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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: RIGHT ANGLE COAXIAL CABLE AND CONNECTOR ASSEMBLY

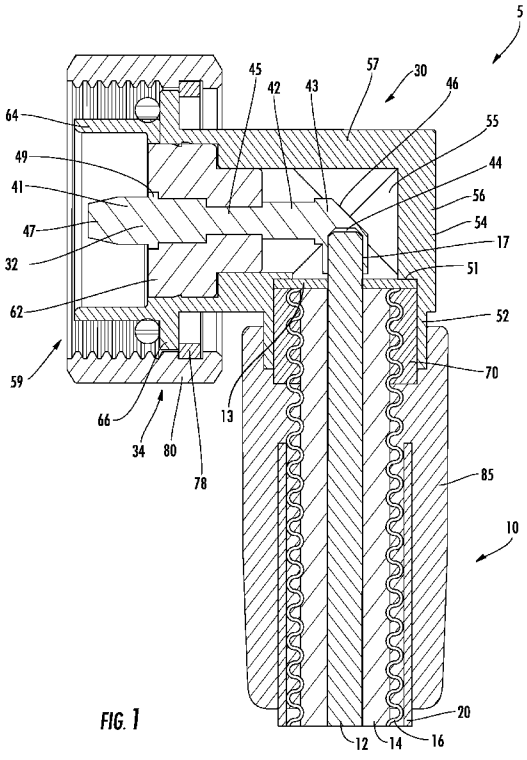


FIG. 1

(57) Abstract: A coaxial cable-connector assembly includes a coaxial cable and a right angle coaxial connector. The cable comprises: an inner conductor having a termination end; a first dielectric layer; and an outer conductor having a termination end. The connector comprises: an inner contact comprising a post configured to mate with the inner conductor body of a mating cable jack, the inner contact further including a receptacle that receives the termination end of the inner conductor such that the post is generally perpendicular to the inner conductor; and an outer conductor body configured to mate with the outer conductor body of the mating jack, the outer conductor body being connected with the termination end of the outer conductor. A second dielectric layer is interposed between the inner contact of the connector and the inner conductor of the coaxial cable that creates a capacitive element between the inner contact and the inner conductor.

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RIGHT ANGLE COAXIAL CABLE AND CONNECTOR ASSEMBLY

Field of the Invention

[0001] The present application claims the benefit of and priority from U.S. Provisional Application No. 62/111,300, filed February 3, 2015, the disclosure of which is hereby incorporated herein in its entirety.

Field of the Invention

[0002] The present invention is directed generally to electrical cable connectors, and more particularly to coaxial connectors for electrical cable.

Background of the Invention

[0003] Coaxial cables are commonly utilized in RF communications systems. A typical coaxial cable includes an inner conductor, an outer conductor, a dielectric layer that separates the inner and outer conductors, and a jacket that covers the outer conductor. Coaxial cable connectors may be applied to terminate coaxial cables, for example, in communication systems requiring a high level of precision and reliability.

[0004] Coaxial connector interfaces provide a connect/disconnect functionality between (a) a cable terminated with a connector bearing the desired connector interface and (b) a corresponding connector with a mating connector interface mounted on an apparatus or on another cable. Typically, one connector will include an inner contact, such as a pin or post connected to an inner conductor and an outer conductor connector body connected to the outer conductor; these are mated with a mating sleeve (for the pin or post of the inner conductor) and another outer conductor connector body of a second connector. Coaxial connector interfaces often utilize a threaded coupling nut or other retainer that draws the

connector interface pair into secure electro-mechanical engagement when the coupling nut (which is captured by one of the connectors) is threaded onto the other connector.

[0005] Although many coaxial connectors are configured to be oriented "in line" with their attached cables (i.e., such that the inner contact is generally coaxial with the inner conductor of the cable), some coaxial connectors are configured such that the inner contact is oriented generally perpendicular to the attached cable. These so-called "right angle" connectors can raise different issues than inline connectors when being attached to a cable due to their geometry.

[0006] Passive Intermodulation Distortion (PIM) is a form of electrical interference/signal transmission degradation that may occur with less than symmetrical interconnections and/or as electro-mechanical interconnections shift or degrade over time. Interconnections may shift due to mechanical stress, vibration, thermal cycling, and/or material degradation. PIM can be an important interconnection quality characteristic, as PIM generated by a single low quality interconnection may degrade the electrical performance of an entire RF system. Thus, the reduction of PIM via connector design is typically desirable.

Summary

[0007] As a first aspect, embodiments of the invention are directed to a coaxial cable-connector assembly. The assembly comprises a coaxial cable and a right angle coaxial connector. The coaxial cable comprises: an inner conductor having a termination end; a first dielectric layer that overlies the inner conductor; and an outer conductor that overlies the first dielectric layer having a termination end. The right angle coaxial connector comprises: an inner contact comprising a post configured to mate with the inner conductor body of a mating coaxial cable jack, the inner contact further including a receptacle that receives the termination end of the inner conductor such that the post is generally perpendicular to the inner conductor; and an outer conductor body configured to mate with the outer conductor body of the mating coaxial cable jack, the outer conductor body being connected with the termination end of the outer conductor. A second dielectric layer is interposed between the inner contact of the connector and the inner conductor of the coaxial cable, the second dielectric layer creating a capacitive element between the inner contact and the inner conductor.

[0008] As a second aspect, embodiments of the invention are directed to a right angle coaxial connector comprising: an inner contact comprising a post configured to mate with

the inner conductor body of a mating coaxial cable jack, the inner contact further including a receptacle that is configured to receive the termination end of an inner conductor of a coaxial cable such that the post is generally perpendicular to the inner conductor; and an outer conductor body configured to mate with the outer conductor body of the mating coaxial cable jack, the outer conductor body being connected with the termination end of the outer conductor. A dielectric layer is applied to the receptacle of the inner contact.

[0009] As a third aspect, embodiments of the invention are directed to a coaxial cable-connector assembly comprising a coaxial cable and a right angle coaxial connector. The coaxial cable comprises: an inner conductor having a termination end; a first dielectric layer that overlies the inner conductor; and an outer conductor that overlies the first dielectric layer having a termination end. The right angle coaxial connector comprises: an inner contact comprising a post configured to mate with the inner conductor body of a mating coaxial cable jack, the inner contact further including a receptacle that receives the termination end of the inner conductor such that the post is generally perpendicular to the inner conductor; and an outer conductor body configured to mate with the outer conductor body of the mating coaxial cable jack, the outer conductor body being connected with the termination end of the outer conductor. A second dielectric layer is interposed between the inner contact of the connector and the inner conductor of the coaxial cable, the second dielectric layer creating a capacitive element between the inner contact and the inner conductor. The outer conductor body is a monolithic component with a sleeve configured to receive the coaxial cable.

Brief Description of the Figures

[0010] **FIG. 1** is a front section view of a right-angle cable-connector assembly according to embodiments of the present invention.

[0011] **FIG. 2** is an enlarged view of a portion of the assembly of **FIG. 1**.

[0012] **FIG. 3** is a front section view of a right-angle cable-connector assembly according to additional embodiments of the present invention.

[0013] **FIG. 4** is an enlarged view of a portion of the assembly of **FIG. 3**.

[0014] **FIG. 5** is a front section view of a right-angle cable-connector assembly according to further embodiments of the present invention.

Detailed Description of Embodiments of the Invention

[0015] The present invention is described with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments that are pictured and described herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. It will also be appreciated that the embodiments disclosed herein can be combined in any way and/or combination to provide many additional embodiments.

[0016] Unless otherwise defined, all technical and scientific terms that are used in this disclosure have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The terminology used in the above description is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used in this disclosure, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that when an element (e.g., a device, circuit, etc.) is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0017] Referring now to the drawings, a right angle connector-cable assembly, designated broadly at **5**, is shown in **FIGS. 1** and **2**. The assembly **5** comprises a coaxial cable **10** and a right angle plug **30**, each of which is described in detail below.

[0018] Referring to **FIG. 1**, the coaxial cable **10** includes an inner conductor **12**, a dielectric layer **14** that circumferentially overlies the central conductor **12**, an outer conductor **16** that circumferentially overlies the dielectric layer **14**, and a polymeric cable jacket **20** that circumferentially overlies the outer conductor **16**. These components will be well-known to those of skill in this art and need not be described in detail herein. **FIG. 1** illustrates that the outer conductor **16** may be of a corrugated profile; alternatively, the outer conductor **16** may have a smooth, braided or foil profile. All of these outer conductor configurations are known to those of skill in this art and need not be described in detail herein. A solder shield **13** is located at the end of the dielectric layer **14** and outer conductor **16**.

[0019] Referring again to **FIG. 1**, the plug **30** includes an inner contact **32** and an outer conductor body **34**. As can be seen in **FIG. 1**, the inner contact **32** is generally cylindrical

and comprises a post **41** that is configured to mate with the inner conductor body of a mating jack. A ridge **49** extends radially outwardly from the post **41** near the flared tip **47**. A finger **42** with a recessed area **45** extends from one end of the post **41**; a contact block **43** or other receptacle with a pocket **44** extends from the end of the finger **42**. The contact block **43** includes a mitered surface **46**.

[0020] As shown in **FIG. 2**, the pocket **44** of the contact block **43** is lined with a dielectric layer **17**. The dielectric layer **17** may comprise a coating, a sleeve, or take another thin laminar configuration. The dielectric layer **17** may be formed of various materials with a high dielectric constant, such as polyester, PTFE and other polymeric materials, glass, metal oxides and ceramics.

[0021] Referring still to **FIG. 1**, the outer conductor body **34** includes a cable contact sleeve **52**. A housing section **54** rests atop the cable contact sleeve **52**, forming a shoulder **51**. The housing section **54** includes side walls **55**, a rear wall **56**, and a ceiling **57**. A connector contact section **59** extends away from the housing section **54** opposite the rear wall **56**. A dielectric spacer **62** fills an inner portion of the connector contact section **59** and maintains physical and electrical separation of the inner conductor body **32** and the outer conductor body **34**. An annular mating ring **64** extends away from the spacer **62** and is configured to mate with a mating jack. A circular flange **66** extends radially outwardly from the connector contact section **59** and provides a bearing surface **82** for interaction with a coupling nut **80** and/or a retaining clip **78**.

[0022] **FIG. 1** illustrates the assembled plug **30** and cable **10**. The cable contact sleeve **52** of the outer conductor body **34** fits over the outer conductor **16** of the cable **10**, with the termination end of the outer conductor **16** abutting the shoulder **51** of the cable contact sleeve **52** to establish an electrical connection. In illustrated embodiment, a solder joint **70** mechanically and electrically attaches the outer conductor **16** to the cable contact sleeve **52**. The inner conductor **12** extends into the cavity of the housing section **54**. The pocket **44** of the contact block **43** of the inner conductor body **32** receives the end of the inner conductor **12**. The post **41** of the inner conductor body **32** extends through the dielectric spacer **62** and into the space encircled by the mating ring **64**. The "right angle" nature of the plug **30** is thus established by the generally perpendicular orientation of the longitudinal axis of the post **41** of the inner conductor body **32** as compared to the longitudinal axis of the inner conductor **12** and the housing section **54**. A strain relief sheath **85** covers the lower portion of the cable contact sleeve **52** and adjacent portions of the outer conductor **16** and jacket **20**.

[0023] Due to the presence of the dielectric layer **17** lining the pocket **44** of the inner contact **32**, a capacitive element is created between the inner conductor **12** and the inner contact **32**. The capacitive element so created can avoid the generation of PIM that can occur in interconnections between coaxial cables and/or connectors, particularly with soldered connections. Other materials, configurations and techniques for creating capacitive coupling between cable conductors and connectors are discussed in U.S. Patent Publication No. 2014/0370747 to Vaccaro, the disclosure of which is hereby incorporated herein in its entirety.

[0024] Also, because the end of the inner conductor **12** can be fitted into the pocket **44** without soldering, there is no need for the connector body **34** to include a port for soldering, thus enabling the connector body **34** to be formed as a single monolithic component (which can also reduce PIM and eliminate the possibility of a cap on the port becoming dislodged or leaking. The inclusion of the mitered surface **46** can provide better electrical performance (some one-piece connector body designs do not permit the inclusion of a mitered surface due to soldering constraints).

[0025] It should also be noted that, although the pocket **44** in the contact block **43** is shown as continuous, it may be discontinuous; for example, the contact block **43** may include one or more slots to encourage radial expansion. Receptacles of other configurations may also be suitable for use with the plug **30**. In addition, in some embodiments the end of the inner conductor **12** may be covered with the dielectric layer **17** (rather than the pocket **44** being lined with the dielectric layer **17**); such a dielectric layer may be a coating, sleeve or the like.

[0026] Those of skill in this art will appreciate that, although the plug **30** is illustrated herein, a jack or other connector may be suitable for use with the concepts discussed above. Also, although a galvanic connection is anticipated between the plug **30** and a mating jack, the concepts may be employed with connectors designed for capacitive coupling (see, e.g., U.S Patent Application No. 14/303,745, filed June 13, 2014, the disclosure of which is hereby incorporated herein in its entirety).

[0027] **FIGS. 3** and **4** illustrate an alternative embodiment of a cable-connector assembly, designated broadly at **105**. The assembly **105** is similar to the assembly **5** described above, with the exception that an inner conductor post **133** is mounted to the end of the inner conductor **112** of the cable **110** and, thus, serves as an extension of the inner conductor **112**. The inner conductor post **133** has a recess **135** that receives the end of the inner conductor

112, typically with a soldered joint. At its opposite end, the inner conductor post **133** is inserted into a hole **144** in the inner contact **132**. Either of the inner surface of the hole **144** or the outer surface of the inner conductor post **133** includes a dielectric layer **117** that creates a capacitive element between the inner contact **132** and the inner conductor post **133** (see **FIG. 4**).

[0028] This arrangement may have economic and/or practical advantages. Soldering of the secondary inner contact **133** to the end of the inner conductor **112** may be performed prior to insertion into the connector body **134**, therefore being more easily controlled. The secondary inner contact **133** may be configured for easier handling than the inner conductor **112**. Also, the secondary inner contact **133** may have a surface finish (e.g., for applying the dielectric layer **117**) that is preferable to or cannot be achieved by the cable inner conductor **112**.

[0029] **FIG. 5** illustrates an additional embodiment of an assembly **205**. In the assembly **205**, the connector body **234** is not soldered to the outer conductor **216** of the cable **210**; instead, a dielectric layer **218** is interposed between the outer conductor **216** and the sleeve **252** to form a capacitive element therebetween. As such, both of the interfaces between the conductors **212, 216** of the cable **210** and, respectively, the inner contact **232** and the connector body **234** are capacitive, which can reduce PIM. In addition, because no soldering operations are performed, the solder shield shown in assemblies **5, 105** can be omitted.

[0030] The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

That Which is Claimed is:

1. A coaxial cable-connector assembly, comprising:

(a) a coaxial cable comprising:

an inner conductor having a termination end;

a first dielectric layer that overlies the inner conductor; and

an outer conductor that overlies the first dielectric layer having a termination end; and

(b) a right angle coaxial connector comprising:

an inner contact comprising a post configured to mate with the inner conductor body of a mating coaxial cable jack, the inner contact further including a receptacle that receives the termination end of the inner conductor such that the post is generally perpendicular to the inner conductor;

an outer conductor body configured to mate with the outer conductor body of the mating coaxial cable jack, the outer conductor body being connected with the termination end of the outer conductor;

wherein a second dielectric layer is interposed between the inner contact of the connector and the inner conductor of the coaxial cable, the second dielectric layer creating a capacitive element between the inner contact and the inner conductor.

2. The assembly of Claim 1, wherein the outer conductor body is a monolithic component.

3. The assembly of Claim 1, wherein the second dielectric layer is applied to the receptacle of the inner contact.

4. The assembly of Claim 1, wherein the second dielectric layer is applied to the inner conductor.

5. The assembly of Claim 4, wherein the inner conductor includes an inner conductor post at one end, and wherein the second dielectric layer is applied to the inner conductor post.

6. The assembly of Claim 1, wherein the inner contact includes a mitered surface adjacent a vertex between the inner conductor and the inner contact.

7. The assembly of Claim 1, wherein a second capacitive element is interposed between the outer conductor and the connector body.

8. A right angle coaxial connector comprising:

an inner contact comprising a post configured to mate with the inner conductor body of a mating coaxial cable jack, the inner contact further including a receptacle that is configured to receive the termination end of an inner conductor of a coaxial cable such that the post is generally perpendicular to the inner conductor;

an outer conductor body configured to mate with the outer conductor body of the mating coaxial cable jack, the outer conductor body being connected with the termination end of the outer conductor;

wherein a dielectric layer is applied to the receptacle of the inner contact.

9. The connector of Claim 8, wherein the outer conductor body is a monolithic component.

10. The connector of Claim 8, wherein the inner contact includes a mitered surface adjacent a vertex between the inner conductor and the inner contact.

11. A coaxial cable-connector assembly, comprising:

(a) a coaxial cable comprising:

an inner conductor having a termination end;

a first dielectric layer that overlies the inner conductor; and

an outer conductor that overlies the first dielectric layer having a termination end; and

(b) a right angle coaxial connector comprising:

an inner contact comprising a post configured to mate with the inner conductor body of a mating coaxial cable jack, the inner contact further including a receptacle that receives the termination end of the inner conductor such that the post is generally perpendicular to the inner conductor;

an outer conductor body configured to mate with the outer conductor body of the mating coaxial cable jack, the outer conductor body being connected with the termination end of the outer conductor;

wherein a second dielectric layer is interposed between the inner contact of the connector and the inner conductor of the coaxial cable, the second dielectric layer creating a capacitive element between the inner contact and the inner conductor; and

wherein the outer conductor body is a monolithic component with a sleeve configured to receive the coaxial cable.

12. The assembly of Claim 11, wherein the second dielectric layer is applied to the receptacle of the inner contact.

13. The assembly of Claim 11, wherein the second dielectric layer is applied to the inner conductor.

14. The assembly of Claim 13, wherein the inner conductor includes an inner conductor post at one end, and wherein the second dielectric layer is applied to the inner conductor post.

15. The assembly of Claim 11, wherein the inner contact includes a mitered surface adjacent a vertex between the inner conductor and the inner contact.

16. The assembly of Claim 11, wherein a second capacitive element is interposed between the outer conductor and the connector body.

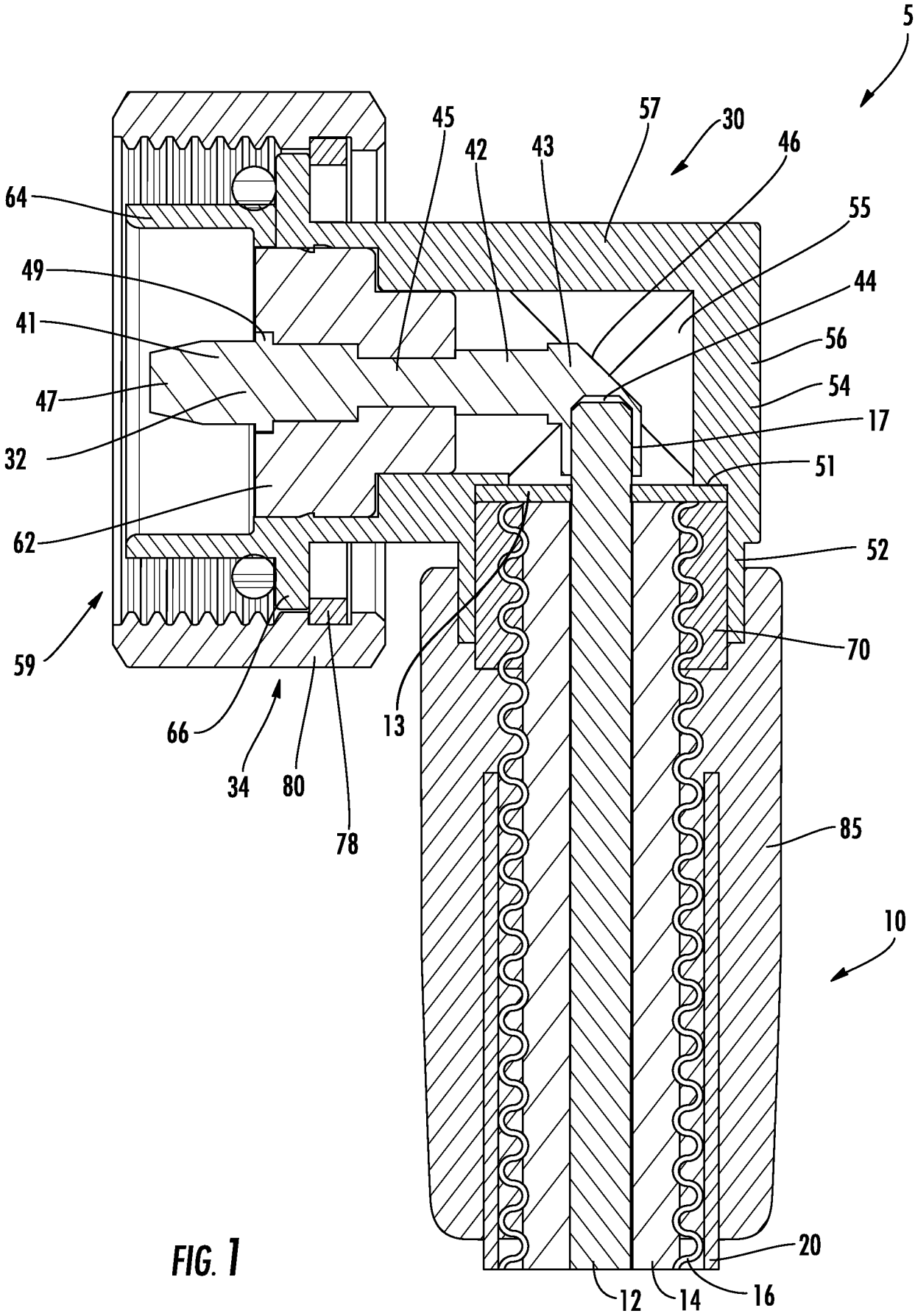

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FIG. 1

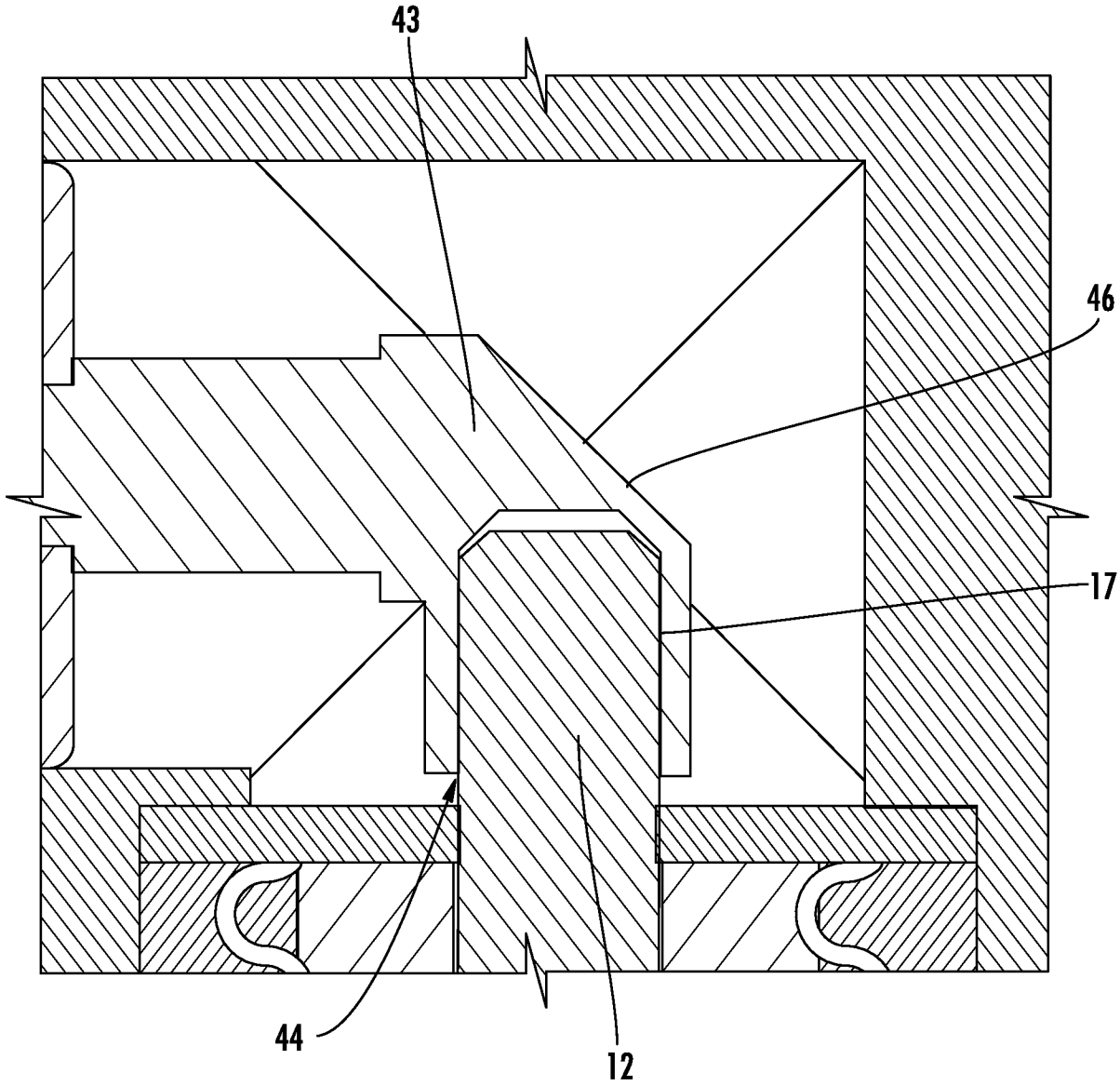


FIG. 2

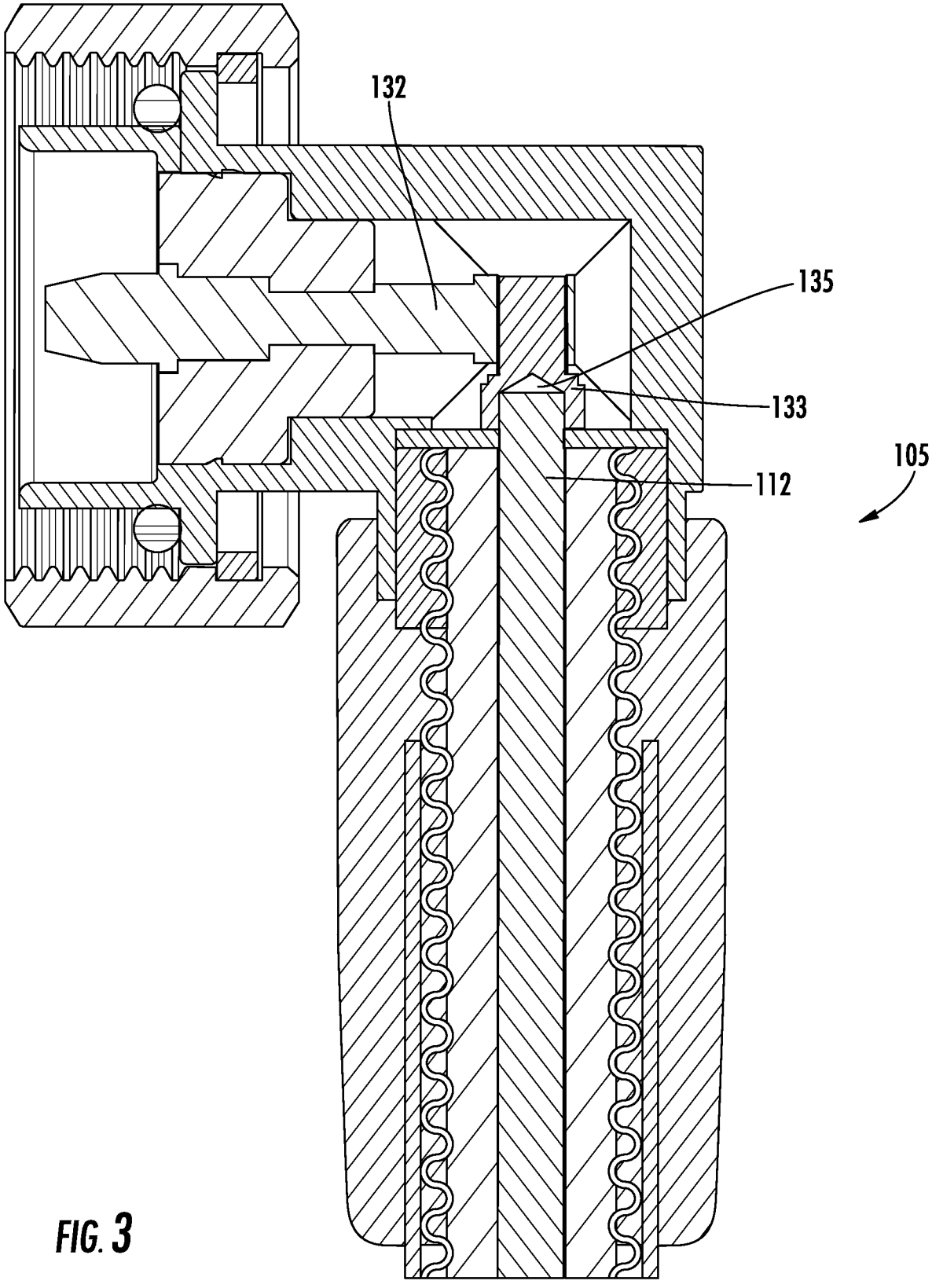


FIG. 3

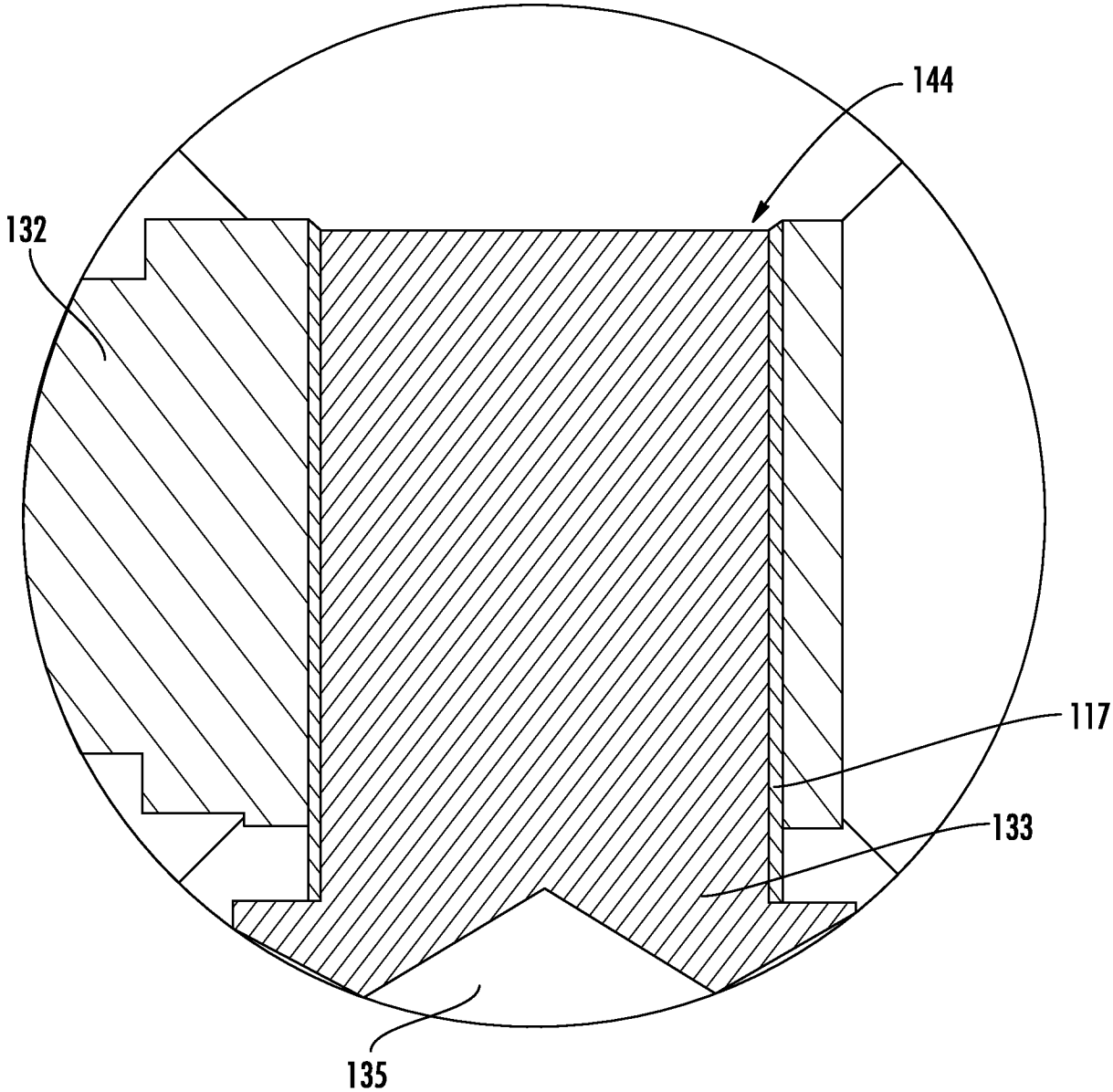


FIG. 4

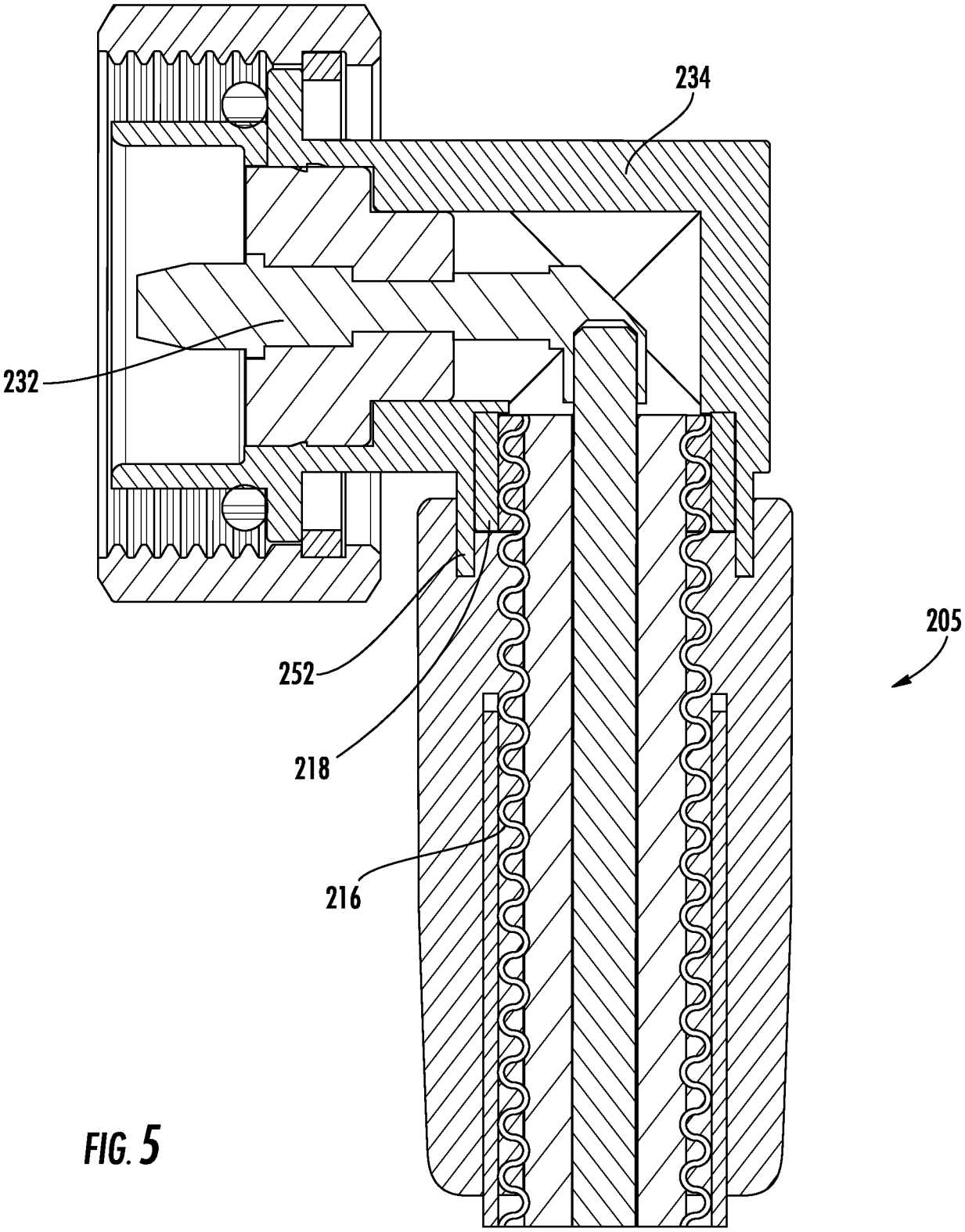


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/015312

A. CLASSIFICATION OF SUBJECT MATTER

H01R 24/38(2011.01)i, H01R 9/05(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01R 24/38; H01R 24/40; H01R 13/639; H01R 24/02; H01R 9/05

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:coaxial cable, right angle coaxial connector, dielectric, capacitive element, conductor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0186522 A1 (JIMMY CIESLA HENNINGSEN) 23 July 2009 See paragraphs [0009], [0019]-[0021], claim 5 and figures 1-3.	8-10
Y		1-7,11-16
Y	US 2014-0370747 A1 (ANDREW LLC.) 18 December 2014 See paragraphs [0004], [0016]-[0018] and figure 2.	1-7,11-16
A	JP 2002-252066 A (TYCO ELECTRONICS CORP.) 06 September 2002 See paragraphs [0010]-[0020] and figures 1-2.	1-16
A	US 2004-0137790 A1 (JOON LEE et al.) 15 July 2004 See paragraphs [0011]-[0014], claim 1 and figures 1-2.	1-16
A	US 7070440 B1 (ARKADY Y. ZEREBILOV et al.) 04 July 2006 See column 4, line 32 - column 5, line 35 and figures 3-6.	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 April 2016 (29.04.2016)	**29 April 2016 (29.04.2016)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2016/015312

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