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CA 2983302 A1 2016/10/27

(21) 2 983 302

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2016/04/20
(87) Date publication PCT/PCT Publication Date: 2016/10/27
(85) Entrée phase nationale/National Entry: 2017/10/18
(86) N° demande PCT/PCT Application No.: US 2016/028391
(87) N° publication PCT/PCT Publication No.: 2016/172176
(30) Priorité/Priority: 2015/04/20 (US62/150,114)

(51) Cl.Int./Int.Cl. *H01R 13/187* (2006.01), *H01R 13/533* (2006.01), *H01R 4/36* (2006.01), *H01R 24/20* (2011.01)

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(54) Titre : CONNECTEURS DE COUPLEURS DE CABLES D'EXPLOITATION MINIERE ET ENSEMBLES ET PROCEDES ASSOCIES

(54) Title: MINING CABLE COUPLER CONNECTORS AND RELATED ASSEMBLIES AND METHODS

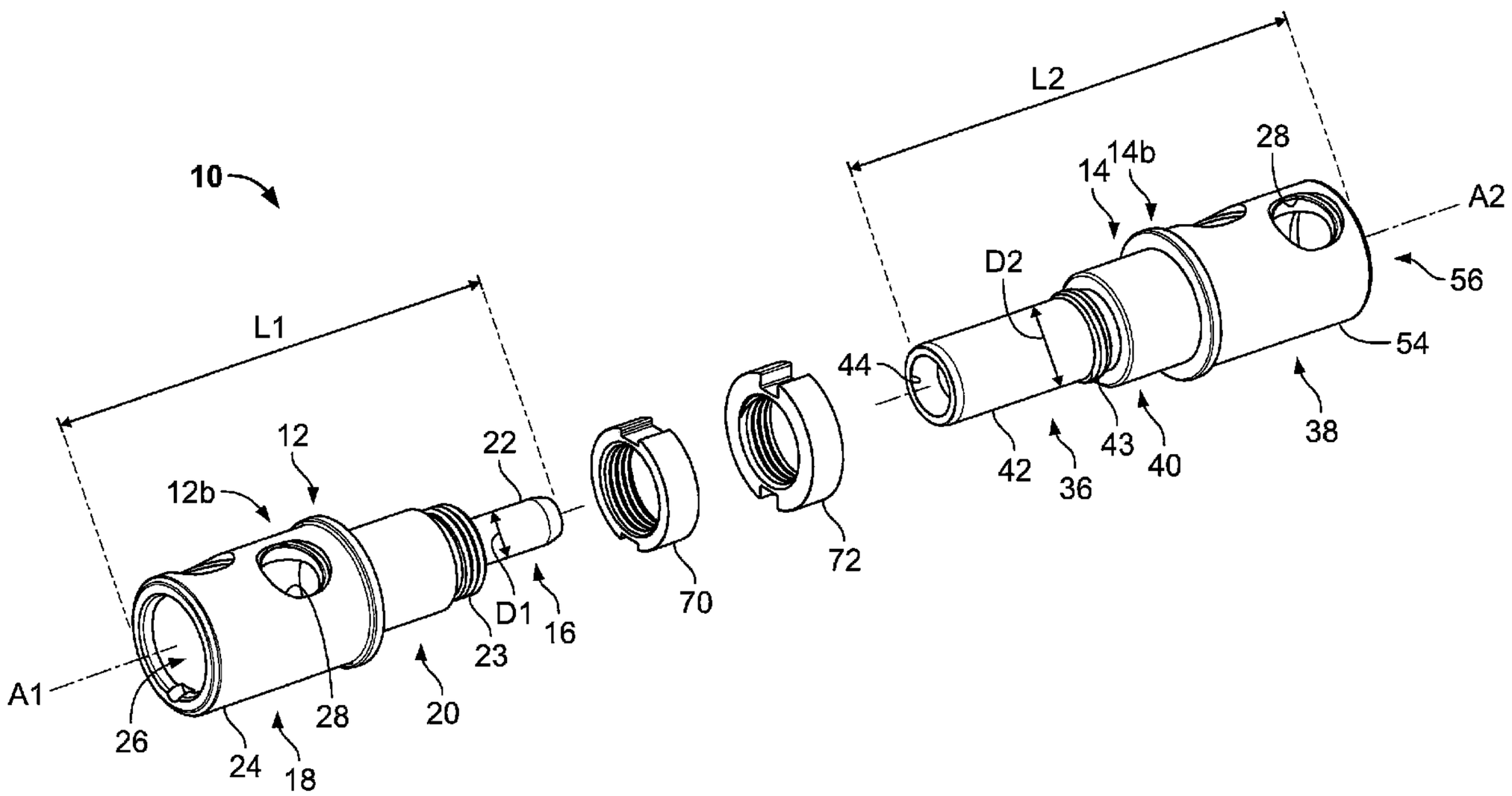

FIG. 1

(57) Abrégé/Abstract:
A connector assembly for use with a mining cable coupler includes a first connector and a second connector. The first connector includes a front portion including a plug and a rear portion including a barrel configured to receive a first conductor. The second connector includes a front portion including a socket having a channel defined therein and a rear portion including a barrel configured to receive a second conductor. An annular groove is defined in an inner surface of the channel. An annular spring held in the annular groove. The channel is sized and configured to receive the plug such that the plug resiliently contacts the spring to electrically connect the first conductor received in the first connector barrel and the second conductor received in the second connector barrel.

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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 October 2016 (27.10.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/172176 A1

(51) International Patent Classification:
H01R 13/187 (2006.01) *H01R 4/36* (2006.01)
H01R 13/533 (2006.01) *H01R 24/20* (2011.01)
H01R 105/00 (2006.01)

(21) International Application Number:
PCT/US2016/028391

(22) International Filing Date:
20 April 2016 (20.04.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/150,114 20 April 2015 (20.04.2015) US

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(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, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, 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).

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: MINING CABLE COUPLER CONNECTORS AND RELATED ASSEMBLIES AND METHODS

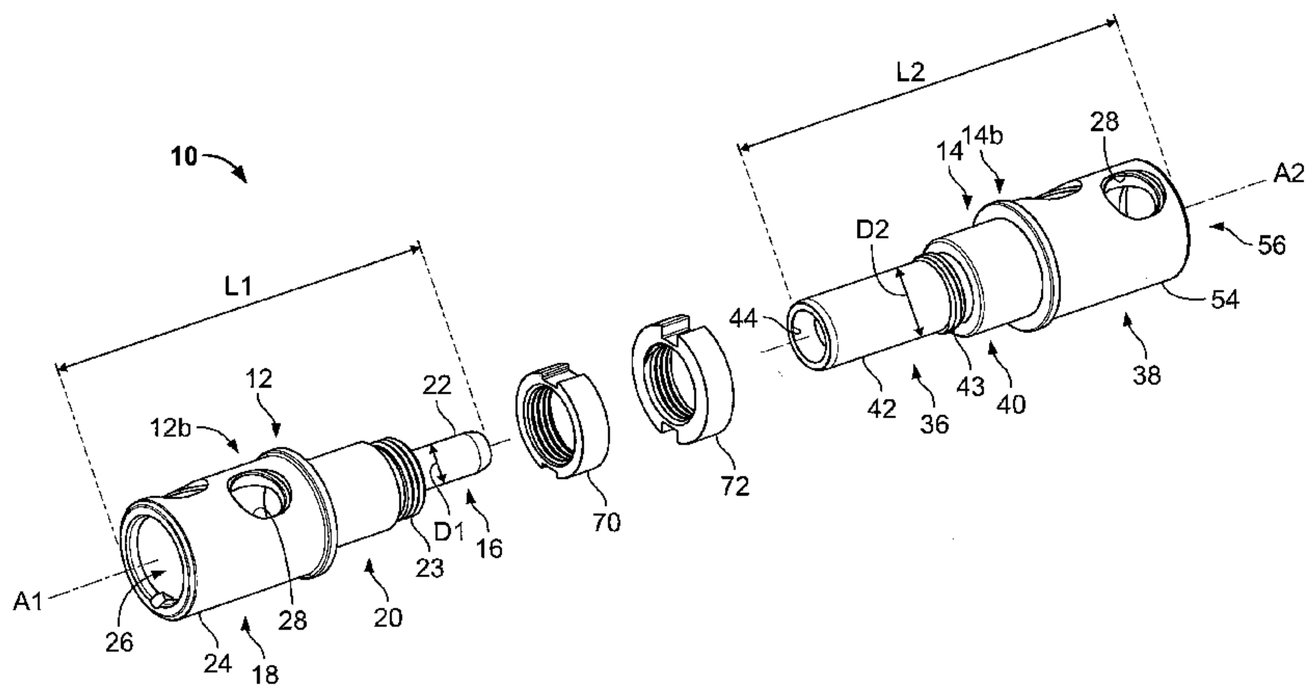

FIG. 1

(57) Abstract: A connector assembly for use with a mining cable coupler includes a first connector and a second connector. The first connector includes a front portion including a plug and a rear portion including a barrel configured to receive a first conductor. The second connector includes a front portion including a socket having a channel defined therein and a rear portion including a barrel configured to receive a second conductor. An annular groove is defined in an inner surface of the channel. An annular spring held in the annular groove. The channel is sized and configured to receive the plug such that the plug resiliently contacts the spring to electrically connect the first conductor received in the first connector barrel and the second conductor received in the second connector barrel.

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MINING CABLE COUPLER CONNECTORS AND RELATED ASSEMBLIES AND METHODS

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/150,114, filed April 20, 2015, the disclosure of which is incorporated by reference in its entirety.

BACKGROUND

[0002] In the mining industry, heavy equipment is powered using mining cables and couplers that provide a three-phase, deadbreak, plug and socket style connection. The couplers are typically used to terminate SHD-GC mining cables that carry three phase conductors, at least one ground conductor and at least one pilot conductor. Each of these conductors are multi-stranded Class I or DLO cable that can have about 1225 strands for a 500 kcmil wire.

[0003] The conductors are terminated on a suitable connector to make the electrical connection. The connectors typically include a plug or pin member that mates with a socket or receptacle member. Each of the plug and socket connector members have previously used a two-piece design having a front mating part (or front end portion) and a rear cable part (or rear end portion) that are threadingly engaged and possibly sealed to help prevent moisture from entering the connector.

[0004] The front end portions of the connectors typically use a tulip (finger-style) or a louvertac band (multilam) style contact interface. The tulip style interface has a high mating force issue and requires a closing tool during connection. The tulip style interface also introduces breaks in contact between the fingers (i.e., the contact between the plug and socket is not continuous). The louvertac band style interface requires less force during mating but there are concerns about performance under contaminated conditions that are found in a mine. The louvertac band style interface also can have breaks in contact due to offset issues associated with the multilam design.

[0005] The rear end portions of the connectors are typically soldered due to the fine-stranded nature of the cable. This requires skilled labor and introduces contact pressure repeatability problems (e.g., due to cold solder resulting in poor contact pressure). Another approach has been to use hex bolts that are tightened by an allen wrench. However, it is

difficult to consistently tighten the bolts to the specified torque to ensure the proper contact pressure.

SUMMARY

[0006] Some embodiments of the present invention are directed to a connector assembly for use with a mining cable coupler. The assembly includes a first connector and a second connector. The first connector includes a front portion including a plug and a rear portion including a barrel configured to receive a first conductor. The second connector includes a front portion including a socket having a channel defined therein and a rear portion including a barrel configured to receive a second conductor. An annular groove is defined in an inner surface of the channel. An annular spring is held in the annular groove. The channel is sized and configured to receive the plug such that the plug resiliently contacts the spring to electrically connect the first conductor received in the first connector barrel and the second conductor received in the second connector barrel.

[0007] In some embodiments, each of the first and second connectors is monolithic.

[0008] The first connector may include a central portion between the front portion and the rear portion. The central portion may include a threaded region on an outer surface thereof. The threaded region may be configured to threadingly engage with a fastener such that the fastener is held around the central portion of the first connector. The second connector may include a central portion between the front portion and the rear portion. The central portion may include a threaded region on an outer surface thereof. The threaded region may be configured to threadingly engage with a fastener such that the fastener is held around the central portion of the second connector.

[0009] In some embodiments, each of the first and second connector barrels comprise a plurality of shear bolt holes configured to receive shear bolts for securing ends of the first and second conductor in the first and second connector barrels, respectively.

[0010] In some embodiments, the assembly is in combination with the first conductor including the first conductor end held in the first connector barrel and/or the second conductor including the second conductor end held in the second connector barrel. Each of the first and second conductor ends may include a plurality of strands. A shielding mesh layer may be wrapped around the plurality of strands of each of the first and second conductor ends to secure the strands together.

[0011] In some embodiments, the spring is a canted coil spring. In some embodiments, the spring is silver-plated.

[0012] In some embodiments, a plurality of spaced apart annular grooves are defined in the inner surface of the socket channel and a spring is held in each of the plurality of annular grooves.

[0013] The first connector may include a central portion between the front portion and the rear portion and the front portion and central portion may be threadingly engaged with one another. The second connector may include a central portion between the front portion and the rear portion and the front portion and central portion may be threadingly engaged with one another.

[0014] Some other embodiments of the present invention are directed to a mining cable coupler assembly. The assembly includes an outer housing. The outer housing includes a first tube shaped housing having first and second opposite ends. The outer housing includes a second tube shaped housing having first and second opposite ends with an elongated annular slot defined in an outer wall of the first end. The first and second housings are coupled at least in part by the first end of the first housing being received in the annular slot of the second housing. The assembly includes a first connector held in the first housing and a second connector held in the second housing. The first connector includes a rear portion including a barrel configured to receive a first conductor, a front portion including one of a plug and a socket, and a central portion between the rear portion and the front portion. The second connector includes a rear portion including a barrel configured to receive a second conductor, a front portion including the other one of a plug and a socket, and a central portion between the rear portion and the front portion. The first and second connectors are coupled by the plug of one of the first and second connectors being received in the socket of the other one of the first and second connectors.

[0015] The first housing may include an annular projection extending inwardly from the outer wall between the first and second ends, a central channel defined by the annular projection, a first end channel defined by the outer wall between the first end and the annular projection, and a second end channel defined by the outer wall between the second end and the annular projection. The second housing may include an annular projection extending inwardly from an outer wall between the first and second ends, a central channel defined by the annular projection, a first end channel defined by the outer wall between the first end and the annular projection, and a second end channel defined by the outer wall between the second end and the annular projection.

[0016] The first connector may be held in the first housing with the front portion of the first connector in the first end channel of the first housing and/or the first end portion of

the second housing, the central portion of the first connector in the central channel of the first housing, and the rear portion of the first connector in the second end channel of the first housing. The second connector may be held in the second housing with the front portion of the second connector in the first end channel of the second housing and/or the first end portion of the first housing, the central portion of the second connector in the central channel of the second housing, and the rear portion of the second connector in the second end channel of the second housing.

[0017] In some embodiments, each of the first and second connectors is a one-piece connector. The central portion of the first connector may include a threaded region on an outer surface thereof and a first fastener may be threadingly engaged with the threaded region. The central portion of the second connector may include a threaded region on an outer surface thereof and a second fastener may be threadingly engaged with the threaded region.

[0018] The first fastener may be adjacent and/or abut a first wall defined by the annular projection of the first housing and the rear portion of the first connector may be adjacent and/or abut a second, opposite wall of the annular projection of the first housing. The second fastener may be adjacent and/or abut a first wall defined by the annular projection of the second housing and the rear portion of the second connector may be adjacent and/or abut a second, opposite wall of the annular projection of the second housing.

[0019] In some embodiments, the assembly includes a plurality of the outer housings with one of the first connectors and one of the second connectors coupled and held in each one of the outer housings. The plurality of outer housings may be held together by a first base plate that engages the outer wall of each of the first housings and a second base plate that engages the outer wall of each of the second housings.

[0020] The socket of one of the first and second connectors may include a channel with an annular groove defined in an inner wall of the channel. A spring may be held in the annular groove. The plug of the other one of the first and second connectors may resiliently contact the spring to electrically connect the first conductor received in the first connector barrel and the second conductor received in the second connector barrel.

[0021] Some other embodiments of the present invention are directed to a method for electrically connecting mining cables. The method includes (a) providing: a first connector comprising a front portion including a plug and a rear portion including a barrel; a second connector comprising a front portion including a socket having a channel defined therein and a rear portion including a barrel, wherein an annular groove is defined in an inner surface of

the channel; an annular spring held in the annular groove; a first tube shaped housing having first and second opposite ends with an elongated annular slot defined in an outer wall of the first housing at the first end; and a second tube shaped housing having first and second opposite ends. The method includes: (b) receiving a first mining cable conductor in the barrel of the first connector; (c) securing the first mining cable conductor in the barrel of the first connector; (d) inserting the first connector with the secured first mining cable conductor into the second end of the first housing toward the first end of the first housing such that the plug is adjacent the first end of the first housing; (e) receiving a second mining cable conductor in the barrel of the second connector; (f) securing the second mining cable conductor in the barrel of the second connector; (g) inserting the second connector with the secured second mining cable conductor into the second end of the second housing toward the first end of the second housing such that the socket is adjacent the first end of the second housing; (h) coupling the first and second housings including receiving the first end of the second housing in the annular slot of the first housing; and (i) coupling the first and second connectors including receiving the plug of the first connector in the socket of the second connector such that the plug resiliently contacts the spring to electrically connect the first mining cable conductor and the second mining cable conductor.

[0022] In some embodiments, the method includes wrapping a shielding mesh layer around the first cable mining cable conductor before step (b) and wrapping a shielding mesh layer around second cable mining cable conductor before step (e). Step (c) may include receiving shear bolts through shear bolt apertures defined in the barrel of the first connector and tightening the shear bolts. Step (f) may include receiving shear bolts through shear bolt apertures defined in the barrel of the second connector and tightening the shear bolts.

[0023] In some embodiments, the method includes providing: three of the first connectors; three of the second connectors; three of the annular springs, one each held in a respective annular groove of a respective second connector; three of the first tube shaped housings; and three of the second tube shaped housing. The method may include performing steps (b) through (i) for each of the first connectors, second connectors, first housings, and second housings. The method may include securing the first housings with a first base plate that engages the outer surfaces of the first housing. The method may include securing the second housings with a second base plate that engages outer surfaces of the second housings.

[0024] Further features, advantages and details of the present invention will be appreciated by those of ordinary skill in the art from a reading of the figures and the detailed

description of the preferred embodiments that follow, such description being merely illustrative of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Figure 1 is an exploded perspective view of a mining cable coupler connector according to some embodiments.

[0026] Figure 2 is a sectional view of a mining cable coupler assembly including two of the connectors of **Figure 1**.

[0027] Figure 3 is a perspective view of the mining cable coupler assembly of **Figure 2**.

[0028] Figure 4A illustrates a conductor end that is configured to be received in a barrel of the connector of **Figure 1**.

[0029] Figure 4B illustrates the wrapping of shielding mesh around the conductor end of **Figure 4A**.

[0030] Figure 4C illustrates securing the shielding mesh on the conductor end of **Figure 4A**.

[0031] Figure 5 illustrates the conductor end as prepared in **Figure 4C** inserted in a barrel of the connector of **Figure 1** and the use of shear bolts to secure the conductor end in the barrel.

[0032] Figure 6A is a side-by-side comparison of a plug connector of **Figure 1** with two known plug connectors used with mining cable couplers.

[0033] Figure 6B is a side-by-side comparison of a socket connector of **Figure 1** with two known socket connectors used with mining cable couplers.

[0034] Figure 7 is an exploded perspective view of a mining cable coupler connector according to some other embodiments.

[0035] Figure 8 is an exploded perspective view of a mining cable coupler connector according to some other embodiments.

[0036] Figure 9 is a sectional view of a mining cable coupler assembly according to some other embodiments.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0037] The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. In the drawings, the relative sizes of regions or features may be exaggerated for

clarity. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth 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.

[0038] It will be understood that when an element is referred to as being "coupled" or "connected" to another element, it can be directly coupled or connected to the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly coupled" or "directly connected" to another element, there are no intervening elements present. Like numbers refer to like elements throughout. As used herein the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0039] In addition, spatially relative terms, such as "under", "below", "lower", "over", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0040] Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0041] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "includes," "comprising," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0042] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is

consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0043] It is noted that any one or more aspects or features described with respect to one embodiment may be incorporated in a different embodiment although not specifically described relative thereto. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination. Applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to be able to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner. These and other objects and/or aspects of the present invention are explained in detail in the specification set forth below.

[0044] A connector assembly **10** for use with a mining cable coupler according to some embodiments is illustrated in **Figure 1**. The connector assembly **10** includes a plug or pin connector **12** (also referred to as the male connector) and a receptacle or socket connector **14** (also referred to as the female connector).

[0045] The plug connector **12** has a body **12b** that defines a longitudinal axis **A1**. The body **12b** includes a front or mating portion **16**, a rear or cable portion **18** and a central portion **20** between the front and rear portions **16, 18**.

[0046] The front portion **16** includes a pin or plug **22**. The plug **22** extends away from the central portion **20** along the longitudinal axis **A1**.

[0047] The rear portion **18** includes a barrel **24** which is a cylindrical portion that has a channel **26** defined therein. The channel **26** is sized and configured to receive a conductor end. A plurality of shear bolt apertures or holes **28** are defined in the barrel **24**. The shear bolt holes **28** are sized and configured to receive shear bolts to secure the conductor end in the channel **26**.

[0048] The socket connector **14** has a body **14b** that defines a longitudinal axis **A2**. The body **14b** includes a front or mating portion **36**, a rear or cable portion **38** and a central portion **40** between the front and rear portions **36, 38**.

[0049] The front portion **36** includes a socket **42** which is a tubular or cylindrical portion that has a channel **44** defined therein. The socket channel **44** is sized and configured to receive the plug **22** of the connector **12**.

[0050] The rear portion **38** includes a barrel **54** which is a cylindrical portion that has a channel **56** defined therein. The channel **56** is sized and configured to receive a conductor end. A plurality of shear bolt apertures or holes **28** are defined in the barrel **54**. The shear

bolt holes **28** are sized and configured to receive shear bolts to secure the conductor end in the channel **56**.

[0051] Further features of the connector assembly **10** are illustrated in **Figure 2**. Two of the three phase conductor connector assemblies **10** are shown in the sectional view of **Figure 2**. Each connector assembly **10** is held within a respective pair of tube-shaped housings **60, 62**. The housing **62** includes an annular slot **64** that is sized and configured to receive an end portion of the housing **60**. Base plates **66** hold the three pair of housings **60, 62** as shown in **Figure 3**.

[0052] Referring to **Figures 1** and **2**, the connector central portions **20, 40** may have a stepped cylindrical configuration and may also include threaded portions **23, 43**. Fasteners **70, 72** (e.g., hex nuts) may threadingly engage the threaded portions **23, 43**, respectively. The stepped cylindrical configuration of the connector central portions **20, 40** and/or the fasteners **70, 72** may hold the connector assemblies **10** in the housings **60, 62**.

[0053] Referring to **Figure 2**, an annular groove or recess **80** is formed in the socket **42** of the connector **14**. The groove **80** surrounds the channel **44** that is also defined in the socket **42**. The groove **80** is sized and configured to receive and hold a ring-shaped annular spring **82**. In some embodiments, the spring **82** is a canted coil spring.

[0054] Relative to known contact interfaces such as tulip type and louvertac band type interfaces, the configuration with the spring **82** provides improved contact area and contact pressure when the plug **22** of the plug connector **12** is received in the socket **42** of the socket connector **14**. In addition, the mating (or insertion) force is reduced as compared to known contact interfaces such as the tulip type and louvertac band type interfaces. The plug connector **12** and the socket connector **14** with the spring **82** may be referred to herein as the annular spring contact type interface.

[0055] The assembly of a mining cable coupler will now be described. First, the conductor ends are stripped to the desired length as shown in **Figure 4A**. A strip of copper shielding mesh is wrapped around the conductors as shown in **Figure 4B**. In some embodiments, the shielding mesh is first folded over the cut end of the conductor and then tightly wrapped in a spiral motion around the fine strands of the conductor. As shown in **Figure 4C**, the shielding mesh may be tied in a sharp knot to help ensure that the mesh does not move during installation. In this regard, a shielding mesh layer **25** is wrapped around the plurality of strands to secure the strands together.

[0056] The prepared conductors are then inserted into the channels **26, 56** of the plug and socket connectors **12, 14**. The conductor end is shown received in the channel **26** of the

plug connector **12** in **Figure 5**. Shear bolts **29** are received in the shear bolt holes **28**. The shear bolts **29** are tightened (e.g., sequentially) until the bolt heads **29h** shear off and the bolt threaded shanks **29s** are left behind.

[0057] The present inventors discovered that the copper shielding mesh effectively contains the highly stranded conductor during insertion into the connector and also helps to ensure efficient current transfer during operation. The present inventors also discovered that the use of the shear bolts helps to ensure proper, repeatable contact pressure compared to techniques typically used with cable mining couplers such as soldering or using compression fittings.

[0058] The connectors **12, 14** with the conductors may be connected by inserting the plug **22** of the plug connector **12** in the socket **42** of the socket connector **14**. As noted above, the insertion force is low due to the contact interface using the spring **82**. The extraction force may be altered (e.g., increased) through contact design to improve retention of the plug.

[0059] The covers **60, 62** and the base plates **66** may be installed around the three phase conductor connectors **10** as shown in **Figures 2** and **3**. As shown in **Figure 3**, a ground conductor connector assembly **10'** may be held by the base plates **66**. The connector **10'** may be the same or substantially the same as the connector **10** described herein. The connector **10'** includes a pin or plug connector **12'** and a socket or receptacle connector **14'**. One ground conductor may be received in a channel **26'** of the pin connector **12'** and another ground conductor may be received in a channel **56'** of the socket connector **14'**. The ground conductors may be secured with the proper contact pressure using shear bolts received in shear bolt holes **28**. The connector **10'** may include the same spring contact interface as the connector **10** allowing for low insertion force and a high and reliable contact area and/or pressure.

[0060] Although not shown, the mining cable coupler may also include a connector assembly for a pilot conductor. The pilot conductor connector assembly may be the same or similar to the phase conductor connector **10** and/or the ground conductor connector assembly **10'** described herein. The pilot conductor connector assembly may be mounted to the base plates **66** using the mounting features **90, 92** (**Figure 3**).

[0061] In addition, the mining cable coupler is typically enclosed in a shell as understood by those skilled in the art.

[0062] As noted above, the present inventors discovered that the spring contact interface provided substantial improvements in insertion force and electrical contact over

known connectors used with mining cable couplers. The present inventors discovered that, due to the improved electrical contact area and/or pressure, the connectors according to embodiments described herein can be substantially smaller than known connectors used for mining cable couplers while maintaining the same ampacity.

[0063] This is illustrated in **Figures 6A** and **6B**. In **Figure 6A**, the front and central portion of the plug connector **12** is juxtaposed with known plug connectors using the tulip style contact interface and the louvertac band style contact interface. The reduced diameter of the plug **22** is readily apparent.

[0064] In **Figure 6B**, the front and central portion of the socket connector **14** is juxtaposed with known socket connectors using the tulip style contact interface and the louvertac band style contact interface. The diameter of the socket **42** is substantially reduced and corresponds to the reduction in diameter of the mating plug **22** (**Figure 6A**).

[0065] The connector assembly **10** is lighter and cheaper to manufacture due to its reduced size. The smaller size of the connectors (e.g., at least three phase connectors, one ground connector and one pilot connector) may help increase the dielectric strength of the mining cable coupler by using additional insulation in the extra space.

[0066] In some embodiments, each of the plug connector **12** and the socket connector **14** are monolithic. That is, the connectors **12, 14** are each single-piece as opposed to known two-piece connectors used with mining cable couplers. This further reduces the size of the connector. Moreover, the single-piece connectors are easier to assemble, install and service and may also be more reliable due to the reduced part count.

[0067] In some embodiments, the spring **82** can be removed and replaced. In this sense, the connector assembly **10** can be serviced in the event the spring **82** is worn or otherwise damaged (e.g., due to handing).

[0068] Referring to **Figure 1**, the plug **22** of the plug connector **12** may have a diameter **D1** of between about 0.25 and 3 inches, between about 0.25 and 1 inch, and, in some embodiments, has a diameter **D1** of about 0.5 inches. The socket **42** of the socket connector **14** may have a diameter **D2** of between about 0.5 and 5 inches, between about 0.5 and 2 inches, and, in some embodiments, has a diameter **D2** of about 1.125 inches. The socket channel **44** of the socket connector **14** may have a diameter of between about 0.5 and 5 inches, between about 0.5 and 2 inches, and, in some embodiments, has a diameter of about 1.125 inches. The plug connector **12** may have a length **L1** of between about 2 and 10 inches, between about 4 and 6 inches, and, in some embodiments, has a length **L1** of about 5 inches. The socket connector **14** may have a length **L2** of between about 2 and 10 inches,

between about 4 and 6 inches, and, in some embodiments, has a length **L2** of about 5 inches. When the connectors **12, 14** are coupled, the coupled connectors have a total length of between about 8 and 12 inches and, in some embodiments, have a total length of about 10 inches.

[0069] The connectors **12, 14** may be made of any suitable electrically conductive material. An exemplary suitable material for the connectors **12, 14** is copper.

[0070] The housings **60, 62** may be made of any suitable electrically insulating material. In some embodiments, the housings **60, 62** are polymeric.

[0071] The spring **82** may be made of any suitable electrically conductive material. An exemplary suitable material for the spring **82** is copper.

[0072] In some embodiments, the spring **82** is silver plated. Connectors typically used with mining cable couplers (e.g., the connectors using the tulip style or louvertac band style contact interfaces described above) have the entire front or "mating" portion silver plated to address oxidation concerns. With the connector assembly **10**, the spring serves as the primary electrical contact while the rest of the connector provides mechanical support and path for current flow. In some embodiments, only the spring **82** is silver plated. In some embodiments, only the spring **82** and a portion of the plug **22** are silver plated. Substantial cost savings may be realized by not silver plating the connectors **12, 14** or a substantial portion of the connectors **12, 14**. Other plating materials are contemplated. For example, the spring **82** and/or a portion of the plug **22** may be tin or gold plated.

[0073] Although the connector assembly **10** has been described as having one spring **82**, it is contemplated that more than one spring may be used. That is, as illustrated in Figure 9, the socket **42** may have two or more spaced apart annular grooves **80** that surround the channel **44** (**Figure 2**) and a spring **82** may be received in each one of the grooves **80**. The use of multiple springs provides increased contact area and may reduce the size of the connectors even further. In addition, the use of multiple springs may be desirable for high current applications (e.g., the multiple springs provide increased contact area for higher current applications).

[0074] It is contemplated that the spring(s) **82** could be located on the outside diameter of the plug **22** instead of the inside diameter of the socket **42**. For example, one or more grooves may be formed in the outer surface of the plug **22** with each groove sized and configured to receive and hold one of the springs **82**.

[0075] It is also contemplated that the spring design and/or the groove design may be varied to vary the insertion and holding forces. For example, the size and/or shape of the

spring **82** and/or the size and/or shape of the groove **80** may be varied for a range of insertion and holding forces. In addition, the plug and/or the socket (e.g., the spring) may be configured to have a locking function. For example, the plug **22** may lock in the socket **42** when inserted therein in a first direction. The plug **22** and socket **42** may be unlocked by further advancing the plug **22** in the first direction a small distance, at which point the plug **22** may be withdrawn from the socket **42** in a second direction that is opposite the first direction.

[0076] A connector assembly **110** for use with mining cable couplers according to some other embodiments is illustrated in **Figure 7**. The connector **110** includes some features that are the same or substantially the same as the connector **10**; these features include like reference numbers and the description will not be repeated below in the interest of brevity.

[0077] The connector assembly **110** includes a two-piece plug or pin connector **112** and a two-piece receptacle or socket connector **114**. A front portion **116** of the plug connector **112** includes the plug **22** that extends away from a threaded fitting **174**. A central portion **120** of the plug connector **116** includes a cylindrical portion **176** with a channel **178** defined therein. The channel **178** is sized and configured to receive the fitting **174**. The fitting **174** and the channel **178** may threadingly engage one another such that the front portion **116** and the central portion **120** are securely held together.

[0078] A front portion **136** of the socket connector **114** includes the socket **42** which is a cylindrical member that has a channel **180** defined therein opposite the socket channel **44**. A central portion **140** of the socket connector **114** includes a threaded fitting **182**. The channel **180** is sized and configured to receive the fitting **182**. The fitting **182** and the channel **180** may threadingly engage one another such that the front portion **136** and the central portion **140** are securely held together.

[0079] A connector assembly **210** for use with mining cable couplers according to some other embodiments is illustrated in **Figure 8**. The connector assembly **210** includes the same plug connector **112** as the connector **110**. The connector **210** includes a different socket connector **214** as will now be described.

[0080] A front portion **236** of the socket connector **214** includes the socket **42** and a threaded fitting **190** opposite the socket channel **44**. A central portion **240** of the socket connector **214** includes a cylindrical portion **192** with a channel **194** defined therein. The channel **194** is sized and configured to receive the fitting **190**. The fitting **190** and the channel **194** may threadingly engage one another such that the front portion **236** and the central portion **240** are securely held together.

[0081] The connectors **110, 210** may include the spring contact interface on the "front end" and/or the shear bolt cable securing mechanism on the "back end" as described above in connection with the connector **10**. The two-piece design may be useful for end users that already have a two-piece design but would like to replace at least one of the pieces to take advantage of at least one of these features.

[0082] A female to female connector is contemplated. For example, a female (socket) connector similar to the socket member **42** could be connected to the socket member **42** (e.g., using the threading **43** shown in **Figure 7** or the fitting **190** shown in **Figure 8**). In this regard, the connector has oppositely facing socket portions which may each include the spring contact interface. This may be advantageous to reduce the number of components. For example, male (plug) connectors could be on the conductor ends and the female to female connector could provide a compact junction for mating in the field.

[0083] It is noted that while the connectors **10, 110, 210** illustrate the use of shear bolts on the rear portions, it is contemplated that the conductors may be secured in the connectors in other ways. For example, the rear end portion of the connector may be a smooth barrel to accommodate soldering the connector and the conductor. In some other embodiments, compression fittings such as hex nuts may be used.

[0084] Referring again to **Figure 2**, the relationship between the connectors **12, 14** and the housings **60, 62** will now be described in greater detail. The housings **60, 62** may collectively be referred to as the outer housing. The first housing **60** is a generally tube shaped housing having an outer wall **60w** and first and second opposite ends $\mathbf{60_1}$, $\mathbf{60_2}$. The second housing **62** is also a generally tube shaped housing having an outer wall **62w** and first and second opposite ends $\mathbf{62_1}$, $\mathbf{62_2}$. An elongated annular groove or slot **64** is defined in the outer wall **62w** of the second housing **62**. The first end $\mathbf{60_1}$ of the first housing **60** is received and held in the annular slot **64**.

[0085] An annular projection or step **74** extends inwardly from the outer wall **60w** between the first and second ends $\mathbf{60_1}$, $\mathbf{60_2}$ of the first housing **60**. A central channel **76** is defined by the annular projection **74**. A first end channel **77** is defined by the outer wall **60w** of the first housing **60** between the first end $\mathbf{60_1}$ of the first housing **60** and the annular projection **74**. A second end channel **78** is defined by the outer wall **60w** of the first housing **60** between the second end $\mathbf{60_2}$ of the first housing **60** and the annular projection **74**.

[0086] Similarly, an annular projection or step **84** extends inwardly from the outer wall **62w** between the first and second ends $\mathbf{62_1}$, $\mathbf{62_2}$ of the second housing **62**. A central channel **86** is defined by the annular projection **84**. A first end channel **87** is defined by the

outer wall **62w** of the second housing **62** between the first end $\mathbf{62_1}$ of the second housing **62** and the annular projection **84**. A second end channel **88** is defined by the outer wall **62w** of the second housing **62** between the second end $\mathbf{62_2}$ of the second housing **62** and the annular projection **84**.

[0087] As illustrated in **Figure 2**, the socket connector **14** is held in the first housing **60**. The front portion **36** of the socket connector **14** is in the first end channel **77** of the first housing **60** and/or the first end channel **87** of the second housing **62**. The central portion **40** of the socket connector **14** is in the central channel **76** of the first housing **60**. The rear end portion **38** of the socket connector **14** is in the second end channel **78** of the first housing **60**.

[0088] As also illustrated in **Figure 2**, the plug connector **12** is held in the second housing **62**. The front portion **16** of the plug connector **12** is in the first end channel **87** of the second housing **62** and/or the first end channel **77** of the first housing **60**. The central portion **20** of the plug connector **12** is in the central channel **86** of the second housing **62**. The rear end portion **18** of the plug connector **12** is in the second end channel **88** of the second housing **62**.

[0089] The fastener **72** coupled to the socket connector **14** may be adjacent and/or abut a first wall **94** defined by annular projection **74**. The rear portion **38** of the socket connector **14** may be adjacent and/or abut a second, opposite wall **95** defined by the annular projection **74**. Similarly, the fastener **70** coupled to the plug connector **12** may be adjacent and/or abut a first wall **96** defined by annular projection **84**. The rear portion **18** of the plug connector **12** may be adjacent and/or abut a second, opposite wall **97** defined by the annular projection **84**.

[0090] It will be appreciated that other configurations are contemplated. For example, the plug connector **12** may be in the first housing **60** and the socket connector **14** may be in the second housing **62**. These configurations help provide a secure connection between the connectors **12, 14** and/or the housing **60, 62**.

[0091] The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few 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. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific

embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the invention.

What is claimed is:

1. A connector assembly for use with a mining cable coupler, the assembly comprising:

a first connector comprising a front portion including a plug and a rear portion including a barrel configured to receive a first conductor;

a second connector comprising a front portion including a socket having a channel defined therein and a rear portion including a barrel configured to receive a second conductor, wherein an annular groove is defined in an inner surface of the channel; and

an annular spring held in the annular groove;

wherein the channel is sized and configured to receive the plug such that the plug resiliently contacts the spring to electrically connect the first conductor received in the first connector barrel and the second conductor received in the second connector barrel.

2. The connector assembly of claim 1 wherein each of the first and second connectors is monolithic.

3. The connector assembly of claim 2 wherein:

the first connector comprises a central portion between the front portion and the rear portion, the central portion comprising a threaded region on an outer surface thereof, the threaded region configured to threadingly engage with a fastener such that the fastener is held around the central portion of the first connector; and

the second connector comprises a central portion between the front portion and the rear portion, the central portion comprising a threaded region on an outer surface thereof, the threaded region configured to threadingly engage with a fastener such that the fastener is held around the central portion of the second connector.

4. The connector assembly of claim 1 wherein each of the first and second connector barrels comprise a plurality of shear bolt holes configured to receive shear bolts for securing ends of the first and second conductor in the first and second connector barrels, respectively.

5. The connector assembly of claim 1 in combination with:

the first conductor comprising the first conductor end held in the first connector barrel; and

the second conductor comprising the second conductor end held in the second connector barrel.

6. The combination of claim 5 wherein:

each of the first and second conductor ends comprise a plurality of strands; and

a shielding mesh layer is wrapped around the plurality of strands of each of the first and second conductor ends to secure the strands together.

7. The connector assembly of claim 1 wherein the spring is a canted coil spring.

8. The connector assembly of claim 1 wherein the spring is silver-plated.

9. The connector assembly of claim 1 wherein a plurality of spaced apart annular grooves are defined in the inner surface of the socket channel and a spring is held in each of the plurality of annular grooves.

10. The connector assembly of claim 1 wherein:

the first connector comprises a central portion between the front portion and the rear portion and the front portion and central portion are threadingly engaged with one another; and

the second connector comprises a central portion between the front portion and the rear portion and the front portion and central portion are threadingly engaged with one another.

11. A mining cable coupler assembly comprising:

an outer housing comprising:

a first tube shaped housing having first and second opposite ends;

a second tube shaped housing having first and second opposite ends with an elongated annular slot defined in an outer wall of the first end;

wherein the first and second housings are coupled at least in part by the first end of the first housing being received in the annular slot of the second housing;

a first connector held in the first housing; and

a second connector held in the second housing;

wherein:

the first connector comprises a rear portion including a barrel configured to receive a first conductor, a front portion comprising one of a plug and a socket, and a central portion between the rear portion and the front portion;

the second connector comprises a rear portion including a barrel configured to receive a second conductor, a front portion comprising the other one of a plug and a socket, and a central portion between the rear portion and the front portion;

the first and second connectors are coupled by the plug of one of the first and second connectors being received in the socket of the other one of the first and second connectors.

12. The mining cable coupler assembly of claim 11 wherein:

the first housing comprises an annular projection extending inwardly from the outer wall between the first and second ends, a central channel defined by the annular projection, a first end channel defined by the outer wall between the first end and the annular projection, and a second end channel defined by the outer wall between the second end and the annular projection; and

the second housing comprises an annular projection extending inwardly from an outer wall between the first and second ends, a central channel defined by the annular projection, a first end channel defined by the outer wall between the first end and the annular projection, and a second end channel defined by the outer wall between the second end and the annular projection.

13. The mining cable coupler assembly of claim 11 wherein:

the first connector is held in the first housing with the front portion of the first connector in the first end channel of the first housing and/or the first end portion of the second housing, the central portion of the first connector in the central channel of the first housing, and the rear portion of the first connector in the second end channel of the first housing; and

the second connector is held in the second housing with the front portion of the second connector in the first end channel of the second housing and/or the first end portion of the first housing, the central portion of the second connector in the central channel of the

second housing, and the rear portion of the second connector in the second end channel of the second housing.

14. The mining cable coupler assembly of claim 13 wherein:

each of the first and second connectors is a one-piece connector;

the central portion of the first connector includes a threaded region on an outer surface thereof and a first fastener is threadingly engaged with the threaded region; and

the central portion of the second connector includes a threaded region on an outer surface thereof and a second fastener is threadingly engaged with the threaded region.

15. The mining cable coupler assembly of claim 14 wherein:

the first fastener is adjacent and/or abuts a first wall defined by the annular projection of the first housing and the rear portion of the first connector is adjacent and/or abuts a second, opposite wall of the annular projection of the first housing; and

the second fastener is adjacent and/or abuts a first wall defined by the annular projection of the second housing and the rear portion of the second connector is adjacent and/or abuts a second, opposite wall of the annular projection of the second housing.

16. The mining cable coupler assembly of claim 13 comprising a plurality of the outer housings with one of the first connectors and one of the second connectors coupled and held in each one of the outer housings, wherein the plurality of outer housings are held together by a first base plate that engages the outer wall of each of the first housings and a second base plate that engages the outer wall of each of the second housings.

17. The mining cable coupler assembly of claim 11 wherein:

the socket of one of the first and second connectors comprises a channel with an annular groove defined in an inner wall of the channel;

a spring is held in the annular groove; and

the plug of the other one of the first and second connectors resiliently contacts the spring to electrically connect the first conductor received in the first connector barrel and the second conductor received in the second connector barrel.

18. A method for electrically connecting mining cables, the method comprising:

(a) providing:

a first connector comprising a front portion including a plug and a rear portion including a barrel;

a second connector comprising a front portion including a socket having a channel defined therein and a rear portion including a barrel, wherein an annular groove is defined in an inner surface of the channel;

an annular spring held in the annular groove;

a first tube shaped housing having first and second opposite ends with an elongated annular slot defined in an outer wall of the first housing at the first end;

a second tube shaped housing having first and second opposite ends;

(b) receiving a first mining cable conductor in the barrel of the first connector;

(c) securing the first mining cable conductor in the barrel of the first connector;

(d) inserting the first connector with the secured first mining cable conductor into the second end of the first housing toward the first end of the first housing such that the plug is adjacent the first end of the first housing;

(e) receiving a second mining cable conductor in the barrel of the second connector;

(f) securing the second mining cable conductor in the barrel of the second connector;

(g) inserting the second connector with the secured second mining cable conductor into the second end of the second housing toward the first end of the second housing such that the socket is adjacent the first end of the second housing;

(h) coupling the first and second housings including receiving the first end of the second housing in the annular slot of the first housing; and

(i) coupling the first and second connectors including receiving the plug of the first connector in the socket of the second connector such that the plug resiliently contacts the spring to electrically connect the first mining cable conductor and the second mining cable conductor.

19. The method of claim 18 further comprising wrapping a shielding mesh layer around the first cable mining cable conductor before step (b) and wrapping a shielding mesh layer around second cable mining cable conductor before step (e), wherein securing the first mining cable conductor in the barrel of the first connector comprises receiving shear bolts through shear bolt apertures defined in the barrel of the first connector and tightening the shear bolts, and wherein securing the second mining cable conductor in the barrel of the second connector comprises receiving shear bolts through shear bolt apertures defined in the barrel of the second connector and tightening the shear bolts.

20. The method of claim 18 further comprising:

providing:

three of the first connectors;

three of the second connectors;

three of the annular springs, one each held in a respective annular groove of a respective second connector;

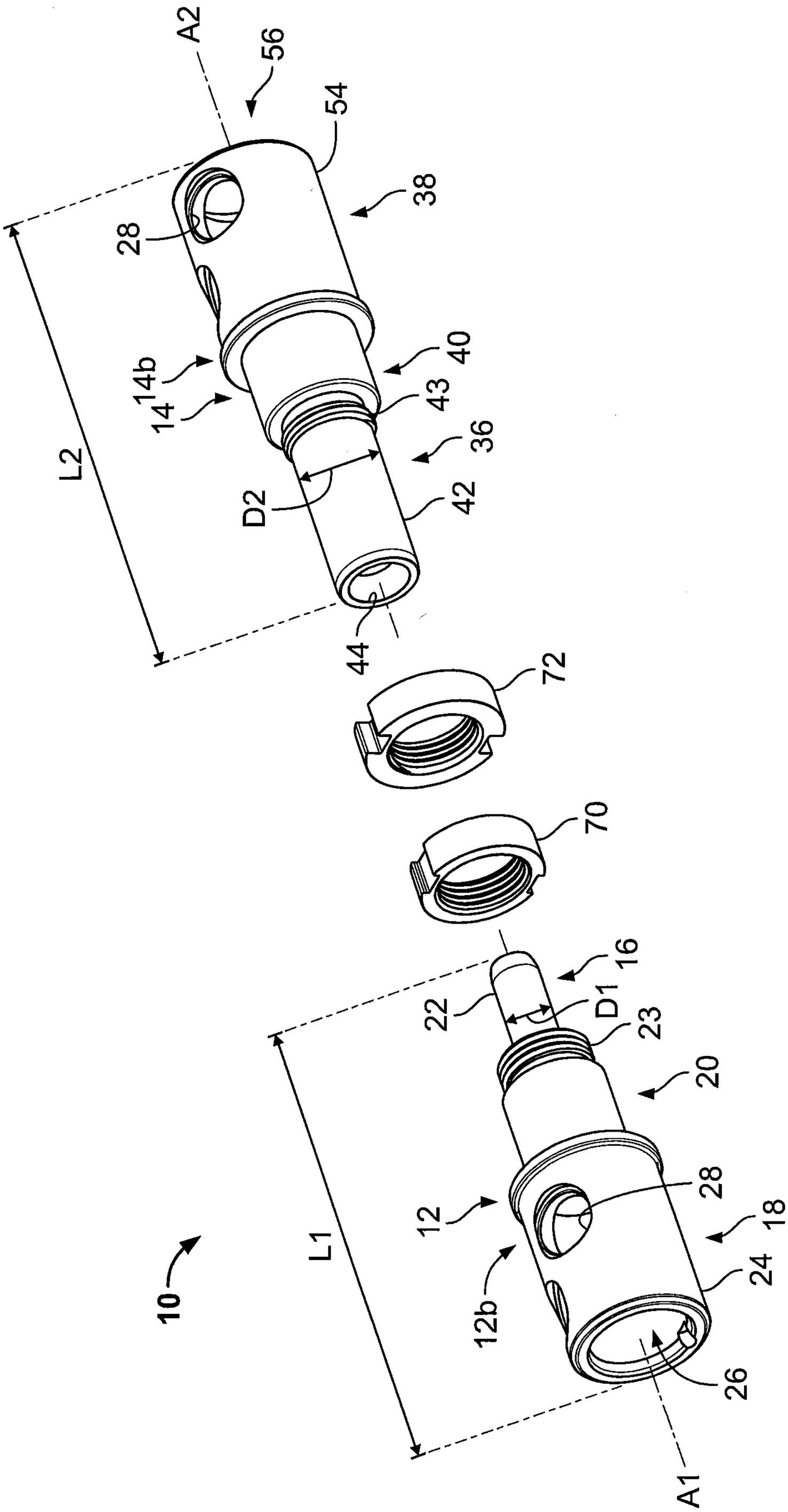
three of the first tube shaped housings; and

three of the second tube shaped housings;

performing steps (b) through (i) for each of the first connectors, second connectors, first housings, and second housings;

securing the first housings with a first base plate that engages the outer surfaces of the first housings; and

securing the second housings with a second base plate that engages outer surfaces of the second housings.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A1

FIG. 1

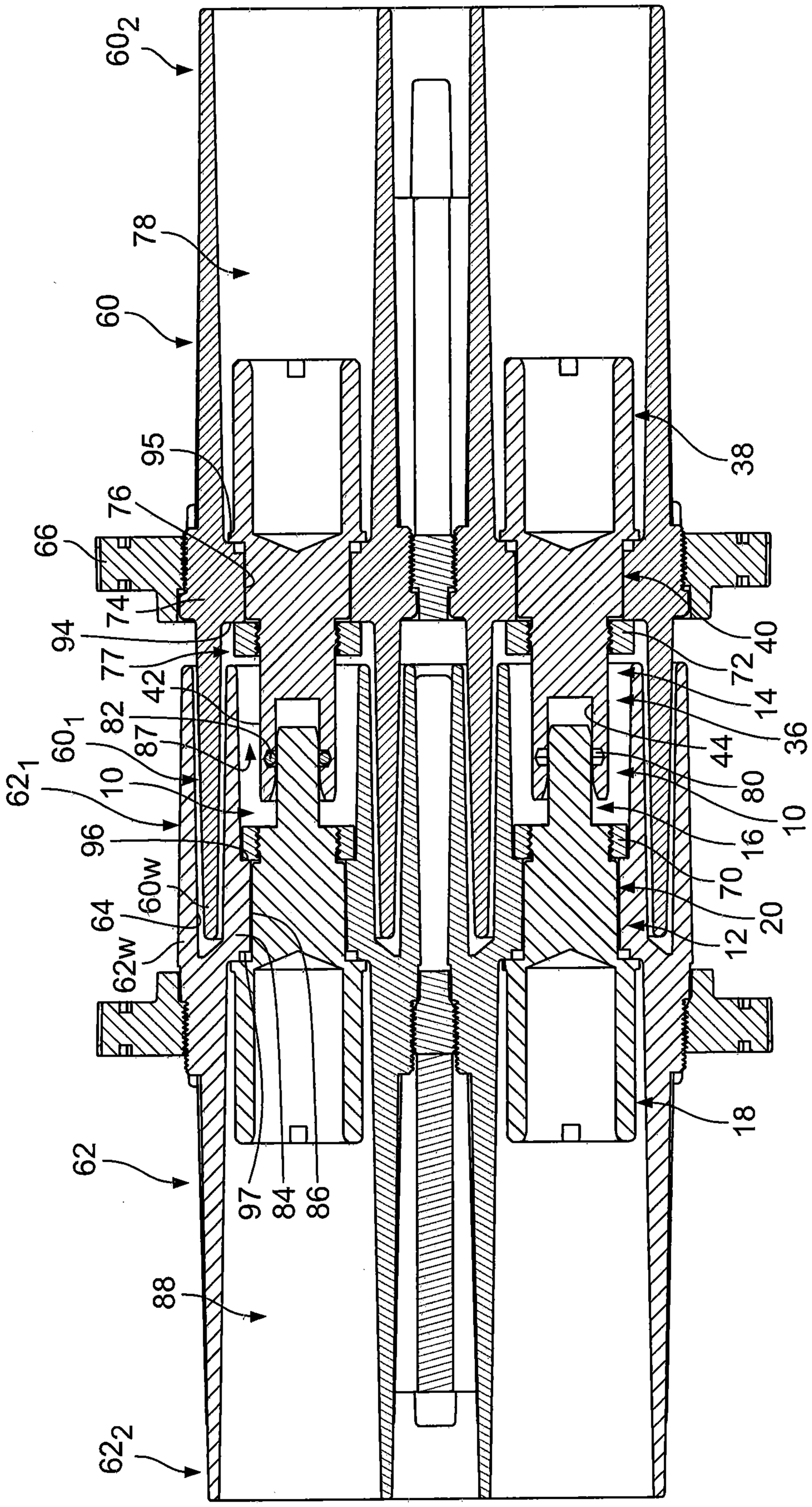
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FIG. 2

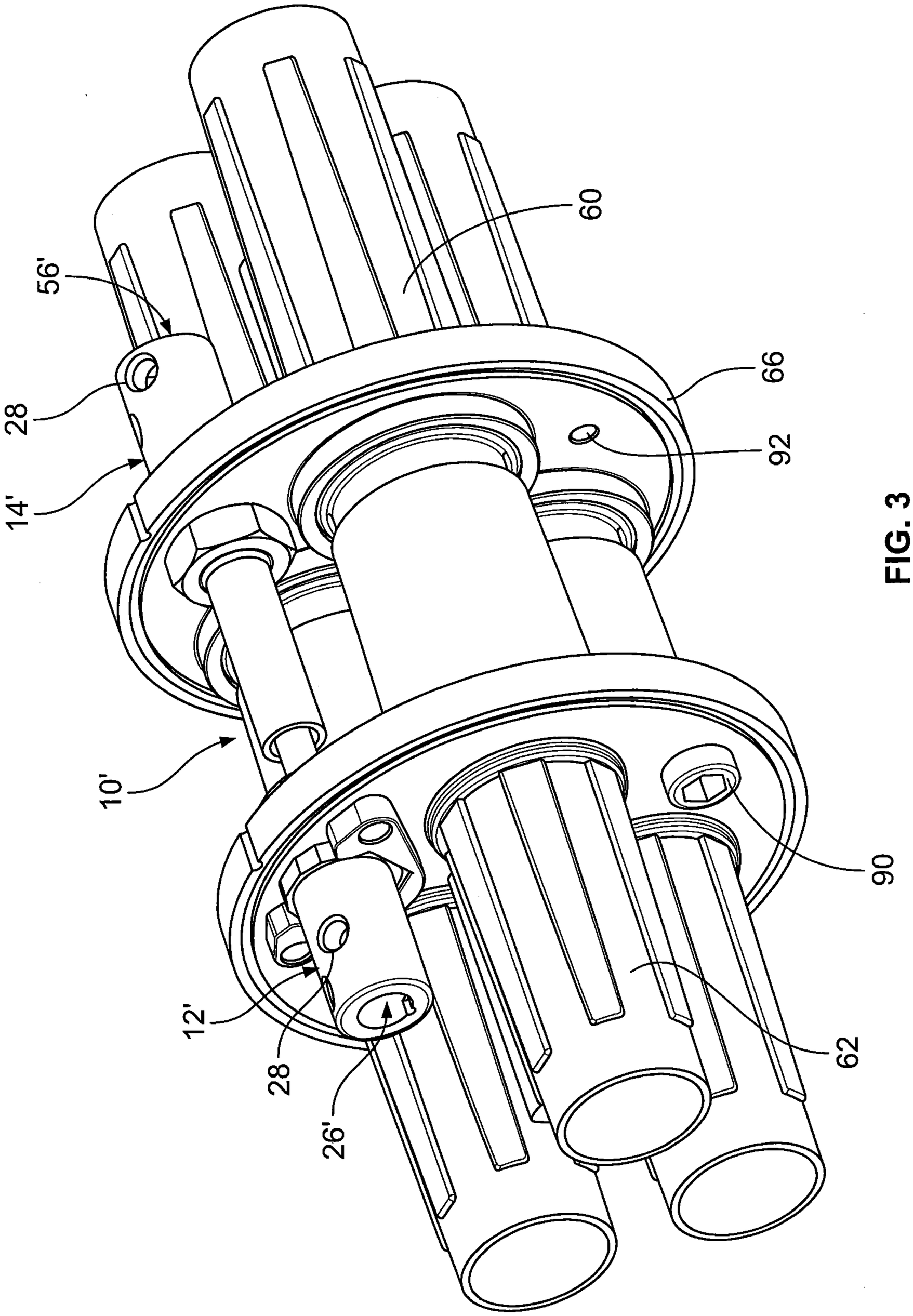

FIG. 3

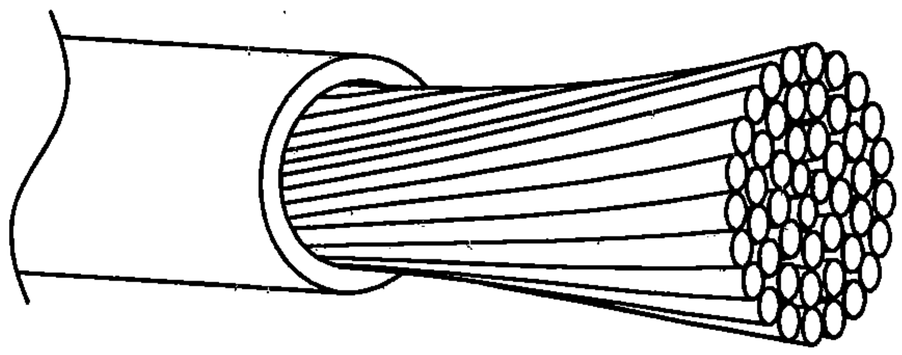

FIG. 4A

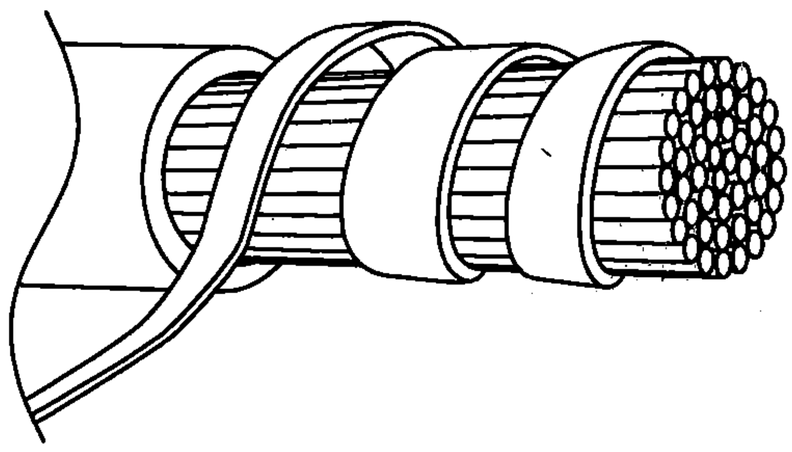

FIG. 4B

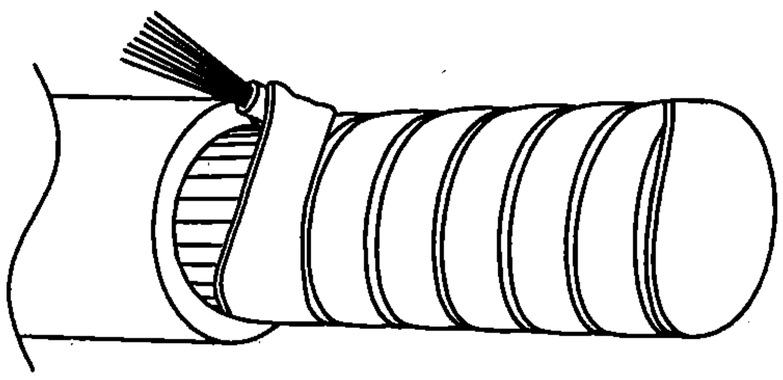

FIG. 4C

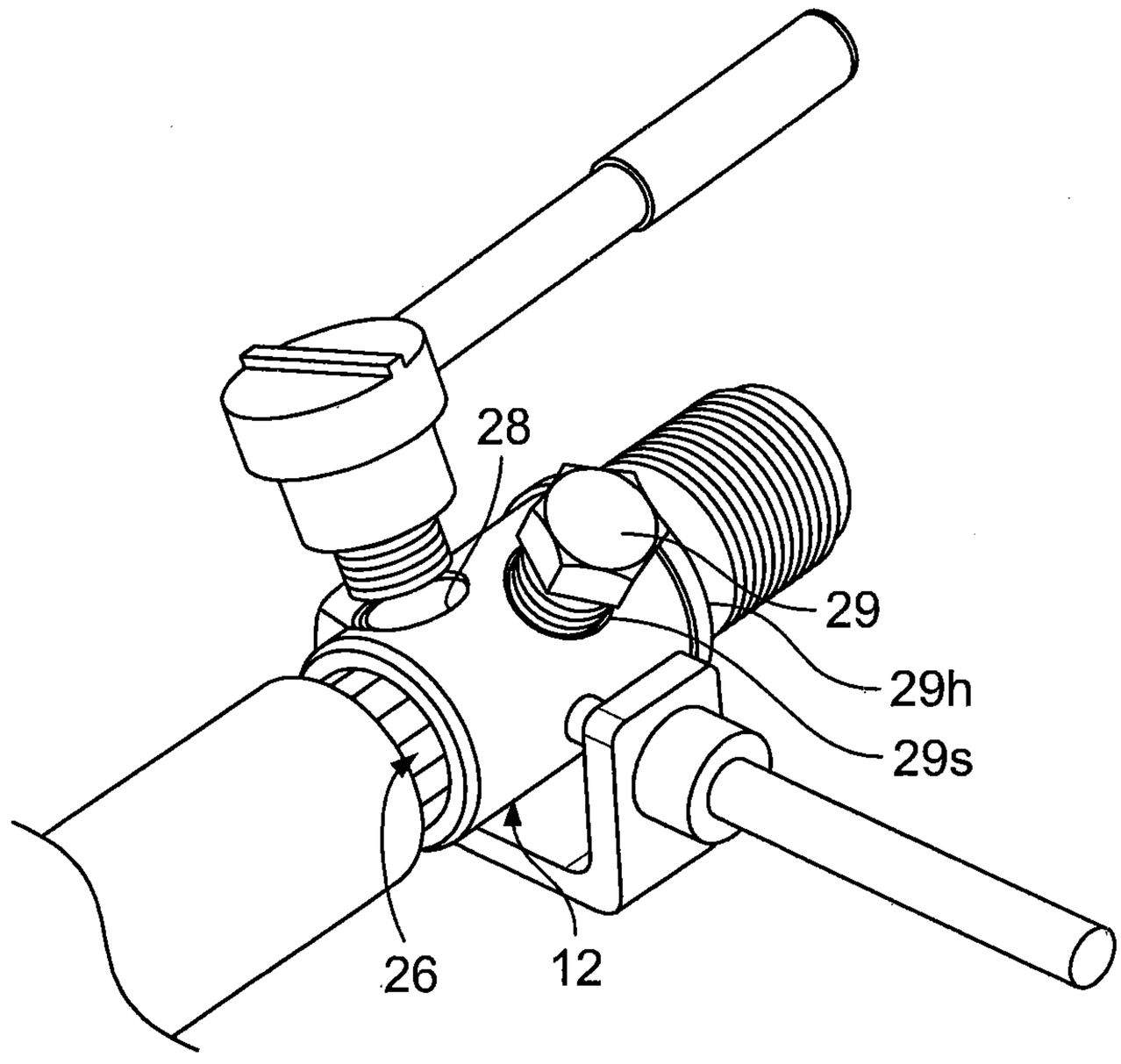

FIG. 5

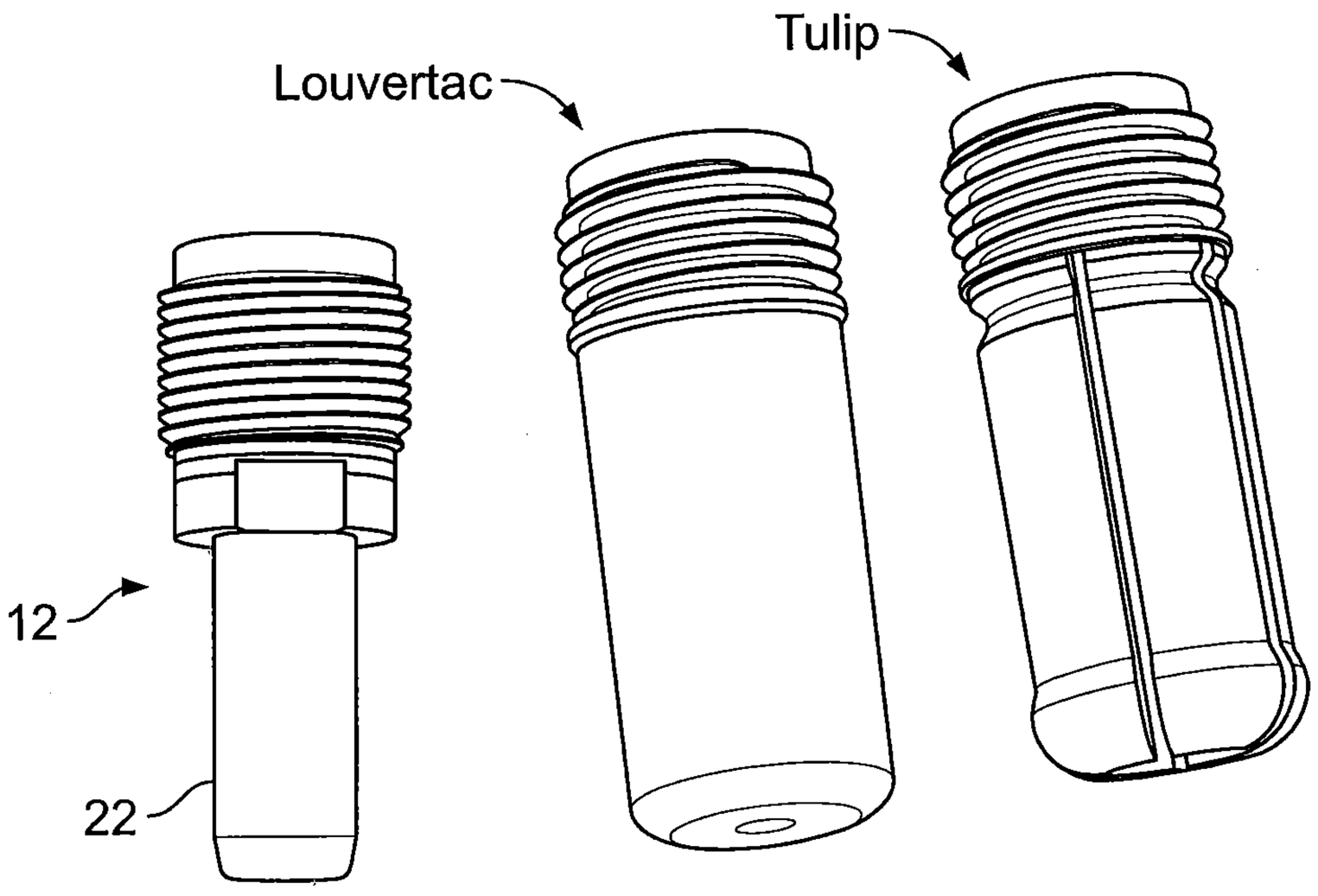

FIG. 6A

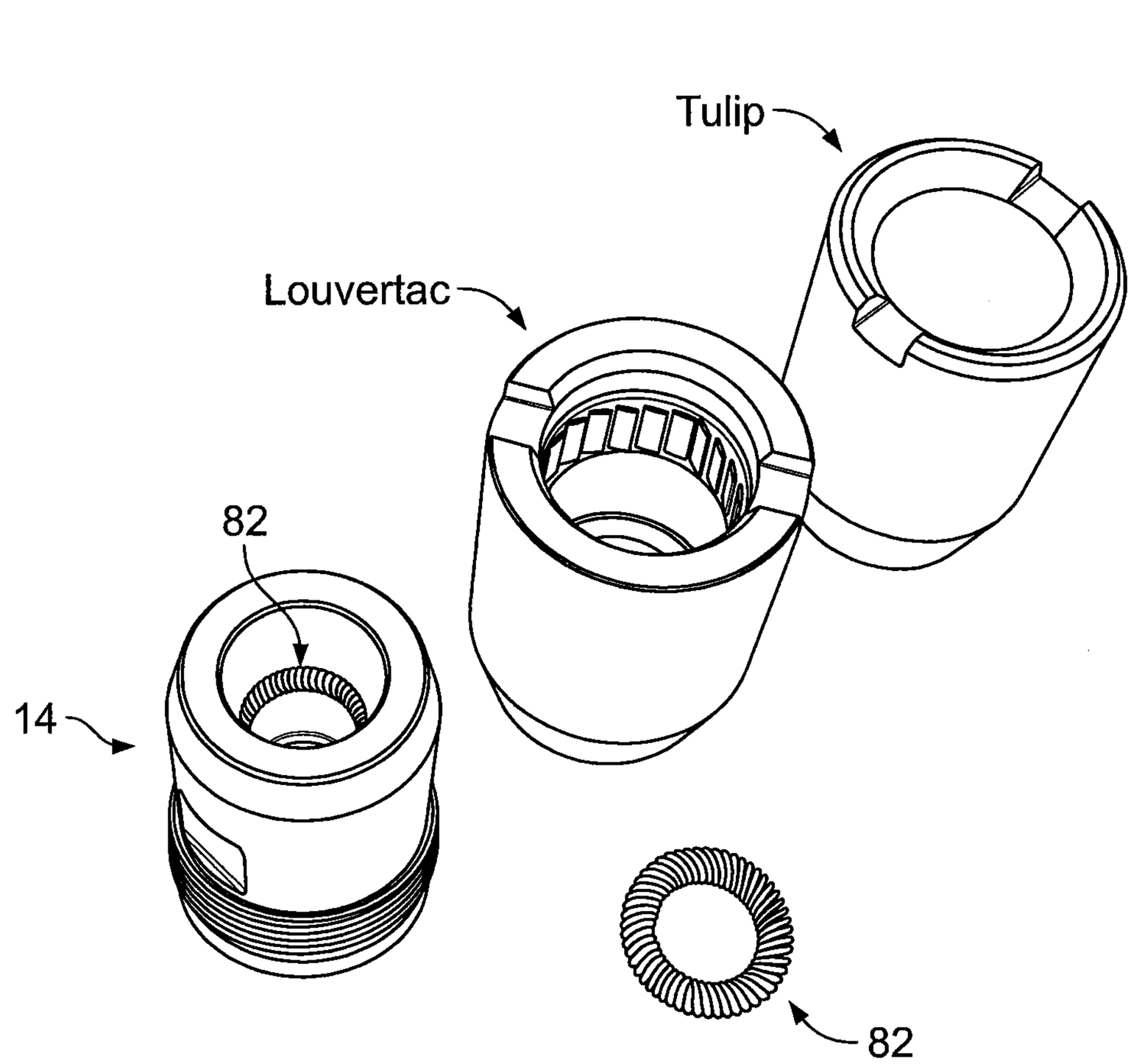

FIG. 6B

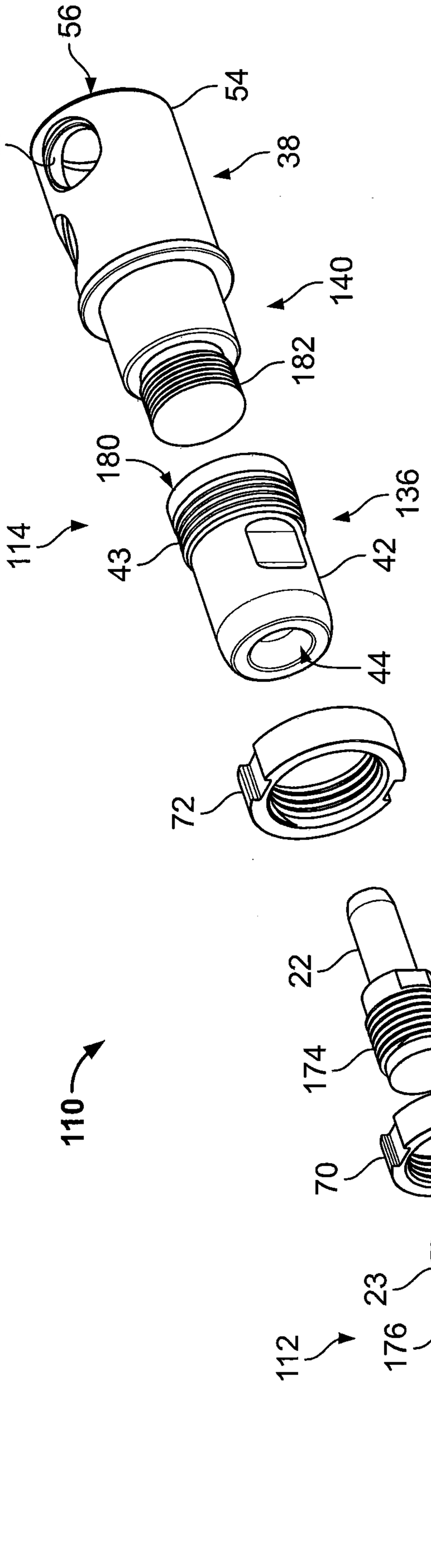
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FIG. 7

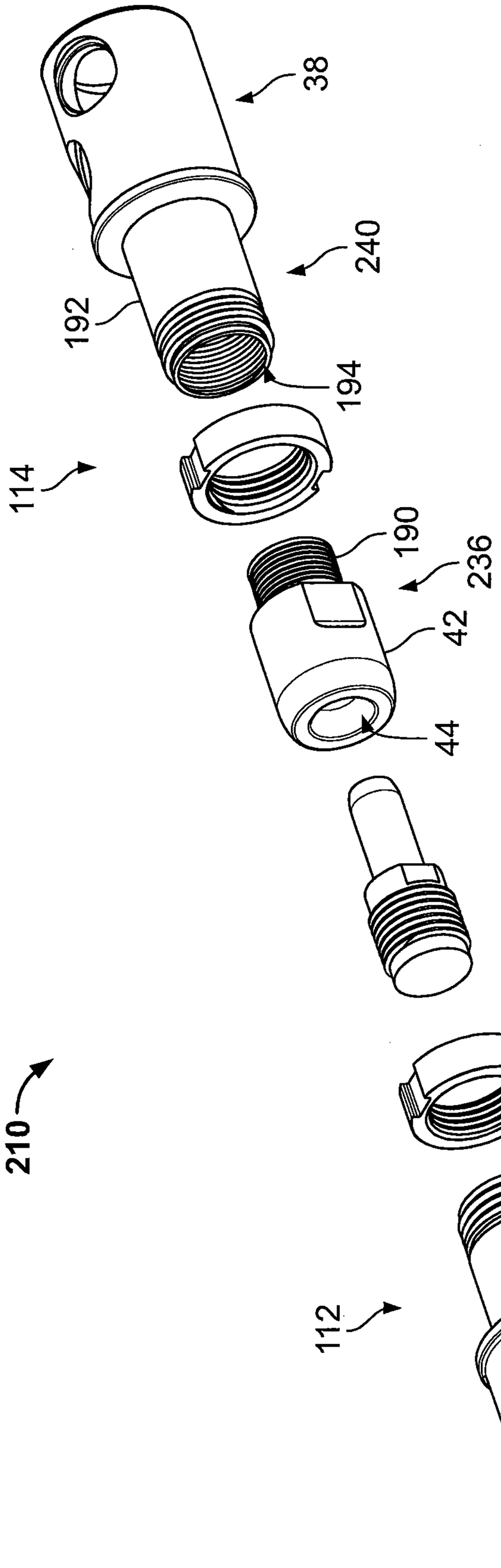


FIG. 8

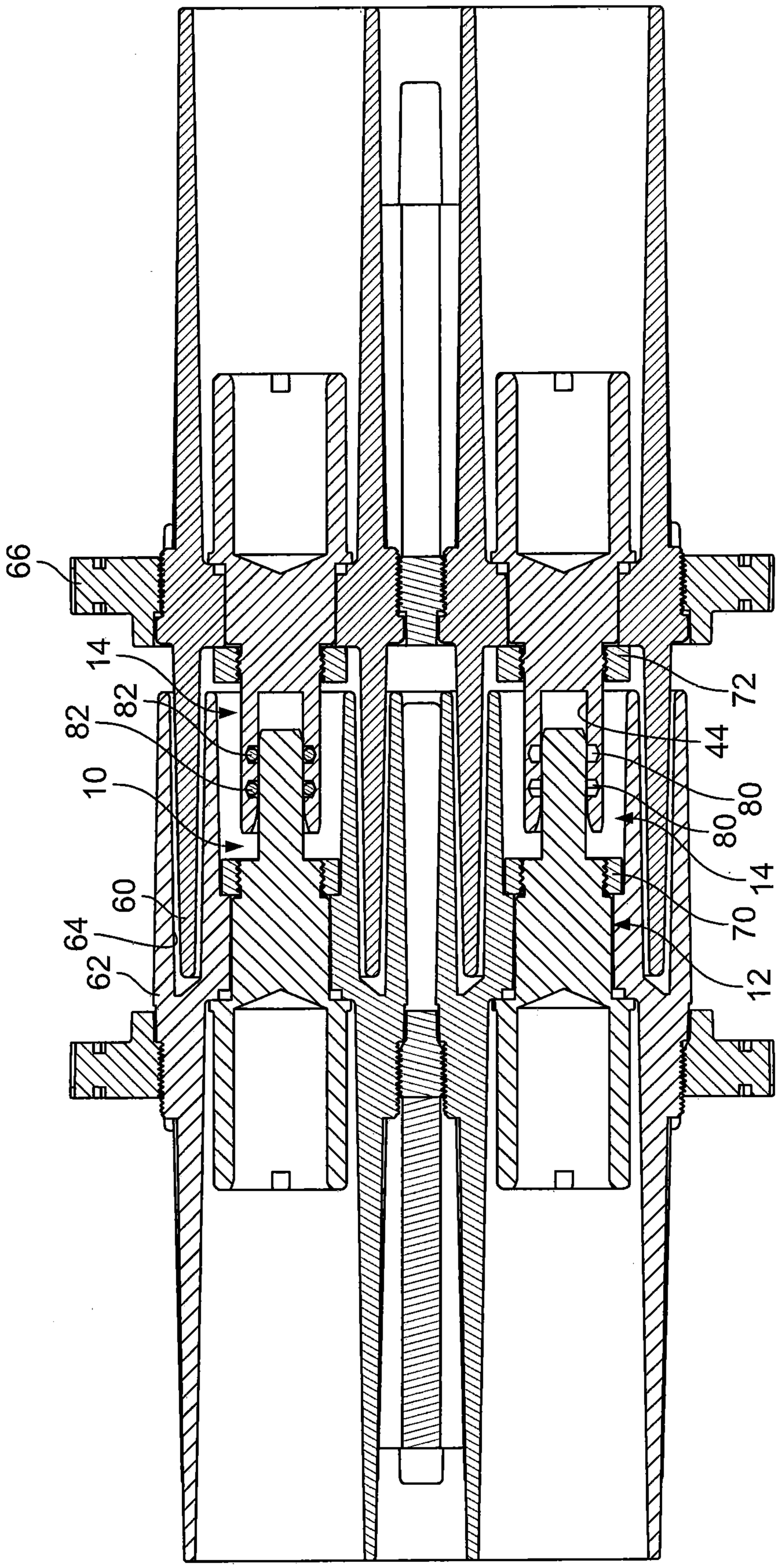
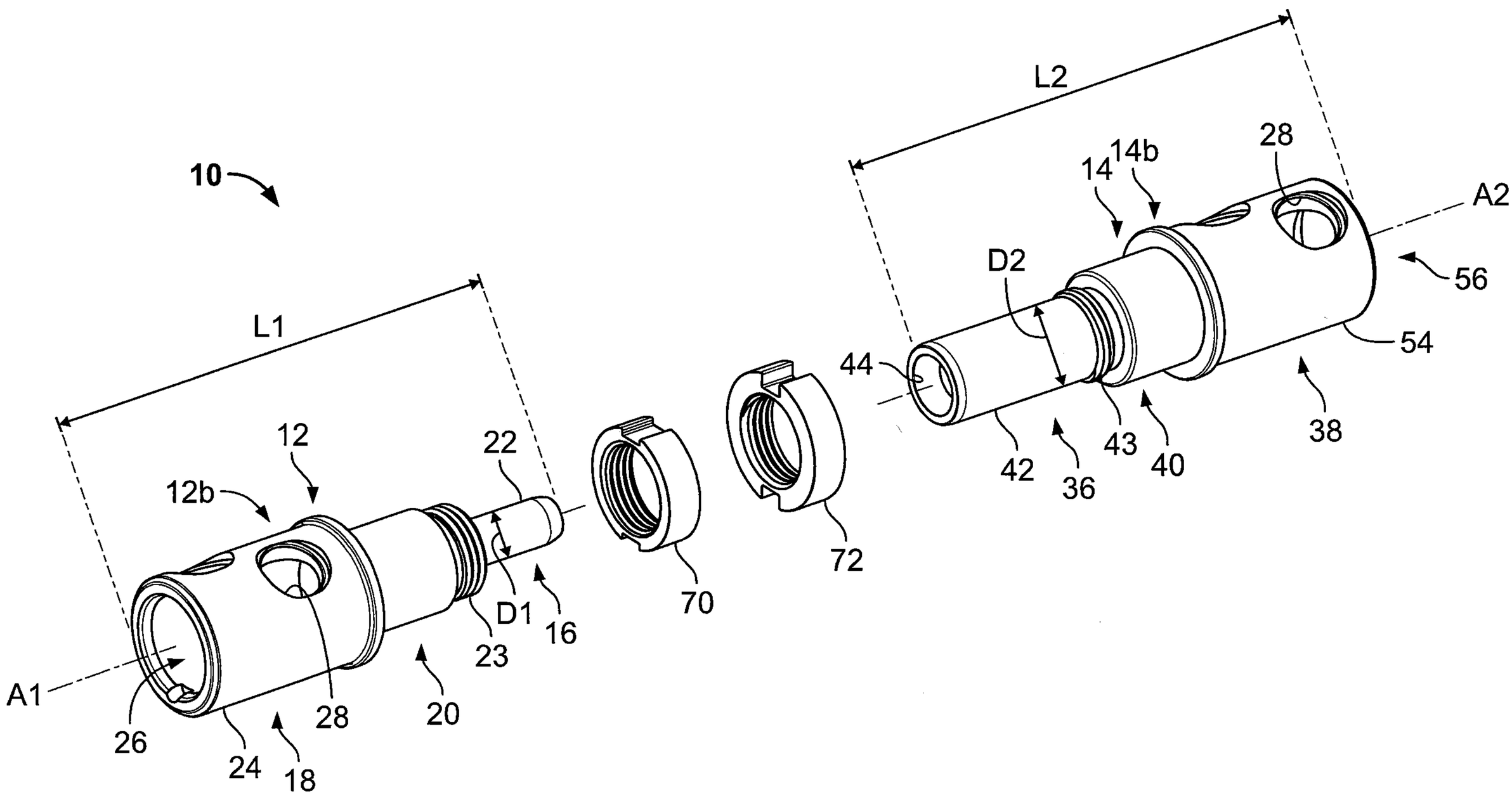


FIG. 9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D1
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A1
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18
20
70
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L2
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14b
28
A2
D2
56
54
44
42
36
43
40
38

FIG. 1