Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2779014 C 2014/07/22

(11)(21) 2 779 014

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2010/11/12
(87) Date publication PCT/PCT Publication Date: 2011/05/26
(45) Date de délivrance/Issue Date: 2014/07/22
(85) Entrée phase nationale/National Entry: 2012/04/25
(86) N° demande PCT/PCT Application No.: US 2010/056528
(87) N° publication PCT/PCT Publication No.: 2011/062847
(30) Priorité/Priority: 2009/11/20 (US61/281,689)

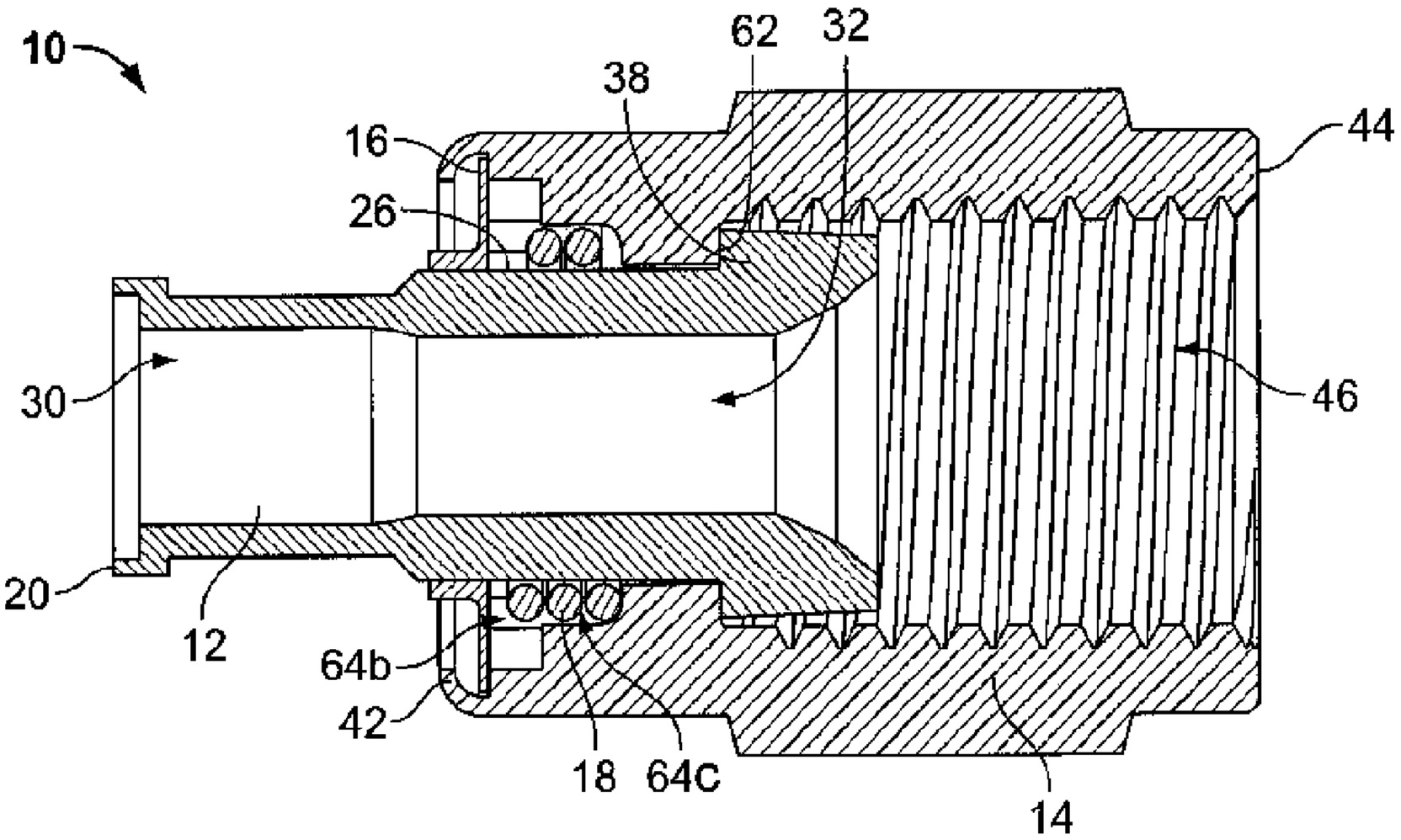
(51) Cl.Int./Int.Cl. *F16L 19/00* (2006.01)

(72) Inventeurs/Inventors:
YAMAMOTO, ALBERT K., US;
FRIAS, EDGAR, US

(73) Propriétaire/Owner:
ALCOA INC., US

(74) Agent: BERESKIN & PARR LLP/S.E.N.C.R.L.,S.R.L.

(54) Titre : RACCORD ANTI-ROTATION SANS FIL DE VERROUILLAGE
(54) Title: LOCKWIRELESS ANTI-ROTATION FITTING



(57) Abrégé/Abstract:
A lockwireless, anti-rotation fitting (10) for attachment to connectors, including a sleeve (12), nut (14), spring (18), and retaining washer (16). The sleeve (12) is slidably inserted within the nut (14) and the spring (18) is inserted on the sleeve (12), grips it, and locks the sleeve (12) with the nut (14). The nut (14) includes a plurality of serrations (68) which engage a tab (82) extending from the spring (18). The spring (18), which is semi- anchored to the nut (14), can only rotate inwardly or in the clockwise direction. The tab (82) of the spring (18) may only ratchet over the serrations (68) when a predetermined counter-clockwise or loosening torque is applied to the nut (14). The serrations (68) allow for rotation in the clockwise direction, while preventing counterclockwise rotation until a predetermined torque is reached in order to prevent self-loosening. The spring (18) prevents accidental loosening due to vibration of components of the system to which the fitting (10) is attached.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 May 2011 (26.05.2011)

PCT

(10) International Publication Number
WO 2011/062847 A1

(51) International Patent Classification:
F16L 19/00 (2006.01)

(21) International Application Number:
PCT/US2010/056528

(22) International Filing Date:
12 November 2010 (12.11.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/281,689 20 November 2009 (20.11.2009) US

(71) Applicant *(for all designated States except US)*: **ALCOA INC.** [US/US]; 201 Isabella Street, Pittsburgh, PA 15212-5858 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **YAMAMOTO, Albert, K.** [US/US]; 8172 Deauville Drive, Huntington Beach, CA 92646 (US). **FRIAS, Edgar** [US/US]; 21142 Richmond Circle, Huntington Beach, CA 92646 (US).

(74) Agent: **AGOSTINO, Joseph**; c/o Greenberg Traurig, LLP, Alcoa Inc., Intellectual Property - Building C, Alcoa Technical Center, 100 Technical Drive Alcoa Center, PA 15069 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: LOCKWIRELESS ANTI-ROTATION FITTING

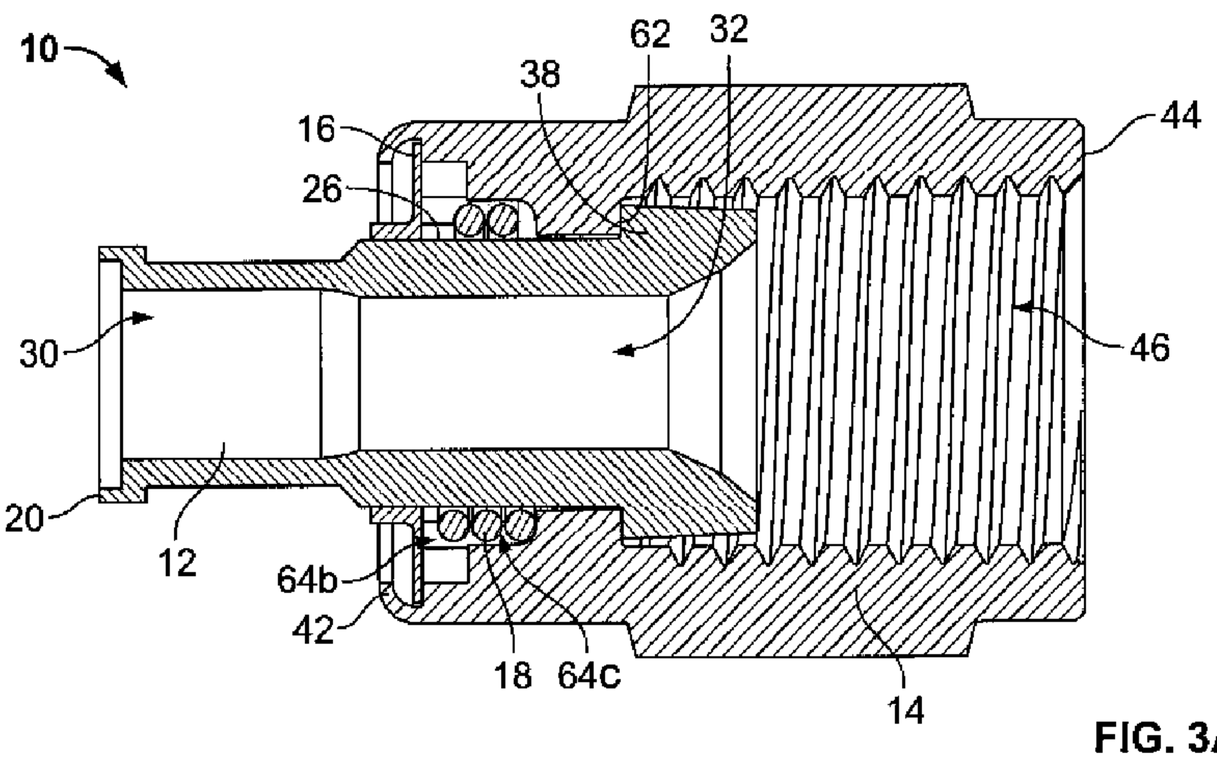


FIG. 3A

(57) **Abstract**: A lockwireless, anti-rotation fitting (10) for attachment to connectors, including a sleeve (12), nut (14), spring (18), and retaining washer (16). The sleeve (12) is slidably inserted within the nut (14) and the spring (18) is inserted on the sleeve (12), grips it, and locks the sleeve (12) with the nut (14). The nut (14) includes a plurality of serrations (68) which engage a tab (82) extending from the spring (18). The spring (18), which is semi- anchored to the nut (14), can only rotate inwardly or in the clockwise direction. The tab (82) of the spring (18) may only ratchet over the serrations (68) when a predetermined counter-clockwise or loosening torque is applied to the nut (14). The serrations (68) allow for rotation in the clockwise direction, while preventing counterclockwise rotation until a predetermined torque is reached in order to prevent self-loosening. The spring (18) prevents accidental loosening due to vibration of components of the system to which the fitting (10) is attached.

WO 2011/062847 A1

LOCKWIRELESS ANTI-ROTATION FITTING

Technical Field of the Invention

The present invention relates to fittings and, more particularly, to lockwireless, anti-rotation type fittings for attachment to a connector.

Background Art

Compression fittings are widely used in a variety of instrumentation, pneumatic, hydraulic, process, power, refrigeration, industrial, mobile, transportation, aerospace, military, commercial, and other fluid power or control applications utilizing plastic or metal tubing. Compression fittings have been adapted for use with many different tubing types including metals such as copper, brass, steel, stainless steel, titanium, aluminum, and alloys such as nickel-copper, Hastelloy, Alloy 600, 6Mo, Inconel, Incoloy, and the like, and many plastics. "Lockwireless" fittings, i.e., anti-rotation fittings which do not employ a lockwire, would be well-received for commercial and military aerospace use, as well as for other applications.

Disclosure of the Invention

The present invention relates to a lockwireless, anti-rotation fitting for attachment to connectors. In one aspect, the fitting includes a sleeve, a nut and a spring. The sleeve has a first end, a second end opposite the first end and an aperture extending from the first end to the second end. The nut has a first end, a second end opposite the first end, an aperture extending from the first end of the nut to second end of the nut, an interior surface and a plurality of serrations formed within the interior surface proximate to the first end of the nut. The spring has an outwardly extending tab. The sleeve is positioned within the aperture of the nut such that the first end of the sleeve protrudes outwardly from the first end of the nut. The spring is mounted on the sleeve and the tab of the spring engages one of the plurality of serrations of the nut, the tab of the spring being adapted to ratchet over the plurality of serrations in a first direction when a predetermined torque is applied to the nut. The spring is a coil spring and the fitting further comprises retaining means located proximate to the first end of the nut for retaining the coil spring on the sleeve so as to prevent disengagement of the tab of the coil spring with one of the plurality of serrations of the nut. The retaining means includes a retaining washer positioned on the sleeve and within the aperture of the nut proximate to the first end of the nut.

The spring prevents accidental loosening due to vibration of components of the system to which the fitting is attached. In an embodiment, the fitting is designed to eliminate the need for a special adapter and does not require special tooling to install or uninstall it. In an embodiment, the fitting further includes a visual indicator that indicates its proper installation.

In an embodiment, the fitting is useful in aerospace applications. In other embodiments, the fitting can be used in any application that encompasses a fluid system, such as manufacturing, automotive, etc.

Further features and advantages of the invention will appear more clearly on a reading of the detailed description of an exemplary

embodiment of the invention, which is given below by way of example only with reference to the accompanying drawings.

Brief Description of the Drawings

Reference is made to the following detailed description of the exemplary embodiment considered in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of a lockwireless, anti-rotation fitting in accordance with an embodiment of the present invention;

FIG. 2 is a side elevational view of the fitting shown in **FIG. 1**;

FIG. 3A is a cross-sectional view, taken along line 3A-3A and looking in the direction of the arrows, of the fitting shown in **FIG. 2**;

FIG. 3B is a near perspective view of the fitting shown in **FIG. 3A**;

FIG. 3C is a partial, enlarged cross-sectional view of the fitting shown in **FIG. 1**;

FIG. 4A is a front elevational view of a sleeve employed by the fitting shown in **FIG. 1**;

FIG. 4B is a cross-sectional view, taken along line 4B-4B and looking in the direction of the arrows, of the sleeve shown in **FIG. 4A**;

FIG. 4C is an enlarged view of Detail 4C of the sleeve shown in **FIG. 4B**;

FIG. 4D is an enlarged view of Detail 4D of the sleeve shown in **FIG. 4B**;

FIG. 5A is a front elevational view of a nut employed by the fitting shown in **FIG. 1**;

FIG. 5B is a cross-sectional view, taken along line 5B-5B and looking in the direction of the arrows, of the nut shown in **FIG. 5A**;

FIG. 5C is an enlarged view of Detail 5C of the nut shown in **FIG. 5A**;

FIG. 6A is a bottom plan view of a retaining washer employed by the fitting shown in **FIG. 3A**;

FIG. 6B is a cross-sectional view, taken along line 6B-6B and looking in the direction of the arrows, of the retaining washer shown in **FIG. 6A**;

FIG. 7A is a top plan view of a spring employed by the fitting shown in **FIG. 3A**;

FIG. 7B is a side elevational view of the spring shown in **FIG. 7A**;

FIG. 8A is a front elevational view of the spring shown in **FIG. 7A** attached to the nut shown in **FIG. 5A**;

FIG. 8B is an enlarged view of Detail 8B of the spring and the nut shown in **FIG. 8A**;

FIG. 9A is a perspective view of the fitting shown in **FIG. 1** connected to a fluid connector;

FIG. 9B is an enlarged view of Detail 9B of the fitting shown in **FIG. 9A**; and

FIG. 9C is an enlarged cross-sectional view of the fitting shown in **FIG. 9B**.

Best Mode for Carrying Out the Invention

Referring to **FIGS. 1, 2** and **3A-3C**, in an embodiment, a lockwireless anti-rotation fitting **10** includes a sleeve **12**, a nut **14,** a retaining washer **16**, and a coil spring **18**. In an embodiment, the sleeve **12** is inserted and maintained within the nut **14**, while the spring **18** is attached to the sleeve **12** and engages the nut **14**. In an embodiment, the spring **18** is held in place by the retaining washer **16**. The features and functions of the aforesaid components will be described in more detail hereinafter.

In an embodiment, the sleeve **12,** the nut **14**, the retaining washer **16**, and the spring **18** are each made from metal. In an embodiment, the sleeve **12**, the nut **14,** the retaining washer **16**, and the spring **18** are each made from steel. In an embodiment, the sleeve **12**, the nut **14,** the retaining washer **16**, and the spring **18** are each made from 321 corrosion-resistant steel. In other embodiments, the sleeve **12,** the nut **14**, the retaining washer **16**, and the spring **18** are each made from other suitable materials known in the art, such as other types of metals or metal alloys, plastics, and any suitable anti-corrosion materials.

Referring to **FIGS. 4A-4D**, in an embodiment, the sleeve **12** includes a first end **20**, a second end **22** opposite the first end **20**, and an aperture **24** that bridges the first end **20** to the second end **22**. In an embodiment, the sleeve **12** is substantially cylindrical in shape. In other embodiments, the sleeve **12** can consist of other suitable shapes and sizes. In an embodiment, the sleeve **12** includes an exterior surface **26** and an interior

surface **28** defined by the aperture **24**. In an embodiment, the sleeve **12** is defined by a first portion **30** and a second portion **32**, which converge with and transition into one another at a tapered portion **34** that is formed on the exterior surface **26**. In an embodiment, the first portion **30** includes an outer diameter that is smaller than an outer diameter of the second portion **32**. In other embodiments, the outer diameter of the first portion **30** is substantially the same as or equal to the outer diameter of the second portion **32**. In an embodiment, the first portion **30** includes a flange **36** formed proximate to the first end **20** (see, in particular, **FIG. 4C**), while the second portion **32** includes a head **38** formed at the second end **22**. The aperture **24** includes a tapered portion **40** formed within the head **38** and proximate to the second end **22**.

Referring to **FIGS. 5A-5C**, in an embodiment, the nut **14** includes a first end **42**, a second end **44** opposite the first end **42**, and an aperture **46** that extends from the first end **42** to the second end **44**. In an embodiment, the nut **14** includes an exterior surface **48** and an interior surface **50** defined by the aperture **46**. In an embodiment, a gripping portion **52** extends from the exterior surface **48** and intermediate the first and second ends **42, 44**. In an embodiment, the gripping portion **52** is sized and shaped to engage a tool, such as wrench, to facilitate the installation and removal of the fitting **10.** In an embodiment, the gripping portion **52** is hexagonal in shape. In other embodiments, the gripping portion **52** consists of other suitable shapes and sizes known in the art.

Still referring to **FIGS. 5A-5C**, in an embodiment, the aperture **46** includes a first interior portion **54** that extends from the first end **42** to a point **56** intermediate the first and second ends **42, 44**, and a second interior portion **58** that extends from the second end **44** to the point **56**. In an embodiment, internal threads **60** are formed on the interior surface **50** of the first interior portion **54** of the aperture **46**. In an embodiment, a partition **62** is formed within the aperture **46** proximate to the point **56,** and which separates the first and second interior portions **54, 58** from one another. In an embodiment, proximate to the first end **42** of the nut **14**, the first interior portion **54** of the aperture **46** is broken down into a plurality of stepped portions **64a-c**, which form corresponding ledges **66a-c**.

Still referring to **FIGS. 5A-5C**, in an embodiment, the nut **14** further includes a plurality of serrations **68** that are circumferentially formed within an interior surface **70** of the stepped portion **64b**. In an embodiment, each of the serrations **68** is sinusoidal in shape. In another embodiment, each of the serrations **68** is saw-tooth in shape. In another embodiment, each of the serrations **68** is rectangular in shape. In other embodiments, each of the serrations **68** consist of other suitable shapes and sizes. The purpose and function of the serrations **68** shall be described hereinafter.

Referring to **FIGS. 6A** and **6B**, in an embodiment, the retaining washer **16** includes a centrally-located, circular-shaped aperture **74,** a hat section **75,** and a circular-shaped flange **76** extending from the hat section **75** and surrounding the aperture **74**. Referring to **FIGS. 7A** and **7B**, the spring **18** includes a first end **78** and a second end **80** opposite thereof, and

a tab **82** that extends angularly from the first end **78** of the spring **18**. In an embodiment, the spring **18** can include any number of coils as desired. In an embodiment, the spring **18** may include any size diameter as required and the thickness of the coils (i.e., diameter) can be varied as desired. In other embodiments, the coils of the spring **18** can consist of any shape or size, such as round wire, square wire, etc.

Referring back to **FIGS. 3A-3C**, in an embodiment, the fitting **10** is assembled in the following manner. The first end **20** of the sleeve **12** is slidably inserted into the aperture **46** of the nut **14**. In an embodiment, when the sleeve **12** is fully inserted within the nut **14**, the head **38** of the sleeve **12** engages the partition **62** of the nut **14**, which acts as a stop against the sleeve **12** so as to prevent the sleeve **12** from exiting the first end **42** of the nut **14**. As a result, in an embodiment, the second portion **32** of the sleeve **12** remains concealed within the aperture **46** of the nut **14**, while the first portion **30** of the sleeve **12** protrudes outwardly from the first end **42** of the nut **14**. Next, the spring **18** is slidably inserted on the sleeve **12** at its first end **20** and is fitted around and grips the exterior surface **26** of the second fitting portion **32** of the sleeve **12**. In an embodiment, the spring **18** is housed within the stepped portion **64c** of the nut **14**. As a result, the tab **82** of the spring **18** extends into the stepped portion **64b** and engages the serrations **68**, which semi-anchors the spring **18** to the nut **14** (see also **FIGS. 8A** and **8B**). In an embodiment, once the spring **18** is in the aforesaid position, it is held in place by the retaining washer **16**, which is inserted within the aperture **46** of the nut **14** at the first end **42** thereof. In

this regard, the aperture **74** of the washer **16** slides around the first end **20** of the sleeve **12** and the flange **76** of the washer is housed within the stepped portion **64a** of the nut **14** (see also **FIG. 9C**). In an embodiment, the first end **42** of the nut **14** is folded (e.g., bent) inwardly so as to secure the retaining washer **16** (see **FIG. 9C**). In other embodiments, the retaining washer **16** is secured by other means known in the art.

Referring to **FIGS. 8A** and **8B**, in an embodiment, the spring **18,** which is semi-anchored to the nut **14,** can only rotate inwardly or in the clockwise direction. In an embodiment, the tab **82** of the spring **18** may only ratchet over the serrations **68** when a predetermined counter-clockwise or loosening torque is applied to the nut **14**. In an embodiment, the serrations **68** allow for rotation in the clockwise direction. In an embodiment, the serrations **68** are designed so that the torque, when turning counterclockwise, is high enough to prevent self-loosening. During installation and tightening of the fitting **10,** the serrations **68** hold the spring in the sleeve **12**. In an embodiment, the tab **82** of the spring **18** will deflect at a predetermined force to allow the nut **14** to rotate at the desired torque. In an embodiment, this torque can be increased or decreased depending on the user specification by altering the design of the fitting **10**. In an embodiment, the fitting **10** can be applied to shaped fittings (e.g., elbows, tees, and crosses) as well as straight fittings.

Referring to **FIGS. 9A-9C**, in an embodiment, a fluid connector **86** is connected to the fitting **10** at the second end **44** of the nut **14.** In an embodiment, the connector **86** includes external threads **88** that threadedly

engage the internal threads **60** of the nut **14** (which are shown in **FIG. 5B**). In an embodiment, the connector **86** may consist of various shapes and sizes. In an embodiment, the fitting **10** and/or the connector **86** includes a sealant for providing a fluid tight seal therebetween. The exposed, first end **20** of the sleeve **12** is connected to a fluid line or another connector (not shown in the Figures).

In an embodiment, a color coded band **84** is applied to the exterior surface **26** of the sleeve **12** proximate to the tapered portion **34** and is hidden by the hat **75** of the washer **16** when the nut **14** is unseated, but is exposed when the nut **14** is in the fully seated position (see **FIGS. 9A-9C)**. In an embodiment, the band **84** acts as a visual indicator to a user that the nut **14** is properly installed. In an embodiment, the band **84** extends circumferentially around the exterior surface **26** of the sleeve **12.** In an embodiment, the band **84** includes a single color. In an embodiment, the band **84** includes a plurality of bands (not shown in the Figures). In another embodiment, the band **84** can include a groove formed within the exterior surface **26** of the sleeve **12** (not shown in the Figures). In another embodiment, the band **84** can include alphanumeric indicia (not shown in the Figures). In another embodiment, the band **84** can be measured with devices known in the art, such as a gauge.

As indicated above, the fitting **10** provides an automatic locking method to prevent the loosening of the locking nut **14**. In an embodiment, an end user may attach fluid lines to the fitting **10** by using his or her fingers and by applying the final torque using a wrench until the band **84** is

visually seen indicating that the fluid lines are fully seated. In an embodiment, the fitting **10** thus enables a threaded connection to remain connected without the need of safety wires.

In an embodiment, the fitting **10** includes a positive-lock feature at the location where nut **14** is wrenched onto. In an embodiment, the spring **18** grips onto the sleeve **12** and, being lightweight, it will effectively resist loosening of components due to vibration forces. The fitting **10** accommodates a large tolerance range of mating diameters. In an embodiment, the fitting **10** can accommodate a wide range of tube sizes, such as (but not limited to) tube sizes from 0.250" to 2". In an embodiment, the fitting **10** can be of any size, and can range from (but is not limited) from fitting sizes -4 to -24. The fitting **10** is relatively simple to manufacture, is cost effective, includes has minimal components, and has low weight. Fewer components reduces the potential of foreign object damage, as well as reduces weight in the fitting **10**, which is a special concern in the aircraft industry where every pound can be very expensive.

It will be understood that the fitting **10** described herein is merely exemplary and that a person skilled in the art may make variations and modifications.

Claims:

1. A fitting, comprising:

- a sleeve having a first end, a second end opposite the first end, and an aperture extending from the first end to the second end;
- a nut having a first end, a second end opposite the first end of the nut, an aperture extending from the first end of the nut to the second end of the nut, an interior surface, and a plurality of serrations formed within the interior surface proximate to the first end of the nut; and
- a spring having an outwardly extending tab,

the sleeve being positioned within the aperture of the nut such that the first end of the sleeve protrudes outwardly from the first end of the nut, and
the spring is mounted on the sleeve and the tab of the spring engages one of the plurality of serrations of the nut, the tab of the spring being adapted to ratchet over the plurality of serrations in a first direction when a predetermined torque is applied to the nut,
where the spring is a coil spring; and
the fitting further comprises retaining means, located proximate to the first end of the nut, for retaining the coil spring on the sleeve so as to prevent disengagement of the tab of the coil spring with the one of the plurality of serrations of the nut,
wherein the retaining means includes a retaining washer positioned on the sleeve and within the aperture of the nut proximate to the first end of the nut.

2. The fitting of Claim 1, wherein the first end of the nut is bent inwardly so as to prevent the retaining washer from disengaging the sleeve.

3. The fitting of Claim 1 or Claim 2, wherein the second end of the nut slidably receives the first end of the sleeve.

4. The fitting of one of the Claims 1 to 3, wherein the aperture of the nut includes a first interior portion located proximate to the first end of the nut and a second interior portion located proximate to the second end of the nut, the first and second interior portions being separated from one another by a partition.

5. The fitting of Claim 4, wherein the coil spring is positioned within the first interior portion of the aperture of the nut.

6. The fitting of Claim 4 or 5, wherein the sleeve includes a head formed at the second end of the sleeve, the head being located within the second interior portion of the aperture of the nut when the nut receives the sleeve, and the head being sized and shaped to engage the partition of the nut so as to prevent the sleeve from exiting the first end of the nut.

7. The fitting of one of the Claims 4 to 6, wherein the second interior portion of the aperture of the nut is adapted to receive a connector.

8. The fitting of Claim 7, wherein the second interior portion of the aperture of the nut includes internal threads that threadedly engage external threads of the connector.

9. The fitting of one of the Claims 1 to 8, wherein the nut includes a gripping portion adapted to receive an installation tool.

10. The fitting of one of the Claims 1 to 9, wherein the sleeve includes an exterior surface an indica means located on the exterior surface for indicating when the nut is in a fully installed position.

11. The fitting of Claim 10, wherein the indicia means includes a band extending circumferentially around the exterior surface of the sleeve, the band being hidden by the nut when the nut is in an uninstalled position and exposed when the nut is in an installed position.

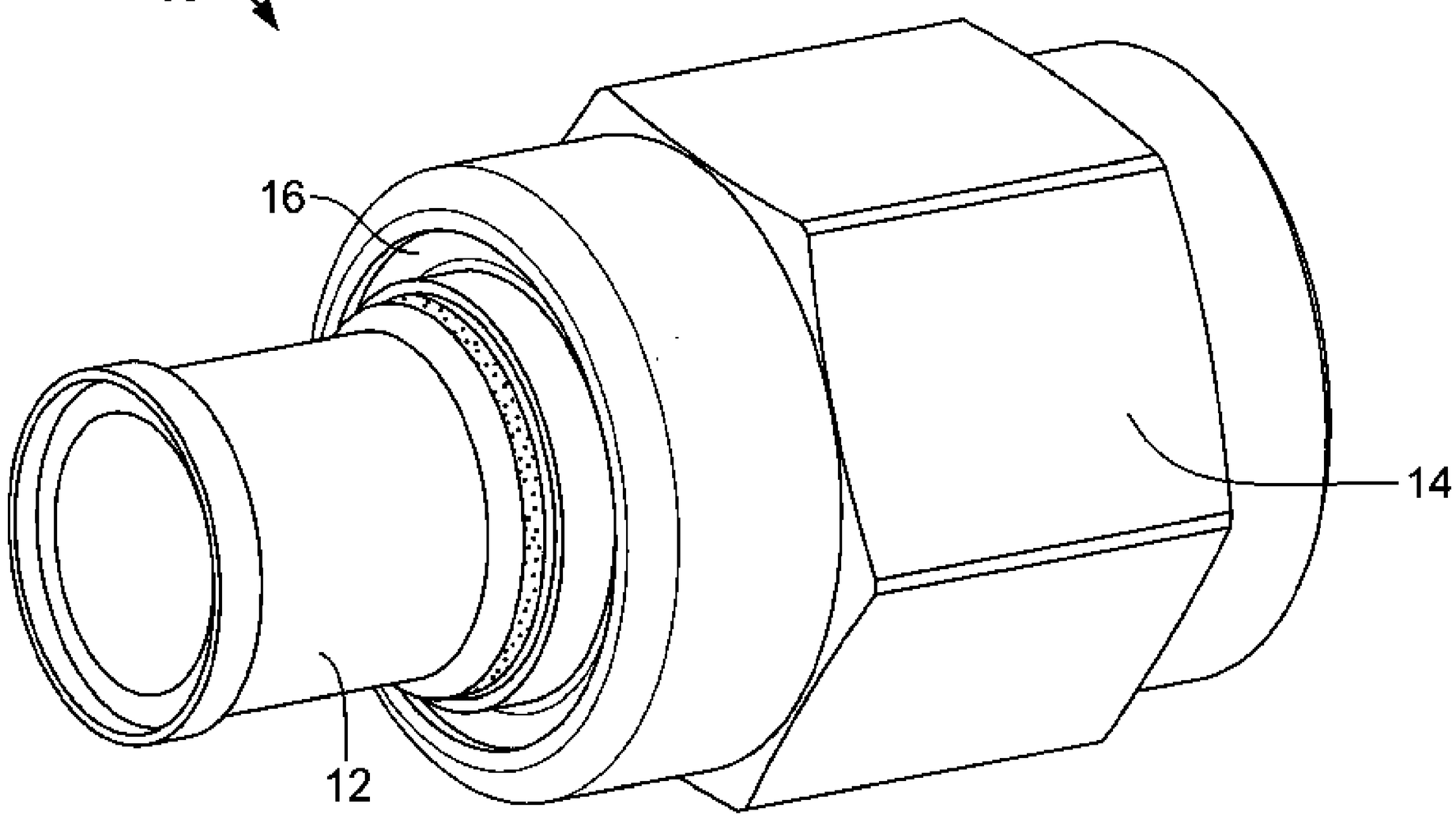


FIG. 1

FIG. 2

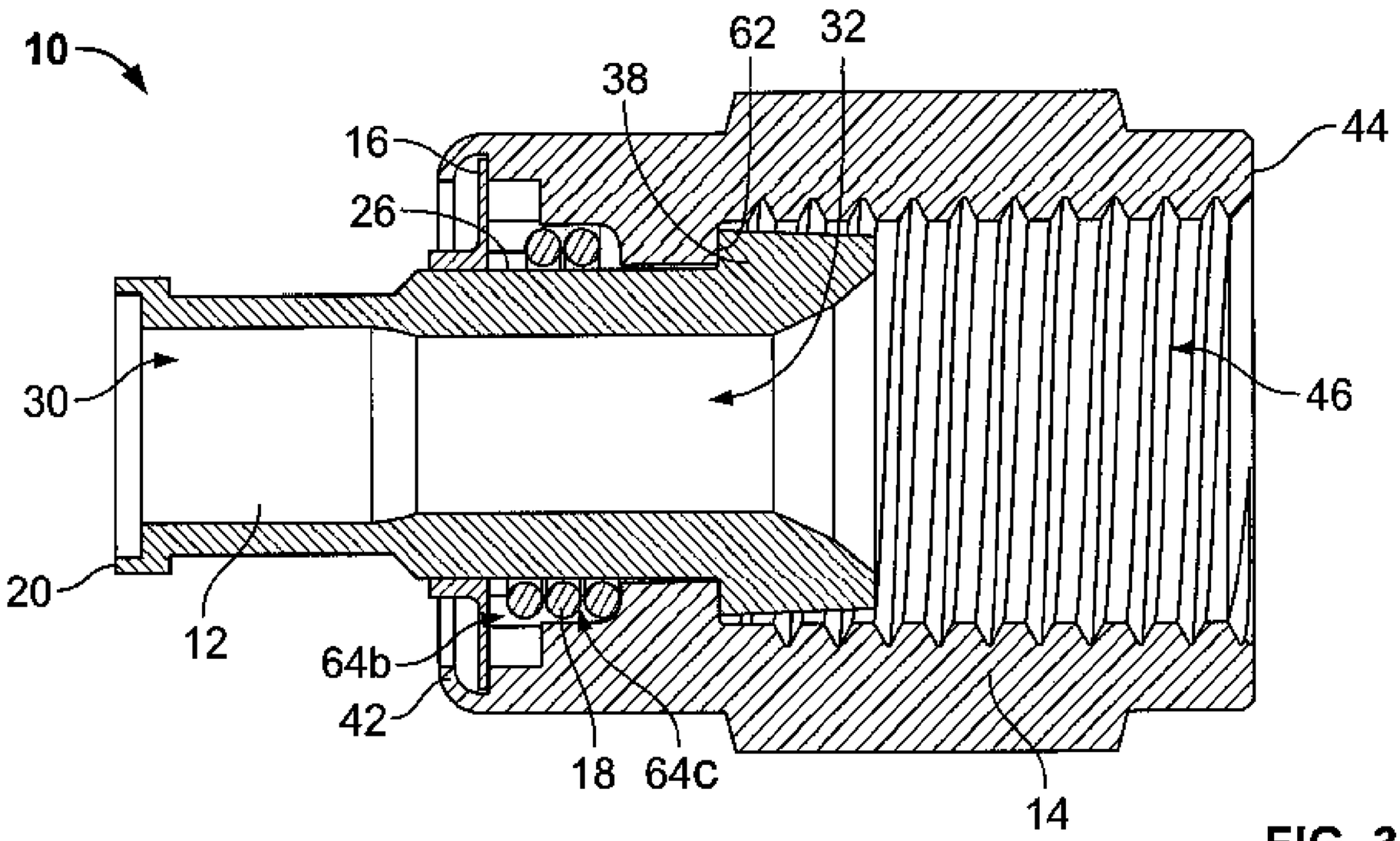

10
62
32
38
16
44
26
30
46
20
12
64b
42
18
64c
14

FIG. 3A

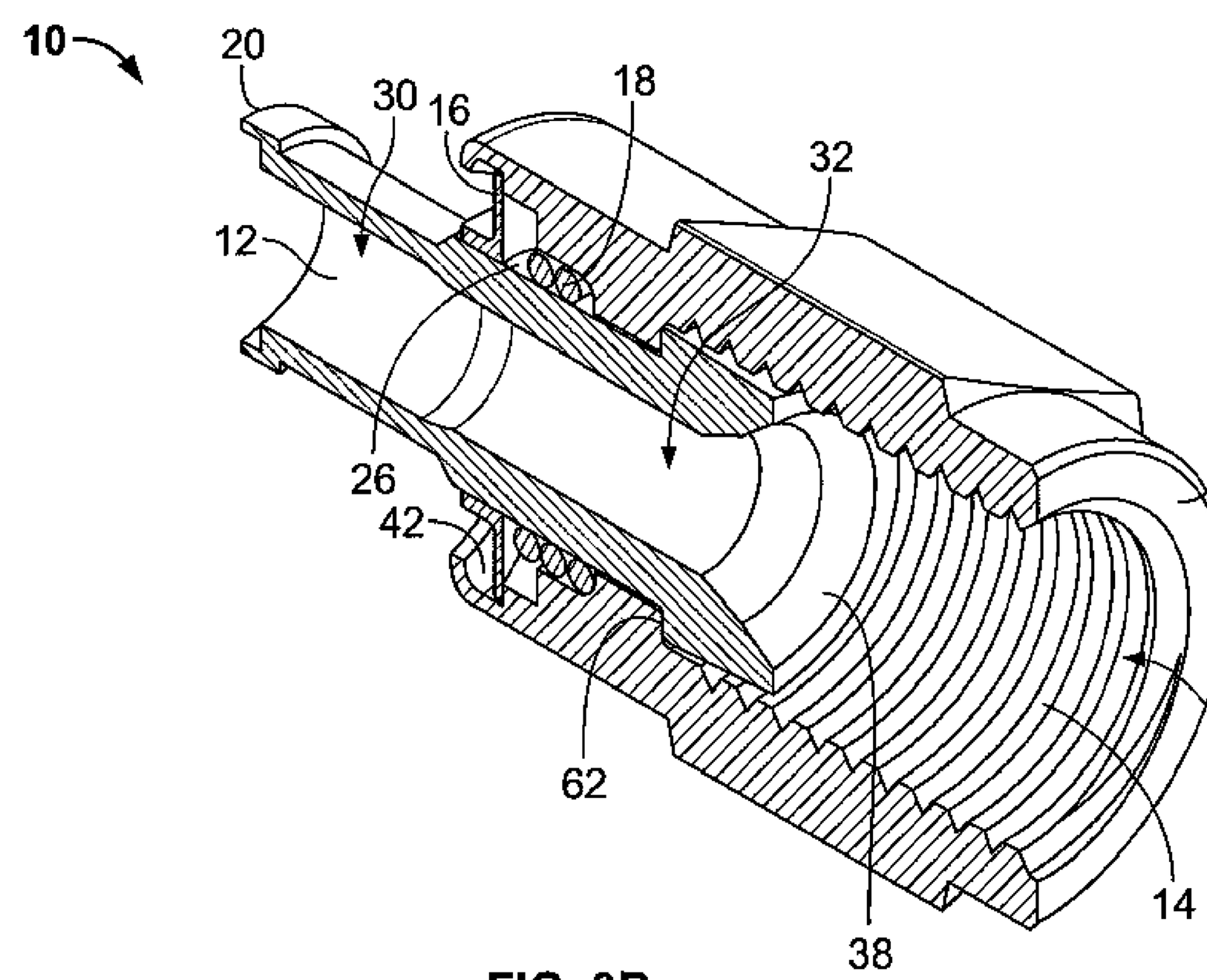

10
20
30
16
18
32
12
26
42
44
46
62
14
38

FIG. 3B

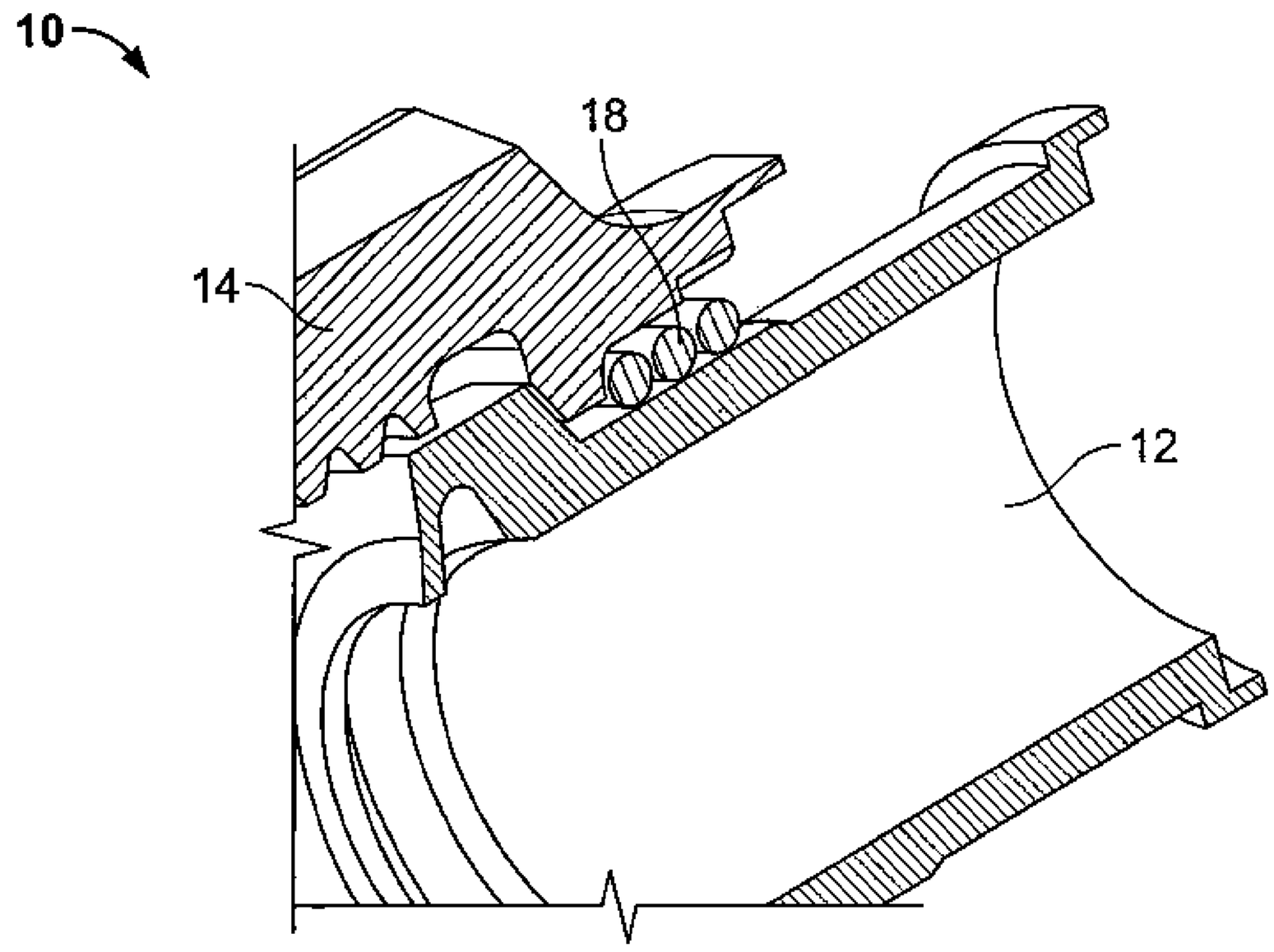


FIG. 3C

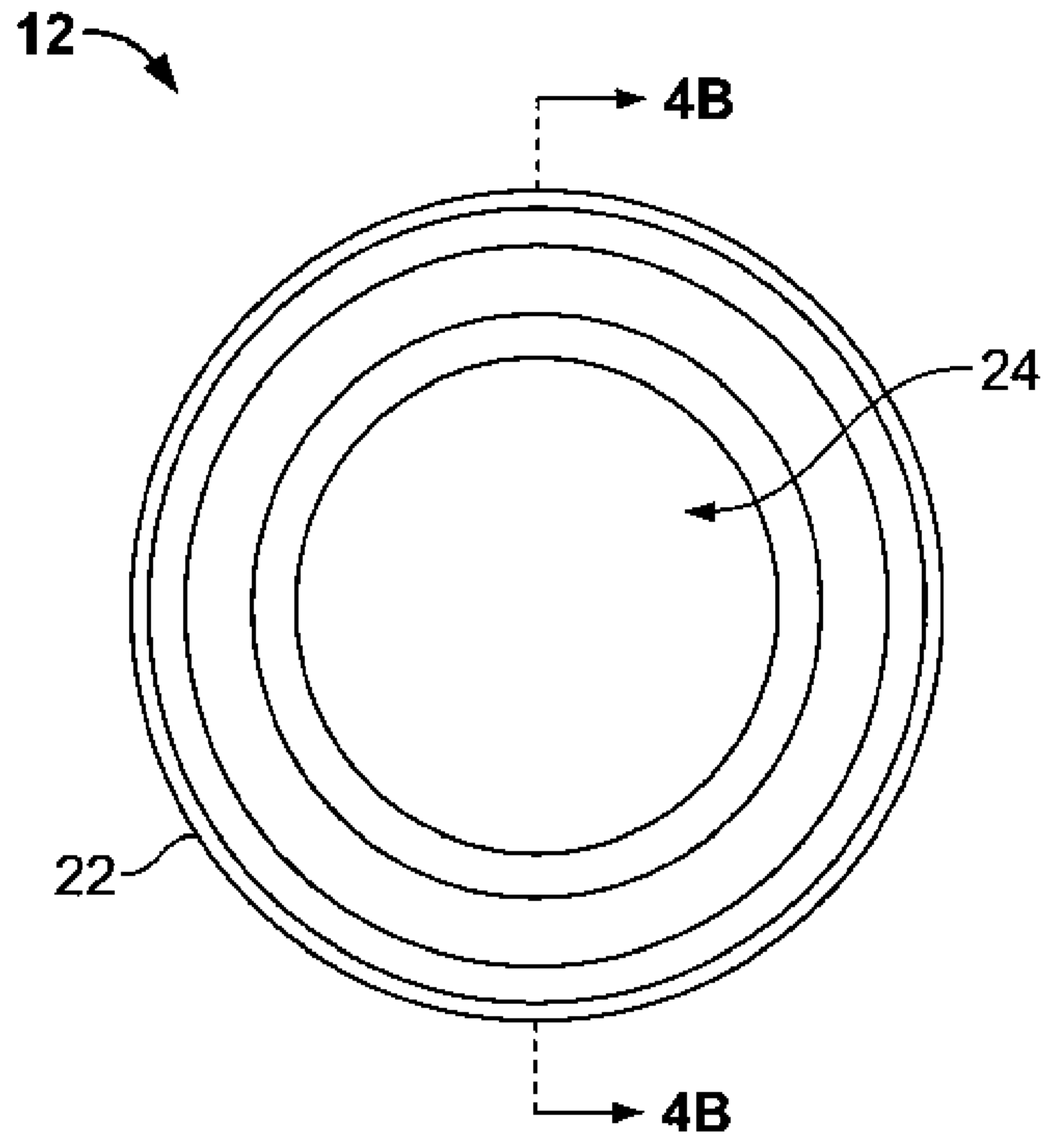


FIG. 4A

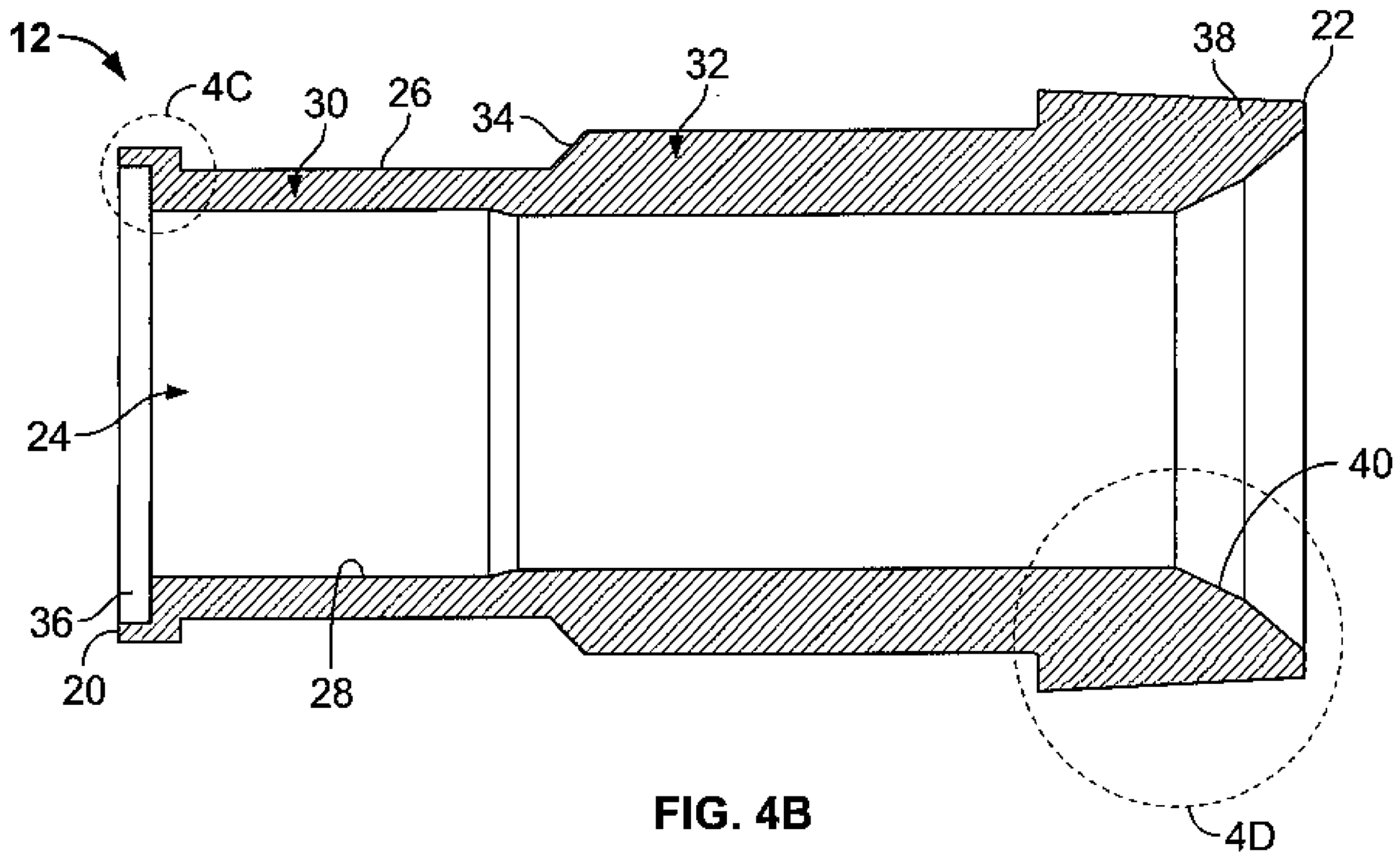


FIG. 4B

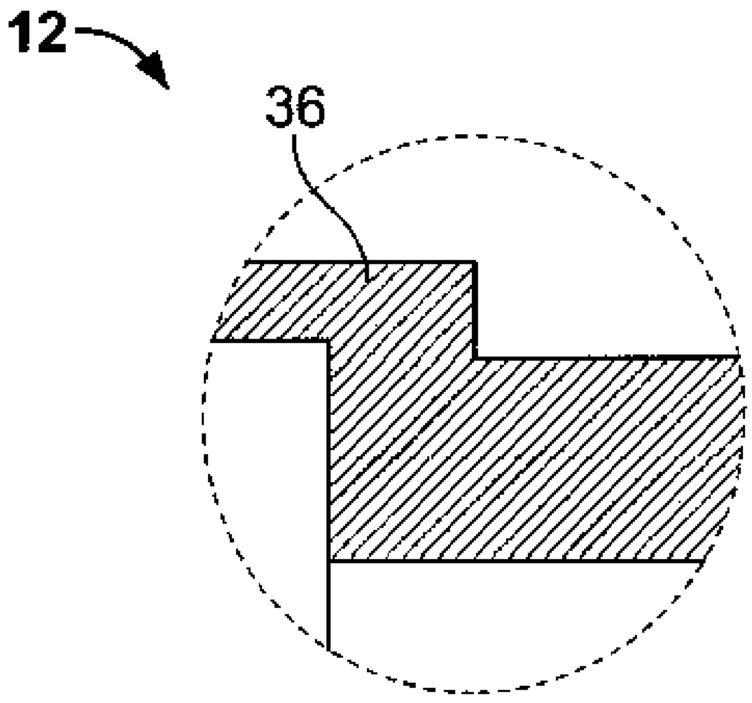


FIG. 4C

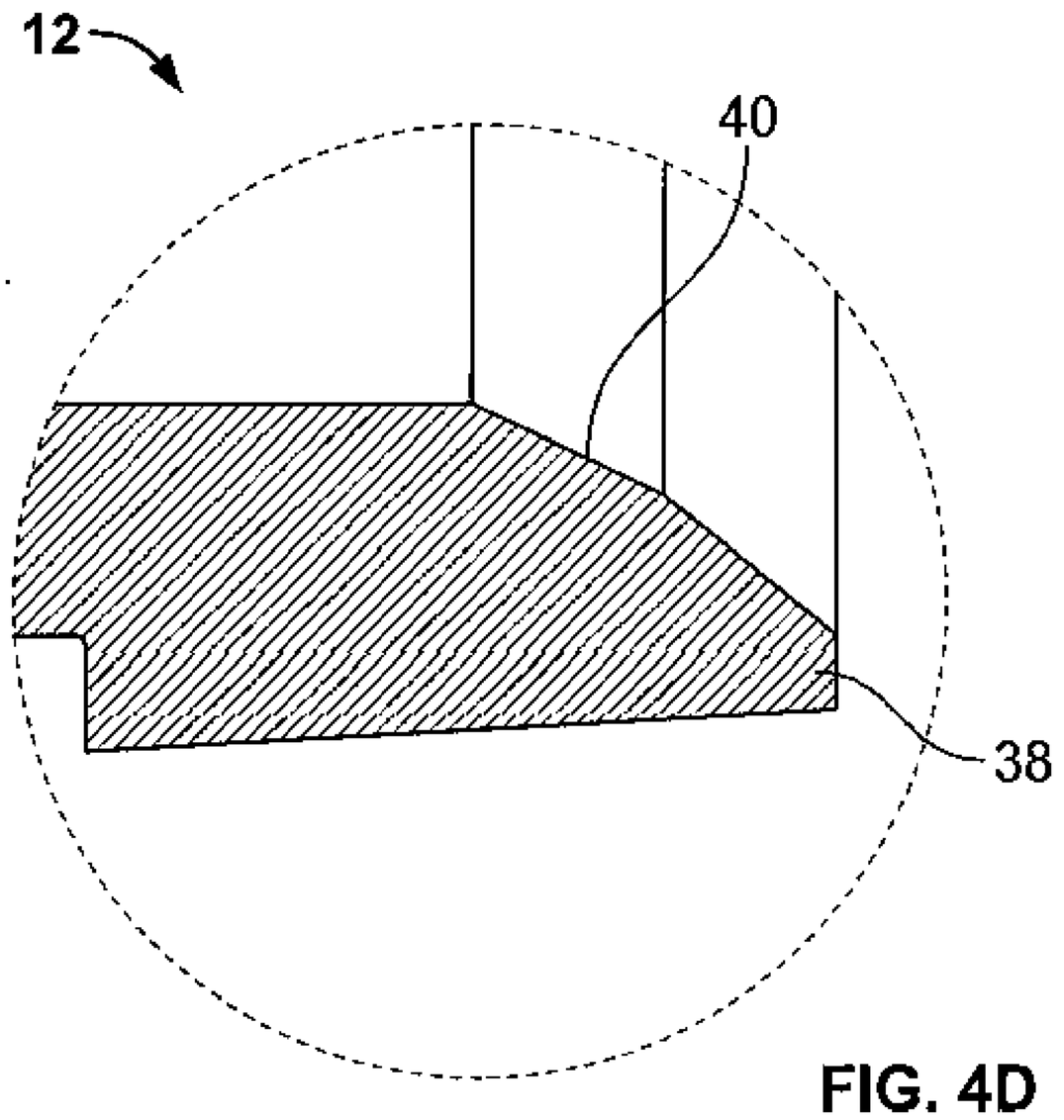


FIG. 4D

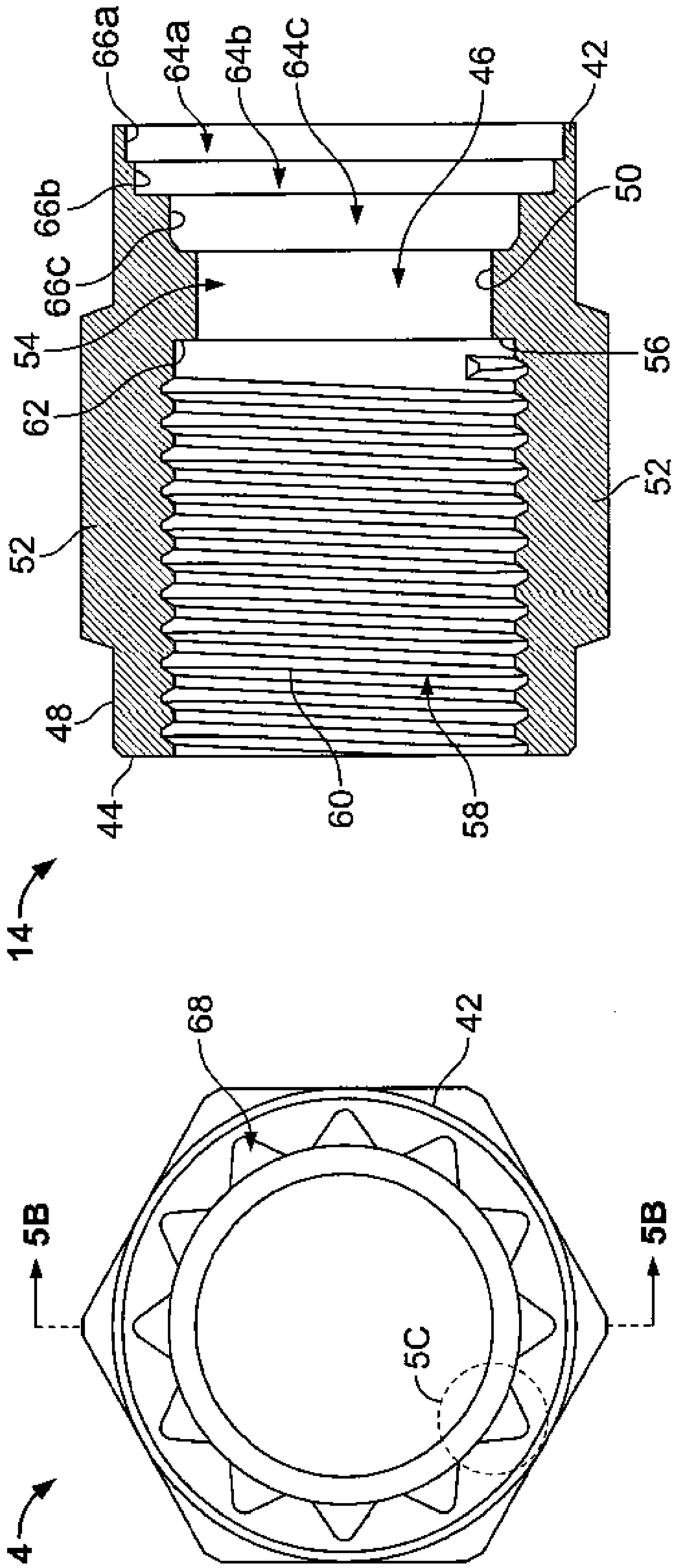


FIG. 5A

FIG. 5B

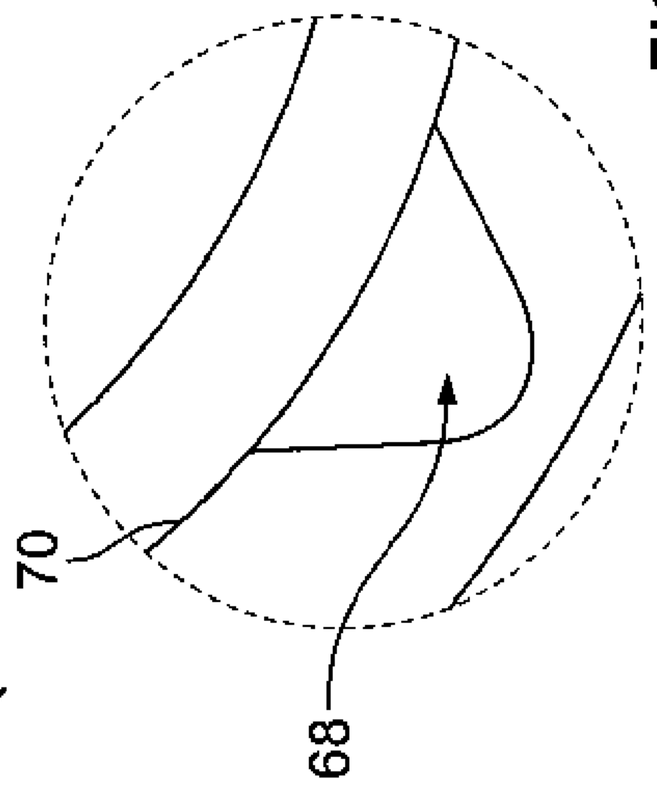


FIG. 5C

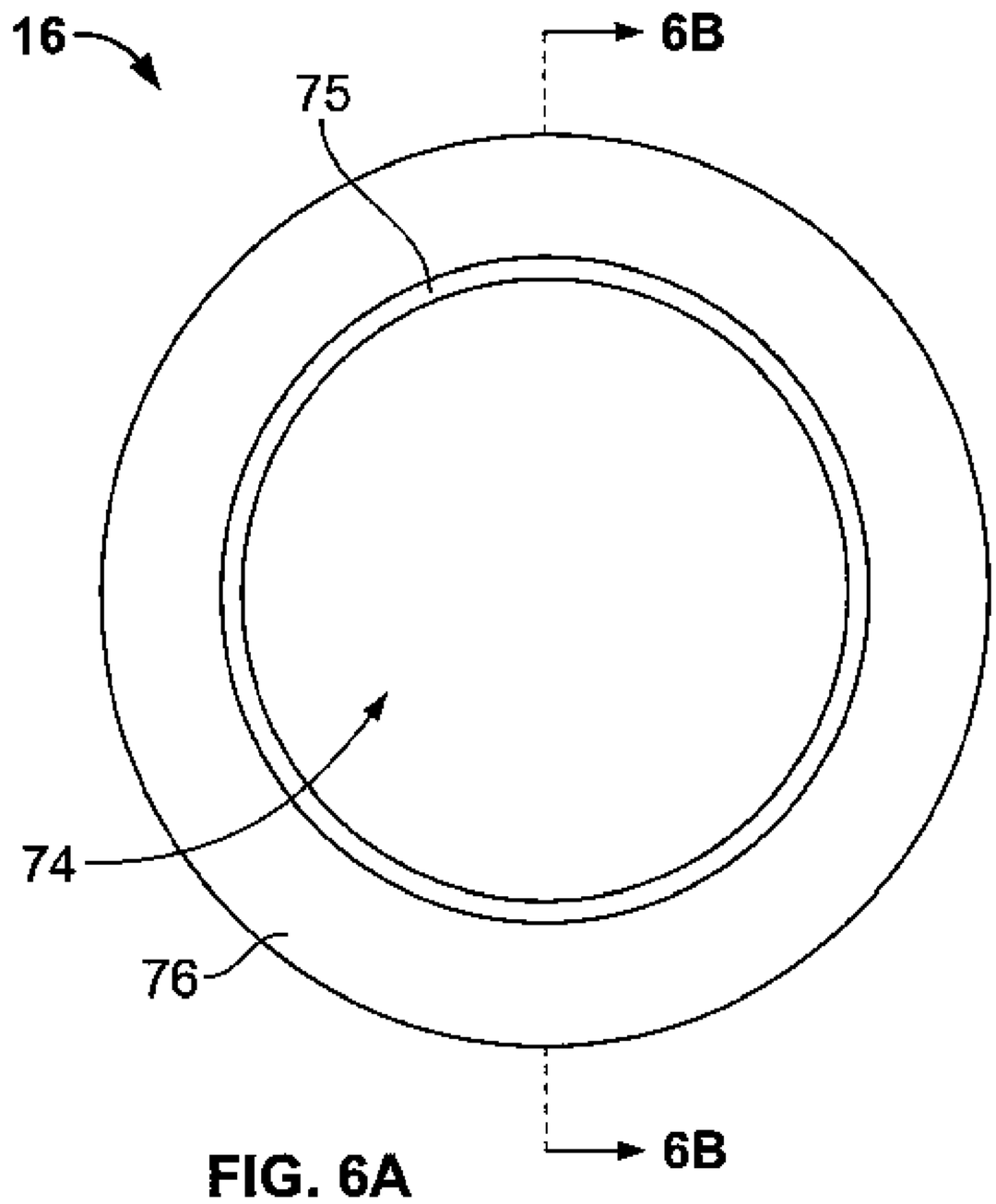


FIG. 6A

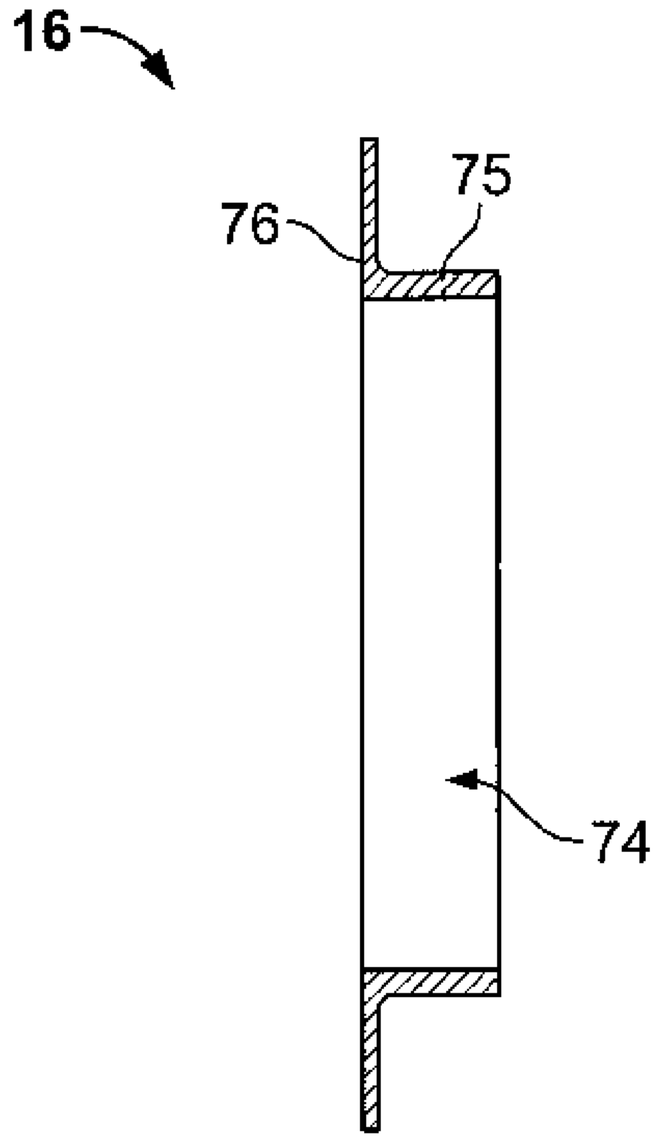


FIG. 6B

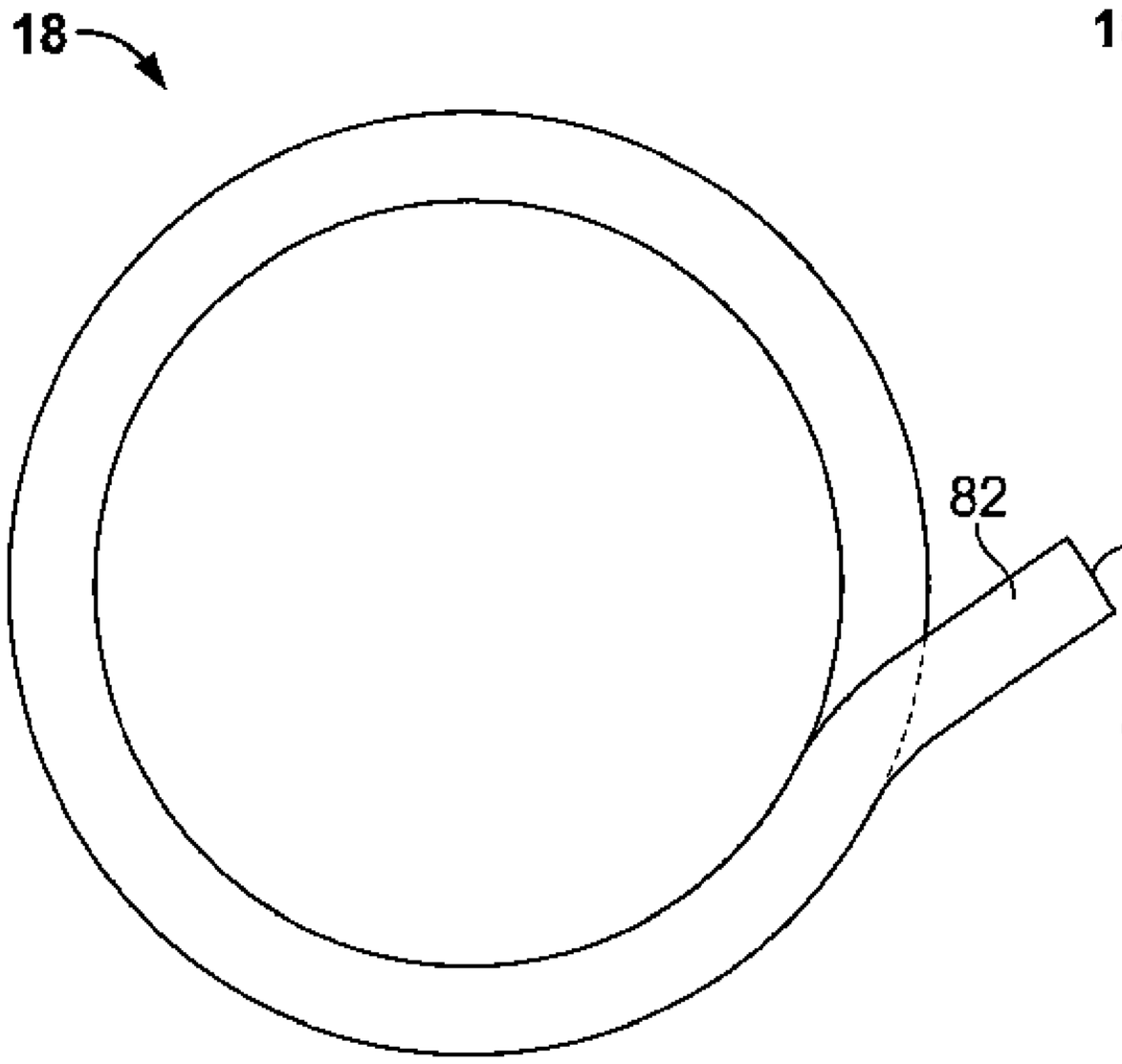


FIG. 7A

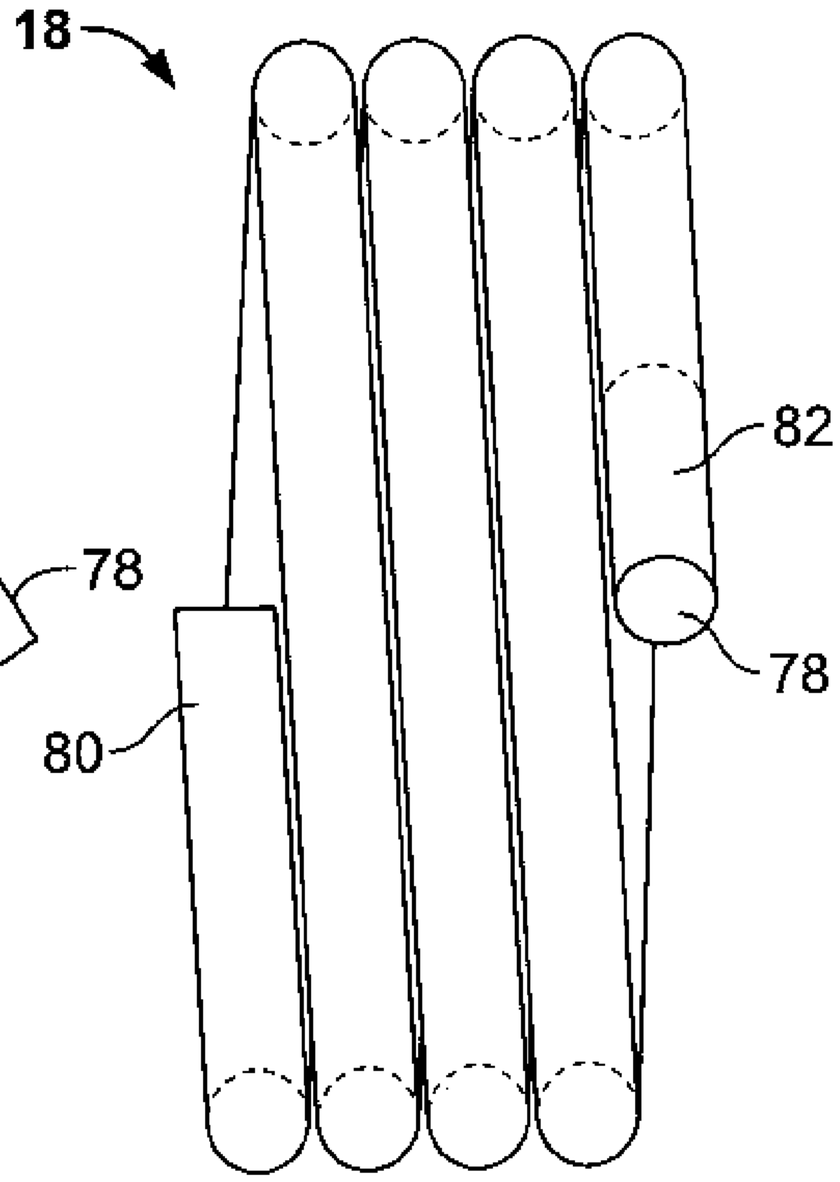


FIG. 7B

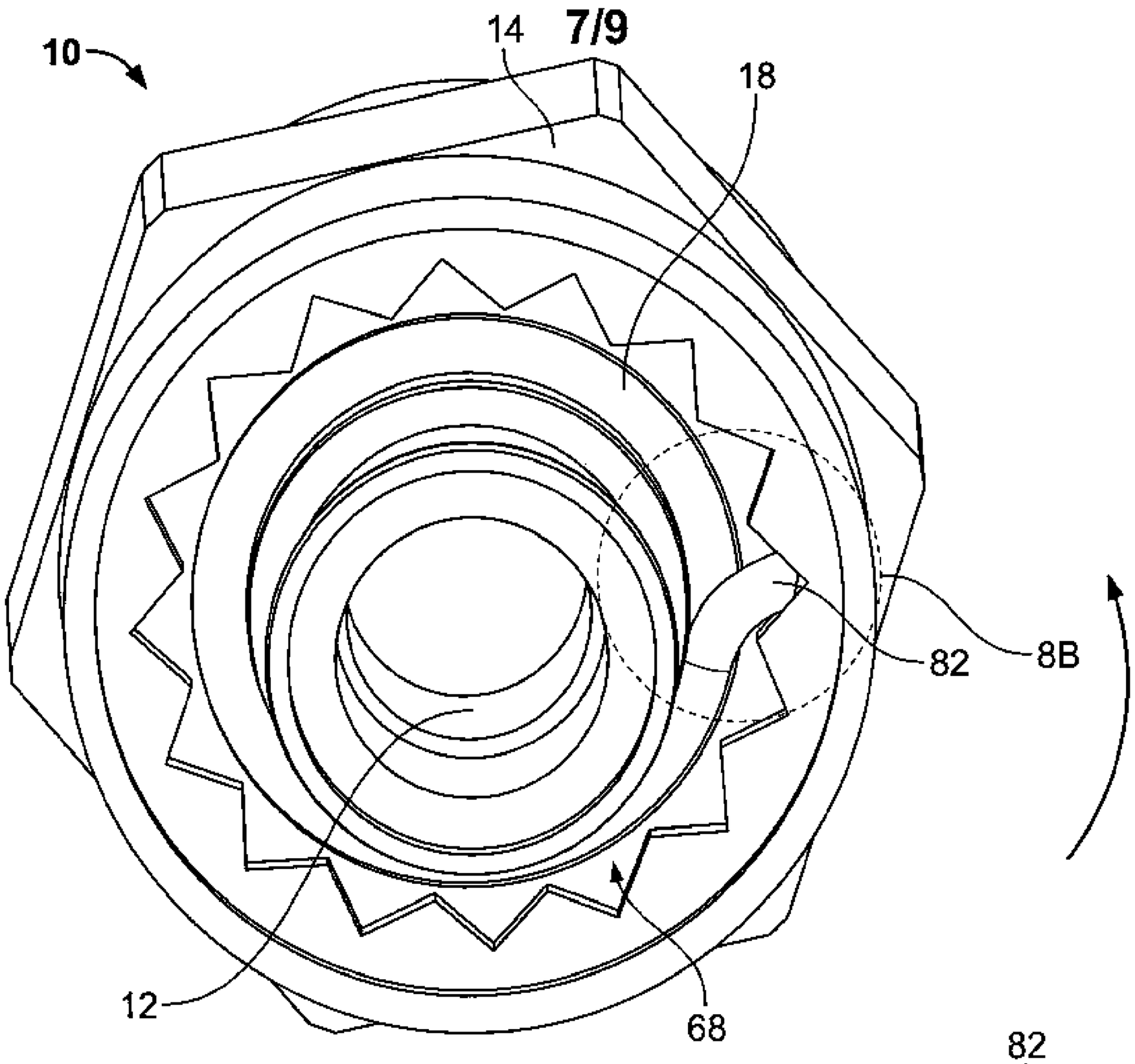


FIG. 8A

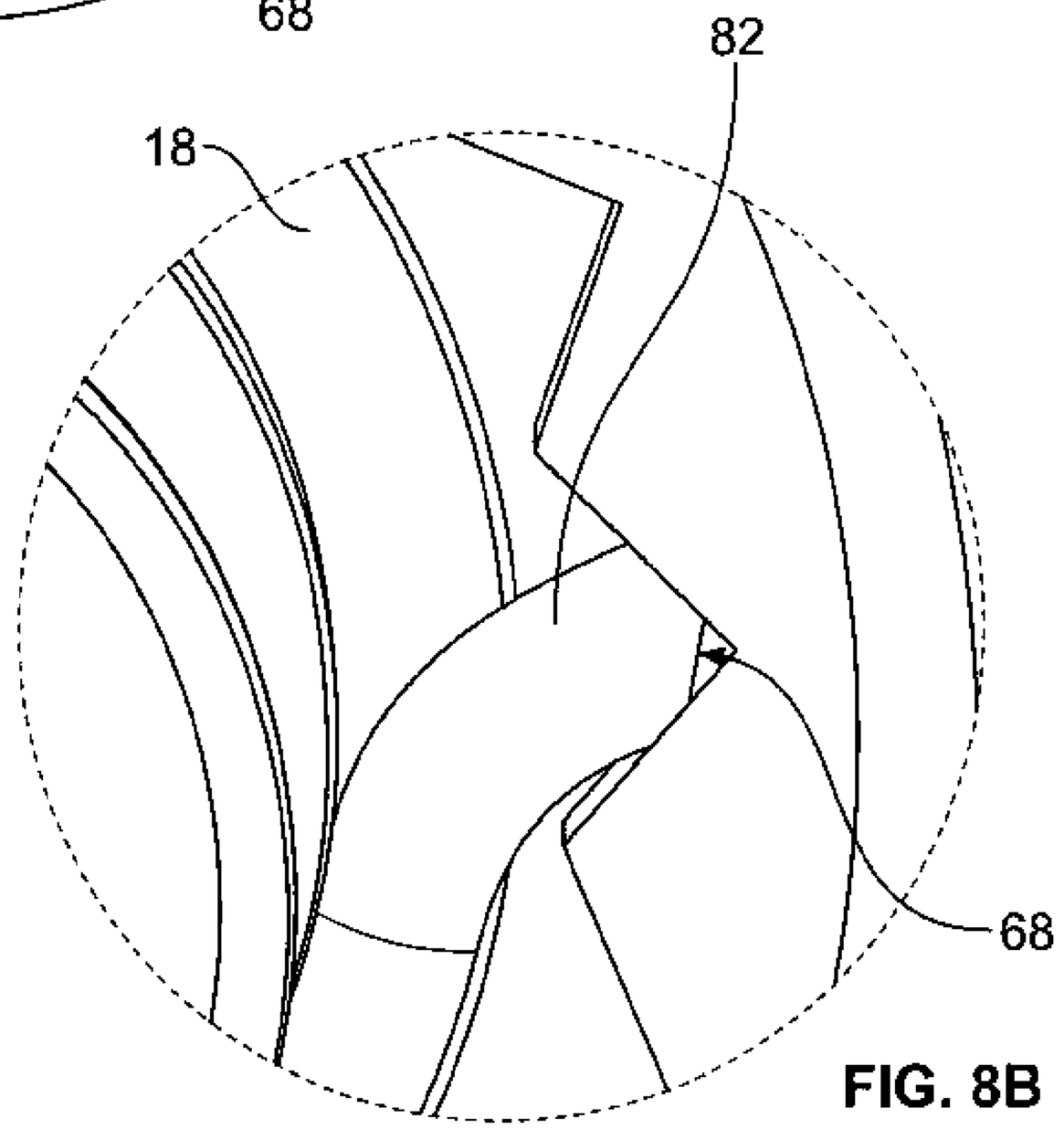


FIG. 8B

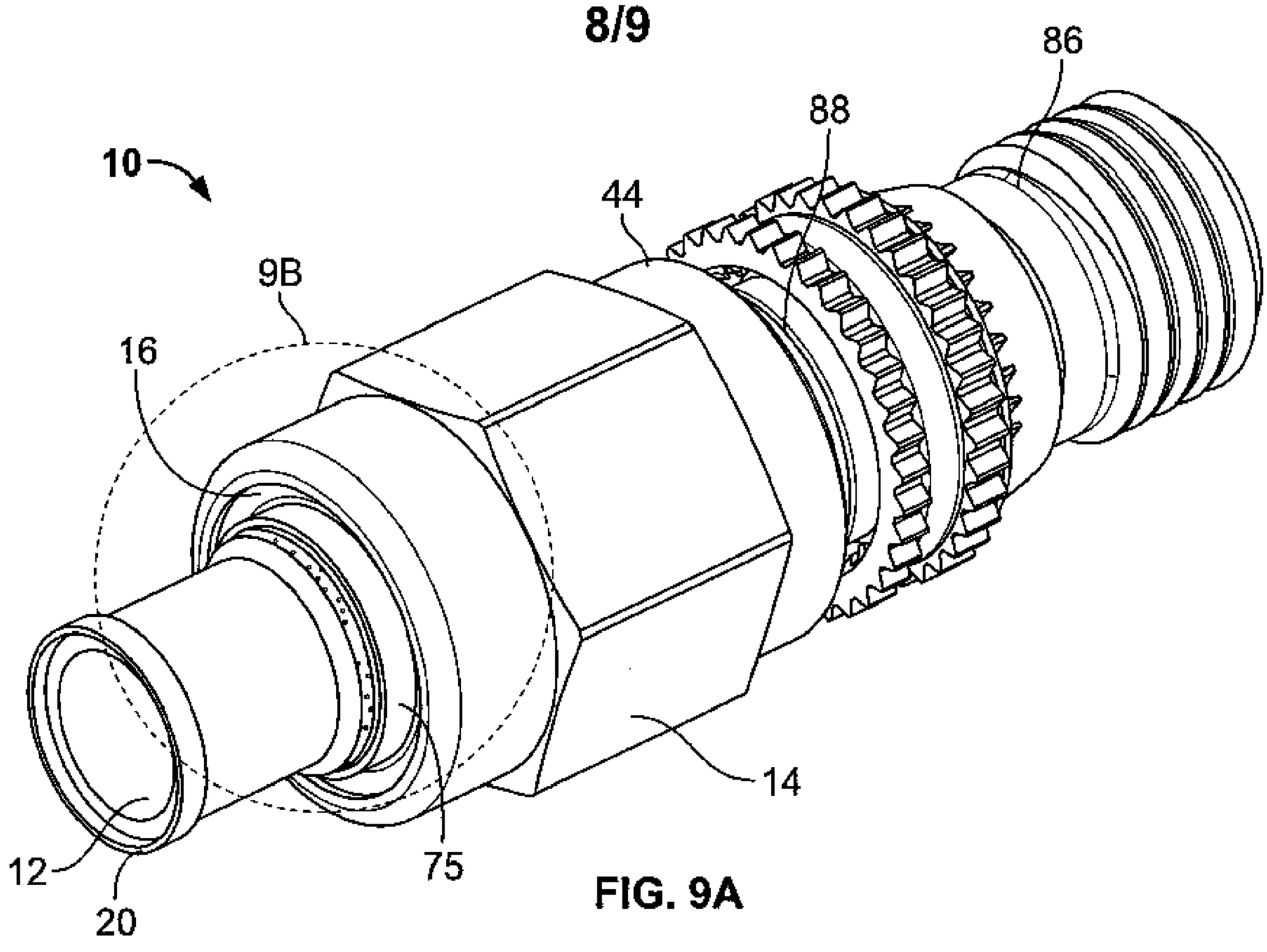


FIG. 9A

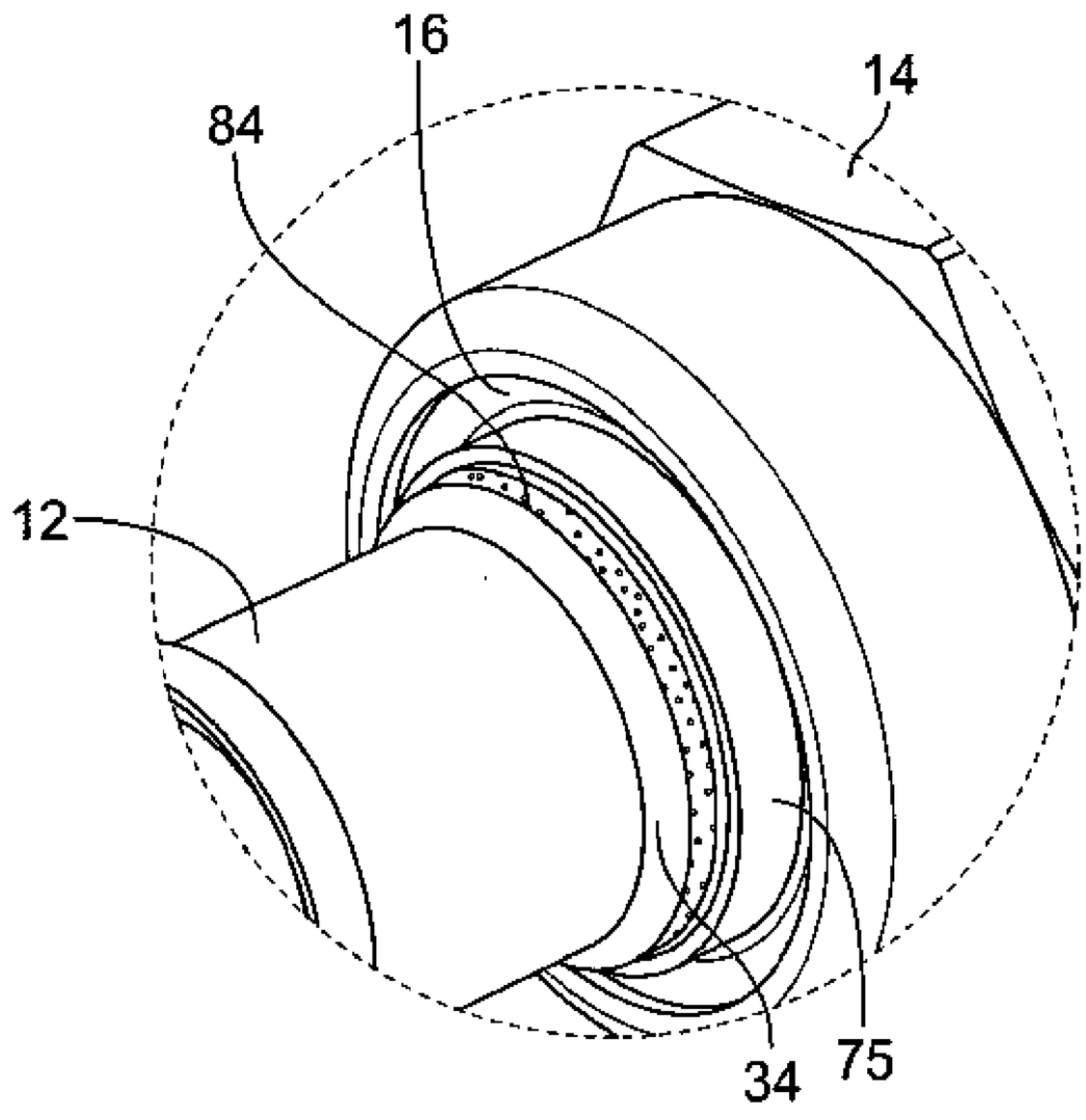


FIG. 9B

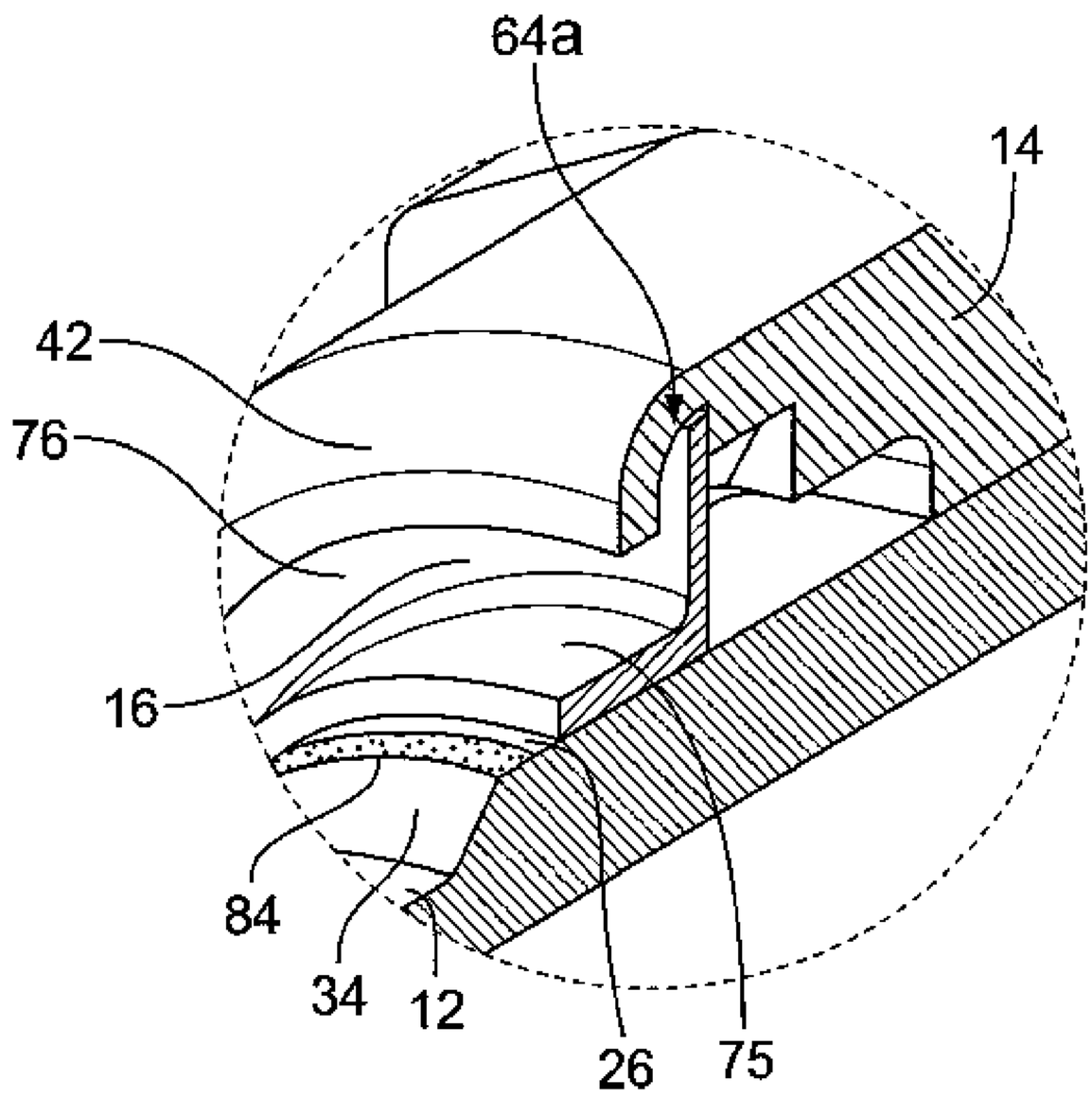
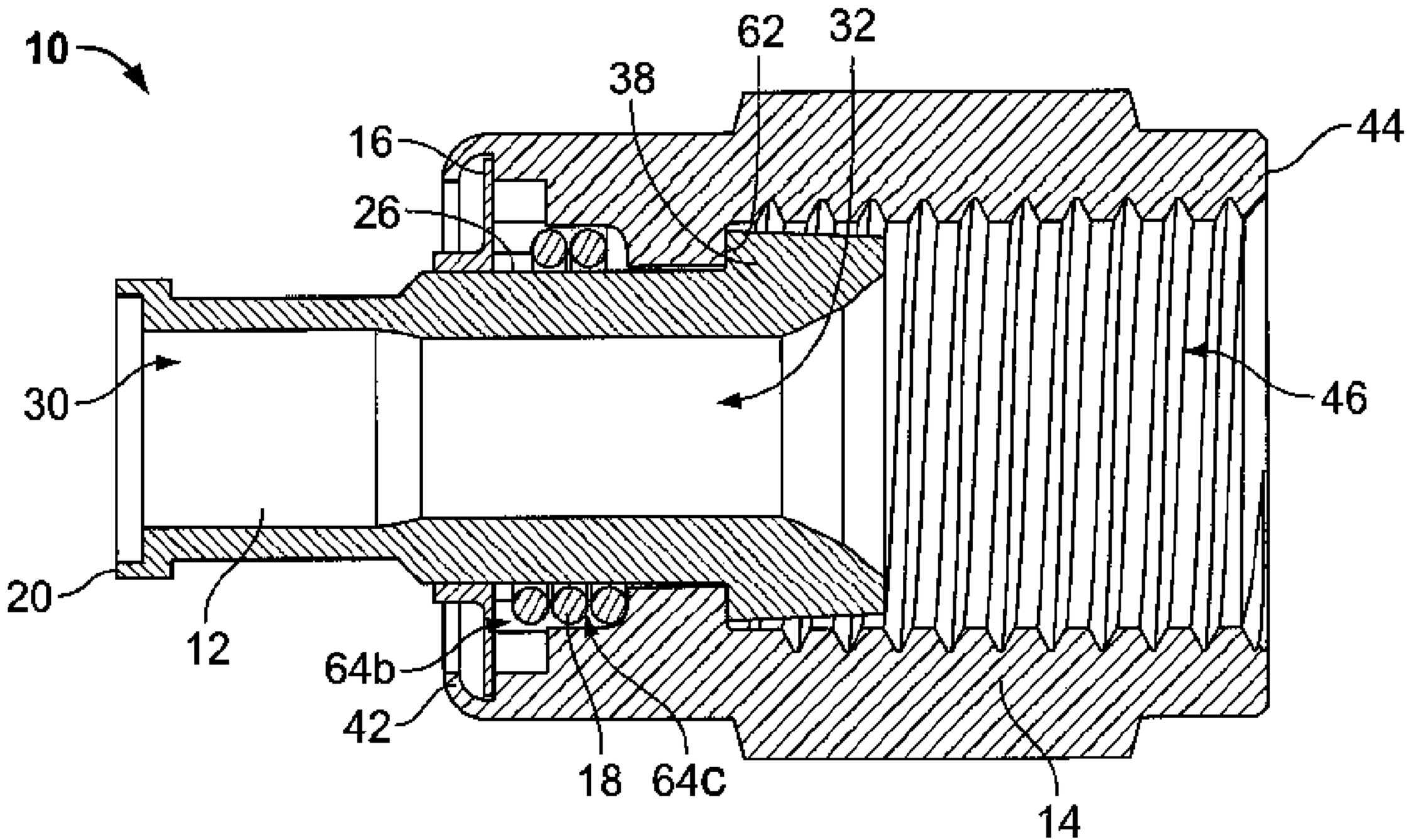


FIG. 9C


10
62
32
38
16
44
26
30
46
20
12
64b
42
18
64C
14