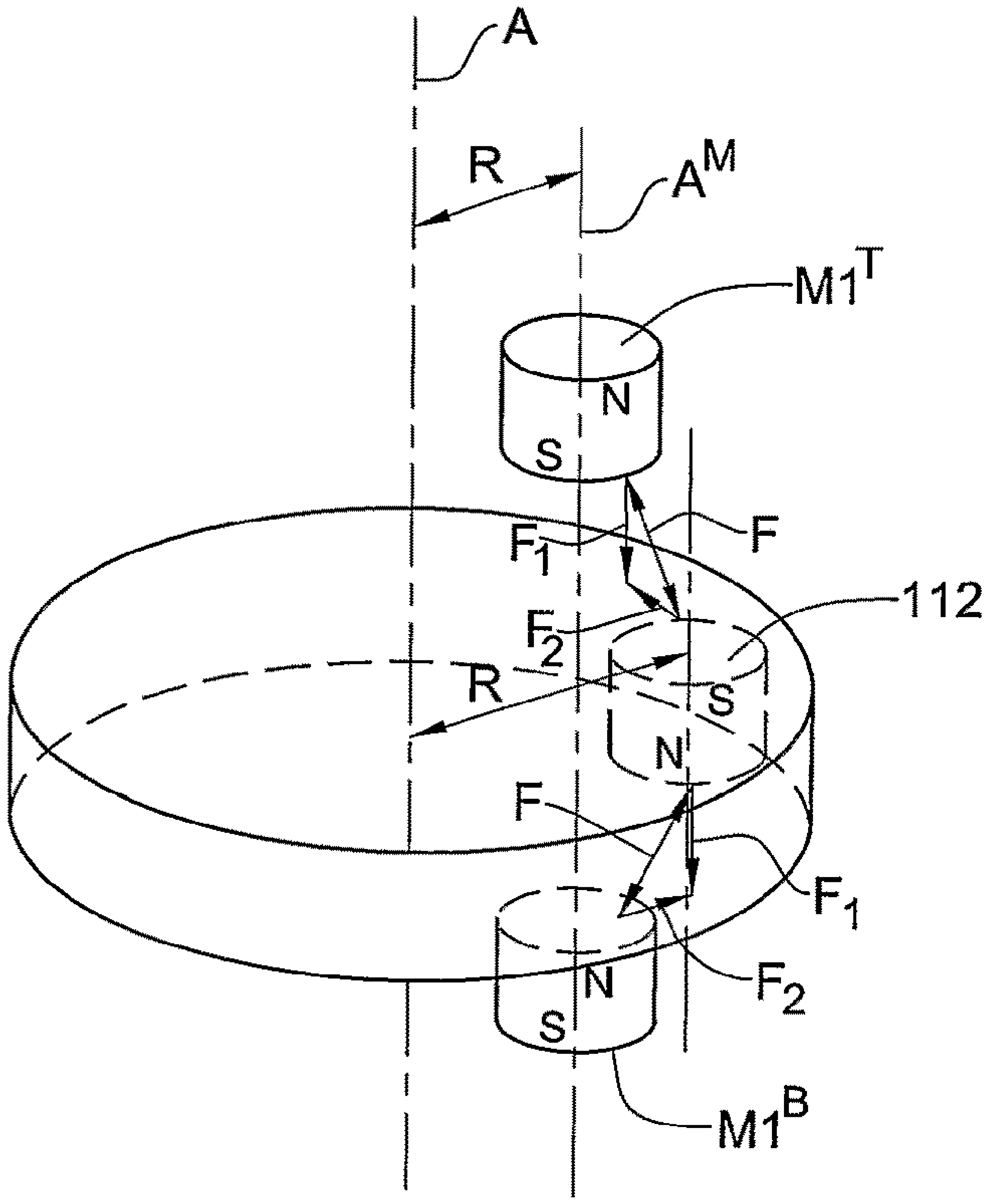

FIG. 4A

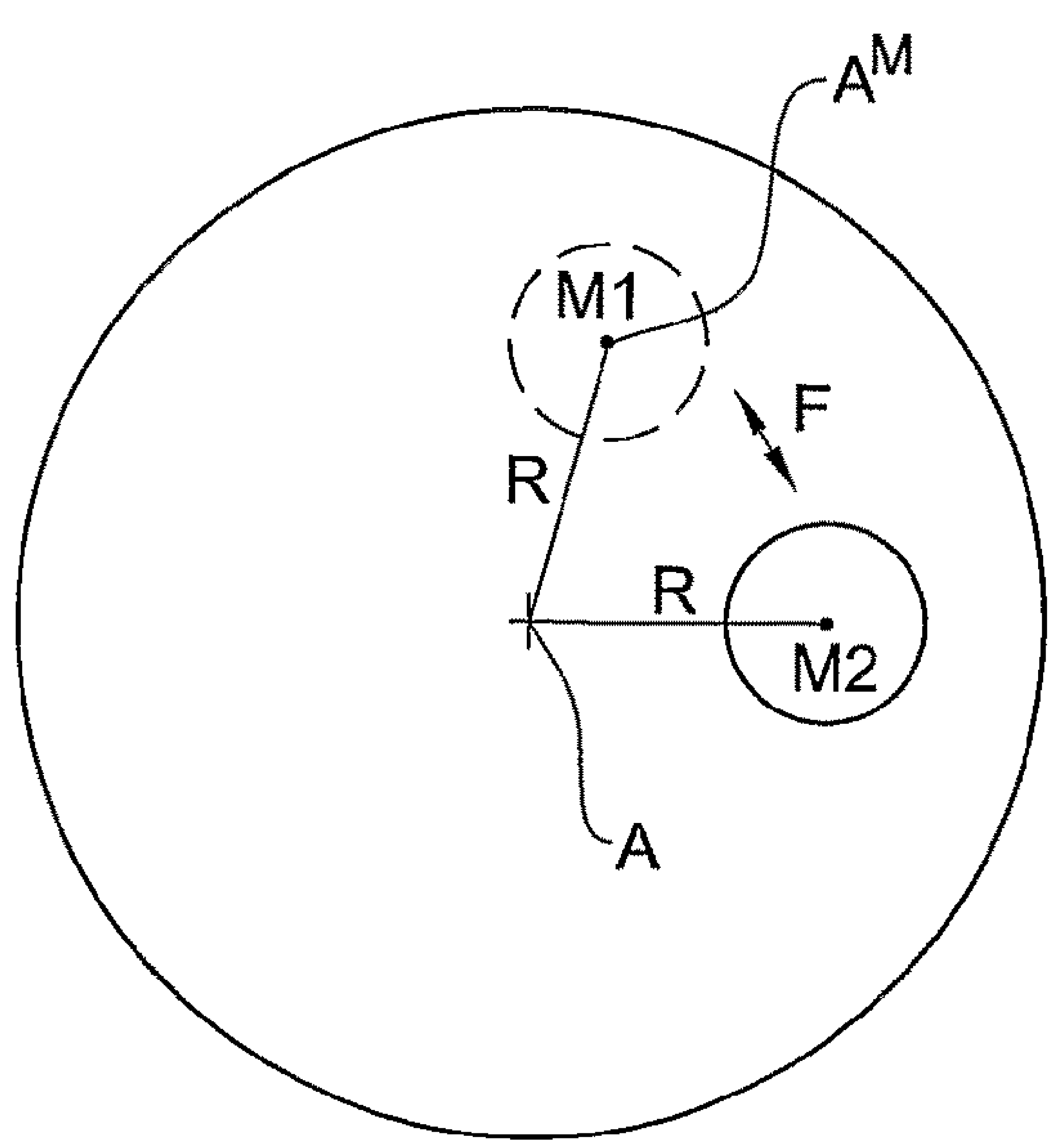

FIG. 4B

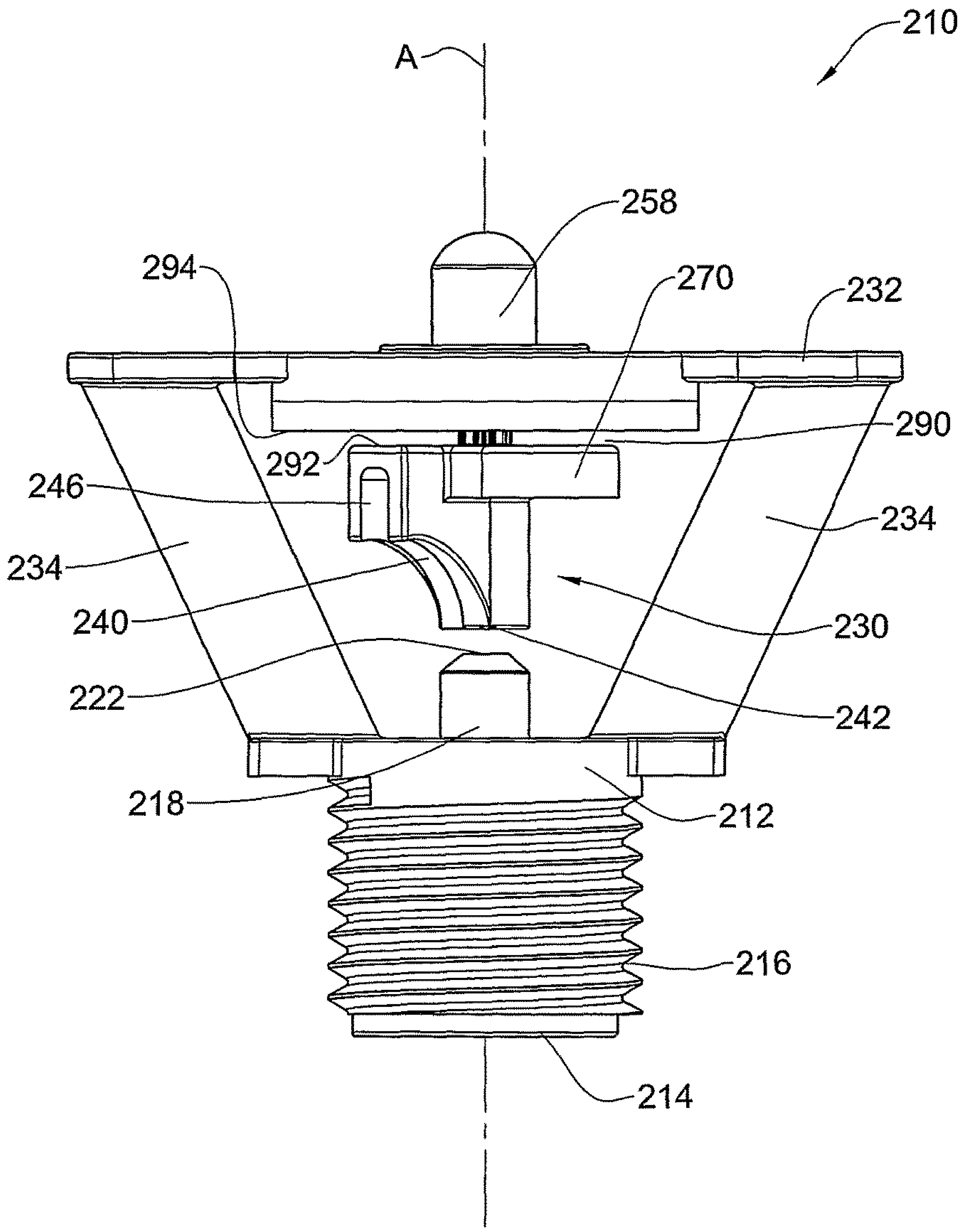
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FIG. 5

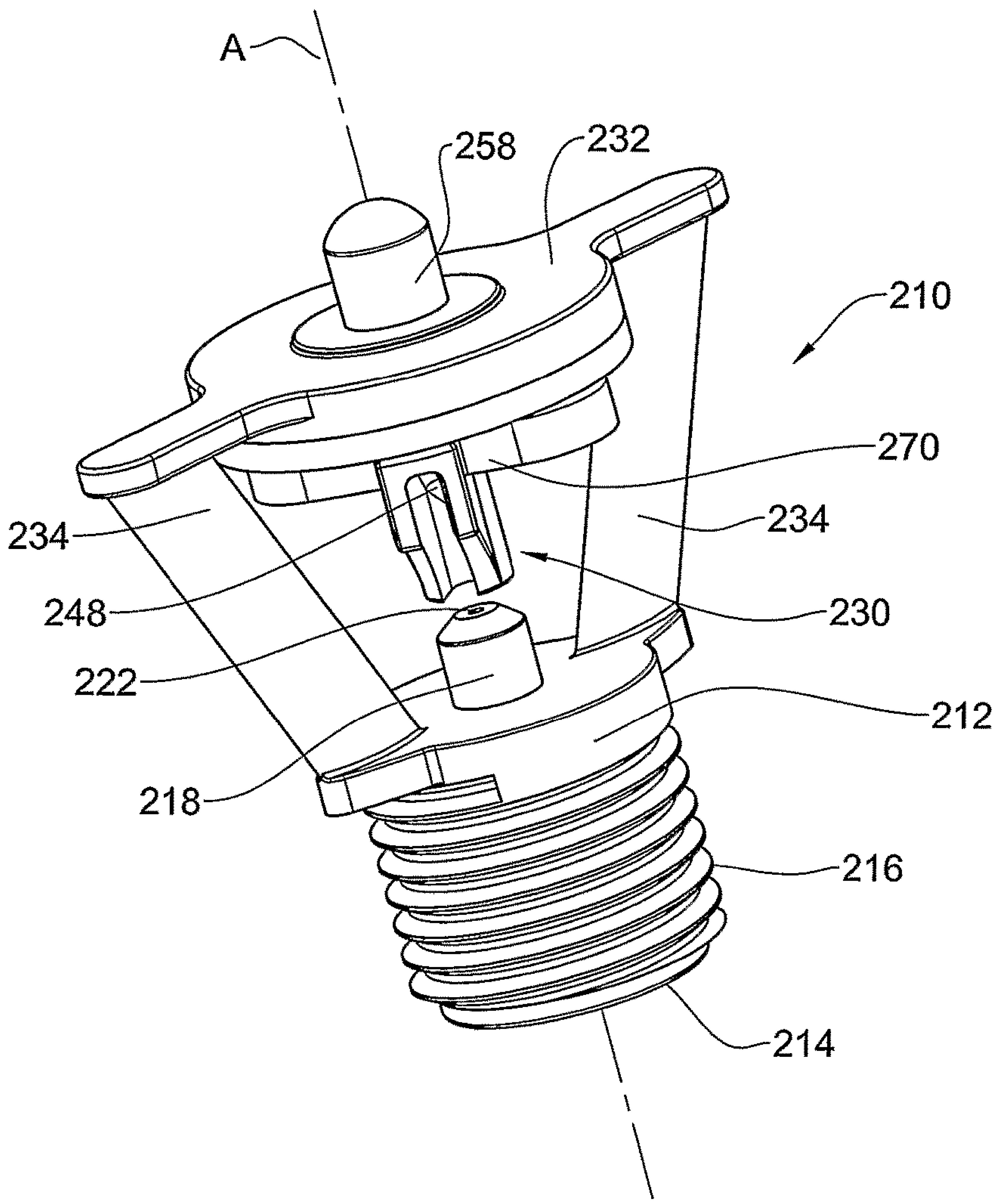

FIG. 6

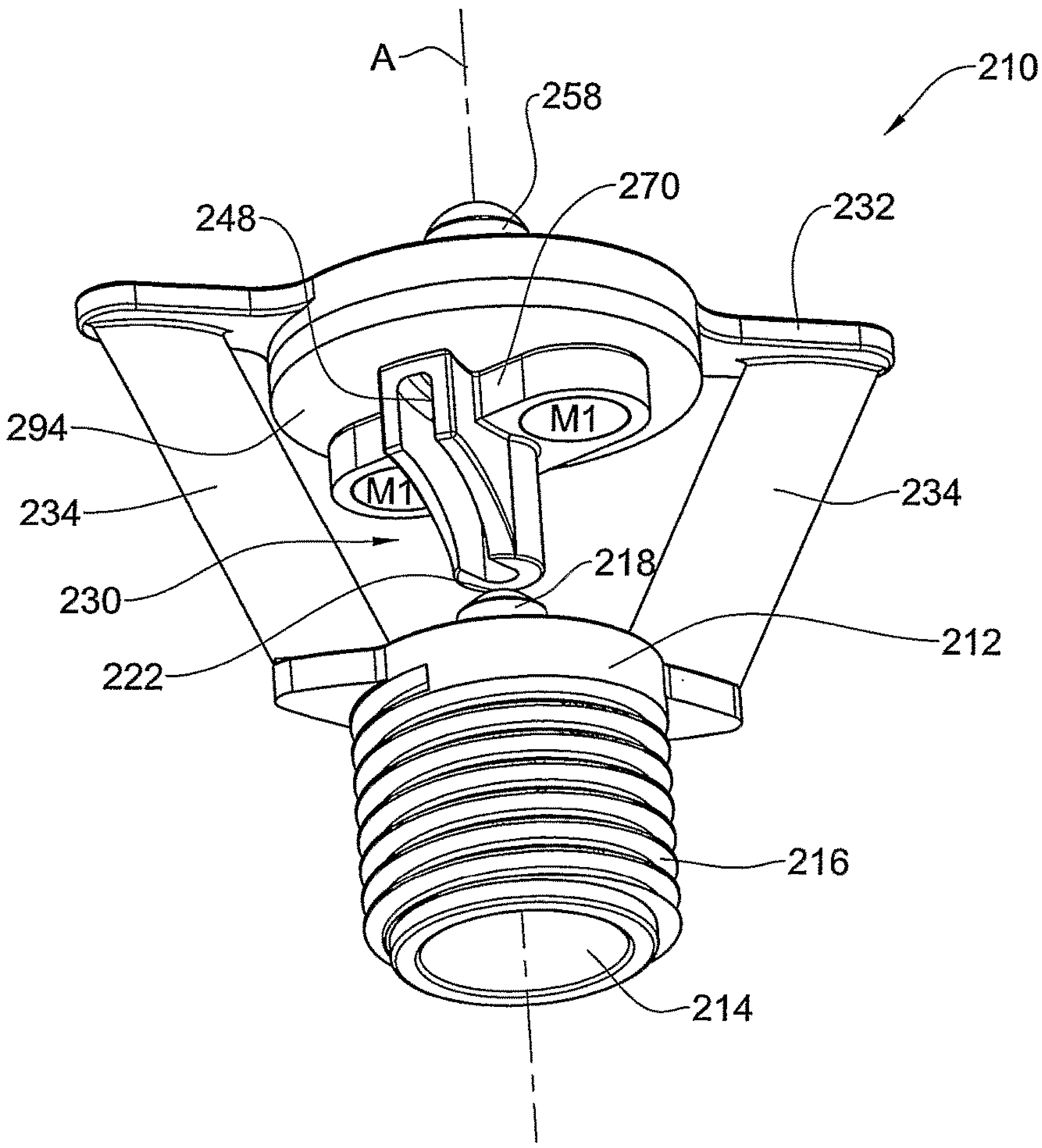

FIG. 7A

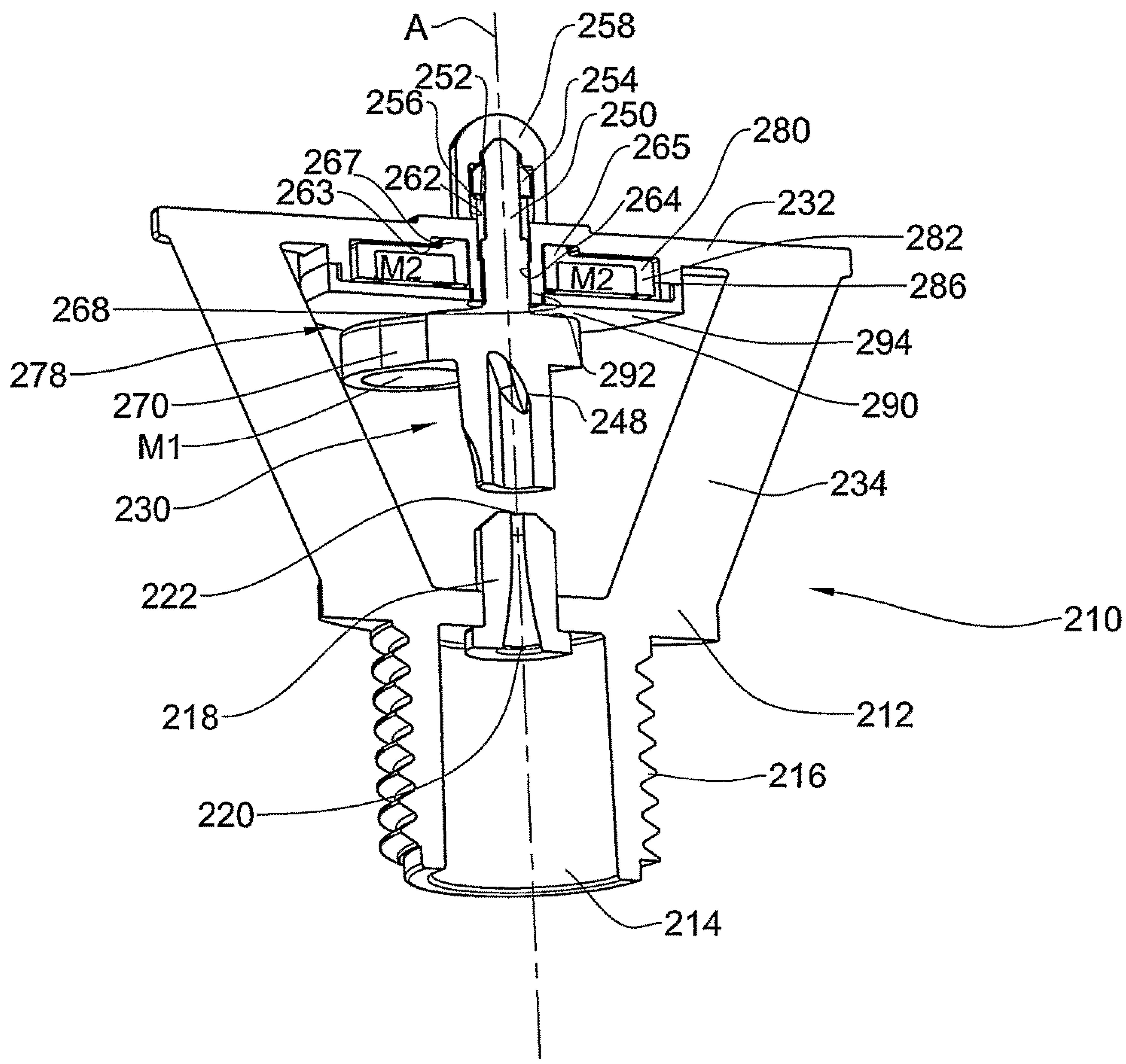
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FIG. 7B

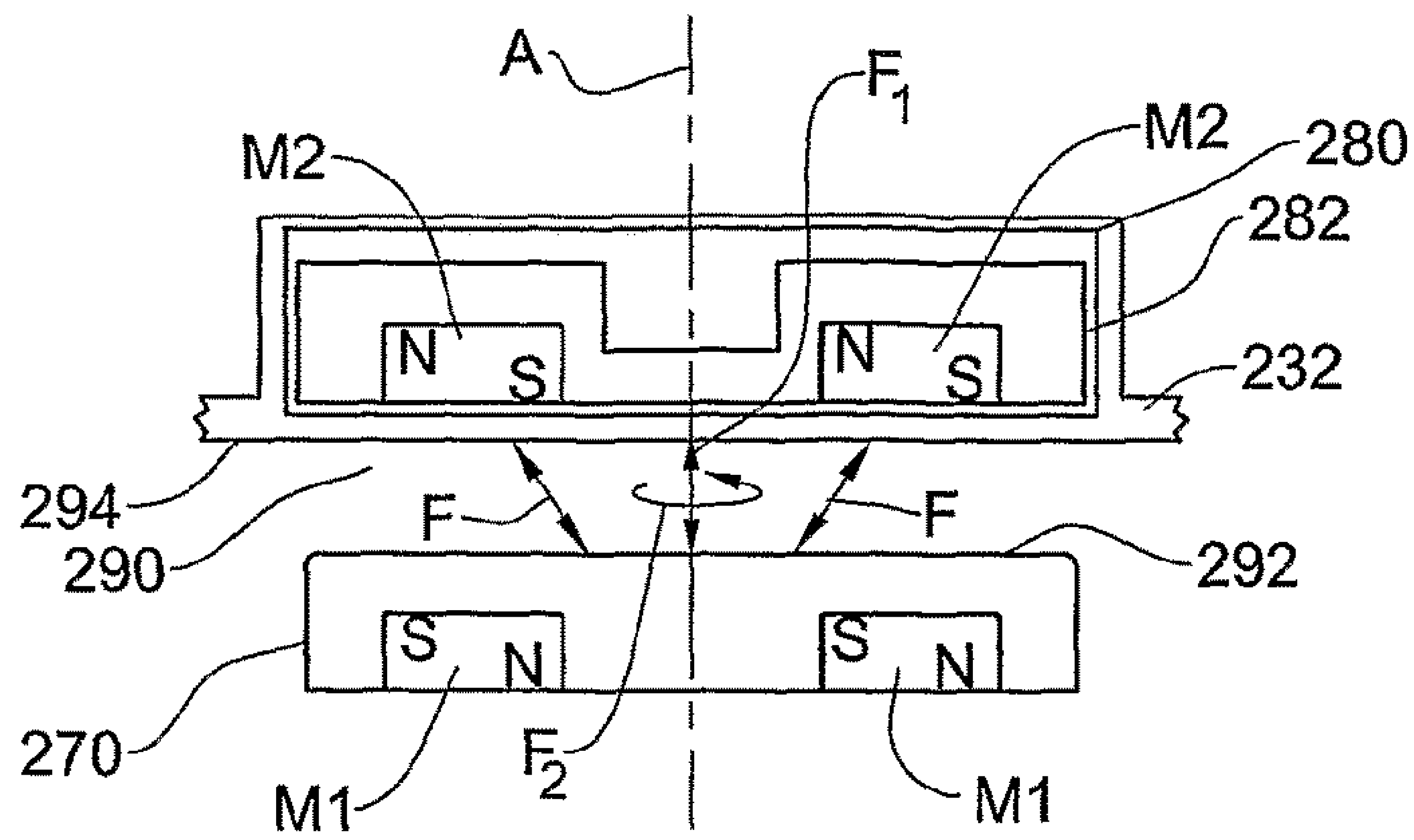

FIG. 8A

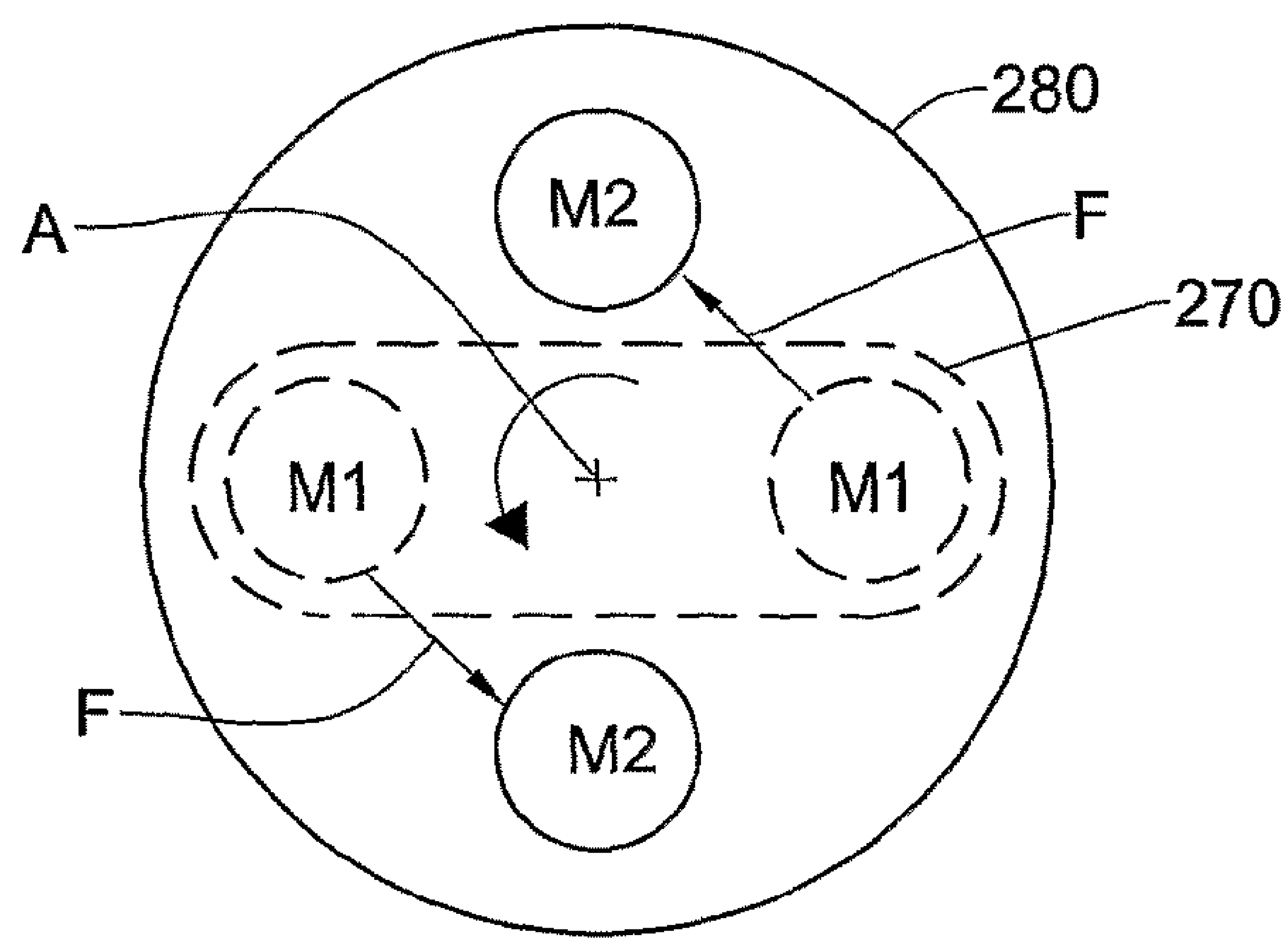

FIG. 8B

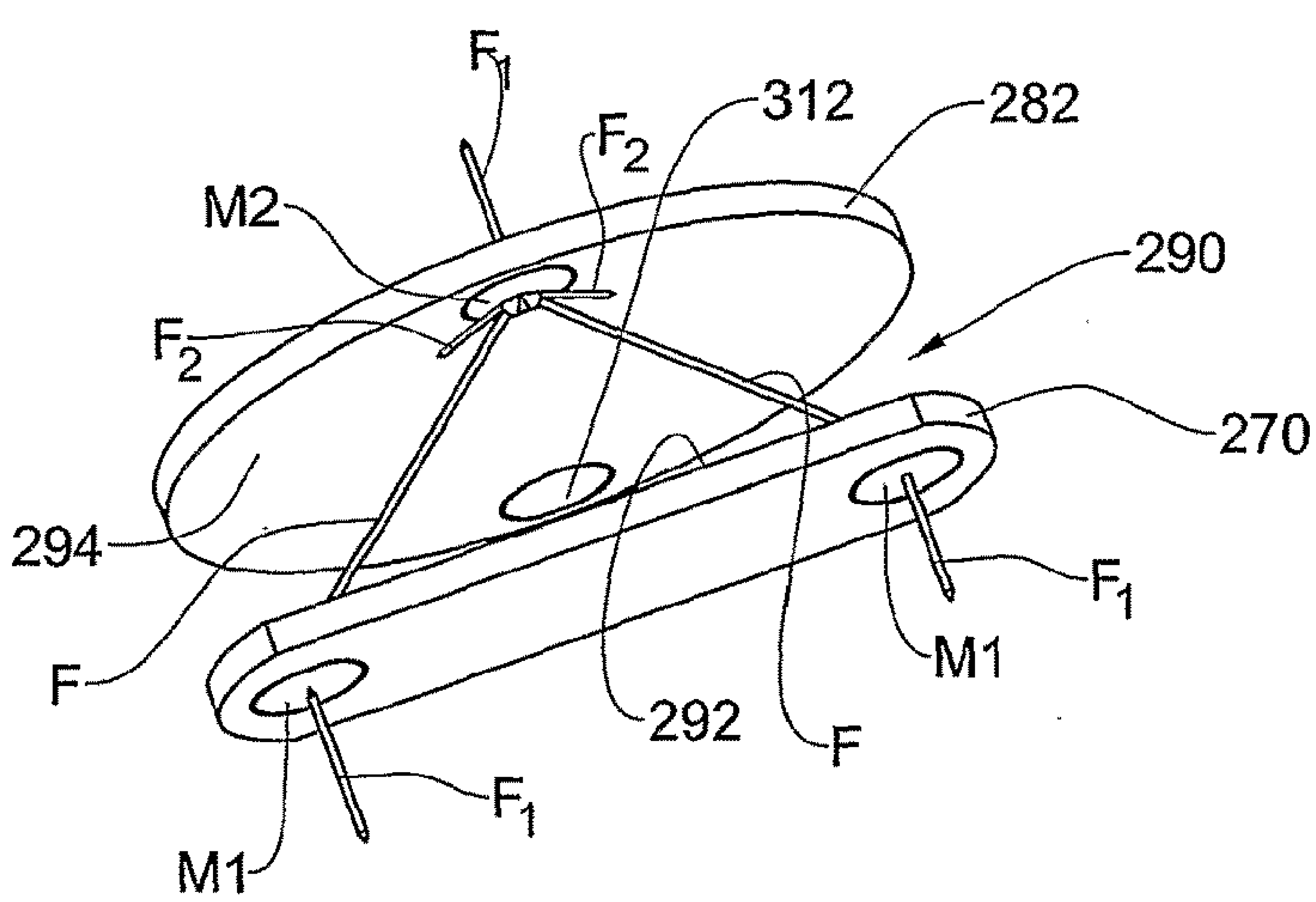

FIG. 8C

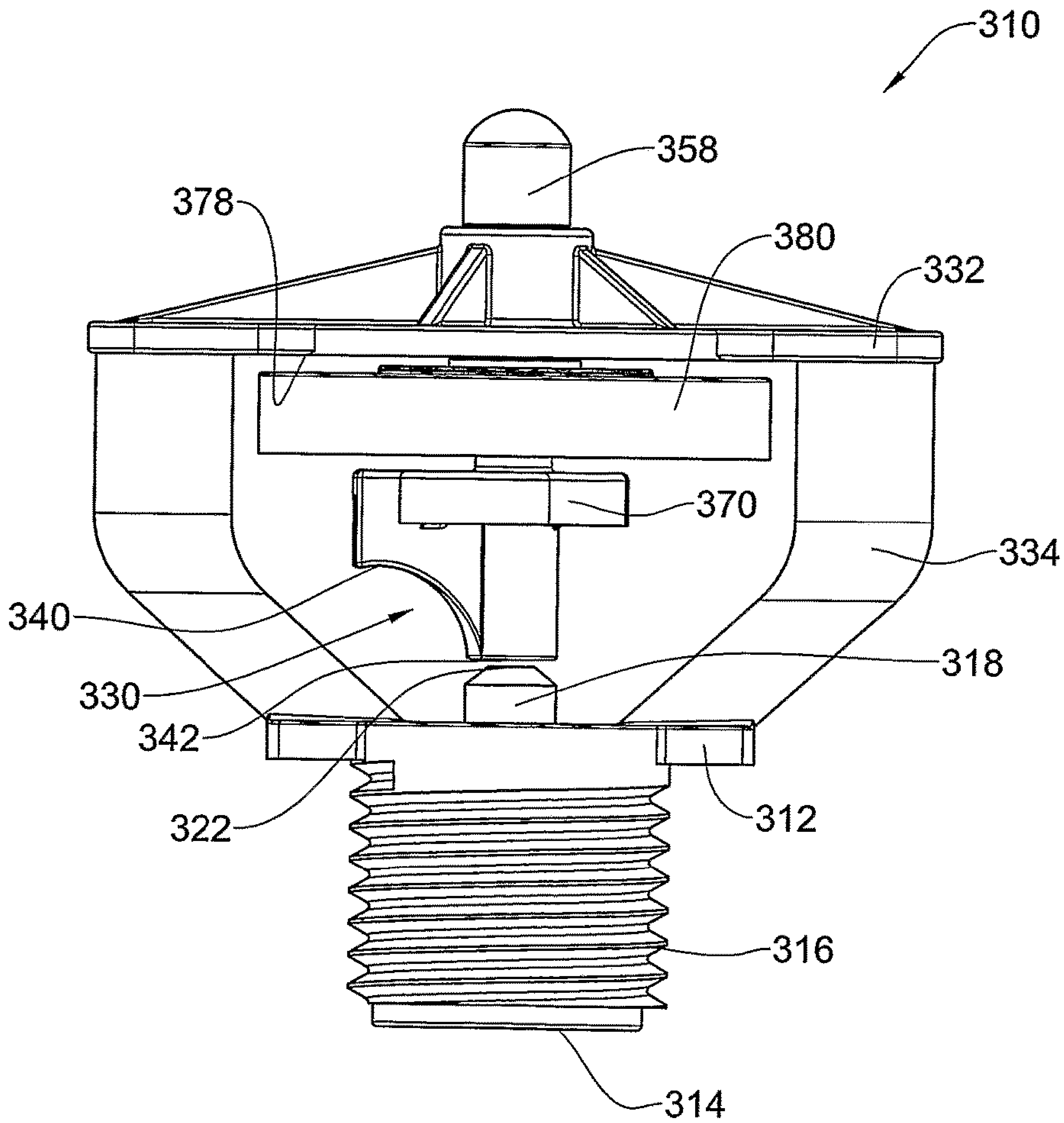

FIG. 9

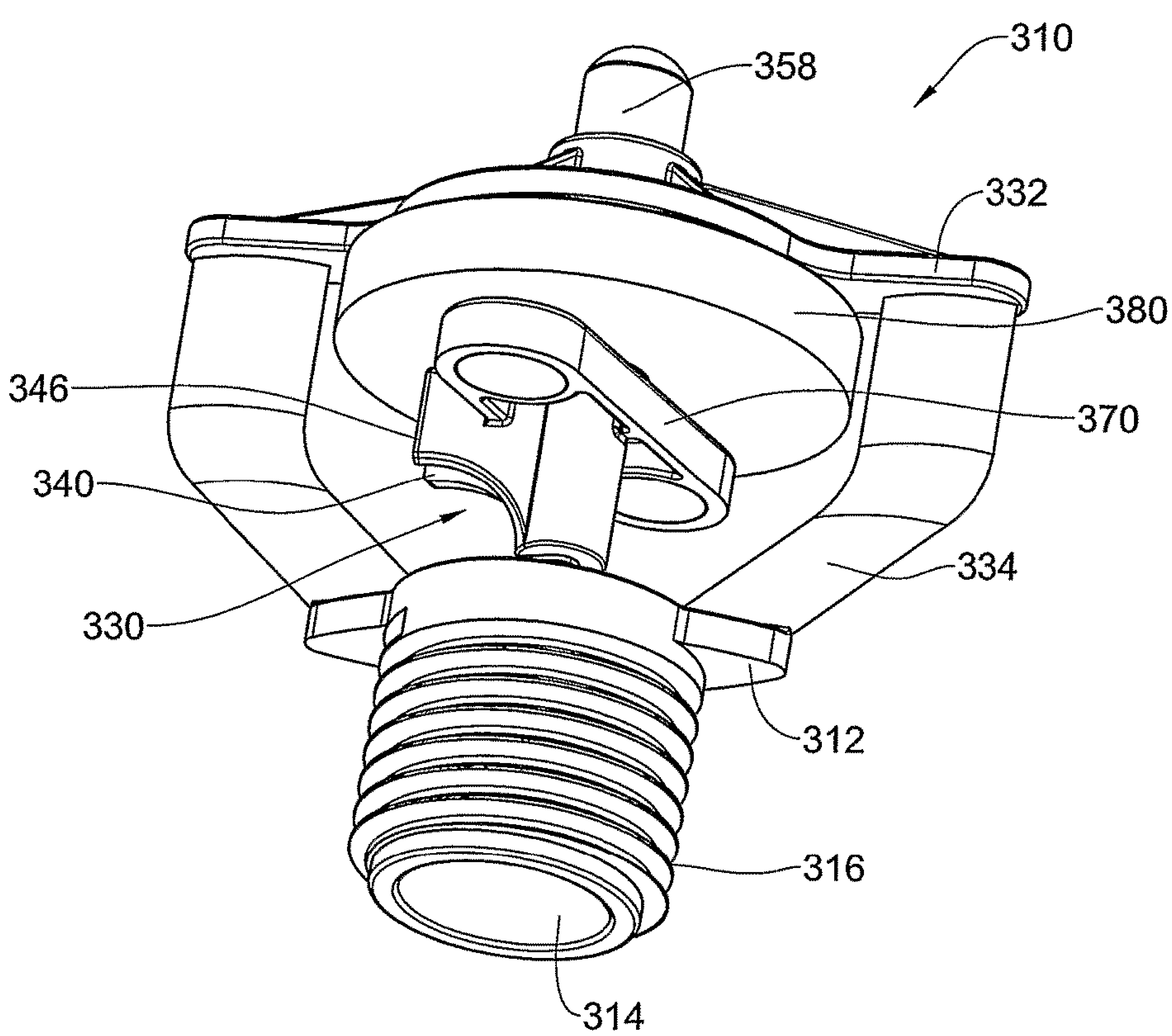

FIG. 10

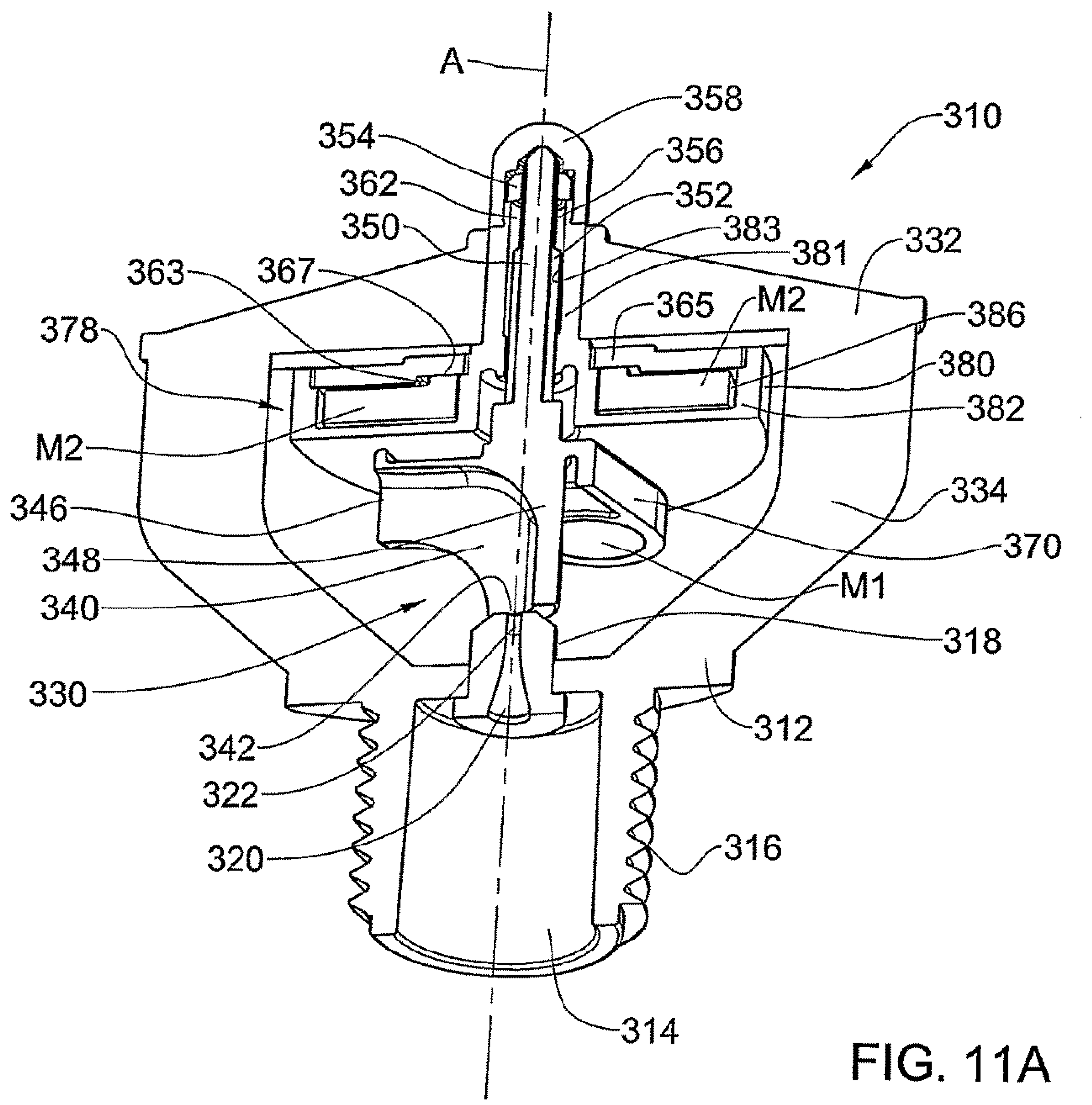

FIG. 11A

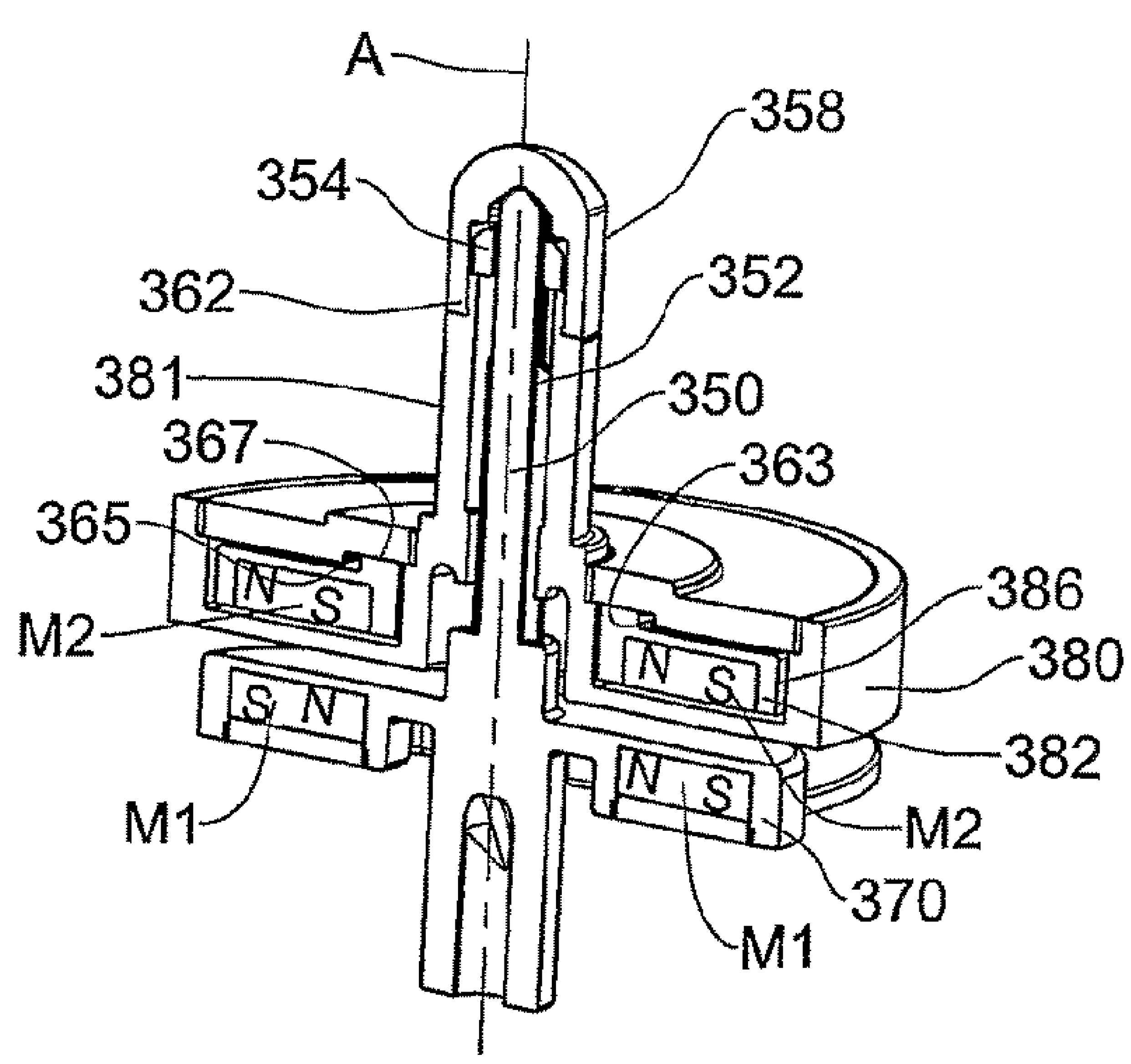

FIG. 11B

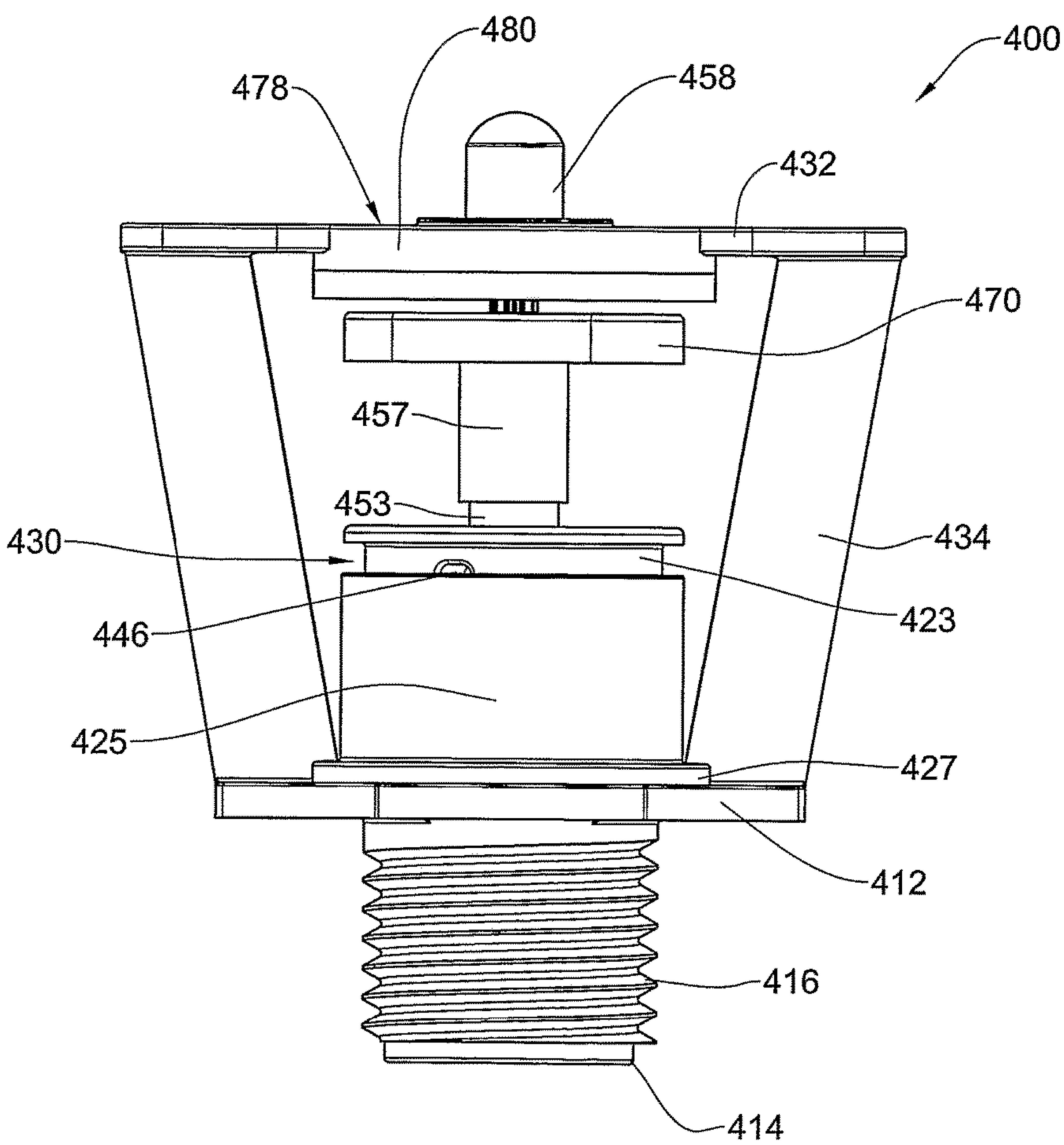
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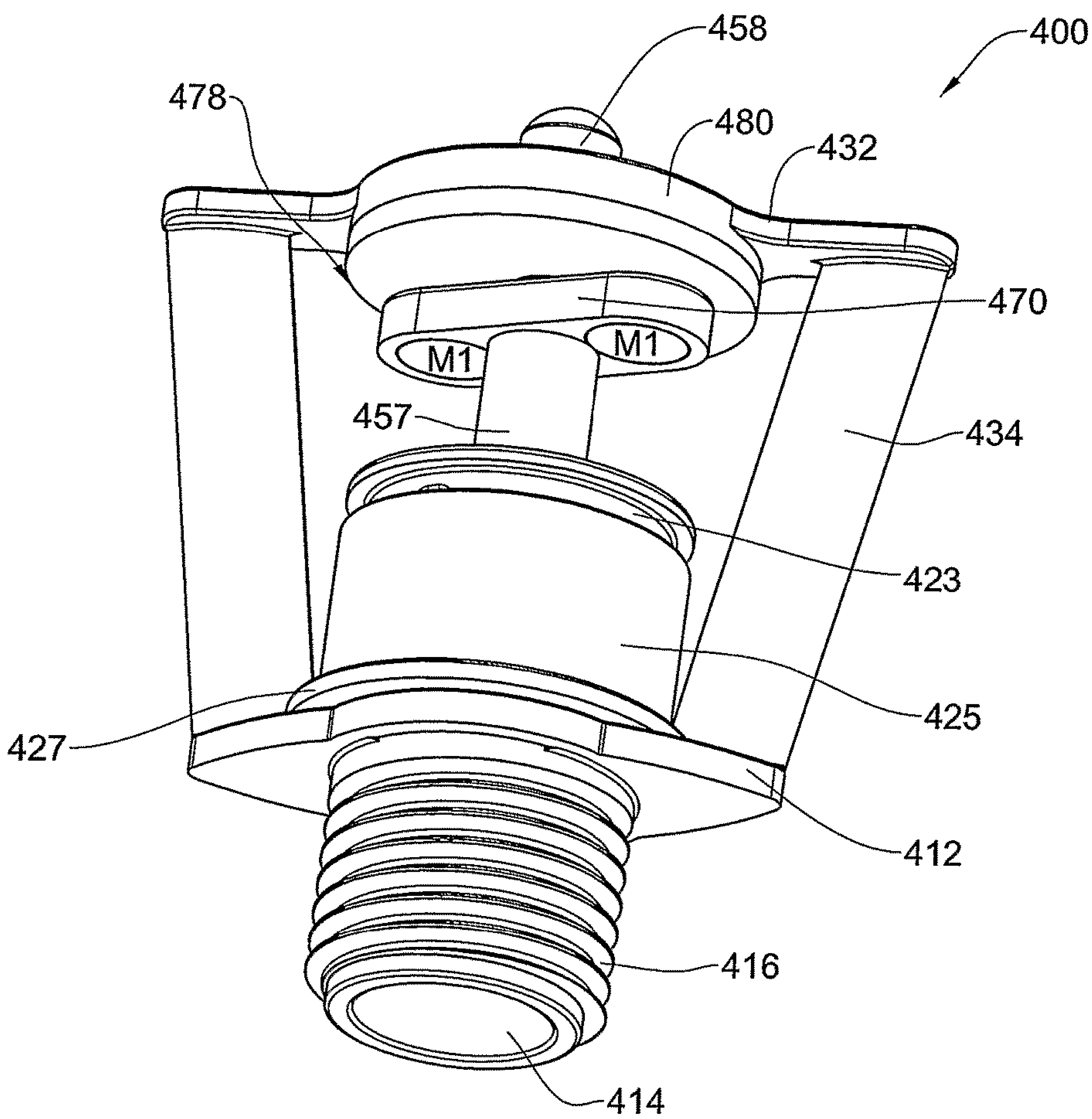
FIG. 12



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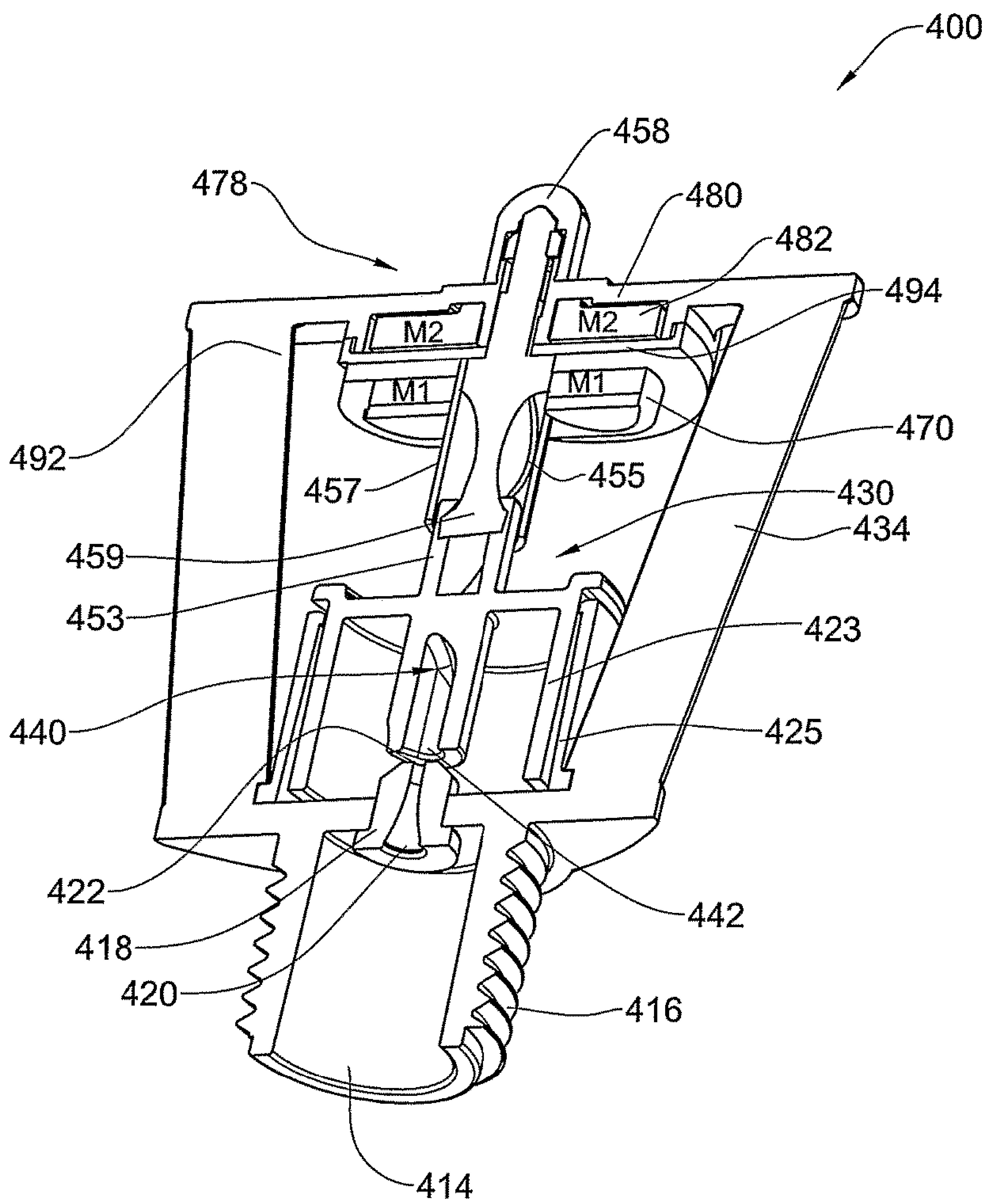
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FIG. 14

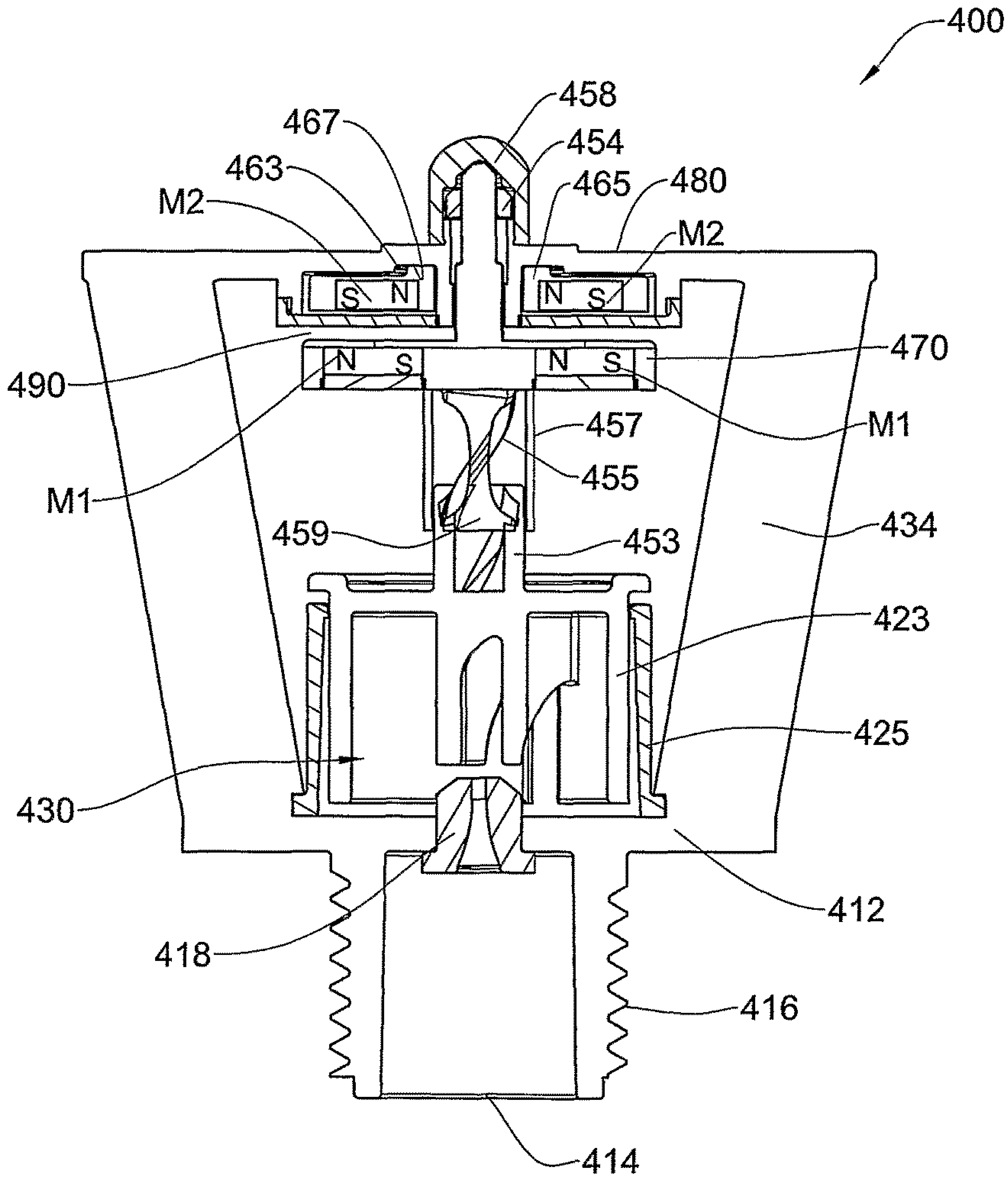
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FIG. 15

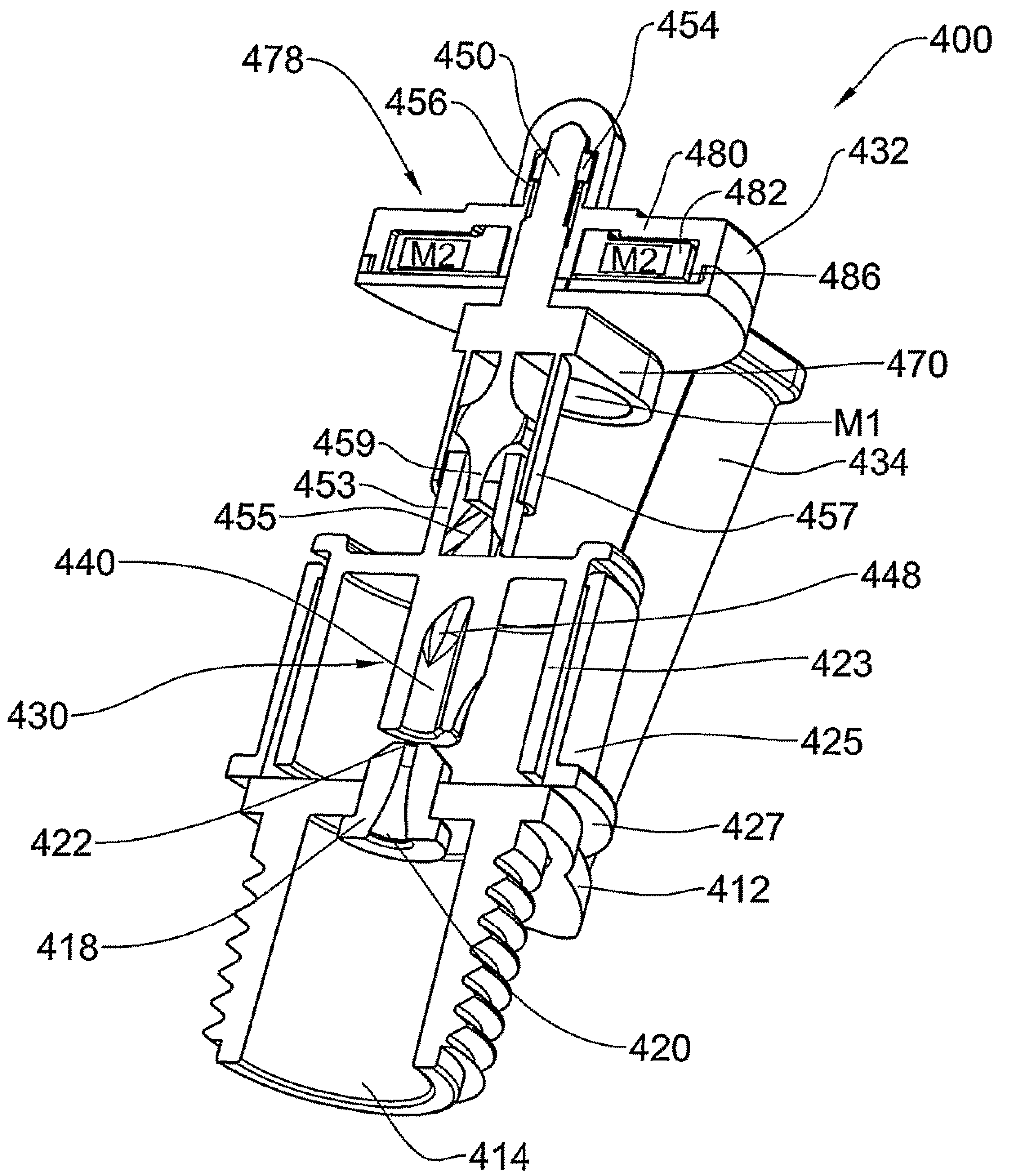
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FIG. 16

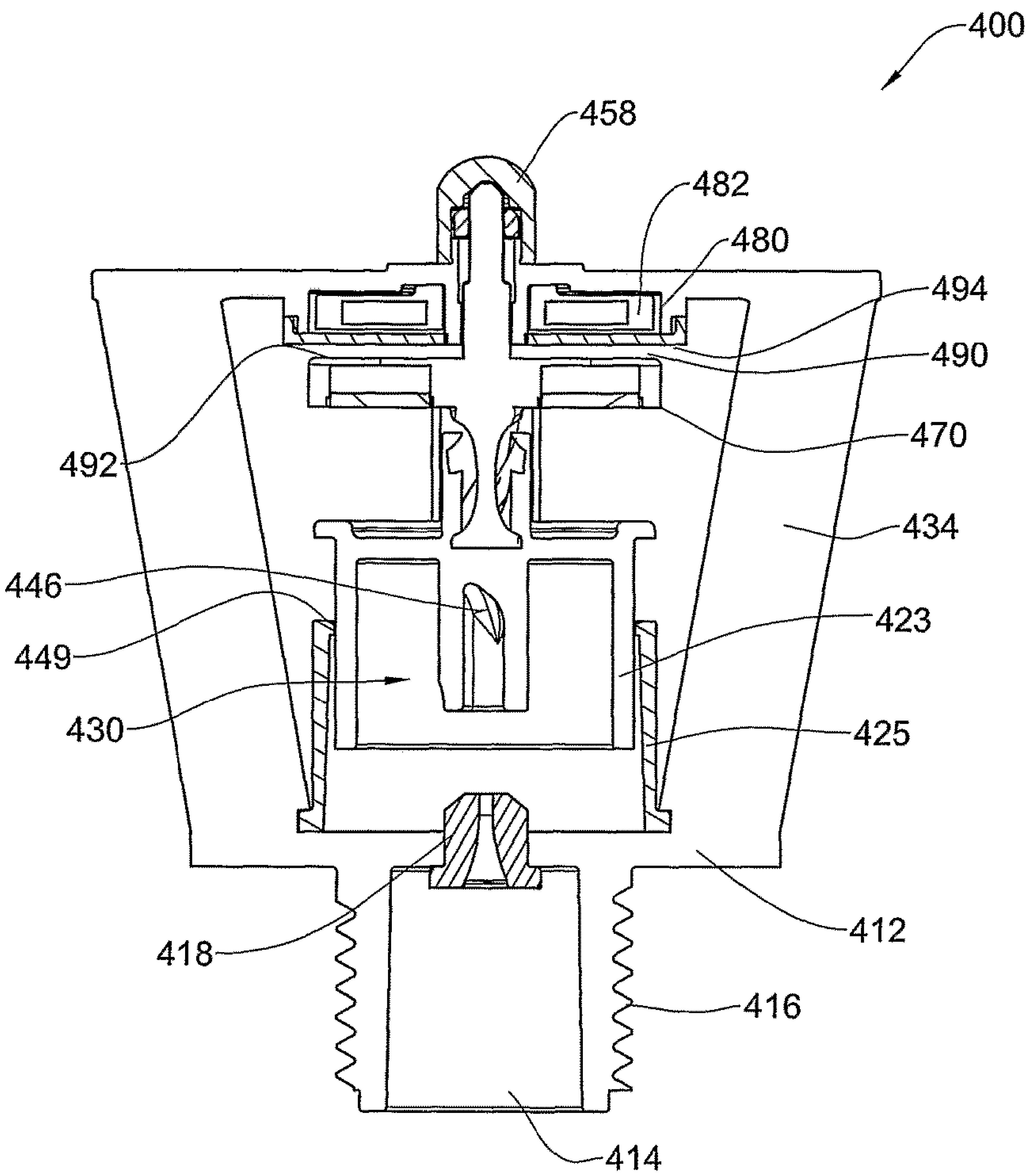
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FIG. 17

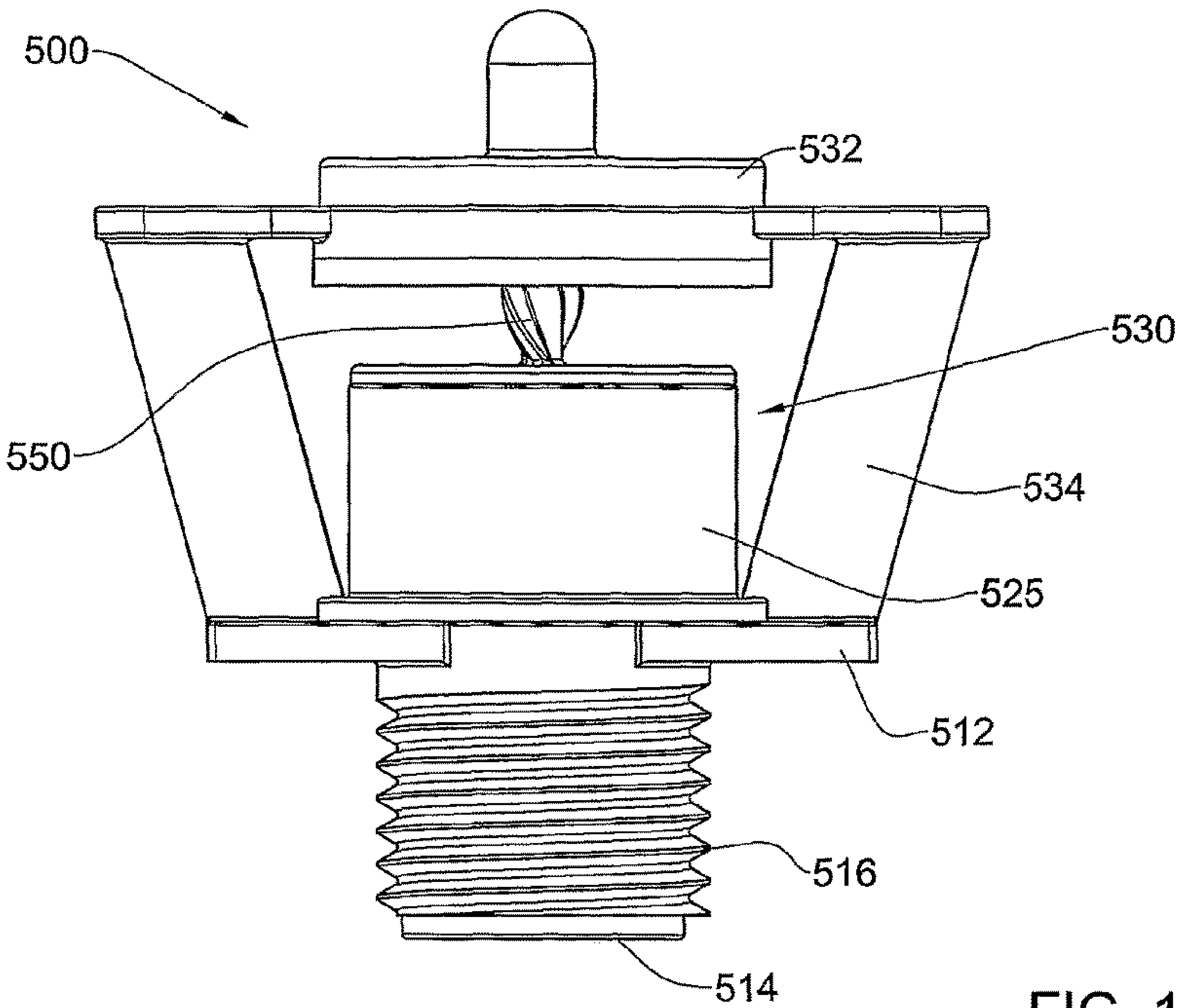

FIG. 18

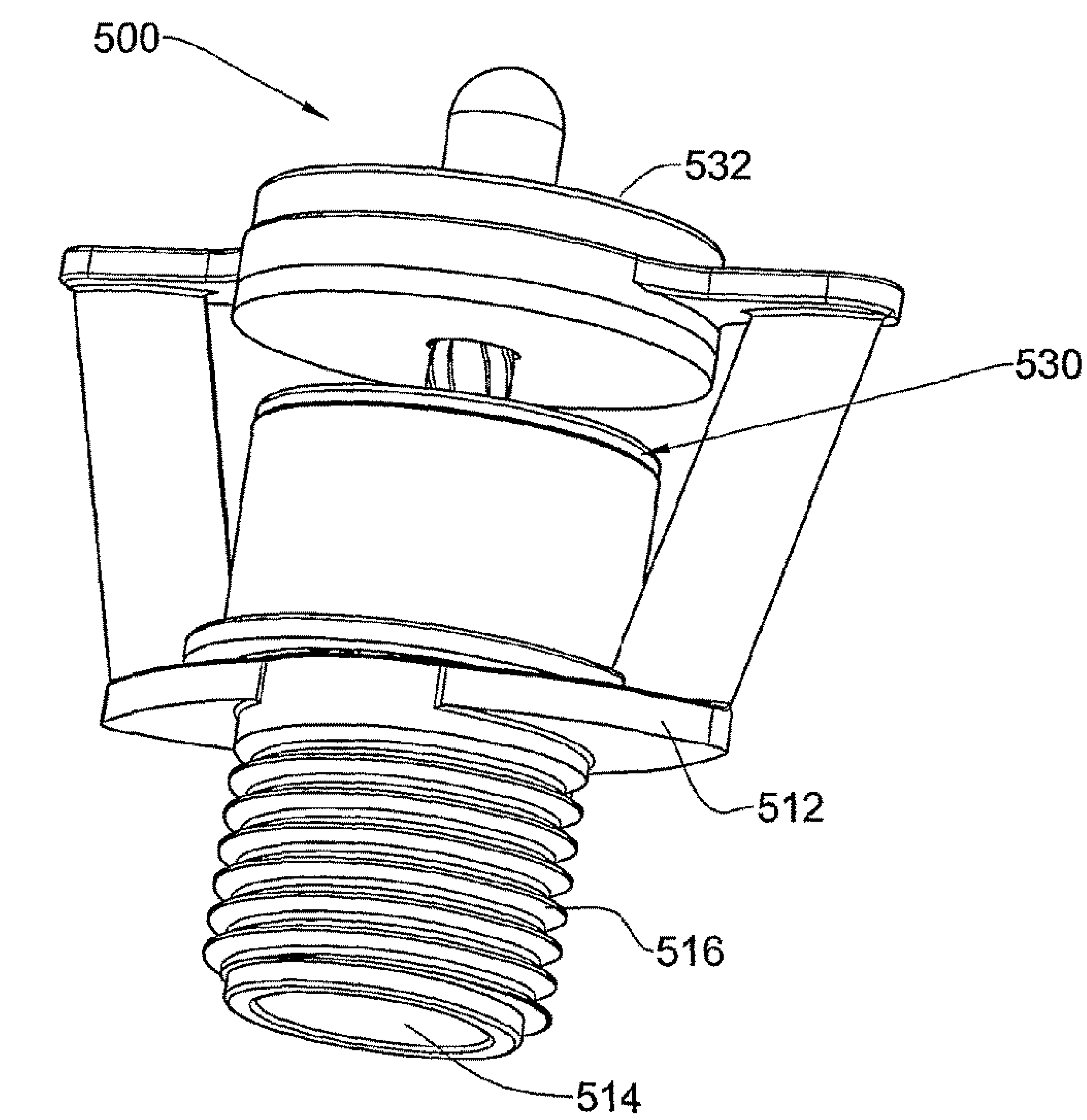

FIG. 19

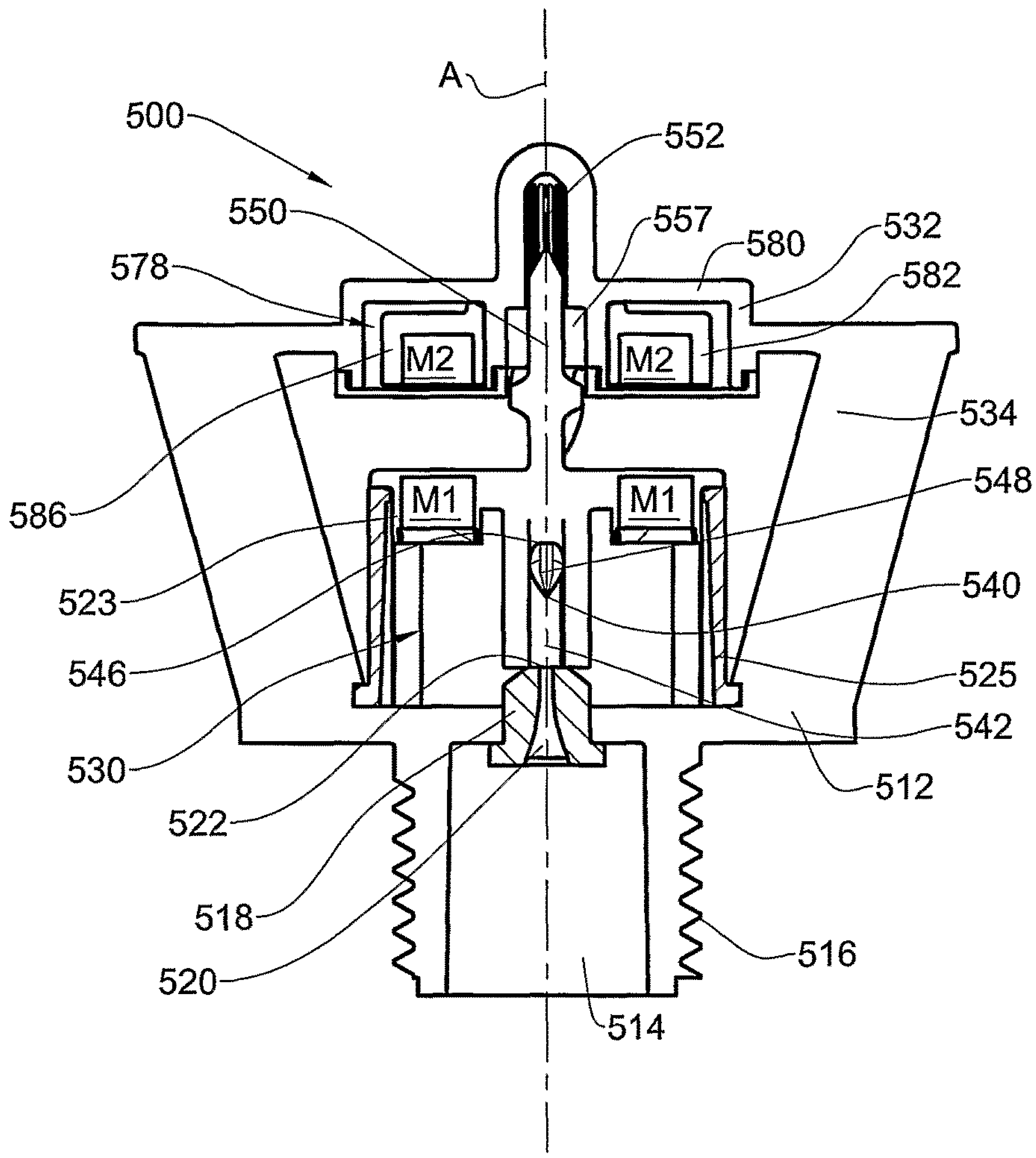
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FIG. 20

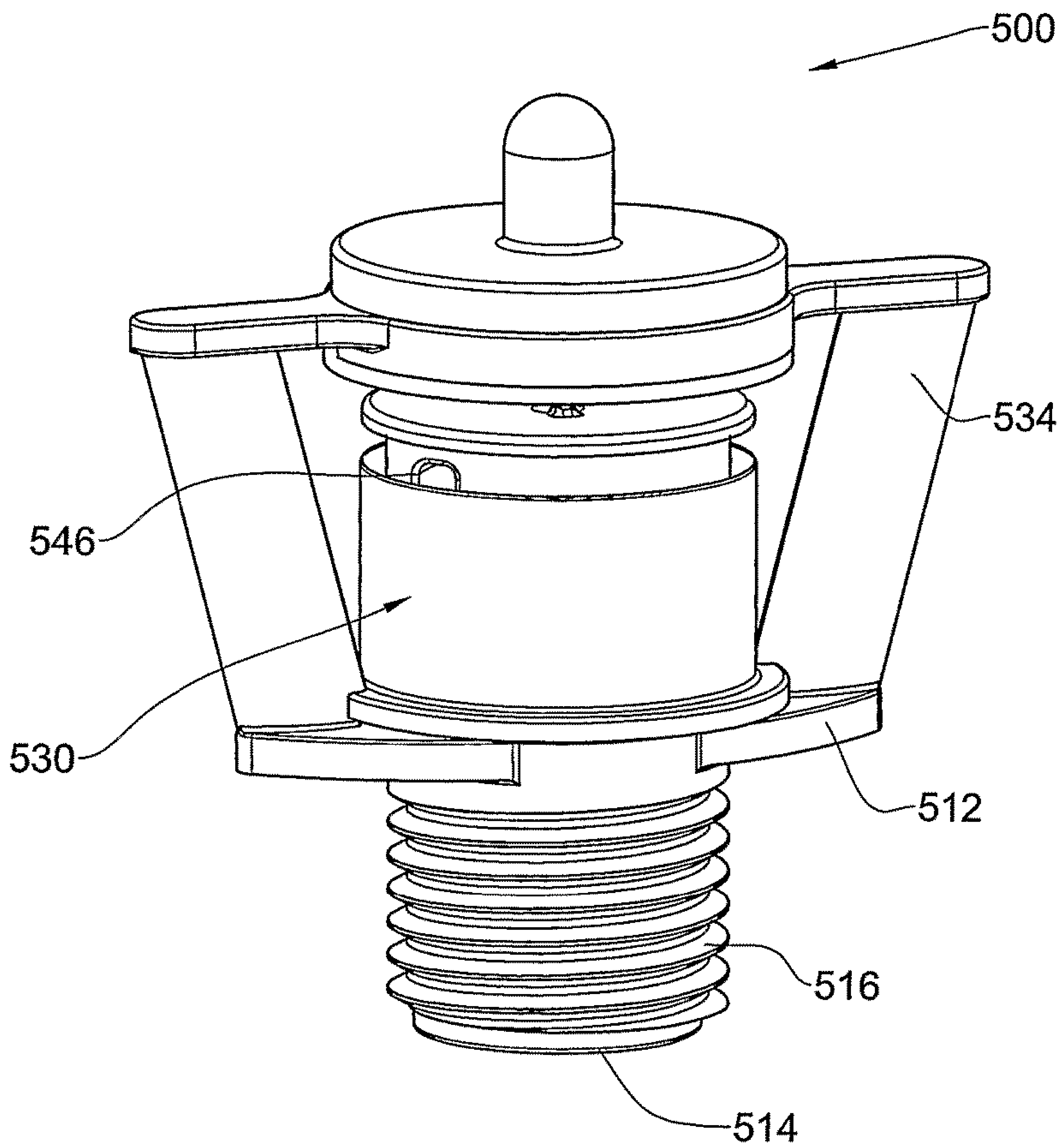

FIG. 21

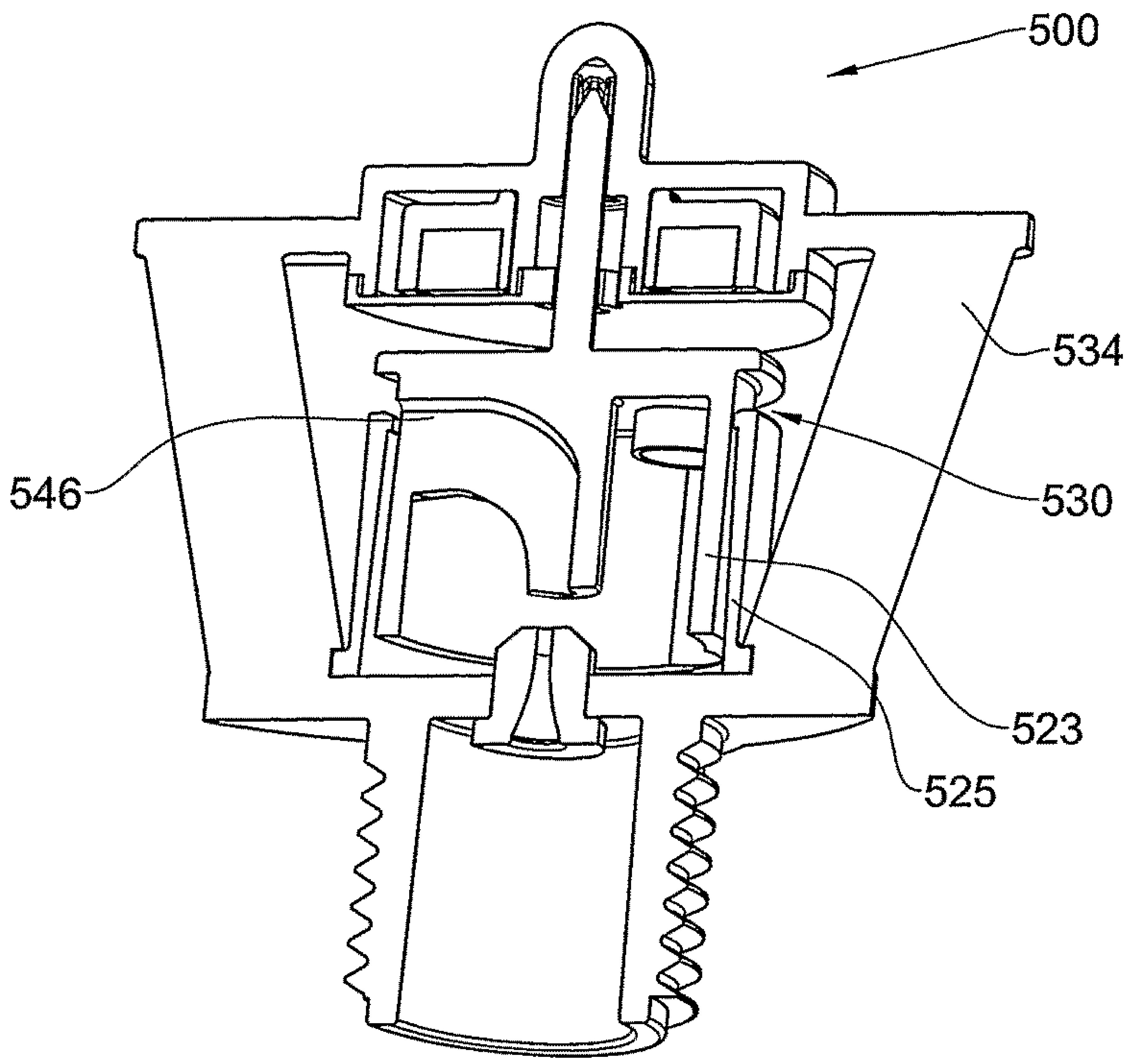

FIG. 22

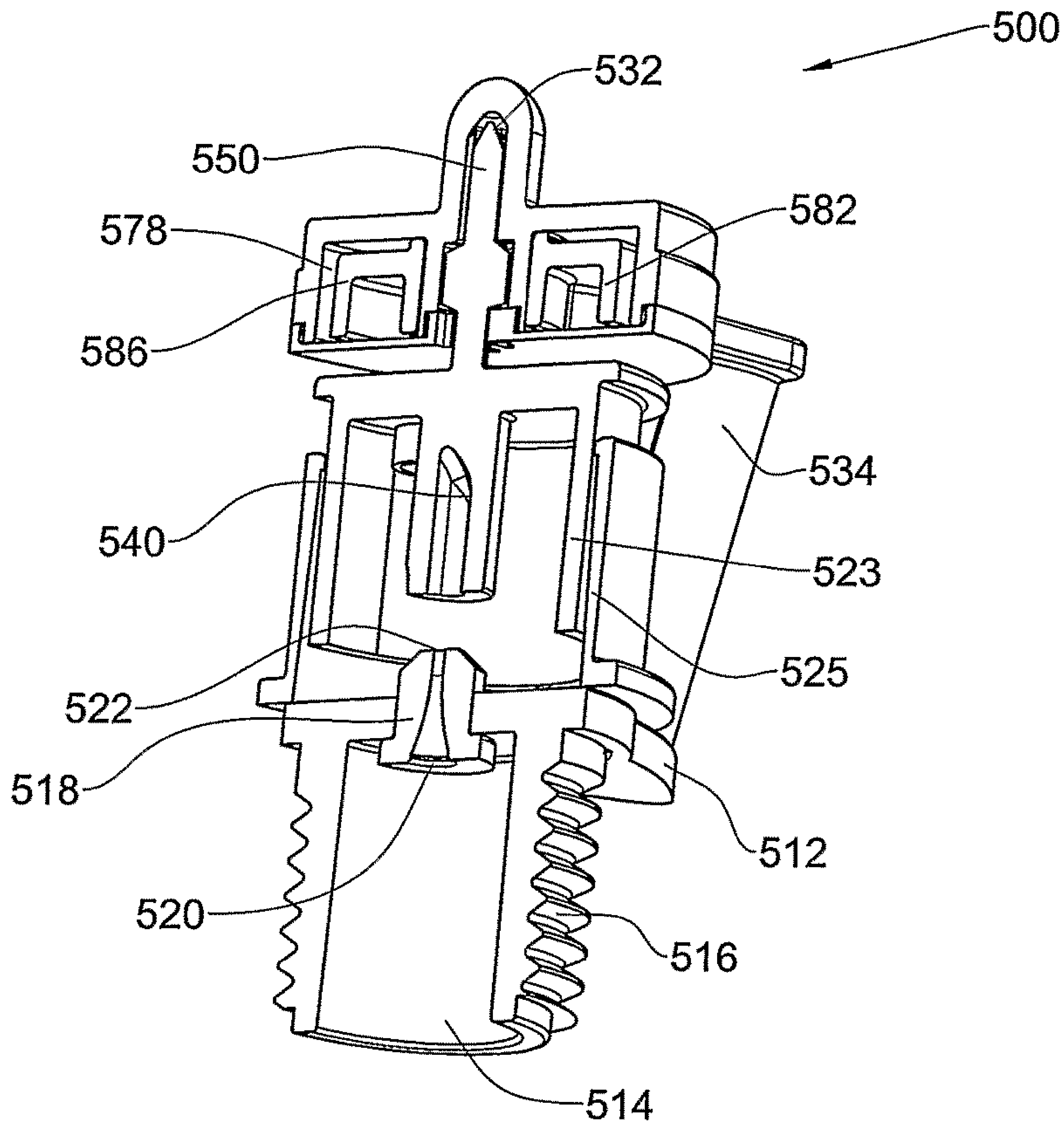

FIG. 23

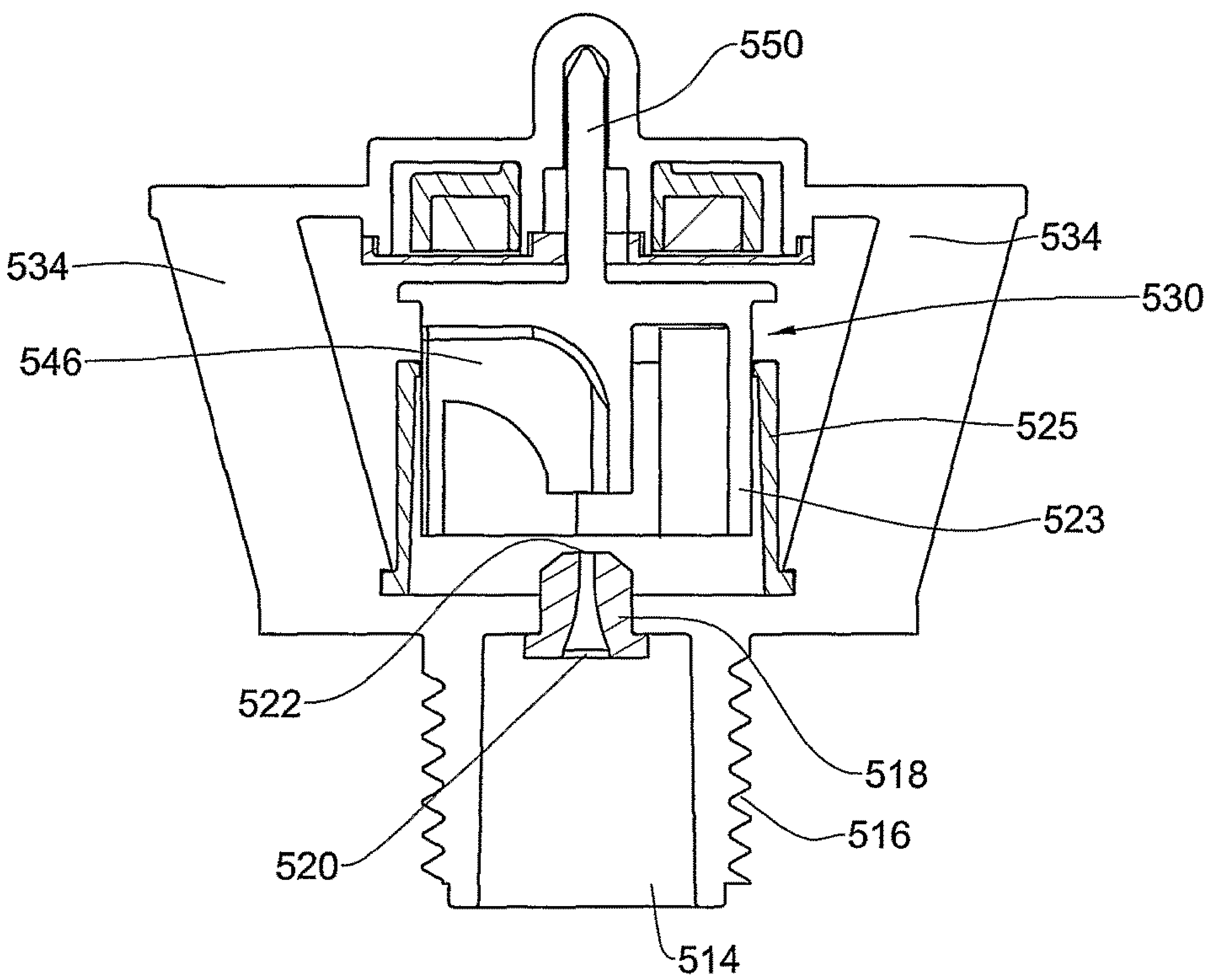

FIG. 24

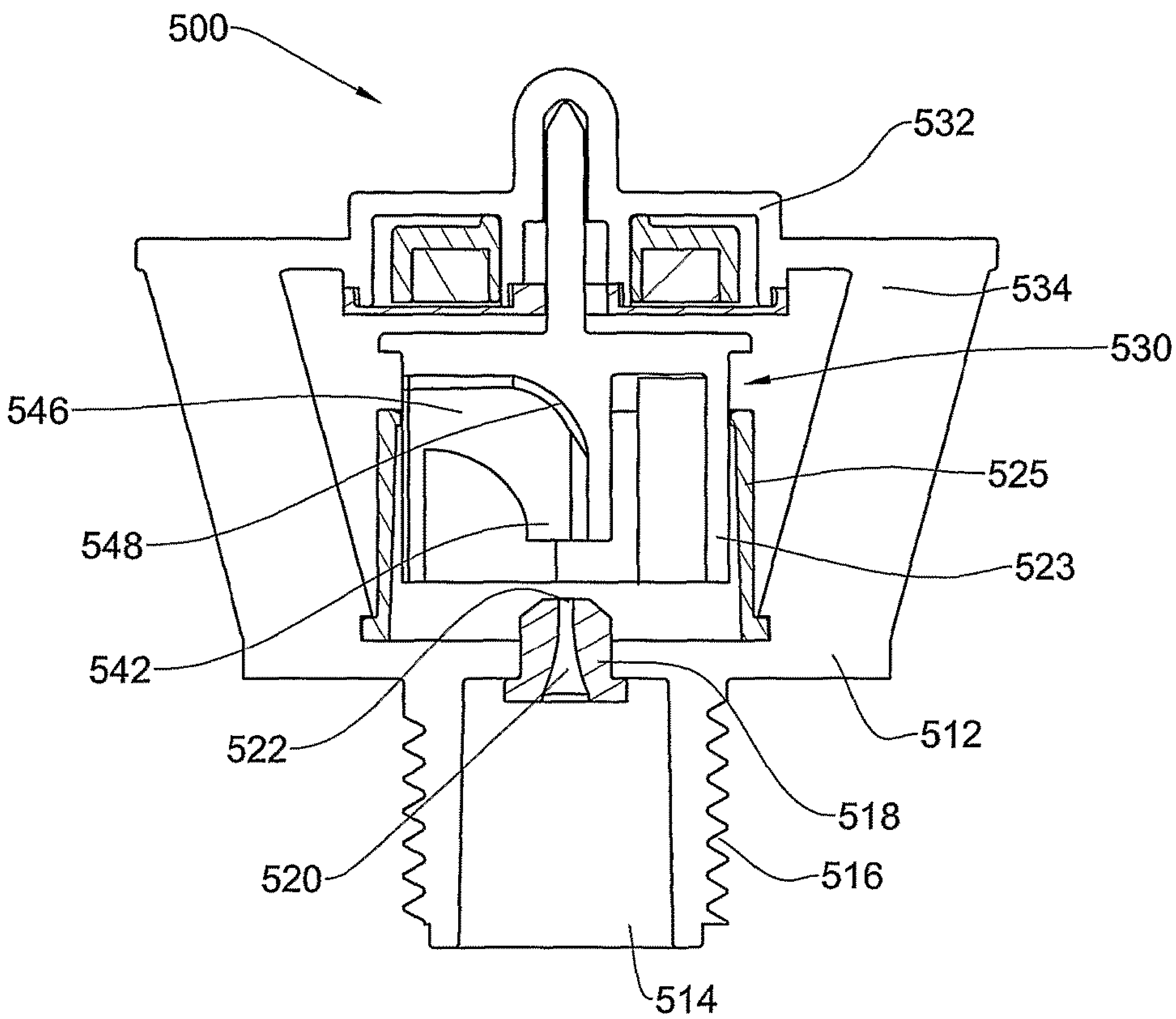

FIG. 25

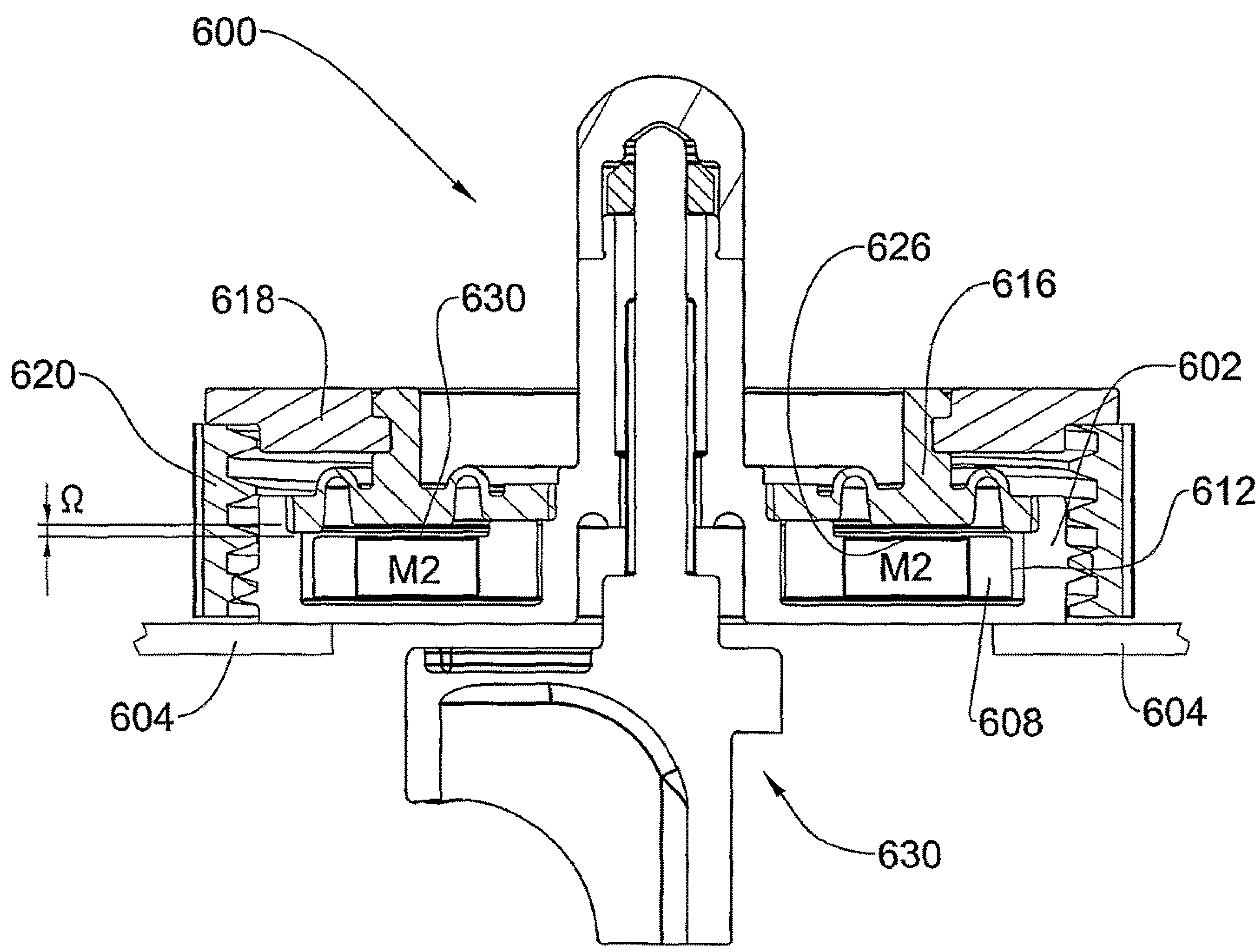

FIG. 26

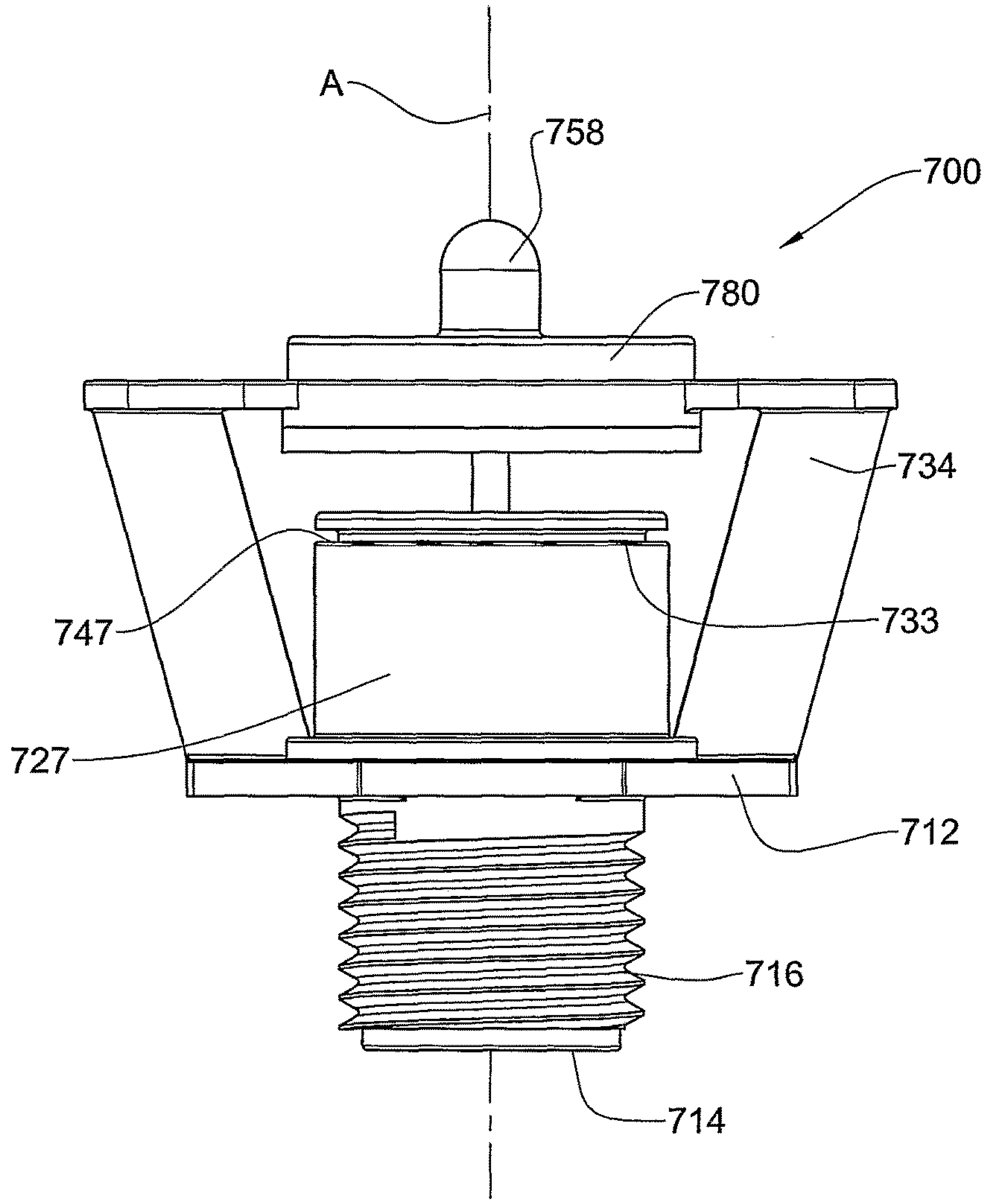

FIG. 27A

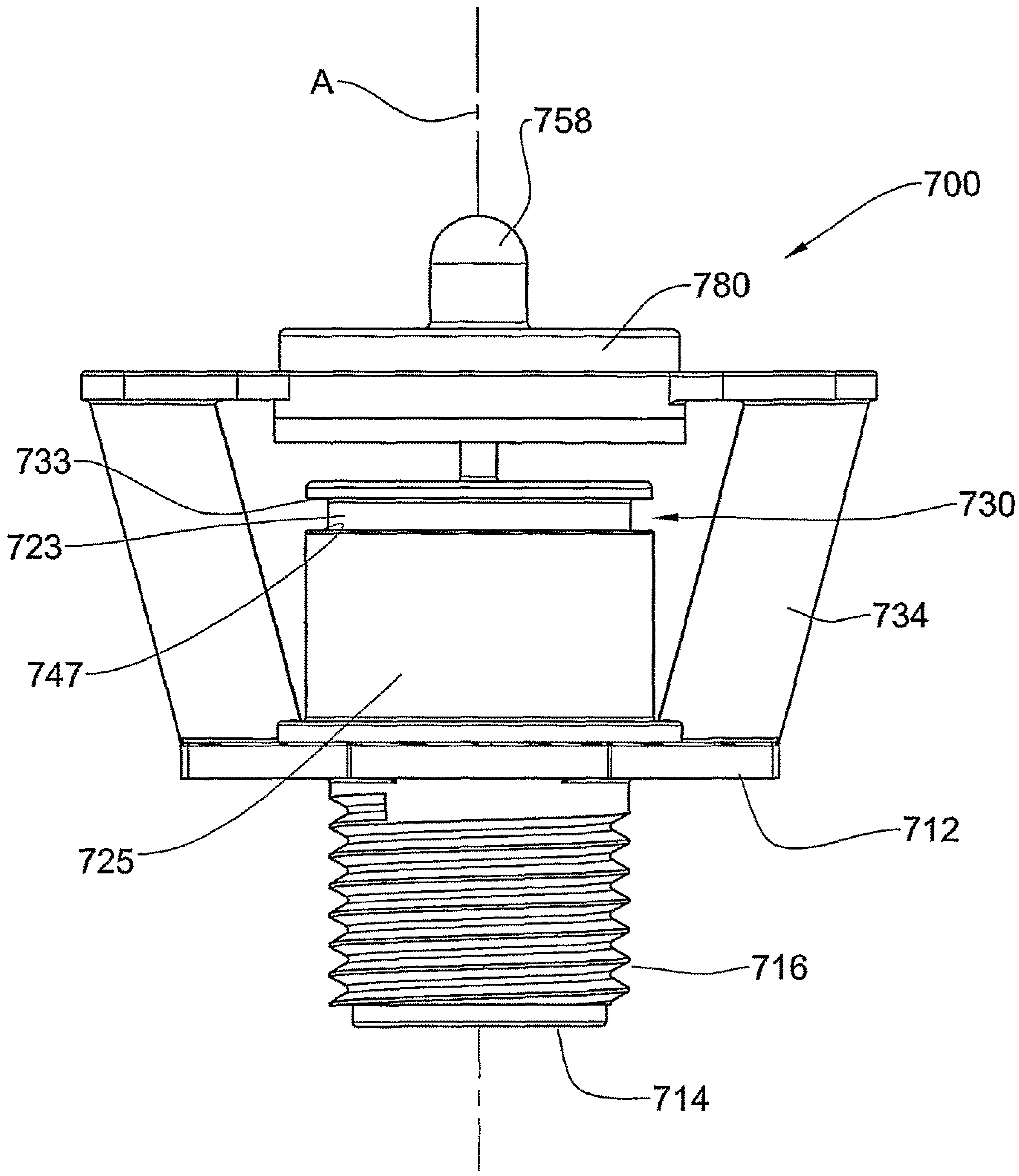

FIG. 27B

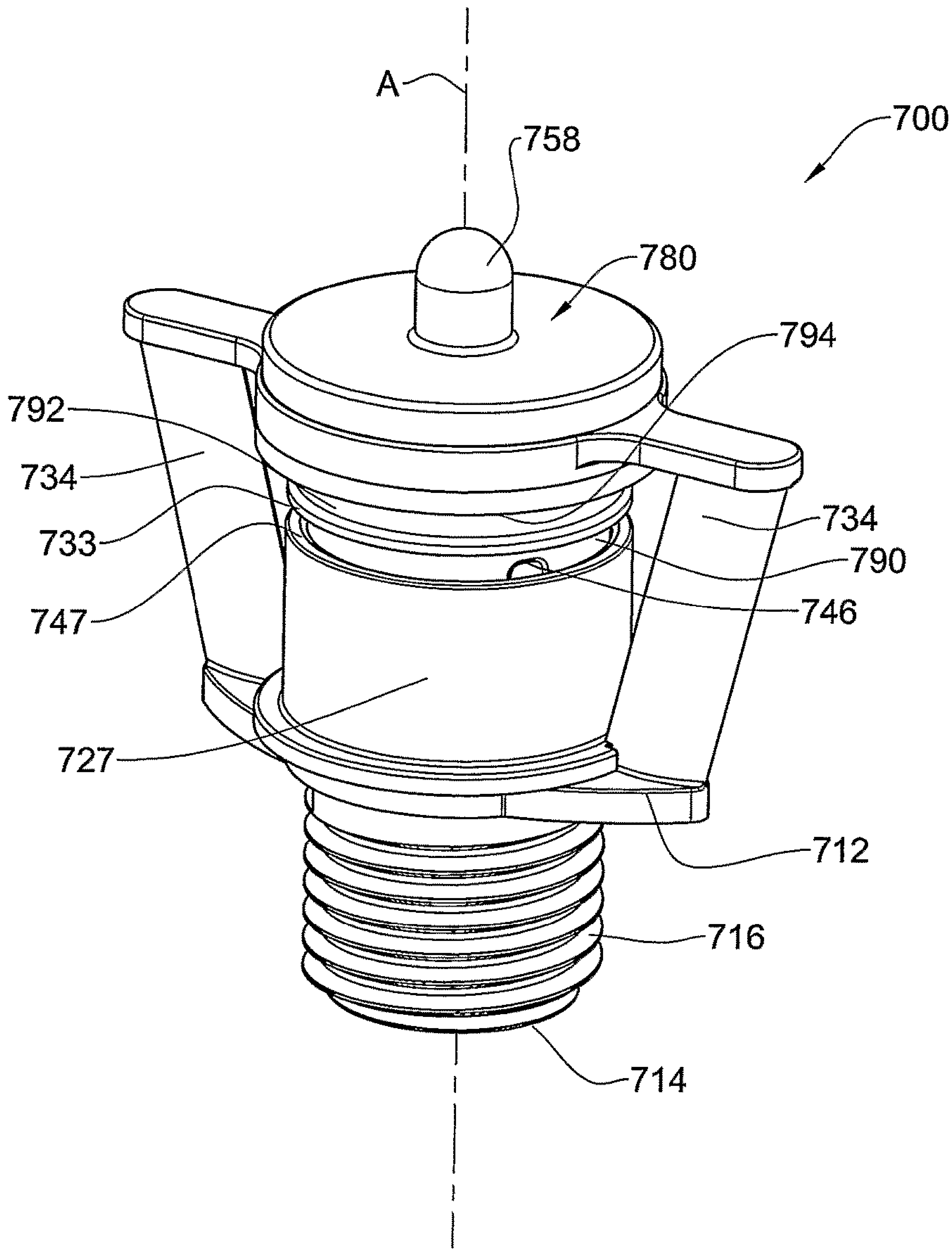

FIG. 28

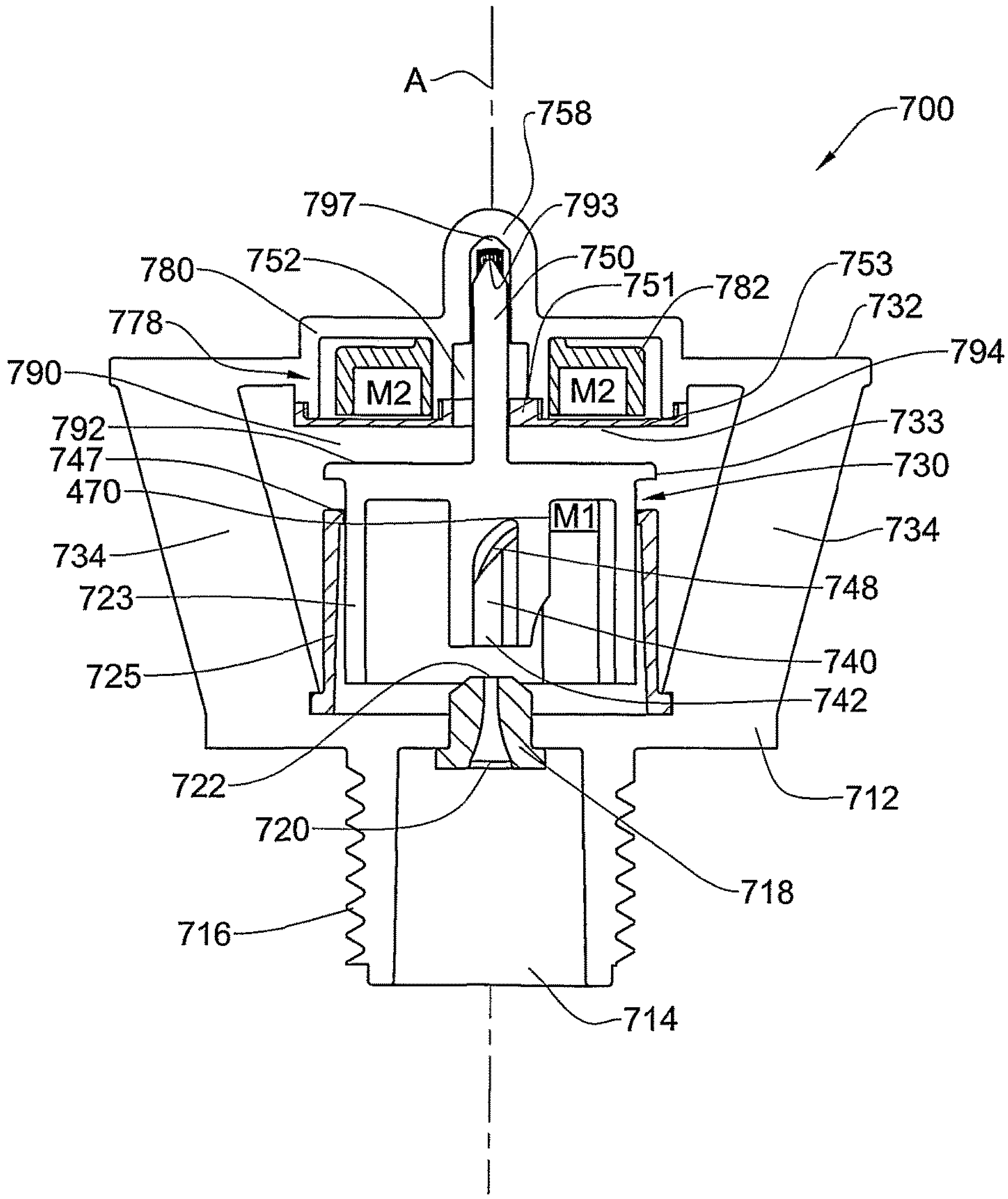
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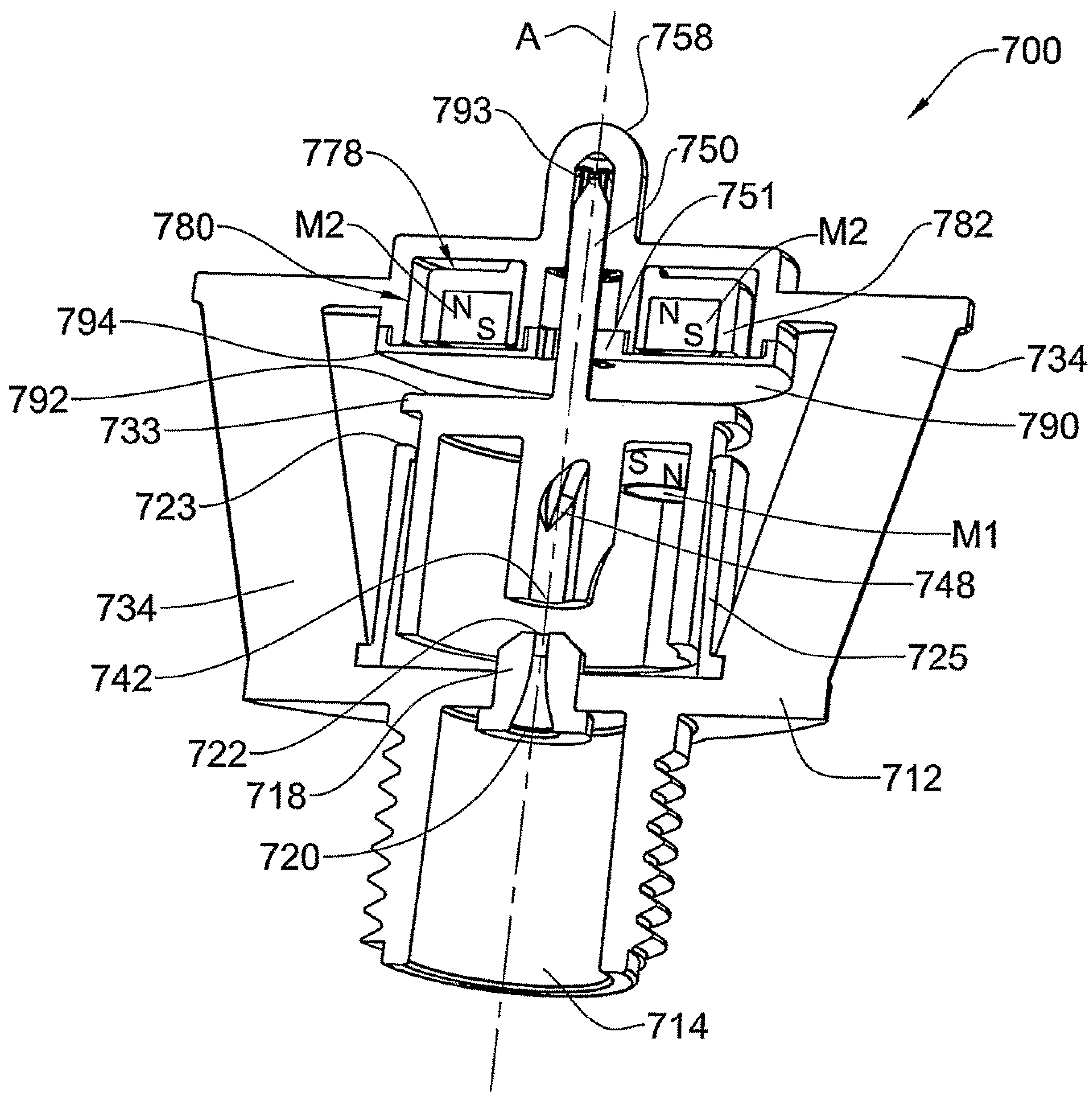
FIG. 29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714

FIG. 30

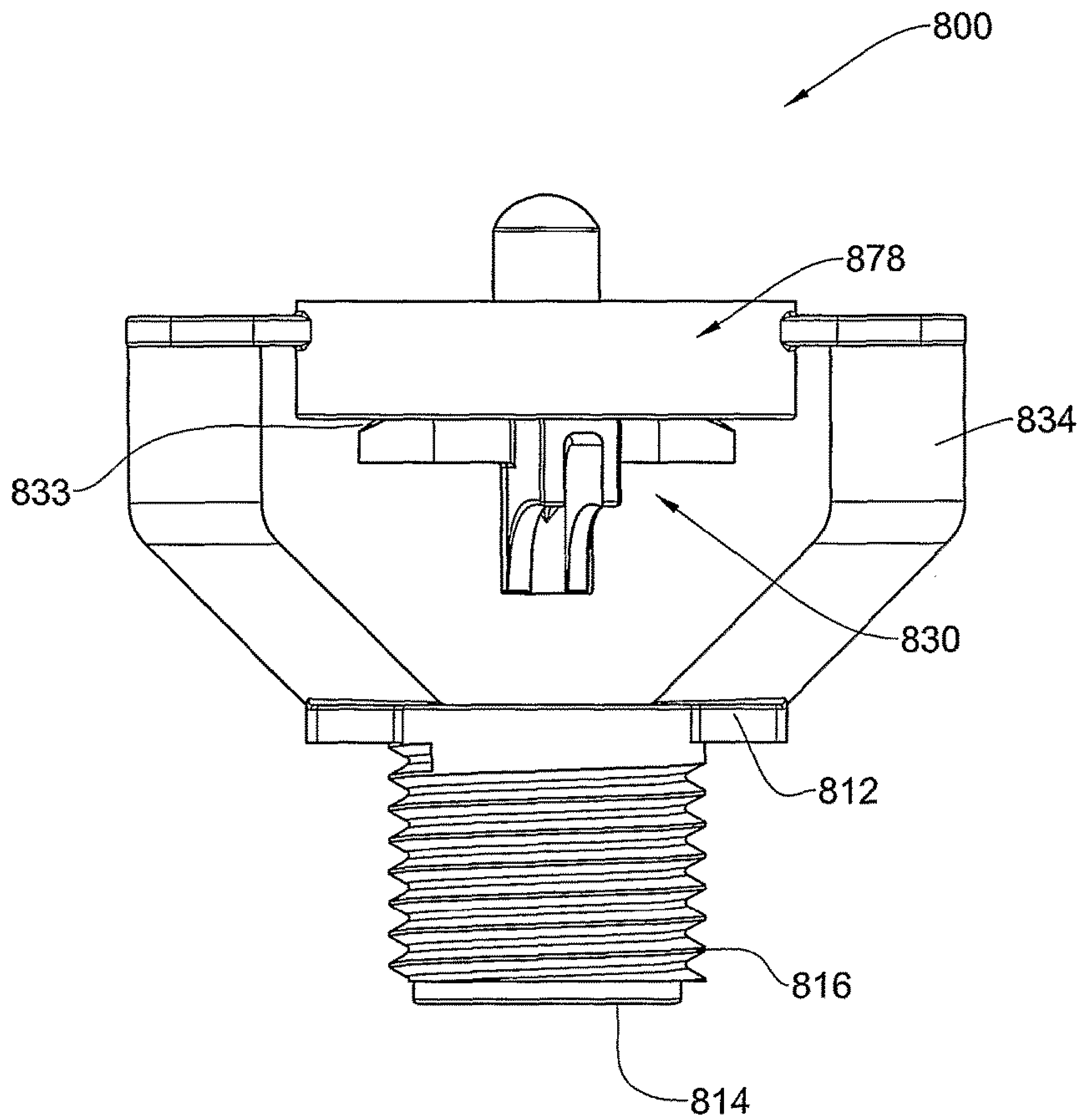


FIG. 31

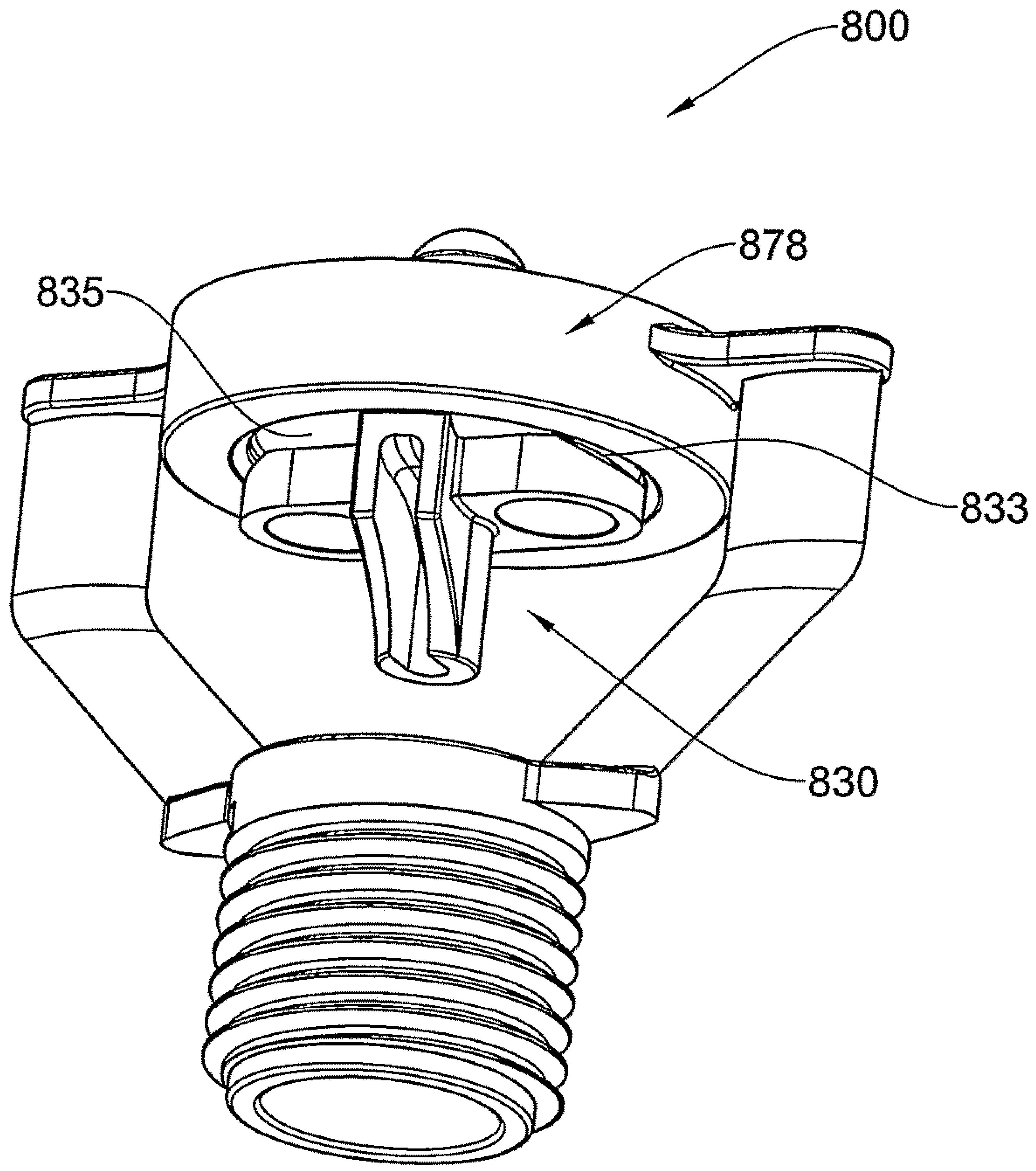


FIG. 32

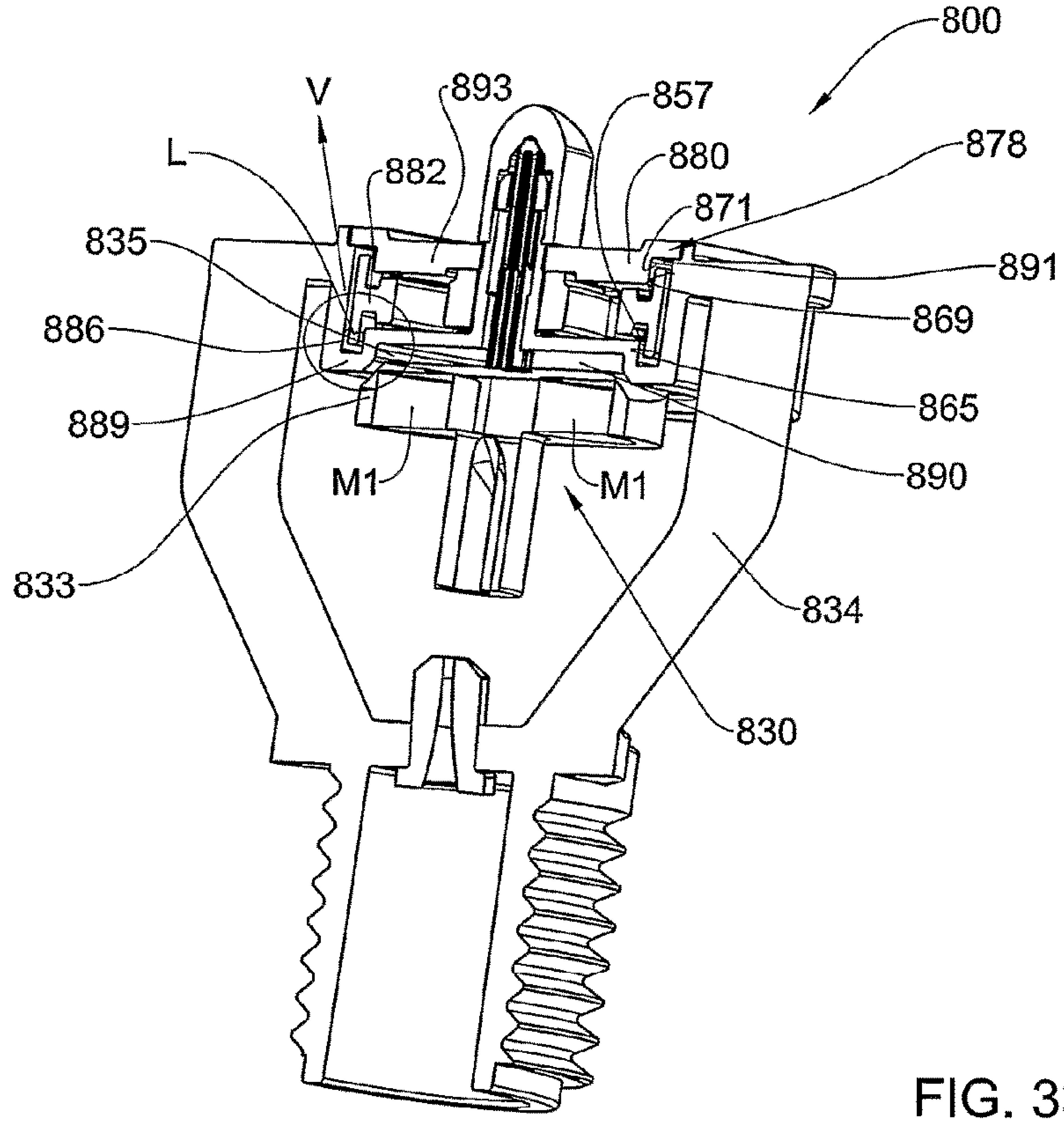


FIG. 33A

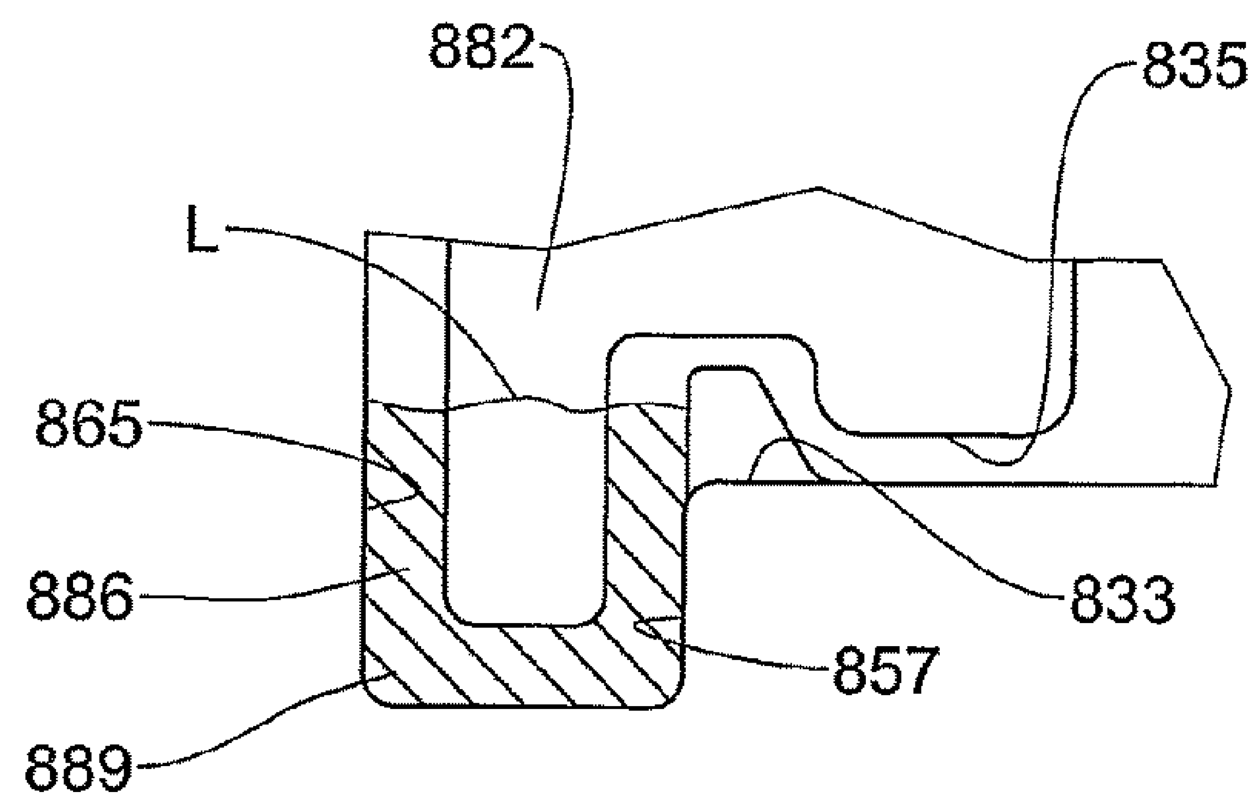


FIG. 33B

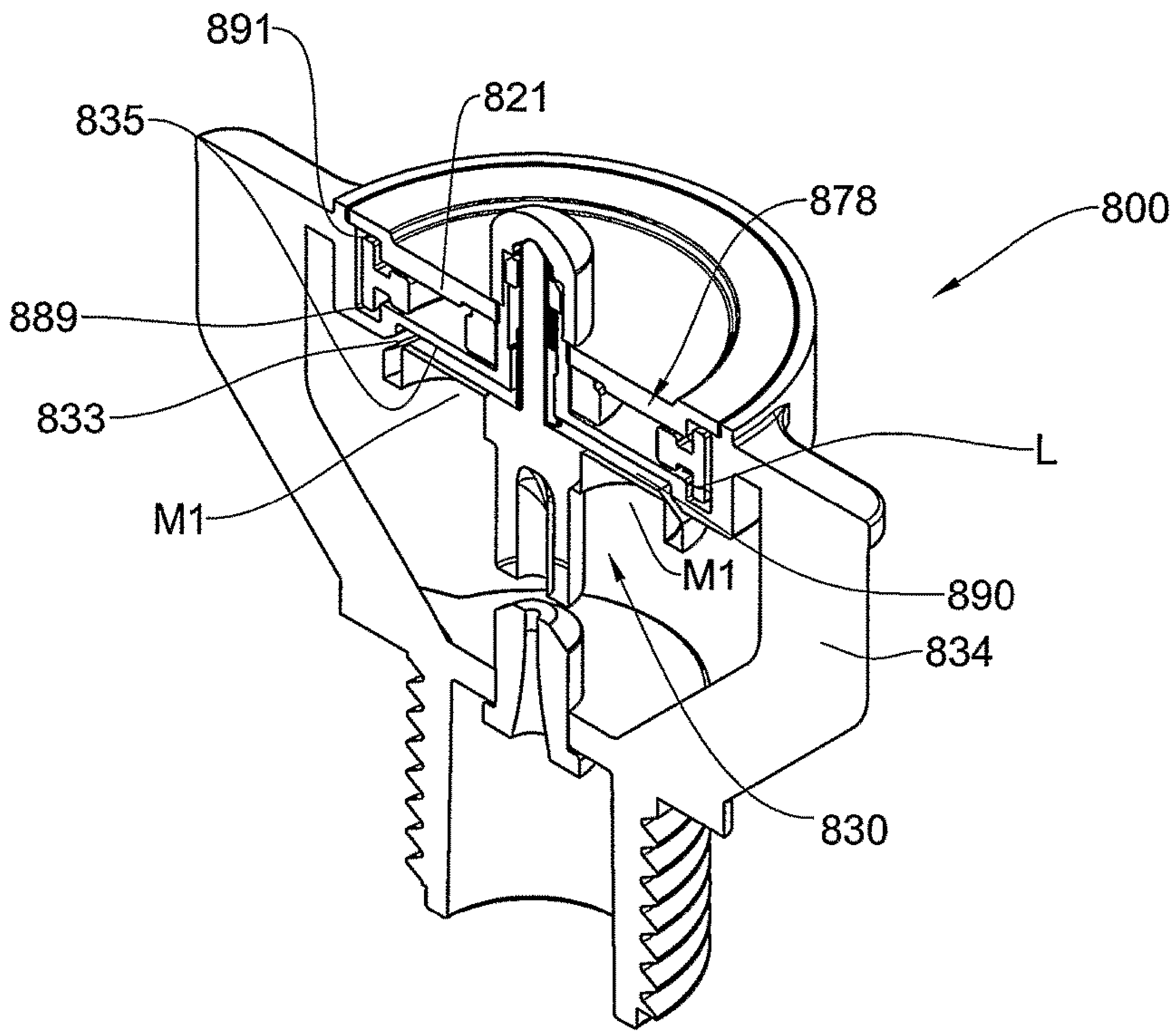


FIG. 34

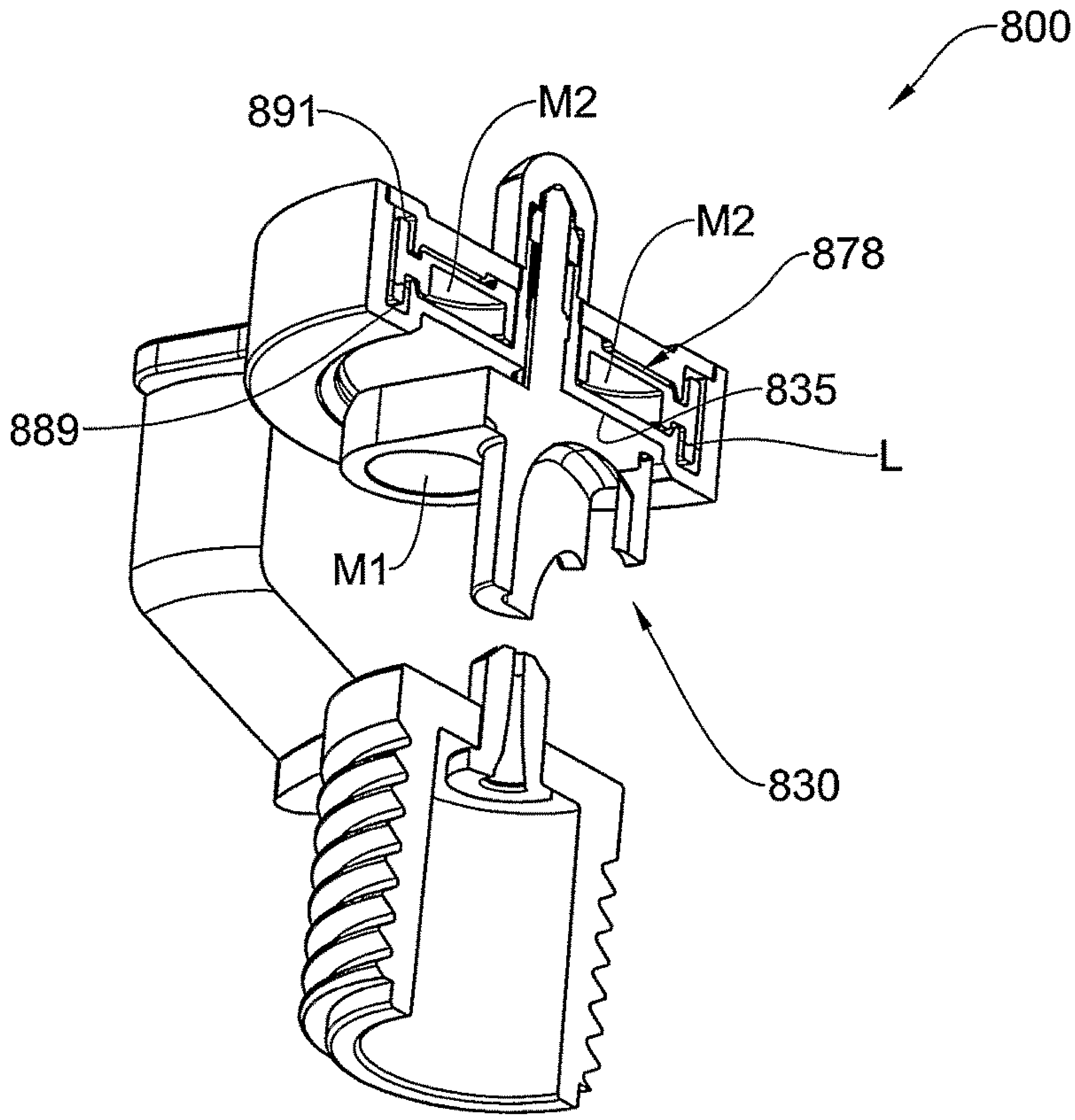


FIG. 35

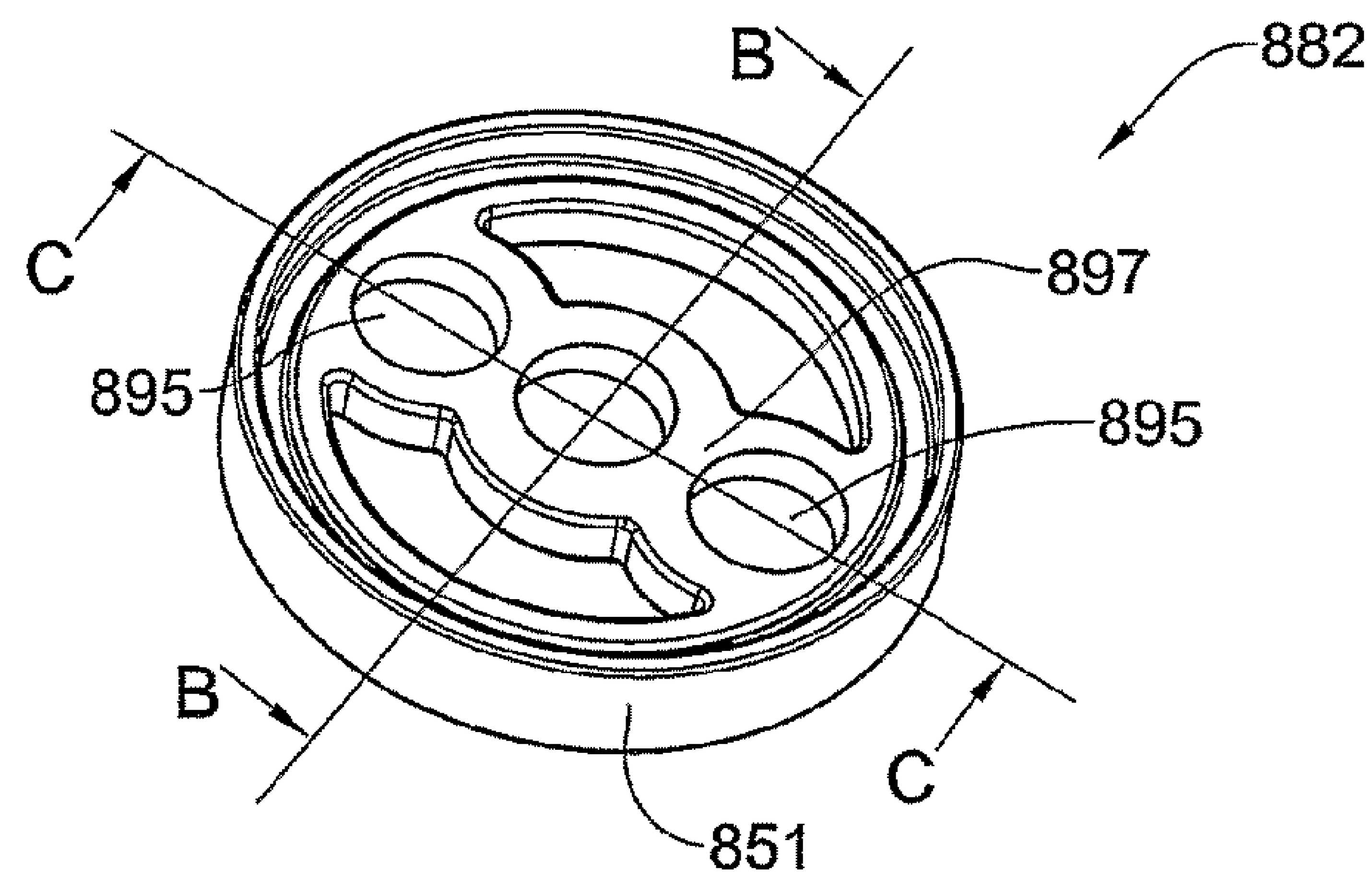


FIG. 36A

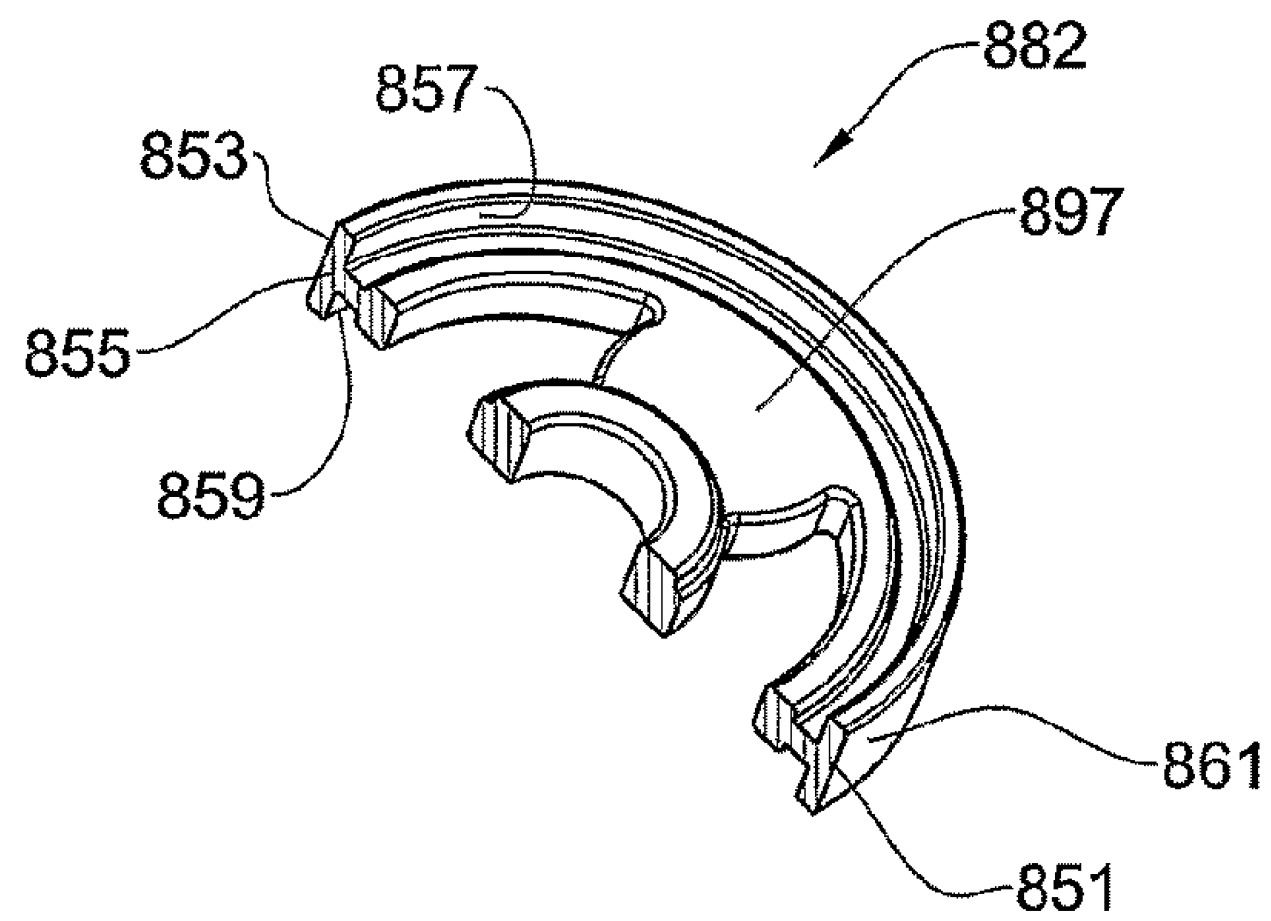


FIG. 36B

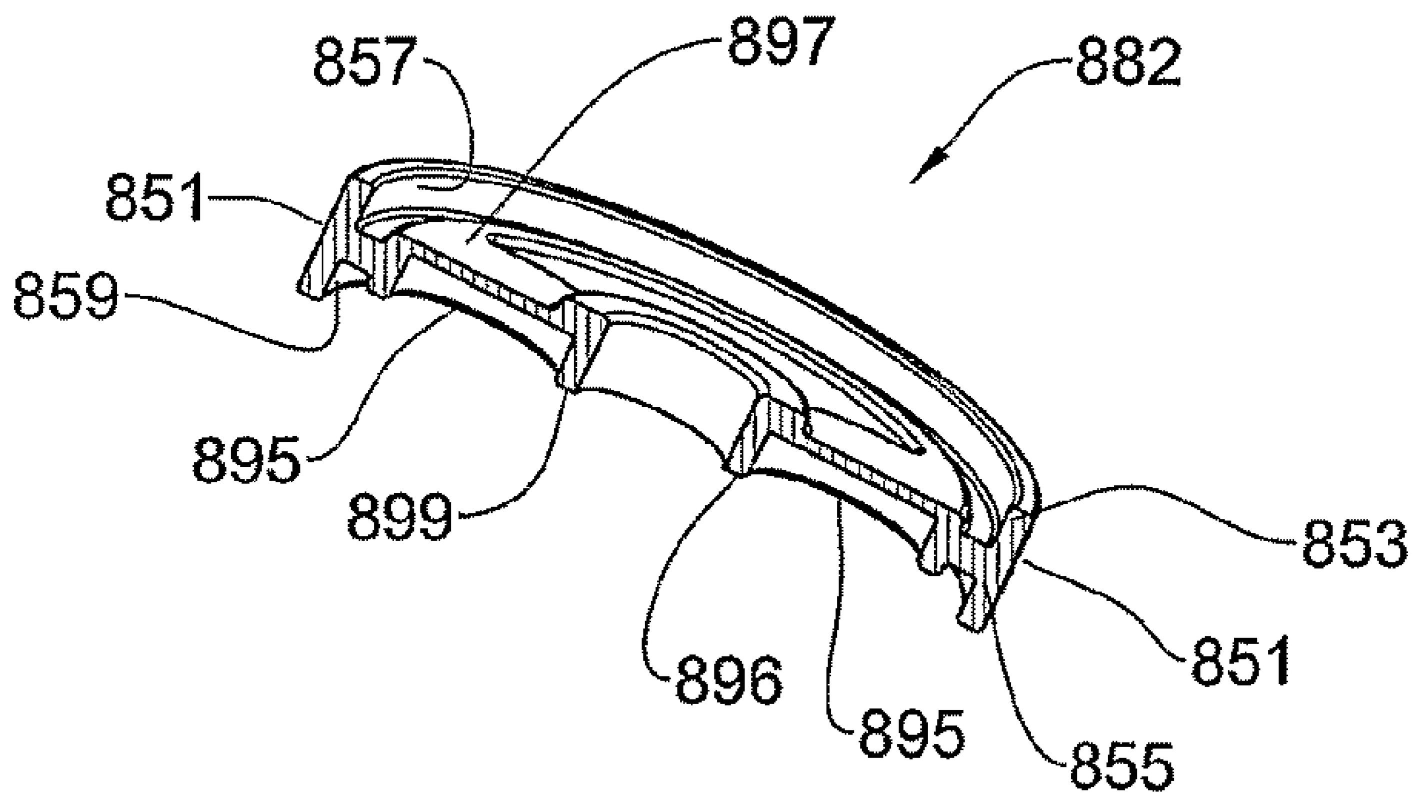


FIG. 36C

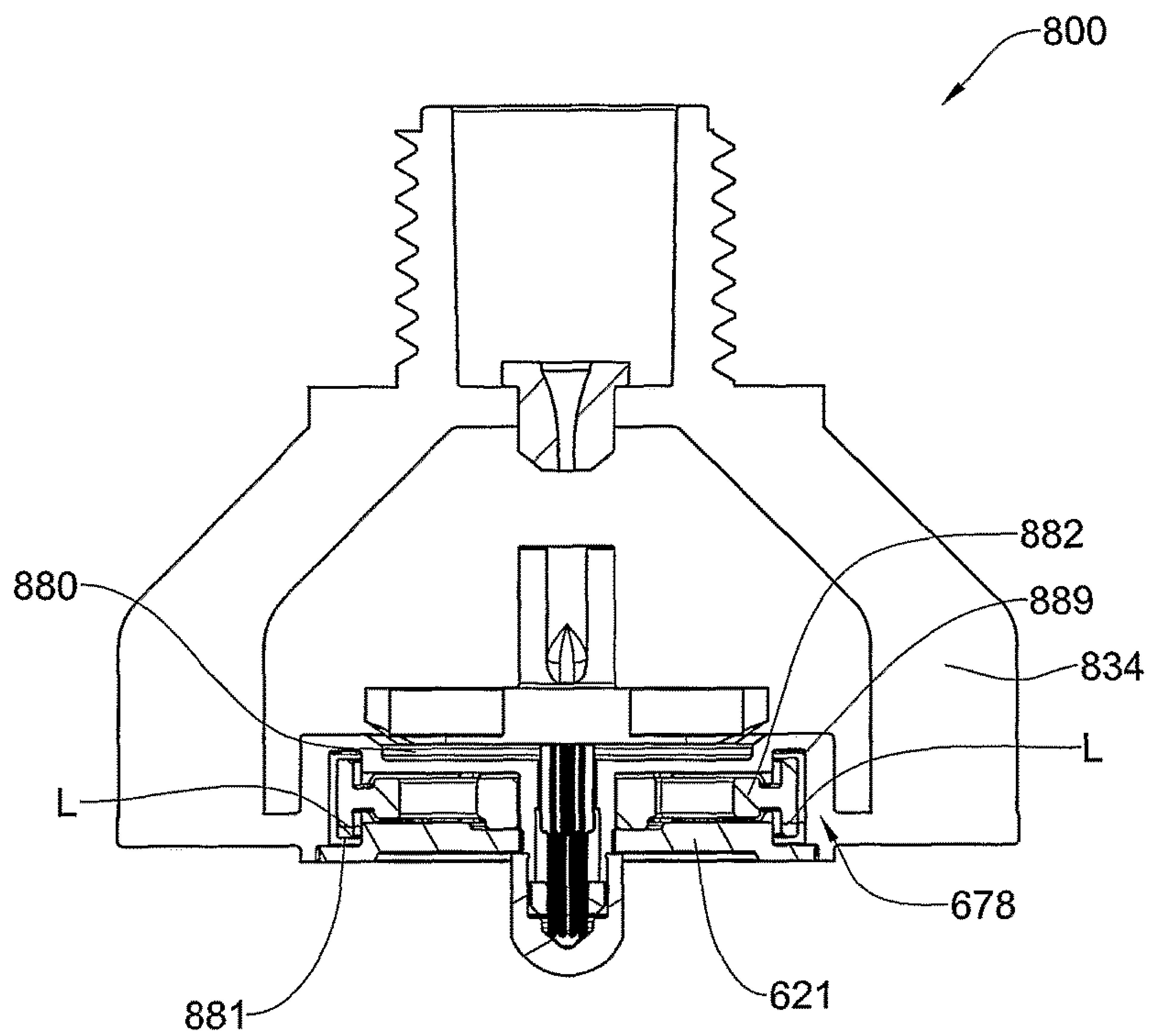


FIG. 37

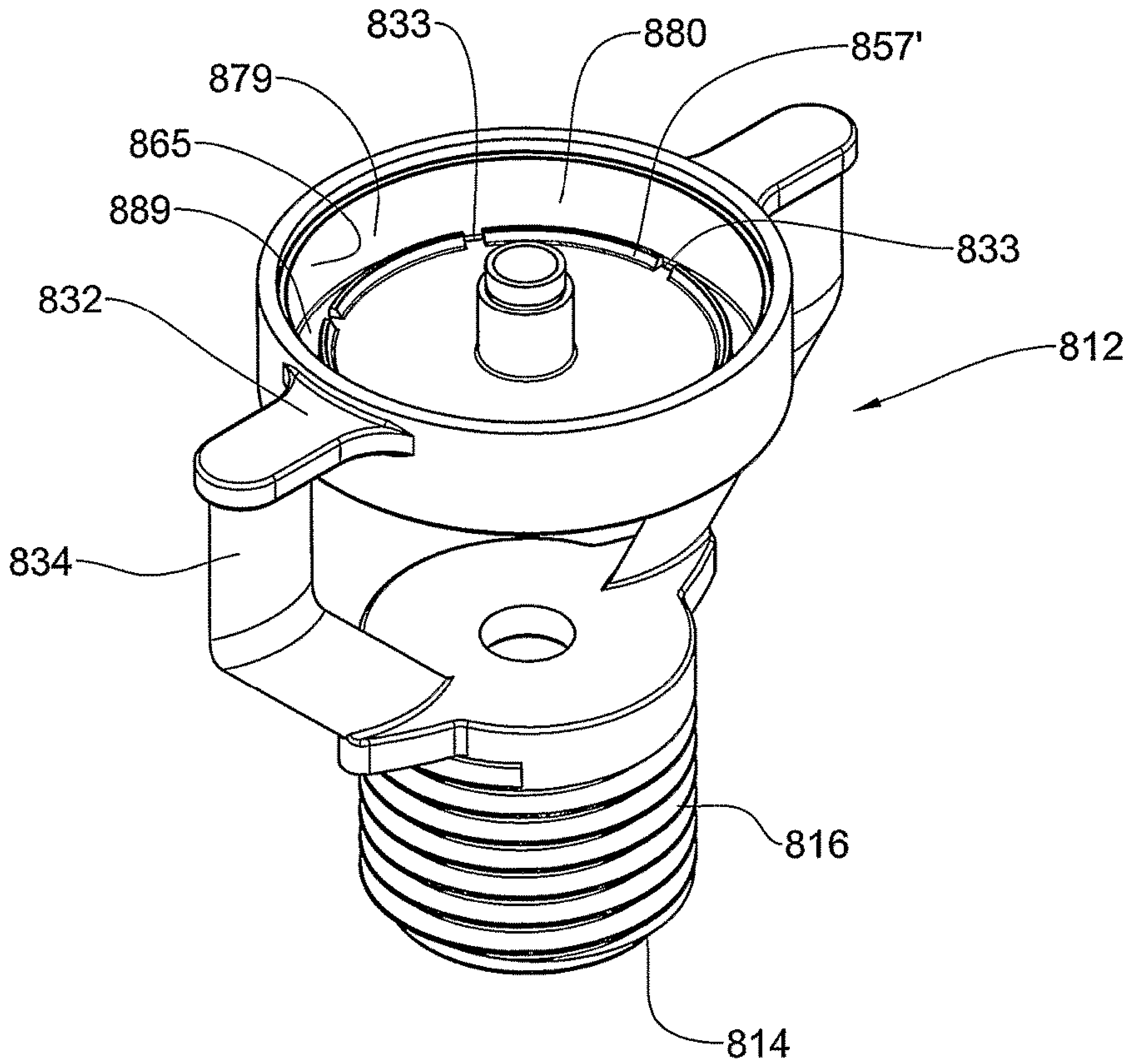


FIG. 38A

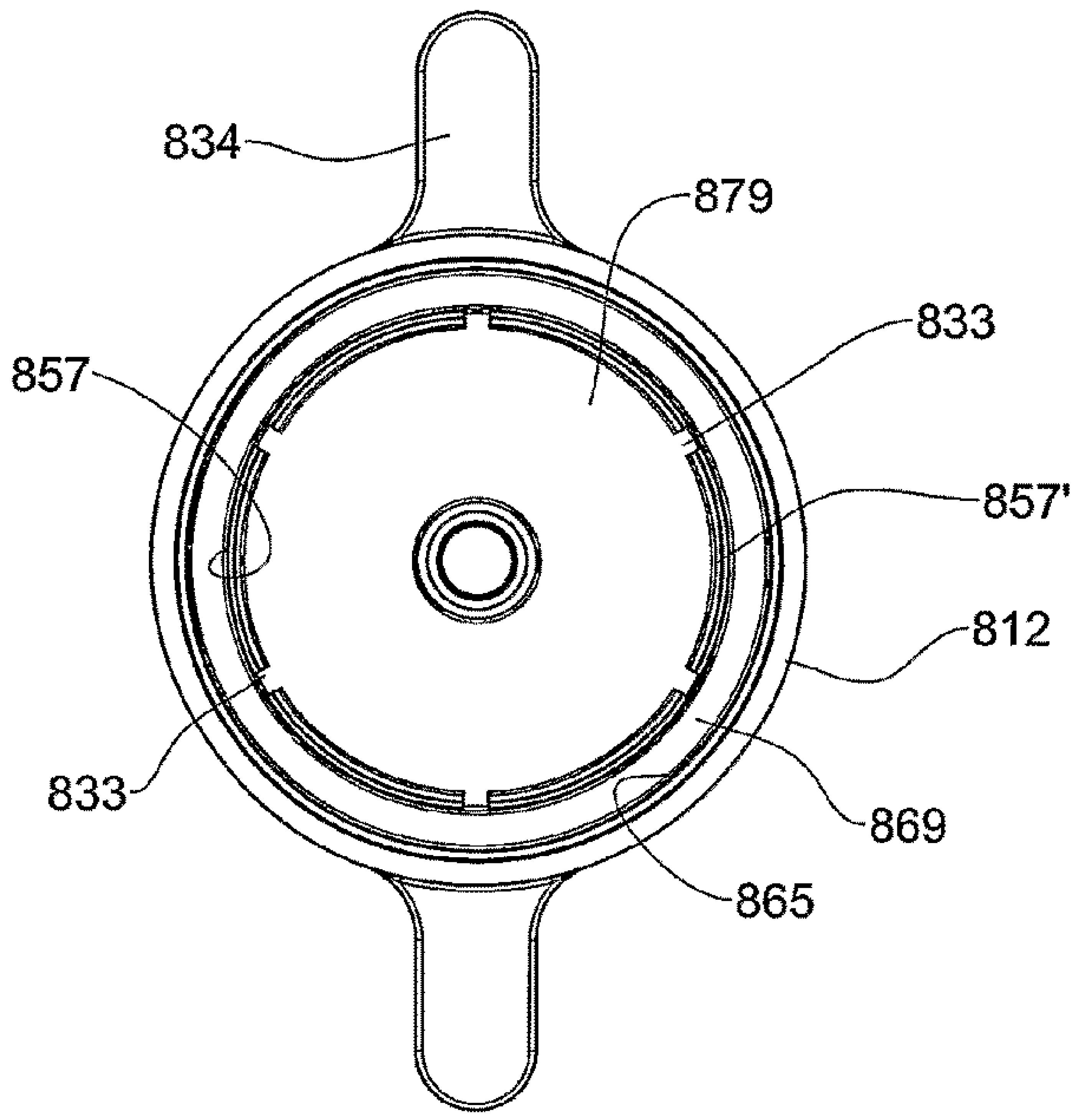


FIG. 38B

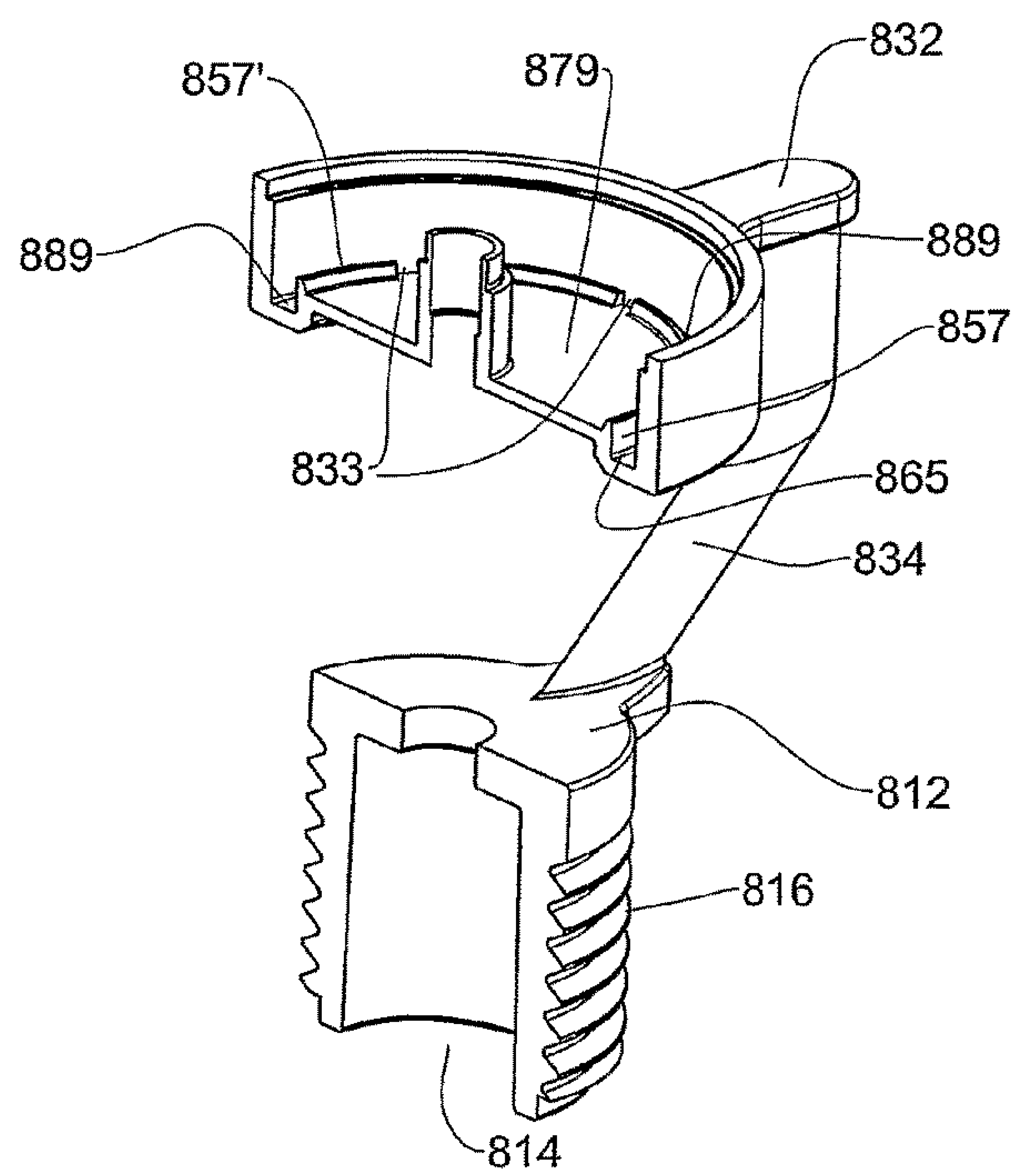
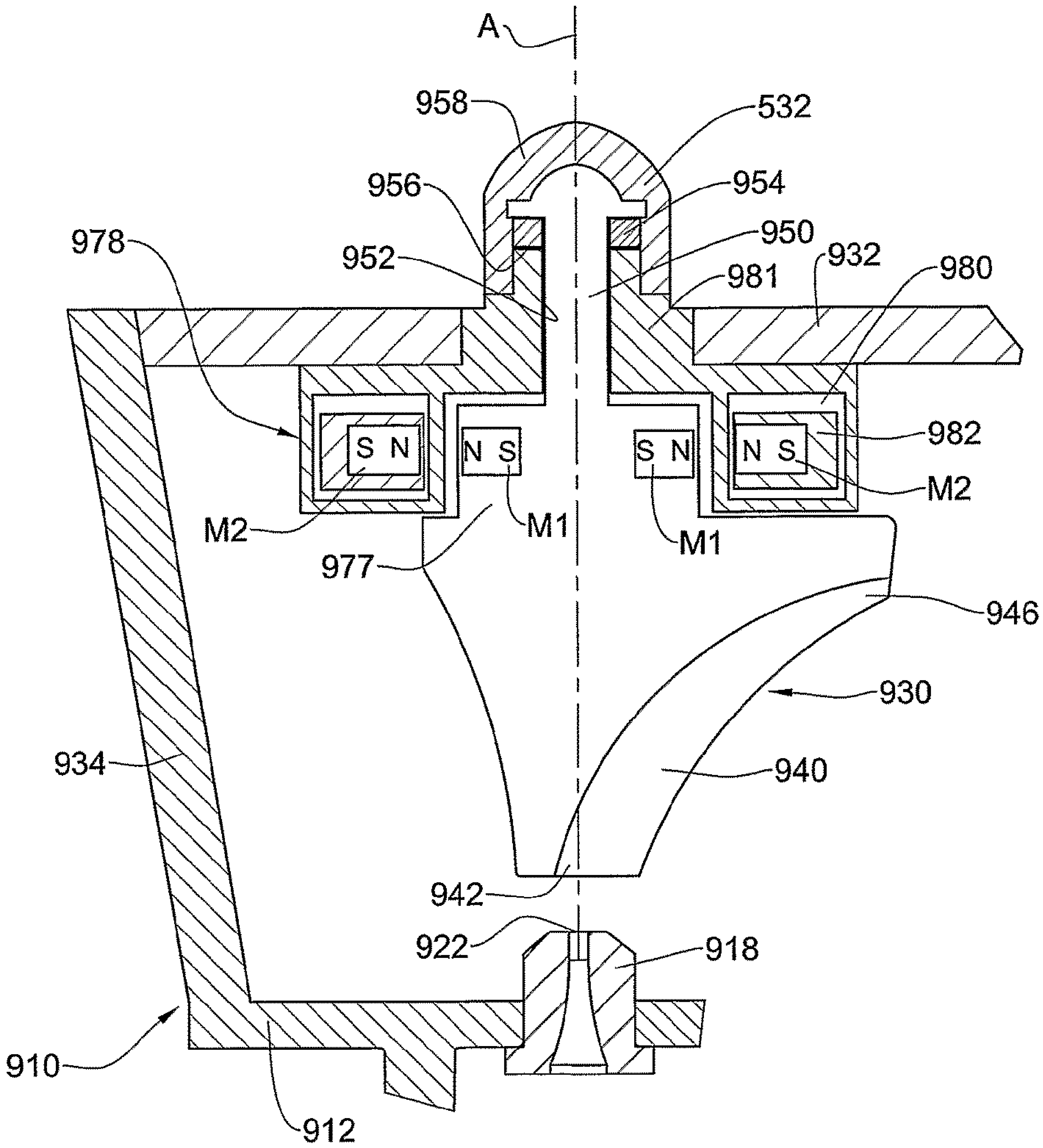


FIG. 38C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M1
M1
977
946
930
934
940
942
922
918
910
912

FIG. 39

SPRINKLER

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

This *is a reissue application of U.S. Pat. No. 8,998,109, which was filed as U.S. patent application Ser. No. 13/001,832 on Dec. 29, 2010 and issued on Apr. 7, 2015, which* is a National Phase Application filed under 35 U.S.C. 371 as a national stage of PCT/IL2009/000653, filed on Jun. 30, 2009, an application claiming the benefit under 35 USC 119(e) of U.S. Provisional Application No. 61/129,471, filed on Jun. 30, 2008, and an application claiming the benefit under 35 USC 119(e) of U.S. Provisional Application No. 61/193,803, filed on Dec. 24, 2008, the content of [each of] which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

This invention relates to rotary sprinklers. More particularly the invention is directed to a rotary sprinkler fitted with a dampening mechanism for controlling the rotary speed of an irrigation head.

BACKGROUND OF THE INVENTION

In rotary sprinklers there is provided an irrigator head/distribution rotor which is rotatable in order to cover a desired land pattern. Rotary motion is imparted by the force of the irrigated media (typically water) acting in conjunction with a rotary mechanism converting some of the stream energy into rotary motion. Such a rotary mechanism could be a water gear, a ball motor, etc.

However, at times it is desired to slow the rotary motion so as to generate a slow and smooth rotary motion, resulting in a uniform precipitation of the irrigated media. Different mechanisms are known in the art for that purpose. For example there are known mechanisms where counter arrangements are provided for generating a reaction force opposite to the desired rotary force. Other arrangements are known for dampening the rotary motion of the irrigation head by utilizing the shear effect of a viscous material. Slowing rotation speed of the sprinkler results in increased irrigation range and homogeneous water precipitation, as well as reducing wear of moving parts.

Yet another arrangement is disclosed in U.S. Pat. No. 7,111,796 to Olson, directed to a sprinkler, comprising: a nozzle having a fluid path formed between an inlet and an outlet, the nozzle rotatably driven by a pressurized flow of fluid along the fluid path; and a housing separating a magnetic drag coupling assembly from the fluid path, the magnetic drag coupling assembly configured to exert a drag force in opposition to the fluid flow force rotating the nozzle; further including a pressure balancing mechanism within the nozzle assembly to generally neutralize any axial force that might otherwise be imparted to the nozzle by the fluid flow wherein the coupling assembly includes a drive magnet and a reactionary magnet positioned that exert an attractive force upon each other, a drag source acting on said reactionary magnet to provide a resistive force to oppose rotation of the nozzle.

U.S. Pat. No. 7,287,710 discloses a nutating-type sprinkler including a sprinkler head incorporating a nozzle; a spool fixed to the sprinkler head in proximity to the nozzle; a cage assembly loosely mounted on the spool, the assembly including a distribution plate at a first end of the assembly downstream of the nozzle and a first magnet at a second opposite end of the assembly upstream of the spool; a mounting element fixed to the assembly between the first and second ends, an inner edge of the mounting element loosely confined between upper and lower flanges of the spool; and a second magnet fixed to the sprinkler head, axially between the spool and the first magnet.

SUMMARY OF THE INVENTION

According to the present invention there is provided a rotary sprinkler wherein rotation dampening of an irrigation head is obtained by magnetic repulsion forces and an associated dampening mechanism.

The invention calls for a rotary sprinkler comprising a housing, a rotatable irrigation head associated with a first magnet assembly; a second magnet assembly associated with the housing and fitted with a rotary dampening mechanism; where said first magnet assembly and said second magnet assembly are arranged with like poles facing each other so as to generate a repulsion force therebetween.

According to a first aspect of the invention there is provided a rotary sprinkler comprising a housing formed with a liquid inlet port, a bridge supporting a pair of first magnets radially offset with respect to a rotary axis of the sprinkler, said first magnets being axially aligned and spaced apart, with their opposite poles facing each other; a rotatable irrigation head supported by said bridge and being in flow communication with a jet forming nozzle being in flow communication with the inlet port; said irrigation head articulated with a second magnet and associated with a rotary dampening mechanism, where said second magnet is co-radial with the first magnets and sandwiched therebetween and is disposed with like poles facing the first magnets so as to generate a repulsion force therebetween.

According to a second aspect of the invention there is provided a rotary sprinkler comprising a housing formed with a liquid inlet port, a rotatable irrigation head comprising a magnet support fixedly fitted with at least one first magnet radially offset with respect to a rotary axis of the irrigation head; said irrigation head being in flow communication with a jet forming nozzle associated with the inlet port; a bridge rotationally supporting said irrigation head and comprising at least one second magnet radially offset and associated with a rotary dampening mechanism; where said at least one first magnet and at least one second magnet are arranged with like poles facing each other so as to generate a repulsion force therebetween.

Any one or more of the following design features may be incorporated in a sprinkler according to the present invention:

- the second magnet is displaceable within a sealed chamber filled with a viscous substance.
- the second magnet is received within a casing displaceable within the sealed chamber, said casing retaining the second magnet at a fixed orientation, to thereby facilitate only rotary displacement thereof.
- the second magnet symmetrically extends between pair of first magnets, at a magnetic force equilibrium.
- the pair of first magnets is fixedly articulated to the irrigation head.

the pair of first magnets and the second magnet are axially fixedly positioned with respect to one another.

the second magnet symmetrically extends between the pair of first magnets, at a magnetic force equilibrium.

the sprinkler is fitted for either heads-up or bottoms-up orientation.

Any one or more of the following design features may be incorporated in a sprinkler according to the second aspect of the invention, though some may apply to the sprinkler according to the second aspect of the present invention:

the repulsion force is coaxial with a rotary axis of the sprinkler and acts to bias the irrigation head in a direction opposite to an axial force applied on the irrigation head by a liquid jet.

the number of first magnets corresponds with the number of second magnets.

the at least one first magnet and the at least one second magnet may have substantially the same magnetic force.

the at least one first magnet and the at least one second magnet may be substantially equally radially offset.

the two first magnets and the two second magnets are symmetrically distributed, namely extend on a diameter of the respective.

the sprinkler is a pop-up type and the irrigation head is fitted with a support boss retained by the bridge and having an axial degree of freedom such that the irrigation head is axially displaceable between a downward, non-operative position and an upper, operative position.

when the irrigation head is at its downward, non-operative position it conceals the jet forming nozzle.

at least one of the irrigation head and the jet forming nozzle is fitted with a peripheral skirt portion for concealing an outlet of the jet forming nozzle and an outlet of a jet emitting portion of the irrigation head, when the irrigation head is at the downward, non-operative position.

the irrigation head is fitted with a skirt portion and the jet forming nozzle is fitted with a fixed skirt portion, said skirt portions being coaxial and having different dimensions, whereby at the non-operative position said skirt portions at least partially overlap.

the at least one second magnet is received within a casing displaceable within the sealed chamber, said casing retaining the at least one second magnet at fixed relation and facilitating only rotary displacement thereof.

the at least one first magnet is fixedly articulated to the irrigation head.

the at least one first magnet is fixed on a magnet support member which is secured to the bridge in a rotatable fashion and in turn is engageable for rotation with the irrigation head.

the magnet support member engages with the irrigation head upon axial displacement of the irrigation head from a downward, non-operative position to an upper, operative position.

rotary engagement between the magnet support member and the irrigation head is facilitated by a helical path formed in one of the magnet support member and the irrigation head and a corresponding helical coupler formed in another of the magnet support member and the irrigation head, whereby axial ascending of the irrigation head entails postponed rotary of the magnet support member.

the rotary dampening mechanism comprises a space control arrangement for altering the sheer force between the at least one second magnet holder and the viscous substance received within the sealed chamber, thus controlling the rotary dampening force.

the space control arrangement comprises an axially displaceable case member, displacement of which entails expansion/contraction of the space of the sealed chamber, said case member comprising a diaphragm sealingly packing said sealed chamber.

the displaceable case member is screw coupled to a casing of the sealed chamber, whereby rotation of the displaceable case member with respect to the casing of the sealed chamber entails axial displacement thereof

the at least one first magnet and the at least one second magnet are received in respective magnet holders which are detachably attachable to the irrigation head and bridge, respectively.

first magnet assembly and the second magnet assembly are axially positioned with respect to one another.

the first magnet assembly and the second magnet assembly are radially positioned with respect to one another.

shear forces between a viscous substance of the dampening mechanism reside over one or more substantially horizontal shear surfaces of a second magnet support member accommodating the at least one second magnets.

shear forces between a viscous substance of the dampening mechanism reside over one or more substantially vertical shear surfaces of a second magnet support member accommodating the at least one second magnets.

the sprinkler is fitted for either heads-up or bottoms-up orientation.

the dampening mechanism is formed with a top annular groove and a bottom annular groove and the second magnet support has a T-like cross section laterally extending with respective portions thereof rotatably displaceable within said a top annular groove and a bottom annular groove, respectively.

flow paths are provided in the sealed chamber for flow of the viscous substance, wherein at either the heads-up or bottoms-up orientation of the sprinkler, the viscous substance occupies only a bottom annular groove.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of a non-limiting example only, with reference to the accompanying drawings, in which:

FIGS. **1** to **4** are directed to a sprinkler according to a first a spect of the present invention, wherein:

FIG. **1**A is a top isometric view of a sprinkler in accordance with the present invention;

FIG. **1**B is a bottom isometric view of the sprinkler seen in FIG. **1**A;

FIG. **2** is a longitudinally sectioned top isometric view of the sprinkler seen in FIG. **1**;

FIG. **3** is a longitudinally sectioned planer view of the sprinkler of the present invention;

FIG. **4**A is a schematic top isometric view illustrating the magnets setup, and the forces acting therebetween; and

FIG. **4**B is a top view of FIG. **4**A.

FIGS. **5** to **39** are directed to a sprinkler according to a first aspect of the invention, wherein:

FIG. **5** is a side view of a sprinkler in accordance with an embodiment of the present invention;

FIG. **6** is a top isometric view of the sprinkler seen in FIG. **5**;

FIG. **7**A is a bottom isometric view of the sprinkler seen in FIG. **5**;

FIG. **7**B is a longitudinally sectioned bottom isometric view of the sprinkler seen in FIG. **5**;

FIG. **8**A is a schematic side view illustrating the magnets setup, and the forces acting therebetween;

FIG. **8**B is a schematic top view illustrating the magnets setup, and the forces acting therebetween;

FIG. **8**C is a schematic bottom isometric view illustrating the magnets setup, and the forces acting therebetween;

FIG. **9** is a side view of a sprinkler in accordance with another embodiment of the present invention;

FIG. **10** is a bottom isometric view of a sprinkler seen in FIG. **9**;

FIG. **11**A is a longitudinally sectioned bottom isometric view of the sprinkler seen in FIG. **9**;

FIG. **11**B is an isometric sectioned view of the dampening mechanism of the sprinkler seen in FIG. **9**;

FIG. **12** is a side view of a sprinkler in accordance with still an embodiment of the present invention, at a non-operative position;

FIG. **13** is a bottom isometric view of the sprinkler of FIG. **8**;

FIG. **14** is a longitudinally sectioned bottom isometric view of the sprinkler of FIG. **12**;

FIG. **15** is a longitudinally sectioned isometric view of the sprinkler of FIG. **12**;

FIG. **16** is a bottom isometric view sectioned longitudinally at a plain perpendicular to that shown in FIG. **14**;

FIG. **17** is a longitudinal section of the sprinkler of FIG. **8**, at its operative, raised position;

FIG. **18** is a side view of a sprinkler, in accordance with a modification of the sprinkler of the embodiment of FIG. **12**, at its non-operative, closed position;

FIG. **19** is a bottom isometric view of the sprinkler seen in FIG. **18**;

FIG. **20** is a longitudinal section of the sprinkler of FIG. **18**;

FIG. **21** is a top isometric view of the sprinkler of FIG. **18** at its operative, open position;

FIG. **22** is a longitudinally sectioned, bottom isometric view of the sprinkler in the position of FIG. **21**;

FIG. **23** is a longitudinally sectioned bottom isometric view of the sprinkler of FIG. **17**, sectioned at a plain perpendicular to that illustrated in FIG. **22**;

FIG. **24** is a longitudinally section of the sprinkler at the position of FIG. **21**;

FIG. **25** is a longitudinal section of the sprinkler of FIG. **18**, at its operative, raised position;

FIG. **26** is a longitudinally sectioned view illustrating an adjustable dampening mechanism according to a modification of the invention.

FIG. **27**A is a sprinkler in accordance with yet another embodiment of the drawings, at its closed, non-operative position;

FIG. **27**B is a front view of a sprinkler in accordance with a modification of the present invention, in a pop-up position;

FIG. **28** is a top isometric view of the sprinkler seen in FIG. **27**;

FIG. **29** is a sectioned view of FIG. **27**;

FIG. **30** is a sectioned, bottom isometric view of the sprinkler of FIG. **27**

FIG. **31** is a front view of a sprinkler in accordance with yet an embodiment of the present invention;

FIG. **32** is a bottom isometric view of the sprinkler illustrated in FIG. **27**;

FIG. **33**A is a longitudinal section of FIG. **28**;

FIG. **33**B is an enlargement of the portion marked V in FIG. **32**A;

FIG. **34** is a top isometric view of the sprinkler of FIG. **27**;

FIG. **35** is a bottom isometric view taking along a plane perpendicular to that illustrated in FIG. **29**;

FIG. **36**A is a top respective view of a second magnet support used in the sprinkler in accordance with the embodiment of FIG. **27**;

FIGS. **36**B and **36**C are sections taken along lines B-B and C-C, respectively, in FIG. **32**A;

FIG. **37** is a sectioned view of the sprinkler of FIG. **23** in an upside irrigating position;

FIG. **38**A is a top isometric view of the housing of the sprinkler of FIG. **27**;

FIG. **38**B is a top view of the sprinkler housing of FIG. **34**A;

FIG. **38**C is a sectioned isometric view of the housing of FIG. **34**A; and

FIG. **39** is a sectioned view illustrating only a top portion of a rotary sprinkler according to yet another embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Attention is first directed to FIGS. **1** to **4** of the drawings, illustrating a sprinkler according to a first aspect of the present invention.

As illustrated in FIGS. **1** and **2** of the drawings there is a rotary sprinkler generally designated **10** in accordance with the invention. The sprinkler comprises a housing **12** which in turn is formed with an inlet port **14** for coupling to a pressurized source of water (not shown) e.g. an irrigation supply line, for example by screw coupling to external threading **16**.

A jet forming nozzle **18** extends from the inlet port **14** having an inlet side **20** being in flow communication with inlet port **14** and a jet outlet **22** facing a rotary irrigation head generally designated **30**.

Integrally formed with the housing **12** there is a bridge member **32** extending over two support arms **34** disposed in a V-like configuration. The support arms **34** have a blade-like cross section so as to cause minimal interference with a jet emitted from the rotary sprinkler head.

The irrigation head **30** is a swivel-type irrigator formed with a reaction generating deflection groove **40** having an inlet end **42** extending substantially vertically above the outlet **22** of the jet forming nozzle **18**, and an outlet opening **46** extending substantially radially, with a reaction generating surface **48** (best seen in FIGS. **2** and **3**), designed for imparting the rotary head **30** with rotary motion upon impinging of a water jet emitted from the jet forming nozzle **22** thereupon.

As seen in FIGS. **2** and **3**, the irrigation head **30** is fitted with an upwardly extending boss **50** snugly fixed within a downwardly projecting receiving boss **51** of a second magnet support chamber generally designated **80** (FIG. **3**). The second magnet support chamber **80** is rotatably received within an enclosure designated **84** extending between the two support arms **34**. The enclosure **84** is assembled of a top cover **90** and a bottom cover **92**, said covers being fixedly secured to one another and prevented from relative rotation with respect to one another by mutually projecting studs **94** and **96** projecting into oppositely positioned bores **98** and **100** fitted in the covers **90** and **92**, respectively.

Each of the covers **92** and **94** fixedly supports a first magnet $M1^T$ and $M1^B$, respectively, said first magnets $M1^T$ and $M1^B$ being coaxially disposed about an axis A^M parallel to a central axis (axis of rotation of the irrigation head **30**), designated A, and radially offset at a distance R from the axis A. The first magnets $M1^T$ and $M1^B$ are fixedly set in the respective top and bottom cover and are positioned with their opposite poles facing one another, e.g. as illustrated in the **2**, **3**, and **4**A. Furthermore, the first magnets $M1^T$ and $M1^B$ are of substantially same magnitude and are substantially equidistantly spaced from the enclosure **84**.

The second magnet support chamber **80** is composed of a top shield **110** and a bottom shield **112** defining together a sealed space **[114]**. Received within the chamber **[114]** *80* there is a second magnet carrier plate **120**, freely rotatable about stem **91**. The second magnet carrier plate **120** accommodates a second magnet designated M2, which together define a rotary dampening mechanism generally designated **78**, as will be explained hereinafter in further detail.

The top shield **110** is fitted with an axially upwardly projecting stem **126** formed with a smooth rounded tip **128**, rotatably bearing against a smooth bearing surface **130** correspondingly formed at a support receptacle **134** of the top cover **90**. Likewise, the bottom shield **112** is integrated with the downwardly projecting receiving boss **51** which is received within an opening **52** formed in the bottom cover **92**, so as to provide a bushing support for the rotating boss **51**. This arrangement results in that the second magnet support chamber **80** is maintained within the enclosure **84**, free to rotate about the central axis A however axially supported.

The second magnet carrier plate **120** accommodates a second magnet M2 disposed such that its poles face corresponding poles of the first magnets $M1^T$ and $M1^B$, respectively, giving rise to repulsion magnetic force F residing therebetween (FIGS. **4**A and **4**B). The arrangement as disclosed in the drawings is such that the second magnet M2 is offset at the same distance R from the axis A as the first magnets $M1^T$ and $M1^B$ (FIG. **3**).

However, it is denoted that the magnets $M1^T$ and $M1^B$ and M2 are not necessarily of identical magnitude nor do magnets $M1^T$ and $M1^B$ and the second magnets M2 have to be disposed on equal radii.

The *sealed* space **[114]** of the rotary dampening mechanism **78** (FIGS. **2** and **3**) is filled with a viscous substance **[86]**, e.g. silicon gel, whereby the second magnet carrier plate **120** is prevented from freely rotating within the sealed chamber **80** as would be the case at the absence of the viscous substance **[86]**. It is thus appreciated that sheer forces extending between the second magnet **[**support member **82]** *carrier plate 120* and the viscous substance **[86]** (and respectively between the smeared viscous substance **[86]** and the inside walls of the sealed chamber **80**), results in slowing down of the rotation of the second magnet carrier plate **120** with respect to the housing **12**. It is appreciated that shear forces developing within the dampening mechanism and acting to slow the second magnet support member develop between the viscous substance and any two surfaces moving in opposite directions.

As can best be seen in FIG. **[8**A**]** *4A*, the repulsion force F acting between the first magnets $M1^T$ and $M1^B$ and the second magnet M2 has force components, namely force vector F**1** axially extending (parallel to axis A) acting to axially repulse the second magnet support chamber **80** and symmetrically maintain it between the first magnets $M1^T$ and $M1^B$, and force vector F**2** giving rise to generating rotary force in a direction opposite to a force applied on the irrigation head **30** by a liquid jet immersing from the outlet **22** of the jet forming nozzle **18**, to thereby dampen said rotary motion.

It is further appreciated that rotational speed of the second magnet carrier plate **120** within the sealed chamber **80** may be governing by providing the second magnet carrier plate **120** with lateral and/or radial protrusions, thereby increasing the surface area thereof.

In operation, irrigation liquid enters through inlet port **14** and exits through jet aperture **22** as a strong jet impinging against surface **48** of the irrigation head **30**, resulting in generating a rotary reactionary force, causing irrigation head **30** to rotate about the rotary axis A. As rotation of the irrigation head **30** commences with the associated second magnet carrier plate **120** and the articulated second magnet M**2** within the sealed chamber **80**, magnet repulsion forces F (FIG. **[8**A**]** *4A*) result in generating a reactionary rotary force between the first magnets $M1^T$ and $M1^B$ and the second magnet M2. However, owing to the presence of a viscous substance **[86]** within the sealed chamber **80**, rotation of the second magnet carrier plate **120** is dampened, which in turn yields corresponding slowing of the rotary motion of the associated irrigation head **30**.

It is appreciated that the position illustrated in FIGS. **6** and **7** is a temporary intermediate operative position which can not occur while the sprinkler is at rest, i.e. the second magnet M2 will normally not extend axially aligned with the first magnets $M1^T$ and $M1^B$. Rather, the second magnet M2 is angularly spaced from the axial location of the first magnets $M1^T$ and $M1^B$, however extends axially between the pair of first magnets retaining a magnetic force equilibrium.

One or more through-going apertures **123** are formed in the second magnet carrier plate **120**, whereby the viscous substance **[86]** is free to flow between surface of the second magnet carrier plate **120** at either an up-right or a bottoms-up position of the sprinkler.

A second aspect of the invention is now illustrated with reference to FIGS. **5** to **39**.

Attention is first directed to FIGS. **5** to **7** of the drawings illustrating a rotary sprinkler generally designated **210** in accordance with a first embodiment of the invention. The sprinkler comprises a housing **212** which in turn is formed with an inlet port **214** for coupling to a pressurized source of water (not shown) e.g. an irrigation supply line, for example by screw coupling to external threading **216**.

A jet forming nozzle **218** extends from the inlet port **214** having an inlet side **220** (not shown) being in flow communication with inlet port **214** and a jet outlet **222** facing a rotary irrigation head generally designated **230**.

Integrally formed with the housing **212** there is a bridge member **232** extending over two support arms **234** disposed in a V-like configuration. The support arms **234** have a blade-like cross section so as to cause minimal interference with a jet emitted from the rotary sprinkler head.

The irrigation head **230** is a swivel-type irrigator formed with a reaction generating deflection groove **240** having an inlet end **242** (FIG. **5**) extending substantially vertically above the jet outlet **222** of the jet forming nozzle **218**, and an outlet opening **246** extending substantially radially, with a reaction generating surface **248** (best seen in FIGS. **6**, **7**A and **7**B) designed for imparting the rotary head **230** with rotary motion upon impinging of a water jet emitted from the jet forming nozzle **218** thereupon.

As seen in FIG. **7**B, the irrigation head **230** is fitted with an upwardly extending boss **250** extending into an aperture

252 formed in the bridge **232** and axially retained in place by means of a retention ring **254** however free to rotate about longitudinal axis (rotary axis A). It is noticed that the retention ring **254** rests over an axial projection **256** extending from the bridge member **232**. The retention arrangement is concealed by a cap **258** which is snap fitted to the bridge member **232** at **262** or maybe screw coupled or adhered thereto.

As can further be noticed in FIG. **7**B, the irrigation head **230** is formed with a widened section **264** serving as a bushing opposite surface **268** of the housing, preventing bobbing of the irrigation head **230**.

Formed with the irrigation head **230** is a magnet housing **270** comprising two disk-like magnets designated M**1**. The magnets M**1** are fixedly positioned within the magnet housing **270** and are arranged such that like poles thereof extend in the same direction. In the present example, the north pole of the two magnets M**1** face downwards, as illustrated in FIG. **8**A (it should be appreciated that the relative position of the magnet housing **270** and the second magnet support member **282** as illustrated in FIG. **8**A is theoretical situation is illustrated for sake of clarity only (in practice, under no-flow conditions, an equilibrium of force exists, and the first magnets M**1** and the second magnets M**2** are rotated at 90° with respect to one another, as can best be appreciated from FIGS. **8**B and **8**C). This comment applies as well to the position depicted in FIGS. **11**B, **14**, **16**, **17** and **20**, depicted for sake of explanation and clarity only. Furthermore, the two magnets M**1** are equally radially offset from the rotation axis A and said magnets M**1** are substantially the same magnitude.

However, it is denoted that the magnets M**1** and M**2** are not necessarily of identical magnitude nor do the sets of first magnets M**1** and the set of second magnets M**2** have to be disposed on equal radii. However, it is desirable that the magnets of each of the set of first magnets M**1** and the set of second magnets M**2** be substantially of same magnitude and disposed substantially on the same radii from the center (axis of rotation A), to thereby eliminate or at least substantially reduce any bending moments and other parasitic forces which may otherwise reside in the system.

A rotary dampening mechanism generally designated **278** (FIG. **7**B) is formed in the housing **232**. A sealed chamber **280** rotatably accommodates a second magnet support member **282** which in turn is fitted with a pair of second magnets M**2** fixed thereto wherein the second magnets M**2** are disposed such that their like poles face towards like poles of the first magnets M**1**, as can be seen in FIG. **8**A, thus giving rise to repulsion force acting therebetween. The second magnets M**1** are also disposed symmetrically about the rotary axis A and are of substantially like magnitude.

As can best be seen in FIG. **8**C, the repulsion force F acting between the first magnets M**1** and the second magnets M**2** has force components, namely force vector F**1** axially extending (parallel to axis A) acting to eliminate or substantially reduce friction between components of the system (namely, friction of the top end of the boss **250** against the cap **258**, said forces being translated to the lubricated area within the sealed chamber), and force vector F**2** giving rise to generating rotary motion between the magnet arrays, coaxial with a rotary axis A of the sprinkler and acts to bias the irrigation head **230** in a direction opposite to an axial force applied on the irrigation head **230** by a liquid jet immersing from the outlet **222** of the jet forming nozzle **218**.

As can still be noted in FIG. **7**B the sealed chamber **280** is formed with an annular friction surface **263** and the second magnet support member **282** is formed with a corresponding annular projection **265** formed with a top surface **267** bearing against the annular friction surface **263**, said surfaces **263** and **267** being substantially smooth thereby reducing friction therebetween. However it is appreciated that the sealed chamber **280** is filled with a viscous substance such as silicone oil or silicone gel which serves as a lubricant.

The sealed chamber **280** is filled with a viscous substance **286**, e.g. silicon gel, whereby the second magnet support member **282** is prevented from freely rotating within the sealed chamber **280** as would be the case at the absence of the viscous substance **286**. It is thus appreciated that sheer forces extending between the second magnet support member **282** and the viscous substance **286** cause the slowing down of the rotation of the second magnet support member with respect to the housing **212**. It is appreciated that sheer forces developing within the dampening mechanism and acting to slow the second magnet support member develop between the viscous substance and any two surfaces moving in opposite directions.

It is further appreciated that governing the speed of rotation of the second magnet support member **282** within the sealed chamber **280** may be by providing the second magnet support member **282** with lateral and/or radial protrusions, thereby increasing the surface area thereof.

In operation, liquid enters through inlet port **214** and exits through jet aperture **222** as a strong jet impinging against surface **248** of the irrigation head **230**, resulting in generating a rotary reactionary force, causing irrigation head **230** to rotate about the rotary axis A. As rotation of the irrigation head **230** commences, magnet repulsion forces F (FIG. **[**4A**]** *8A*) will result in generating a reactionary rotary force of the second magnets M**2** resulting in rotation of the second magnet support member **282** within the sealed chamber **280**. However, owing to the presence of a viscous substance **286** within the sealed chamber **280**, rotation of the second magnets M**2** is dampened which in turn yields corresponding dampening of the rotary motion of the first magnets M**1** and the associated irrigation head **230**.

Noting the repulsion forces residing between the first magnet M**1** and the second magnets M**2** at the steady state of the system, namely at rest (at the absence of a liquid jet), the magnet housing **270** and the second magnet support member **282** tends to reach an equilibrium position as in the position illustrated in FIG. **8**B. However, as mentioned above, rotation of the magnet housing **270** under influence of the water reactionary forces, tends to rotate the second magnet support member **282** however significantly slower owing to the dampening mechanism as disclosed above.

It is noted that the repulsion magnetic force F extending between the two arrays of magnets M**1** and M**2** urges the rotary irrigation head **230** in a downwards direction and the space designated **290** between the upper face **292** of the magnet housing **270** and the bottom surface **294** of the bridge **232** remains in tact thus assuring a fixed gap therebetween whereby any dirt such as sand grains, etc. do not interfere with proper rotary motion of the irrigation head **230**. As will be disclosed hereinafter in connection with other embodiments of the invention (e.g. in connection with the pop-up embodiment of FIGS. **12** to **17**), the space may vary between an open position (i.e. elevated position of the irrigation head) and a closed position thereof, however the space remains constant at the respective positions.

Disposing each of the first magnets M**1** and the second magnets M**2** with like poles facing each other (and such that they are disposed at identical distances from the axis of rotation A, i.e. at the same radii) results in forced motion of the second magnet support member imparted thereto by rotary motion of the magnet housing **270**. However, provision of only one first magnet M**1** and one second magnet M**2** may result in generation of undesirable bending moments and friction forces. On the other hand, providing more than a pair of first magnets M**1** and respectively a pair of second magnets M**2**, may effect the magnitude of the rotary moment (imparted by force vector F**2**) developing between the magnet housing **270** and the second magnet support member **282** which effectively results in an increased repulsion force F however lower rotary resistance.

Turning now to FIGS. **9** to **11**B there is illustrated embodiment of the sprinkler in accordance with the present invention wherein like elements have been designated like numbers as in connection with the previous embodiment depicted in connection with FIGS. **5** to **8**, however shifted by **300**.

The sprinkler generally designated **310** comprises a housing **312** formed with an inlet port **314** and an external threaded portion **316** for screw coupling to a liquid supply line (not shown). A jet-forming nozzle **318** extends from the inlet port **314** and has an inlet side **320** (not shown) and a jet outlet **322** axially extending opposite a rotary irrigation head generally designated **330**. A bridge member **332** is integrally formed with the housing **312** extending over two support arms **334** generally in a V-like configuration. The irrigation head **330** is substantially similar to the irrigation head disclosed in connection with the previous embodiment of FIGS. **5** to **8** and comprises like elements namely a reaction generating deflection groove **340** having an inlet **342** extending axially aligned with the jet outlet **322**, and an outlet **346** (FIG. **10**) extending substantially radially, with a reaction generating surface **348** (not shown) designed for imparting the rotary head **330** with rotary motion upon impinging of a water jet there against.

The irrigation head **330** is fitted with a long boss **350** extending through an aperture **352** formed in the bridge member **332** and retained in place by retention ring **354** allowing for substantially free rotation of irrigation head **330** about longitudinal axis A (rotational axis). Like in the previous embodiment, it is noticed that the retention ring **354** rests over an axial projection **356** extending from a boss **381** extending from the sealed chamber **380**. The retention arrangement is covered by cap **358** snap-fitted to the bridge member **332** at **362**.

Unlike the previous embodiment, the rotary dampening mechanism [**178**] *378* is not integrated with the bridge member [**132**] *332* but is rather articulated thereto. The dampening mechanism [**178**] *378* comprises a sealed chamber [**180**] *380* rotatably accommodating a second magnet support member [**182**] *382* which in turn arrests a pair of second magnets M**2**.

Like in the previous embodiment, the second magnets M**2** are disposed such that their like poles face towards their like poles of the first magnets M**1** and further, the first magnets M**1** and the second magnets M**2** are substantially uniformly distributed and are of substantially equal magnetic magnitude (FIGS. **11**A and **11**B). However, as indicated hereinabove, the magnets M**1** and M**2** are not necessarily of identical magnitude nor do the sets of first magnets M**1** and the set of second magnets M**2** have to be disposed on equal radii. However, it is desirable that the magnets of each of the set of first magnets M**1** and the set of second magnets M**2** be substantially of same magnitude and disposed substantially on the same radii from the center (axis of rotation A), to thereby eliminate or at least substantially reduce any bending moments and other parasitic forces which may otherwise reside in the system.

A viscous substance **386** fills the sealed chamber **380** so as to apply a braking force on the second magnet support member **382**, owing to sheer forces therebetween.

The sealed chamber **380** is rotationally and axially secured to the bridge member **332** by a boss portion **381** coaxially receiving the boss **350** of the irrigation head **330** and securely fitted within an aperture **383** formed in the bridge member **332**.

The principles of operation of the sprinkler **310** in accordance with the second embodiment are similar to those explained in connection with the previous embodiment.

Yet another embodiment of the invention is disclosed with further reference to FIGS. **12** through **17** of the drawings where like elements have been designated with like reference numbers as in connection with the first embodiment hereinabove, however, shifted by **400**.

The sprinkler in accordance with this embodiment, generally designated **400**, comprises a housing **412** formed with an inlet port **414** connectable to a liquid irrigation supply (not shown) by means of a threaded coupling **416** (as is apparent that other couplings are possible too, e.g. snap-fitting, press-fitting, etc.). A jet-forming nozzle **418** (FIG. **14**) is secured within the housing extending from the inlet port **414** and has an inlet port **420** for liquid ingress and a jet outlet **422** through which a liquid jet is upwardly directed towards a rotary irrigation head generally designated **430**. A bridge member **432** is integrally formed with the housing **412** extending over two support arms **434**.

The rotary irrigation head **430** comprises a reactionary deflection groove **440** having an inlet **442** extending axially opposite the jet outlet **422**, and a jet outlet **446** (FIGS. **12** and **17**) extending substantially radially, with a reaction-generating surface **448** (FIG. **16**) designed for imparting the rotary head **430** with rotary motion as well as with an axial displacement upwardly, upon impinging of a water jet there against.

However, unlike the previous embodiments, the sprinkler **400** in accordance with the present embodiment is a pop-up type, namely comprises an arrangement for concealing the rotary irrigation head **430** and the jet forming nozzle **418**. For that purpose, the rotary irrigation head is formed with a downwardly extending skirt **423** telescopically received within an upwardly extending skirt **425** snappingly fitted at **427** to the base of housing **412**. Upwardly extending from the rotary irrigation head **430** there is a hollow boss **453** internally formed with a helical path (i.e., a threaded profile) designated at **455**. The boss **453** is coaxially displaceable within a downwardly extending sleeve **457** extending from a magnet support **470** fixedly fitted with a pair of first magnets M**1** and further comprising within the downwardly extending sleeve **457** a helical rider **459** (FIGS. **14** to **16**) bearing against the helical path **455**. Upwardly extending from the magnet support **470** there is a boss **450** supported within the bridge member **432** as in the previous embodiments, namely by means of a retention ring **454** bearing against radial protruding shoulders **456** extending from the bridge **432**, whereby the magnet support **470** is freely rotatable with respect to the bridge member **432** (and respectively with respect to the housing **412**) however being axially retained.

A rotary dampening mechanism generally designated **478** comprises a sealed chamber **480** rotatably accommodating a second magnet support member **482** accommodating a pair of second magnets M**2** fixed thereto as disclosed in connection with the previous embodiments. The sealed chamber 480 is filled with a viscous substance 486 (FIG. 16) whereby the second magnet support member 482 (FIG. 14) is prevented from freely rotating within the sealed chamber 480 as will be the case at the absence of the viscous substance 486.

The arrangement in accordance with the sprinkler 400 is such that a liquid jet emitted through jet outlets 422 at a first instance causes the irrigation head 430 to rise (at least to a position where outlet 446 extending above the external skirt 425), whilst simultaneously causing it to rotate owing to reactionary forces developed by the liquid impinging against the deflection surface 448 (FIG. 17). Rising of the irrigation head 430 entails rotary displacement of the magnet support 470 owing to the rider 459 bearing against the helical path 455 whereby rotary coupling takes place between the irrigation head 430 and the magnet support 470. It is appreciated that rising of the rotary irrigation head is to an extent sufficient to expose the jet outlet 446 beyond an upper edge 449 of the skirt 425, so as not to interfere with a water jet emitted therefrom.

The dampening mechanism acts in the same manner as disclosed hereinabove in connection with the previous embodiments.

Upon termination of the water jet immersing through the outlet 422, the rotary irrigation head 430 descends, under force of gravity) to its lower position as in FIGS. 12 to 17, thus concealing the irrigation outlets 446 as well as the jet outlet 422, thus preventing access to dirt and insects which might have otherwise clogged the outlets and interfere with proper operation of the sprinkler.

Like in the previous embodiments, it is noticed that just like in the previous embodiments disclosed hereinbefore, the repulsion force acting between the first magnets M1 and the second magnets M2 acts coaxial with the rotary axis A of the sprinkler and acts to bias irrigation head 430 downwards, against the force imparted by the emitted liquid jet tending to raise the irrigation head into its operative position. However clearance 490 between a top surface 492 of the magnet support 470 and a bottom surface 494 of the sealed chamber 480, remains fixed owing to geometrical relation of the components of the sprinkler.

Turning now to FIGS. 18 to 25 there is illustrated yet another embodiment of the present invention wherein like elements have been designated with like reference numbers as in connection with the first embodiment hereinabove, however shifted by **[400]** *500*.

The sprinkler, generally designated 500 comprises a housing 512 formed with a liquid inlet port 514 connectable to a liquid irrigation supply line (not shown) e.g., by means of threaded coupling 516. A jet forming nozzle 518 (FIG. 20) is secured within the housing, extending from the inlet port 514 and formed with an inlet 520 for liquid ingress and a jet outlet 522 through which a liquid jet is upwardly directed towards a rotary irrigation head generally designated 530. A bridge member 532 is integrally formed with the housing 512 extending over two support arms 534.

The rotary irrigation head 530 comprises a reactionary deflection groove 540 formed with an inlet 542 extending axially above the jet outlet 522, and a jet outlet 546 (FIGS. 20 to 25) extending substantially radially with a reaction-generating surface 548 designed for imparting the rotary head 530 with rotary motion upon impinging of a water jet there against as well as axial displacement in an upward direction, as will be discussed hereinafter.

Likewise in connection with the previous embodiment, the sprinkler 500 is a pop-up type and comprises a concealing arrangement composed of a downwardly extending skirt 523 extending from the rotary irrigation head 530 and telescopically received with an upwardly extending skirt 525 fitted to the base of the housing 512.

Upwardly extending from the rotary irrigation head 530 there is a boss 550 supported within a receptacle 552 of a bridge member 532 integrated with the housing and supported over a pair of support arms 534. Boss 550 is axially displaceable along the rotational axis A of the irrigation head 530 and is bushed by a bushing ring 557 to cancel radial tolerances.

The rotary irrigation head 530 is fitted with a pair of first magnets M1 and the bridge member 532 is fitted with a rotary dampening mechanism 578 comprising a sealed chamber 580 accommodating a second magnetic support member 582 fitted with a pair of second magnets M2, said sealed chamber being fitted with a substantially viscous substance 586. It is appreciated that the first magnets M1 and the second magnets M2 are disposed in substantially the same configurations as disclosed hereinabove to thereby impart a repulsion force acting substantially coaxially along the rotary axis A and substantially eliminating moments of force in other directions.

At the normal position of the sprinkler, at the absence of liquid supply, the repulsion forces acting between the magnets M1 and M2, together with force of gravity tend to displace the rotary irrigation head 530 in a downwards direction (FIGS. 18 to 22), wherein the jet outlet 522 and the outlet 546 are concealed thus preventing dirt and insects from entering and possibly interfering with smoother operation of the sprinkler. However, a liquid supplied through the inlet 514 results in a jet emitted through outlet jet 522 generating a reactionary force which will first act to raise the illustrated irrigation head 530 against the gravity force and against the repulsion magnetic force and will further cause the rotary irrigation head to rotate about the rotational axis A (FIGS. 22 to 25).

Turning now to FIG. 26 there is illustrated only a rotary dampening mechanism generally designated 600 with a rotary irrigation head 630 articulated thereto. Rotary irrigation head 630 is for example of the type disclosed in connection with the first embodiment of FIGS. 5 to 7 and is fitted with a pair of first magnets M1 (not seen in this figure owing to the angle at which the representative figure is shown). The dampening mechanism 600 comprises a sealed chamber 602 constituting part of a bridge supported by arms 604 to the sprinkler housing. The sealed chamber 602 accommodates a pair of second magnets M2 which like in the previous embodiments are arrangement such that their poles face like poles of the first magnets M1.

The magnets M2 are fixedly received within a second magnet support member 608 the latter embedded within a viscous substance 612 filling the sealed chamber 602.

However, unlike the previous embodiments, the sealed chamber 602 is fitted with a flexible membrane-like top seal member 616 supported by a rigid actuator 618, however sealing the sealing chamber 602. The actuator 618 is engaged to the bridge 604 by a coupling ring 620, and is designed such as to convert rotary motion into axial motion, whereby rotation of the ring 620 entails corresponding axial displacement of the actuator 618 and the associated flexible seal 616, effectively resulting in displacement of a bottom surface 626 of the top seal member 616 upwards and downwards, thus increasing/decreasing the gap designated S between a top surface 630 of the second magnet support member 608 from subsurface 626 thereby effecting the sheer force residing between the second magnet support member 608 and viscous chamber at 612 in a manner so as to increase/decrease the resistance to rotation thereof, which will effectively result the rotational speed of the irrigation head.

Turning now to FIGS. **27** to **30** there is illustrated yet another embodiment of a sprinkler in accordance with the present invention wherein like elements have been designated with like reference numerals as in connection with the first embodiment hereinabove, however shifted by **700**.

The sprinkler, generally designated **700**, comprises a housing **712** formed with an inlet liquid port **714** connectable to a liquid irrigation supply line (not shown) e.g. by threaded neck portion **716**. A jet forming nozzle **718** (FIGS. **29** and **30**) is secured within the housing, extending from the inlet port **714** and is formed with an inlet **720**, for liquid ingress, and a jet outlet **722** through which a jet is upwardly directed towards a rotary irrigation head generally designated **730**. A bridge member **732** is integrally formed with the housing **712**, extending over two support arms **734** having a blade-like cross section, as discussed hereinabove, to thereby cause minimal interference with a jet emitted from the rotary sprinkler head **730**.

The rotary irrigation head **730** comprises a reactionary deflection groove **740** formed with an inlet **752** extending axially above the jet outlet **722**, and a jet outlet **746** (best seen in FIG. **28**) extending substantially radially, with a reaction-generating surface **748** designed for imparting the rotary head **730** with rotary motion upon impinging of a water jet there against, as well as axial displacement in an upward direction (FIGS. **27**B to **30**) as discussed in connection with the position embodiments. The sprinkler of FIGS. **27** to **30** is a pop-up type sprinkler and comprises a concealing arrangement for concealing the rotary irrigation head, thereby preventing dirt and insects from entering the outlet nozzle and the jet outlet. The concealing arrangement is composed of a downwardly extending skirt **723** extending from the irrigation head **730**, and telescopically received within an upwardly extending skirt **725** fitted to the base of the housing **712** or integrally formed therewith. Upwardly extending from the rotary irrigation head **730** there is an integral boss **750** supported within a receptacle **752**. The boss **750** is axially displaceable along the rotational axis A of the irrigation head **730** and is bushed by a bushing ring **751** constituting part of a sealing plate **753** sealingly secured to the sealed chamber **780** at a bottom site thereof.

The arrangement is such that the rotary irrigation head **730** is rotatably secured and is axially displaceable between its closed, non-operative position of FIG. **27**A, and an open, operative position wherein the rotary irrigation head **730** is axially displaced upwardly (FIGS. **27**B to **30**) whereby the outlet nozzle **746** is exposed over an upper rim **747** of the skirt **725**.

It is noted that the rotary irrigation head **730** is formed with an annular rim **733** which at the closed position (FIG. **27**A) comes to rest over the upper edge **747** in a sealing manner, owing to gravity force and repulsion force between the first magnets M**1** and the second magnets M**2**

The rotary irrigation head **730** is fitted with a pair of first magnets M**1** and similar to the disclosure of the previous embodiments, a rotary dampening mechanism generally designated **778** comprises a sealed chamber **780** rotatably accommodating a second magnet support member **782** accommodating a pair of second magnets M**2** fixed thereto as disclosed in connection with the previous embodiments. It is appreciated that the first magnets M**1** and the second magnets M**2** are axially disposed with their like poles facing each other. The sealed chamber **780** is filled with a viscous substance whereby the second magnet support member **782** is prevented from freely rotating within the sealed chamber **780**.

A liquid jet emitted through jet outlet **722** at a first instance causes the irrigation head **730** to raise to the position illustrated in FIG. **28**, wherein the outlet nozzle **746** extends above the top rim **747** of skirt **725**, simultaneously causing the irrigation head **730** to rotate, owing to reactionary forces developed by the liquid impinging against the deflection surface **748**. The irrigation head **730** raises to a maximum axial displacement (FIGS. **27**B-**30**) leaving an interstice **790** between **[**the**]** *a* top surface **792** of the **[**magnet support **270]** *irrigation head 730* and a bottom surface **794** of the sealed chamber **780**, thus *preventing* particles from accumulating in that space and interrupting **[**with**]** proper operation of the sprinkler.

FIGS. **31** through **38**C are directed to a modification of a sprinkler in accordance with the present invention which for sake of clarity is of the type disclosed in connection with the first embodiment depicted in FIGS. **5** to **7**B however, with the respective differences as will be discussed hereinafter. For sake of clarity, the present embodiment is designated with like elements as in the first embodiment wherein like elements have been designated like reference numbers shifted by **800**.

The sprinkler **800** is principally similar to that disclosed in connection with the first embodiment but nevertheless comprises several differences concerned with the rotary irrigation head and **830** and in particular with the dampening mechanism generally designated at **878** and as can best be seen in the sectioned FIGS. **31** to **33**.

A first difference is noticed by reducing the overall size of the sprinkler **800** by its compacting wherein the rotary irrigation head **830** is fitted at its top end with chamfered edges **833** wherein the bridge portion constituting the dampening mechanism **878** is formed at its bottom side with an indention **835** whereby the rotary irrigation head **830** is partially received there within, however maintaining a gap **890** therebetween.

Yet another difference resides in the dampening mechanism **878** rendering the sprinkler **800** suitable for operating in an upright position (FIGS. **31** to **35**), or at an inverted position, namely heads down ('bottoms-up'), as in FIG. **37**, as will be discussed hereinafter in further detail.

Apart for these differences, the sprinkler **800** is constructed and operates similar to the principles disclosed in connection with FIGS. **5** to **8**.

As can further be seen in FIGS. **33** to **35**, the dampening mechanism **878** is formed with a sealed chamber **880** fitted with a disk-like second magnet support member **882** seen in FIGS. **36**A to **36**C. The sealed chamber **880** is filled with a viscous substance **886** to an extent that it occupies a peripheral annular groove **889** formed in the sealed chamber **880**. As will be discussed hereinafter, a corresponding groove **891** is formed at the top cover **893** of the sealed chamber **880**, for a purpose to become apparent hereinafter.

Turning now to FIGS. **36**A to **36**C, the second magnet support member **882** is formed with two receptacles **895**, the arrangement being such that two second magnets M**2** (not seen in FIGS. **36**A-**36**C) are press-fit and securely sealed within apertures **895**, the arrangement being such that the faces of the magnets M**2** are substantially flush with the respective top surface **897** and bottom surface **899** of the second magnet support member **882**. It is further noticed that the second magnet support member **882** is formed with a peripheral T-like shaped rim designated **851** having an upwardly extending rim **853** and a downwardly extending rim portion **853** and downwardly extending rim portion **855** wherein the upwardly extending rim portion **853** is received at the assembled position within the annular groove **891** and likewise, the downward rim **855** is received within the lower annular groove **889** of the sealed chamber **880**.

The above disclosed arrangement shifts the shearing plane from the substantially horizontal plane (of the top and bottom surfaces of the second magnet support member **882**) to substantially axial planes namely inner wall surfaces **857** and **859** and outside wall surface **861** of the T-like annular rim with respect to corresponding sidewalls **865** and **857**, **869** and **871** of the bottom groove **889** and the top groove **891**, respectively. Likewise, the viscous fluid extends in an annular path rather than over a plane.

In accordance with this embodiment, the viscous substance received within the annular groove **889** extends within the groove at a level designated L.

An advantage of the above structure is apparent from FIG. **37** wherein the sprinkler **800** is illustrated in an inverted position namely upside down suitable for suspension. In this case, the viscous substance (e.g. silicon gel, etc.) will gather within the peripheral groove **899** filling the groove to level L where shear forces act against the substantially vertically extending sidewalls of the T-like annular rim **851** and versus the corresponding sidewalls of the annular rim **891**.

Turning now to FIGS. **38**A to **38**C there is illustrated an alternative housing useful in particular for a sprinkler such as sprinkler **[260]** *800* illustrated in FIGS. **31** to **37**. The housing generally designated **812** is substantially similar to previously disclosed housings, in particular that of FIGS. **5** to **7**. The housing is formed with a receptacle **879** for receiving the dampening mechanism (**878** in FIG. **33**) wherein in this particular embodiment, the annular rim **857'** (constituting the inner wall of the annular groove **889**) is formed with a plurality of radially extending grooves **833** forming a draining channel for draining viscous substance from the well-like receptacle **879** towards the annular groove **889**, thereby ensuring efficient shear in substantially vertical planes, as discussed hereinabove. It is appreciated that likewise, the top cover **821** may be formed with radial draining grooves similar to grooves **[633]** *833* disclosed in connection with the **[**well **679]** *well-like receptacle 879* of the sealed chamber.

In the embodiments discussed hereinabove the first magnets M**1** and the second magnets M**2** are axially distributed, namely extend at different level along the axial axis of the sprinkler, however arranged with like poles facing each other so as to generate a repulsion force therebetween. In the embodiment illustrated in FIG. **39** there is presented a sprinkler wherein the first magnets M**1** and the second magnets M**2** are radially distributed.

For sake of clarity, the present embodiment is designated with like elements as in the first embodiment wherein like elements have been designated like reference numbers shifted by **900**.

The rotary sprinkler generally designated **910** comprises a housing **912** integrally formed with a bridge member **932** extending over two support arms **934** disposed in a V-like configuration. An irrigation head **930** is a swivel-type irrigator formed with a reaction generating deflection groove **940** having an inlet end **942** extending substantially vertically above an outlet **922** of the jet forming nozzle **918**, and an outlet opening **946** extending substantially radially, with a reaction generating surface **948** designed for imparting the rotary head **930** with rotary motion upon impinging of a water jet emitted from the jet forming nozzle **918** thereupon.

The irrigation head **930** is fitted with an upwardly extending boss **950** extending into an aperture **952** formed in the bridge **932** and axially retained in place by means of a retention ring **954** however free to rotate about longitudinal axis (rotary axis A). It is noticed that the retention ring **954** rests over an axial projection **956** extending from the bridge member **981**. The retention arrangement is concealed by a cap **958**.

Formed with the irrigation head **930** is a magnet housing **977** comprising two magnets designated M**1**. The magnets M**1** are fixedly positioned within the magnet housing **977** and are arranged such that like poles thereof face each other. In the present example, the magnets M**1** are radially disposed over the diameter of the magnet housing **977**, and the south pole of the two magnets M**1** face radially inwards.

A pair of second magnets M**2** are secured within a second magnet support member **982** which in turn is rotatably received within a sealed chamber **980** filled with a viscous substance, constituting together a rotary dampening mechanism generally designated **978**. The second magnets M**2** are radially disposed over the diameter of the second magnet support **982** and arranged such that like poles thereof face like poles of the first magnets M**1**, namely where the south pole of the two magnets M**2** face radially outwards. The magnets M**1** and M**2** are disposed substantially co-planer giving rise to generating a repulsion force between the first magnets M**1** and the second magnets M**2**.

Operation of the sprinkler according to this embodiment is principally similar to that disclosed in connection with the previous embodiments. Accordingly, a water jet from the jet forming nozzle **918** impinges of the reaction generating surface **948**, rendering the irrigation head **930** rotary motion about the longitudinal axis A, together with the articulated first magnets M**1**. As a result of rotation of the first magnets M**1** the second magnets M**2** attempt to rotate, under repulsion force residing between the pairs of magnets M**1** and M**2**, respectively. However, the dampening mechanism **978** significantly slows the rotary motion of the second magnet support **982**, resulting in corresponding dampening (slowing) of the revolution of the irrigation head **930**.

Those skilled in the art to which this invention pertains will readily appreciate that numerous changes, variations, and modifications can be made without departing from the scope of the invention, mutatis mutandis.

The invention claimed is:

1. A rotary sprinkler comprising a housing, a rotatable irrigation head fitted with a rotary dampening mechanism and associated with a first magnet assembly, said dampening mechanism being configured for resisting movement of said **[**first magnet assembly**]** *rotatable irrigation head*; a second magnet assembly associated with the housing; said first magnet assembly and said second magnet assembly **[**are**]** *being* arranged with like poles facing each other so as to generate a repulsion force therebetween,

wherein, at least during operation of the sprinkler, said first magnet assembly and said second magnet assembly are in a state of static magnetic equilibrium.

2. The rotary sprinkler according to claim **1**, where the housing is formed with a liquid inlet port and a jet forming nozzle extending opposite said rotatable irrigation head, said housing further comprising a bridge with a magnet support fixedly fitted with said second magnet assembly, said bridge rotationally supporting said irrigation head which comprises said first magnet assembly.

3. The rotary sprinkler according to claim **1**, wherein said second magnet assembly comprises at least a pair of magnets axially positioned with respect to one another and the first magnet assembly is in the form of a magnet [which extends axially symmetrically] between said pair of [first] magnets, at a magnetic force equilibrium.

4. The rotary sprinkler according to claim **1**, wherein said first magnet assembly comprises at least a first magnet and said second magnet assembly comprises at least a second magnet, said first magnet and said second magnet [are] *being* substantially equally radially offset from a rotary axis of the irrigation head.

5. The rotary sprinkler according to claim **1**, wherein the first magnet assembly is displaceable within a sealed chamber filled with a viscous substance, said chamber constituting the dampening mechanism, and comprising a holder being configured for retaining the first magnet *assembly* at a fixed distance from [the] *an* axis of rotation and facilitating only rotary displacement thereof.

6. The rotary sprinkler according to claim **1**, wherein magnets of the second magnet assembly are fixedly articulated to the housing.

7. The rotary sprinkler according to claim **1**, wherein said first magnet assembly comprises at least a first magnet and said second magnet assembly comprises at least a second magnet, said first magnet and said second magnet [are axially positioned] *being axially offset* with respect to one another.

8. The rotary sprinkler according to claim **1**, wherein the sprinkler is [fitted] *configured* for either heads-up or bottoms-up orientation.

9. The rotary sprinkler according to claim **1**, wherein the number of [first] magnets [of] *in* said first magnet assembly corresponds with the number of [second] magnets [of] *in* the second magnet assembly.

10. The rotary sprinkler according to claim **1**, wherein [the] *a* first magnet of the first magnet assembly and [the] *a* second magnet of the second magnet assembly have substantially the same magnetic force.

11. The rotary sprinkler according to claim **2**, wherein the irrigation head is fitted with a support boss retained by the bridge and having an axial degree of freedom such that the irrigation head is axially displaceable between a downward, non-operative position and an upper, operative position.

12. The rotary sprinkler according to claim **11**, wherein when the irrigation head is [at its] *in said* downward, non-operative position it conceals the jet forming nozzle.

13. The rotary sprinkler according to claim **11**, wherein at least one of the irrigation head and the jet forming nozzle is fitted with a peripheral skirt portion for concealing an outlet of the jet forming nozzle and an outlet of a jet emitting portion of the irrigation head, when the irrigation head is [at] *in* the downward, non-operative position.

14. The rotary sprinkler according to claim **13**, wherein the irrigation head is fitted with a skirt portion and the jet forming nozzle is fitted with a fixed skirt portion, said skirt portions being coaxial and having different dimensions, whereby [at] *in* the non-operative position said skirt portions at least partially overlap.

15. The rotary sprinkler according to claim **2**, wherein the [at least one] first magnet *assembly* is fixed on a magnet support member which is secured to the bridge in a rotatable fashion and is in turn engageable for rotation with the irrigation head.

16. The rotary sprinkler according to claim **15**, wherein the magnet support member engages with the irrigation head upon axial displacement of the irrigation head from a downward, non-operative position to an upper, operative position.

17. The rotary sprinkler according to claim **15**, wherein rotary engagement between the magnet support member and the irrigation head is facilitated by a helical path formed in one of the magnet support member and the irrigation head and a corresponding helical coupler formed in another of the magnet support member and the irrigation head, whereby axial ascending of the irrigation head entails postponed [rotary] *rotation* of the magnet support member.

18. The rotary sprinkler according to claim **2**, wherein the [at least one] first magnet *assembly* and the [at least one] second magnet *assembly* are received in respective magnet holders which are detachably attachable to the irrigation head and *said* bridge, respectively.

19. The rotary sprinkler according to claim **1**, wherein the repulsion force is coaxial with a rotary axis of the sprinkler and acts to bias the irrigation head in a direction opposite an axial force applied on the irrigation head by a liquid jet.

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