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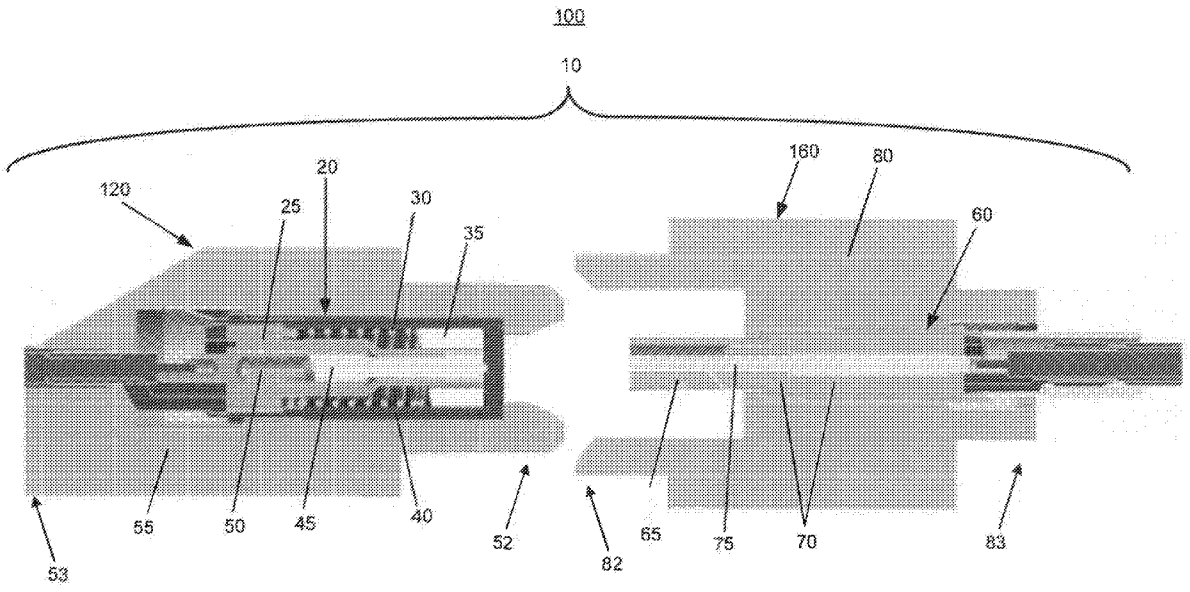
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(54) Title: COAXIAL CONNECTOR

Fig. 1



(57) Abstract: Technologies are described for devices and methods to connect contacts. A female component may include a female housing, an outer socket body, an outer spring, an outer piston, and a center contact. The outer piston may be a cylindrical tube segment with a first end including a flat surface and dimples on a plane essentially perpendicular to inner and outer surfaces of the outer piston. A second end of the outer piston may include a flat skewed surface which is not on a plane essentially perpendicular to the inner and outer surfaces. A male component may include a male housing, an outer pin, and a center pin. The female housing may couple with the male housing. The outer socket may couple with the outer pin. The outer pin may engage with the outer piston. The outer piston may, upon engagement, contact the center contact with the center pin.

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COAXIAL CONNECTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Application No. 2019-025592 filed with the Japan Patent Office on February 15, 2019. The disclosures of the above application are hereby incorporated by reference for all purposes.

BACKGROUND

[0002] Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art by inclusion in this section.

[0003] Coaxial connectors may be used in industrial applications to connect coaxial cables that transmit data. Coaxial connectors may include an outer conductor contact and an inner conductor contact. Coaxial connectors may mechanically couple to another coaxial connector. Coaxial connectors may have a male connector component and a female connector component which join together to form a mated pair. A male connector component may be referred to as a plug or pin and a female connector component may be referred to as a jack or socket. Coaxial connector pairs may be coupled or mated by threading, bayonet coupling, or snap-on coupling.

SUMMARY

[0004] One embodiment of the invention is a connector effective to connect coaxial contacts. The connector may comprise a female component. The female component may include a female housing. The female component may include an outer socket body within the female housing. The female component may include an outer spring within the outer socket body. The female

component may include an outer piston within the outer socket. The outer piston may be a cylindrical tube segment with an inner surface and an outer surface. The outer piston may have a first piston end and a second piston end. The first piston end may have a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface. The first piston end may include dimples protruding out from the flat surface of the first piston end. The second piston end may have a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface. The second piston end may be in contact with an end of the outer spring. The female component may include a center contact effective to conduct electricity and within the outer spring and the outer piston. The female component may include a first insulator between the center contact and the outer spring. The connector may comprise a male component. The male component may include a male housing. The male component may include an outer pin within the male housing. The male component may include a center pin effective to conduct electricity and within the outer pin. The male component may include a second insulator between the center pin and the outer pin. A first end of the female housing may be configured to couple with a first end of the male housing. The outer socket may be configured to couple with the outer pin. The outer pin may be configured to engage with the outer piston. The outer piston may be configured to, upon engagement with the outer pin, contact the center contact with the center pin.

[0005] Another embodiment of the invention includes a system to connect coaxial contacts. The systems may comprise a receptacle. The receptacle may include at least one female component. The at least one female component may include a female housing. The female component may include an outer socket body within the female housing. The female component may include an outer spring within the outer socket body. The female component may include

an outer piston within the outer socket. The outer piston may be a cylindrical tube segment with an inner surface and an outer surface. The outer piston may have a first piston end and a second piston end. The first piston end may have a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface. The first piston end may include dimples protruding out from the flat surface of the first piston end. The second piston end may have a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface. The second piston end may be in contact with an end of the outer spring. The female component may include a center contact effective to conduct electricity and within the outer spring and the outer piston. The female component may include a first insulator between the center contact and the outer spring. The system may comprise a plug. The plug may include at least one a male component. The at least one male component may include a male housing. The male component may include an outer pin within the male housing. The male component may include a center pin effective to conduct electricity and within the outer pin. The male component may include a second insulator between the center pin and the outer pin. A first end of each female housing may be configured to couple with a first end of a respective male housing. The outer socket may be configured to couple with the outer pin. The outer pin may be configured to engage with the outer piston. The outer piston may be configured to, upon engagement with the outer pin, contact the center contact with the center pin.

[0006] Another embodiment of the invention is a method to connect coaxial contacts. The methods may comprise aligning a first end of a female housing of a female component with a first end of a male housing of a male component. The female component may include a female housing. The female component may include an outer socket body within the female housing. The female component may include an outer spring within the outer socket body. The female

component may include an outer piston within the outer socket. The outer piston may be a cylindrical tube segment with an inner surface and an outer surface. The outer piston may have a first piston end and a second piston end. The first piston end may have a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface. The first piston end may include dimples protruding out from the flat surface of the first piston end. The second piston end may have a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface. The second piston end may be in contact with an end of the outer spring. The female component may include a center contact effective to conduct electricity. The center contact may be within the outer spring and the outer piston. The female component may include a first insulator between the center contact and the outer spring. The male component may include a male housing. The male component may include an outer pin within the male housing. The male component may include a center pin effective to conduct electricity. The center pin may be within the outer pin. The male component may include a second insulator between the center pin and the outer pin. The methods may comprise coupling the first end of the female housing with the first end of the male housing. The methods may comprise coupling the outer socket with the outer pin. The methods may comprise engaging the outer pin with outer piston. The methods may comprise contacting the center contact with the center pin.

[0007] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

[0008] The foregoing and other features of this disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

[0009] Fig. 1 is side cutout view of a female component of a coaxial connector and a male component of a coaxial connector;

Fig. 2A is side perspective view of an outer piston of a female component of a coaxial connector;

Fig 2B is a side perspective view of a dimple of an outer piston of a female component of a coaxial connector;

Fig. 3 is side cutout view of a female component of a coaxial connector coupled to a male component of a coaxial connector;

Fig. 4 is side cutout view of a female component of a coaxial connector coupled to a male component of a coaxial connector;

Fig. 5 is side cutout view of a female component of a coaxial connector coupled to a male component of a coaxial connector;

Fig. 6A is side perspective view of a plug and receptacle;

Fig. 6B is side perspective view of a plug coupled with a receptacle;

Fig. 7 is a side perspective view of a medical testing device utilizing multiple plugs and receptacles;

Fig. 8 is a long side cut out view of a plug with a clam shell and a receptacle;

Fig. 9 is a short side cut out view of a plug with a clam shell and a receptacle; and

Fig. 10 illustrates a flow diagram for an example process to connect coaxial contacts, all arranged according to at least some embodiments described herein.

DETAILED DESCRIPTION

[0010] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0011] Fig. 1 is side cutout view of a female component of a coaxial connector and a male component of a coaxial connector, arranged in accordance with at least some embodiments described herein. System 100 may include coaxial connector 10. Coaxial connector 10 may include female connector 120 and male connector 160. Female connector 120 may include female component 20 and female housing 55. Female component 20 may include an insulator 25, an outer spring 30, an outer piston 35, an outer socket body 40, a center contact 45 effective to conduct electricity, and an inner spring 50. Outer socket body 40 may be within female housing 55. Outer spring 30 and outer piston 35 may be within outer socket body 40. Center contact 45 may be within outer spring 30 and outer piston 35. Insulator 25 may be between

center contact 45 and outer spring 30. Female housing 55 may include a first end 52 and a second end 53. Male connector 160 may include male component 60 and male housing 80. Male component 60 may include an outer pin 65, an insulator 70, and a center pin 75 effective to conduct electricity. Insulator 70 may be between center pin 75 and outer pin 65. Male housing 80 may include a first end 82 and a second end 83. First end 52 of female housing 55 may be configured to couple with first end 82 of male housing 80. First end 52 of female housing 55 may be aligned with first end 82 of male housing 80 and first end 52 of female housing 55 may fit within first end 82 of male housing 80. First end 52 of female housing 55 may be configured to facilitate coupling of center contact 45 of outer socket body 40 of female component 20 with outer pin 65 of male component 60. Outer pin 65 may fit within outer socket body 40 when female component 20 and male component 60 couple, and outer pin 65 may engage with outer piston 35. Outer socket body 40 and outer piston 35 may be non-magnetic and may be coated in nickel-phosphorus thin film plating or a ternary alloy of copper, tin and zinc thin film plating. All metal components of female component 20 may be non-magnetic. Outer pin 65 may engage with outer piston 35 and compress outer spring 30 when female component 20 and male component 60 couple. All metal components of male component 60 may be non-magnetic. Spring 30 may be beryllium copper and may be non-magnetic. Upon mating of male component 60 and female component 20, outer piston 35 may move with compressed spring 30 and may expose center contact 45. Center contact 45 of female component 20 may fit within outer pin 65 and may engage with center pin 75 of male component 60. Inner spring 50 may compress when center contact 45 engages with center pin 75. Center pin 75 may be non-magnetic and may be coated in nickel-phosphorus thin film plating or a ternary alloy of copper, tin and zinc thin film plating. As explained in more detail below, outer piston 35 may be configured to engage with

outer pin 65 and facilitate coupling of center contact 45 of female component 20 with center pin 75 of male component 60.

[0012] Fig. 2A is side perspective view of an outer piston of a female component of a coaxial connector, arranged in accordance with at least some embodiments described herein. Fig 2B is a side perspective view of a dimple of an outer piston of a female component of a coaxial connector, arranged in accordance with at least some embodiments described herein. Those components in Figs. 2A and 2B that are labeled identically to components of Fig. 1 will not be described again for the purposes of brevity.

[0013] Outer piston 35 may be a hollow cylindrical tube segment with a first end 205, a second end 210, an outer surface 212a and an inner surface 212b. Outer piston may be a copper alloy such as brass or bronze. Inner surface 212b or outer piston 35 may define a channel 215 through outer piston 35 from first end 205 to second end 210. First end 205 of outer piston 35 may have a flat surface 220 on a plane essentially perpendicular to outer surface 212a and inner surface 212b. Second end 210 of outer piston 35 may have a flat skewed surface 222. Skewed surface 222 may not be on a plane essentially perpendicular to outer surface 212a and inner surface 212band may be at an angle from flat surface 220 of first end 205. Outer piston 35 not be uniform in length due to skewed surface 222 and may range from a longest length of 214a to a shortest length of 214b. Flat surface 220 of first end 205 may include dimples 225 protruding out from flat surface 220. Dimples 225 may be half cylinders, bisected through a circular face of the cylinder, with a flat side 230 and a curved side 235. Flat side 230 of dimples 225 may be contiguous with flat surface 220 of outer piston 35 and curved side 235 may protrude from flat surface 220 of outer piston 35.

[0014] Fig. 3 is side cutout view of a female component of a coaxial connector coupled to a male component of a coaxial connector, arranged in accordance with at least some embodiments described herein. Those components in Fig. 3 that are labeled identically to components of Figs. 1-2 will not be described again for the purposes of brevity.

[0015] Outer pin 65 of male component 60 may fit within outer socket body 40 of female component 20 when male component 60 and female component 20 couple. Outer pin 65 may contact and engage with dimples 225 of outer piston 35. Dimples 225 may reduce a contact area between outer piston 35 and outer pin 65. Dimples 225 may reduce contact stress between outer piston 35 and outer pin 65. Dimples 225 may optimize a Hertz stress during contact between outer piston 35 and outer pin 65.

[0016] Outer pin 65 may engage with dimples 225 of outer piston 35 and compress outer spring 30. Outer piston 35 may move with compressed spring 30 and may expose center contact 45. Center contact 45 of female component 20 may fit within outer pin 65 and may engage with center pin 75 of male component 60. Outer spring 30 may, upon compression, apply a force 310 to skewed surface 222 of outer piston 35 at longest side length of 214a and may apply a second force 320 to skewed surface 222 of outer piston 35 at shortest side length 214b. Force 310 may be greater than force 320 due to spring 30 being more compressed by skewed surface 222 of outer piston 35 at longest side length of 214a than by skewed surface 222 of outer piston 35 at shortest side length 214b. Force 310, being greater than force 320, may in turn apply a force 330, at an end of longest side length 214a that is adjacent to skewed surface 222, towards outer socket body 40. Force 310 being greater than force 320, may, in turn, also apply a force 340, at an end of shortest side length 214b and adjacent to flat surface 220, towards outer socket body 40. Forces 330 and 340 may allow outer piston 35 to slide within outer socket body 40 with low

contact resistance. Outer piston 35 engaged with outer pin 65 may facilitate contact between center contact 45 of female component 20 with center pin 75 of male component 60.

[0017] Fig. 4 is side cutout view of a female component of a coaxial connector coupled to a male component of a coaxial connector, arranged in accordance with at least some embodiments described herein. Those components in Fig. 4 that are labeled identically to components of Figs. 1-3 will not be described again for the purposes of brevity.

[0018] First end 52 of female housing 55 may be configured to couple with first end 82 of male housing 80. First end 52 of female housing 55 may fit within first end 82 of male housing 80 and may be configured to facilitate coupling of contact of outer socket body 40 of female component 20 with outer pin 65 of male component 60. First end 52 of female housing 55 and first end 82 of male housing 80 may be misaligned and may include a gap between a side of first end 52 of female housing 55 and a side of first end 82 of male housing 80. Outer pin 65 of male component 60 may fit within outer socket body 40 of female component 20 when male component 60 and female component 20 couple. Outer pin 65 may contact and engage with dimples 225 of outer piston 35. Outer pin 65 may engage with dimples 225 of outer piston 35 and compress outer spring 30. Outer piston 35 may move with compressed spring 30 and may expose center contact 45. Center contact 45 of female component 20 may fit within outer pin 65 and may engage with center pin 75 of male component 60.

[0019] As explained above, outer spring 30 may, upon compression, apply forces to outer piston 35 and may allow outer piston 35 to slide within outer socket body 40 with low contact resistance. Outer piston 35 engaged with outer pin 65 may facilitate contact between center contact 45 of female component 20 with center pin 75 of male component 60 and may compensate for a misalignment of outer pin 65 and outer socket body 40 such as coupling at an

oblique angle. Outer piston 35 may compensate for a misalignment of center contact 45 of female component 20 with center pin 75 of male component 60 of +/- 0.3 mm in an axial (X,Y) direction.

[0020] Fig. 5 is side cutout view of a female component of a coaxial connector coupled to a male component of a coaxial connector, arranged in accordance with at least some embodiments described herein. Those components in Fig. 5 that are labeled identically to components of Figs. 1-4 will not be described again for the purposes of brevity.

[0021] First end 52 of female housing 55 may be configured to couple with first end 82 of male housing 80. First end 52 of female housing 55 may fit within first end 82 of male housing 80 and may be configured to facilitate coupling of outer socket body 40 of female component 20 with outer pin 65 of male component 60. First end 52 of female housing 55 and first end 82 of male housing 80 may be misaligned and may include a gap 510 between end of first end 52 of female housing 55 and male housing 80. Outer pin 65 of male component 60 may fit within outer socket body 40 of female component 20 when male component 60 and female component 20 couple. Outer pin 65 may contact and engage with dimples 225 of outer piston 35. Outer pin 65 may engage with dimples 225 of outer piston 35 and compress outer spring 30. Outer piston 35 may move with compressed spring 30 and may expose center contact 45. Center contact 45 of female component 20 may fit within outer pin 65 and may engage with center pin 75 of male component 60.

[0022] As explained above, outer spring 30 may, upon compression, apply forces to outer piston 35 and may allow outer piston 35 to slide within outer socket body 40 with low contact resistance. Outer piston 35 engaged with outer pin 65 may facilitate contact between center contact 45 of female component 20 with center pin 75 of male component 60. Outer piston 35

may compensate for a misalignment of outer pin 65 and outer socket body 40. Outer piston 35 may compensate for a misalignment gap between first end 52 of female housing 55 and male housing 80 of up to 1 mm.

[0023] Fig. 6A is side perspective view of a plug and a receptacle, arranged in accordance with at least some embodiments described herein. Fig. 6B is side perspective view of a plug coupled with a receptacle, arranged in accordance with at least some embodiments described herein. Those components in Figs. 6A and 6B that are labeled identically to components of Figs. 1-5 will not be described again for the purposes of brevity.

[0024] System 600 may include a plug 610 and a receptacle 620. In an embodiment, plug 610 may include multiple male components 60 and receptacle 620 may include multiple female components 20. Plug 610 may be configured to couple with receptacle 620 such that each male component 60 is coupled to a respective female component 20 within receptacle 620. Plug 610 and receptacle 620 may be components for a coaxial connector. Plug 610 and receptacle 620 may be waterproof and may be utilized in industry. All metal components of plug 610 and receptacle 620 may be non-magnetic. Plug 610 and receptacle 620 may be used on medical testing equipment such as magnetic resonance imaging (MRI) equipment. Plug 610 and receptacle 620 may also be used as a catheter connector or endoscope connector for medical equipment.

[0025] Fig. 7 is a side perspective view of a medical testing device utilizing multiple plugs and receptacles, arranged in accordance with at least some embodiments described herein. Those components in Fig. 7 that are labeled identically to components of Figs. 1-6 will not be described again for the purposes of brevity.

[0026] A medical testing device 710 may include a cover 720 and a base 730. Cover 720 may include multiple male connectors 160 with male components 60. Base 730 may include multiple female connectors 120 with female components 20. Male connectors 160 of cover 720 may couple with female connectors 120 of base 730.

[0027] Fig. 8 is a long side cut out view of a plug with a clam shell and a receptacle, arranged in accordance with at least some embodiments described herein. Those components in Fig. 8 that are labeled identically to components of Figs. 1-7 will not be described again for the purposes of brevity.

[0028] System 800 may include a plug 810 with a clam shell 815 and a receptacle 820. In an embodiment, plug 810 may include clam shell 815 and multiple male components 60. Clam shell 815 may be a waterproof barrier for plug 810. Receptacle 820 may include multiple female components 20. Plug 810 may be configured to couple with receptacle 820 such that each male component 60 is coupled to a respective female component 20 within receptacle 820. Plug 810 and receptacle 820 may be components for a coaxial connector.

[0029] Fig. 9 is a short side cut out view of a plug with a clam shell and a receptacle, arranged in accordance with at least some embodiments described herein. Those components in Fig. 9 that are labeled identically to components of Figs. 1-8 will not be described again for the purposes of brevity.

[0030] System 900 may include plug 810 with clam shell 815 and receptacle 820. Plug 810 may include clam shell 815, lock lever 910, and multiple male components 60. Receptacle 820 may include protrusions 920 and multiple female components 20. Plug 810 may be configured to couple with receptacle 820 such that lock levers 910 clip to protrusions 920 and lock plug 810

to receptacle 820 and each male component 60 is coupled to a respective female component 20 within receptacle 820.

[0031] A device in accordance with the present disclosure may allow for coupling of coaxial contacts through over 100,000 mating cycles. A device in accordance with the present disclosure may provide a spring load coaxial contact that may compensate for misalignment between a male component and a female component of +/- 0.3 mm in an axial (X, Y) direction. A device in accordance with the present disclosure may provide a spring load coaxial contact that may compensate for misalignment gap between an end of a female housing and a male housing of up to 1 mm. A device in accordance with the present disclosure may provide a plug and receptacle for use with medical equipment such as magnetic resonance imaging (MRI) equipment.

[0032] Fig. 10 illustrates a flow diagram for an example process to connect coaxial contacts, arranged in accordance with at least some embodiments presented herein. An example process may include one or more operations, actions, or functions as illustrated by one or more of blocks S2, S4, S6, S8, and/or S10. Although illustrated as discrete blocks, various blocks may be divided into additional blocks, combined into fewer blocks, or eliminated, depending on the desired implementation.

[0033] Processing may begin at block S2, "Align a first end of a female housing of a female component with a first end of a male housing of a male component, wherein the female component includes a female housing, an outer socket body within the female housing; an outer spring within the outer socket body, an outer piston within the outer socket, wherein the outer piston is a cylindrical tube segment with an inner surface and an outer surface, the outer piston has a first piston end and a second piston end, the first piston end has a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface, the first piston end

includes dimples protruding out from the flat surface of the first piston end, the second piston end has a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface, and the second piston end is in contact with an end of the outer spring; a center contact effective to conduct electricity and within the outer spring and the outer piston, and a first insulator between the center contact and the outer spring, and the male component includes, a male housing, an outer pin within the male housing, a center pin effective to conduct electricity and within the outer pin, and a second insulator between the center pin and the outer pin". At block S2, a first end of a female housing of a female component may be aligned with a first end of a male housing of a male component. The female component may include a female housing, an outer socket body within the female housing, an outer spring within the outer socket body, an outer piston within the outer socket, a center contact, and a first insulator between the center contact and the outer spring. The outer piston may be a cylindrical tube segment with an inner surface and an outer surface. The outer piston may have a first piston end and a second piston end. The first piston end may have a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface. The first piston end may include dimples protruding out from the flat surface of the first piston end. The second piston end may have a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface. The second piston end may be in contact with an end of the outer spring. The center contact may be effective to conduct electricity. The center contact may be within the outer spring and the outer piston. The male component may include a male housing, an outer pin within the male housing, a center pin, and a second insulator between the center pin and the outer pin. The center pin may be effective to conduct electricity. The center pin may be within the outer pin.

[0034] Processing may continue from block S2 to block S4, "Couple the first end of the female housing with the first end of the male housing". At block S4, the first end of the female housing may be coupled to the first end of the male housing. The first end of the female housing may be configured to couple with the first end of the male housing.

[0035] Processing may continue from block S4 to block S6, "Couple the outer socket with the outer pin ". At block S6, the outer socket of the female component may be coupled with the outer pin of the male component. The outer socket of the female component may be configured to couple with the outer pin of the male component.

[0036] Processing may continue from block S6 to block S8, "Engage the outer pin with outer piston". At block S8, the outer pin of the male component may engage with the outer piston of the female component. The outer pin of the male component may be configured to engage with the outer piston of the female component.

[0037] Processing may continue from block S8 to block S10, "Contact the center contact with the center pin". At block S10, the center contact of the female component may contact with the center pin of the male component. The outer piston may be configured to, upon engagement with the outer pin, contact the center contact with the center pin.

[0038] While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

CLAIMS

What is claimed is:

1. A connector effective to connect coaxial contacts, the connector comprising:

a female component, wherein the female component includes:

a female housing;

an outer socket body within the female housing;

an outer spring within the outer socket body;

an outer piston within the outer socket body, wherein the outer piston is a cylindrical tube segment with an inner surface and an outer surface, the outer piston has a first piston end and a second piston end, the first piston end has a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface, the first piston end includes dimples protruding out from the flat surface of the first piston end, the second piston end has a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface, and the second piston end is in contact with an end of the outer spring;

a center contact effective to conduct electricity and within the outer spring and the outer piston; and

a first insulator between the center contact and the outer spring;

a male component, wherein the male component includes:

a male housing;

an outer pin within the male housing;

a center pin effective to conduct electricity and within the outer pin; and

a second insulator between the center pin and the outer pin;

wherein a first end of the female housing is configured to couple with a first end of the male housing, the outer socket is configured to couple with the outer pin, the outer pin is configured to engage with the outer piston, and the outer piston is configured to, upon engagement with the outer pin, contact the center contact with the center pin.

2. The connector of claim 1, wherein the dimples are half cylinders, bisected through a circular face of the cylinder, the dimples include a flat side and a curved side, the flat side of the dimples is contiguous with the flat surface of the first piston end and the curved side of the dimples protrude from the flat surface of the first piston end.

3. The connector of claim 2, wherein the dimples reduce a contact area between the first piston end of the outer piston and the outer pin.

4. The connector of claim 2, wherein the dimples reduce contact stress between the first piston end of the outer piston and the outer pin.

5. The connector of claim 2, wherein the dimples optimize a Hertz stress between the first piston end of the outer piston and the outer pin when the first piston end of the outer piston is in contact with the outer pin.

6. The connector of claim 1, wherein the outer socket body and the outer piston are non-magnetic.

7. The connector of claim 1, wherein the outer piston compensates for a misalignment of the center contact and the center pin of +/- 0.3 mm in an axial direction.

8 The connector of claim 1, wherein the outer piston compensates for a misalignment between the first end of the female component and the male housing of up to 1 mm.

9. A system to connect coaxial contacts, the system comprising:

a receptacle wherein the receptacle includes at least one female component, wherein the at least one female component includes:

a female housing;

an outer socket body within the female housing;

an outer spring within the outer socket body;

an outer piston within the outer socket body, wherein the outer piston is a cylindrical tube segment with an inner surface and an outer surface, the outer piston has a first piston end and a second piston end, the first piston end has a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface, the first piston end includes dimples protruding out from the flat surface of the first piston end, the second piston end has a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface, and the second piston end is in contact with an end of the outer spring;

a center contact effective to conduct electricity and within the outer spring and the outer piston; and

a first insulator between the center contact and the outer spring;

a plug, wherein the plug includes at least one a male component, wherein the at least one male component includes:

a male housing;

an outer pin within the male housing;

a center pin effective to conduct electricity and within the outer pin; and

a second insulator between the center pin and the outer pin;

wherein a first end of each female housing is configured to couple with a first end of a respective male housing, the outer socket is configured to couple with the outer pin, the outer pin is configured to engage with the outer piston, and the outer piston is configured to, upon engagement with the outer pin, contact the center contact with the center pin.

10. The system of claim 9, wherein the dimples are half cylinders, bisected through a circular face of the cylinder, the dimples include a flat side and a curved side, the flat side of the dimples is contiguous with the flat surface of the first piston end and the curved side of the dimples protrude from the flat surface the first piston end.

11. The system of claim 10, wherein the dimples reduce a contact area between the first piston end of the outer piston and the outer pin.

12. The system of claim 10, wherein the dimples reduce contact stress between the first piston end of the outer piston and the outer pin.

13. The system of claim 10, wherein the dimples optimize a Hertz stress between the first piston end of the outer piston and the outer pin when the first piston end of the outer piston is in contact with the outer pin.

14. The system of claim 9, wherein the outer socket body and the outer piston are non-magnetic and coated in nickel-phosphorus thin film plating.

15. The system of claim 10, wherein the plug and receptacle are part of magnetic resonance imaging (MRI) equipment.

16. The system of claim 10, wherein the outer piston compensates for a misalignment of the center contact and the center pin of +/- 0.3 mm in an axial direction.

17. The system of claim 10, wherein the outer piston compensates for a misalignment between the first end of the female component and the male housing of up to 1 mm.

18. A method to connect coaxial contacts, the method comprising:

aligning a first end of a female housing of a female component with a first end of a male housing of a male component, wherein the female component includes:

a female housing;

an outer socket body within the female housing;

an outer spring within the outer socket body;

an outer piston within the outer socket body, wherein the outer piston is a cylindrical tube segment with an inner surface and an outer surface, the outer piston has a first piston end and a second piston end, the first piston end has a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface, the first piston end includes dimples protruding out from the flat surface of the first piston end, the second piston end has a flat skewed surface which is not on a plane essentially

perpendicular to the inner surface and the outer surface, and the second piston end is in contact with an end of the outer spring;

a center contact effective to conduct electricity and within the outer spring and the outer piston; and

a first insulator between the center contact and the outer spring; and

the male component includes;

a male housing;

an outer pin within the male housing;

a center pin effective to conduct electricity and within the outer pin; and

a second insulator between the center pin and the outer pin;

coupling the first end of the female housing with the first end of the male housing;

coupling the outer socket with the outer pin;

engaging the outer pin with outer piston; and

contacting the center contact with the center pin.

19. The method of claim 18, wherein the outer piston compensates for a misalignment of the center contact and the center pin of +/- 0.3 mm in an axial direction.

20. The method of claim 18, wherein the outer piston compensates for a misalignment between the first end of the female component and the male housing of up to 1 mm.

Fig. 1

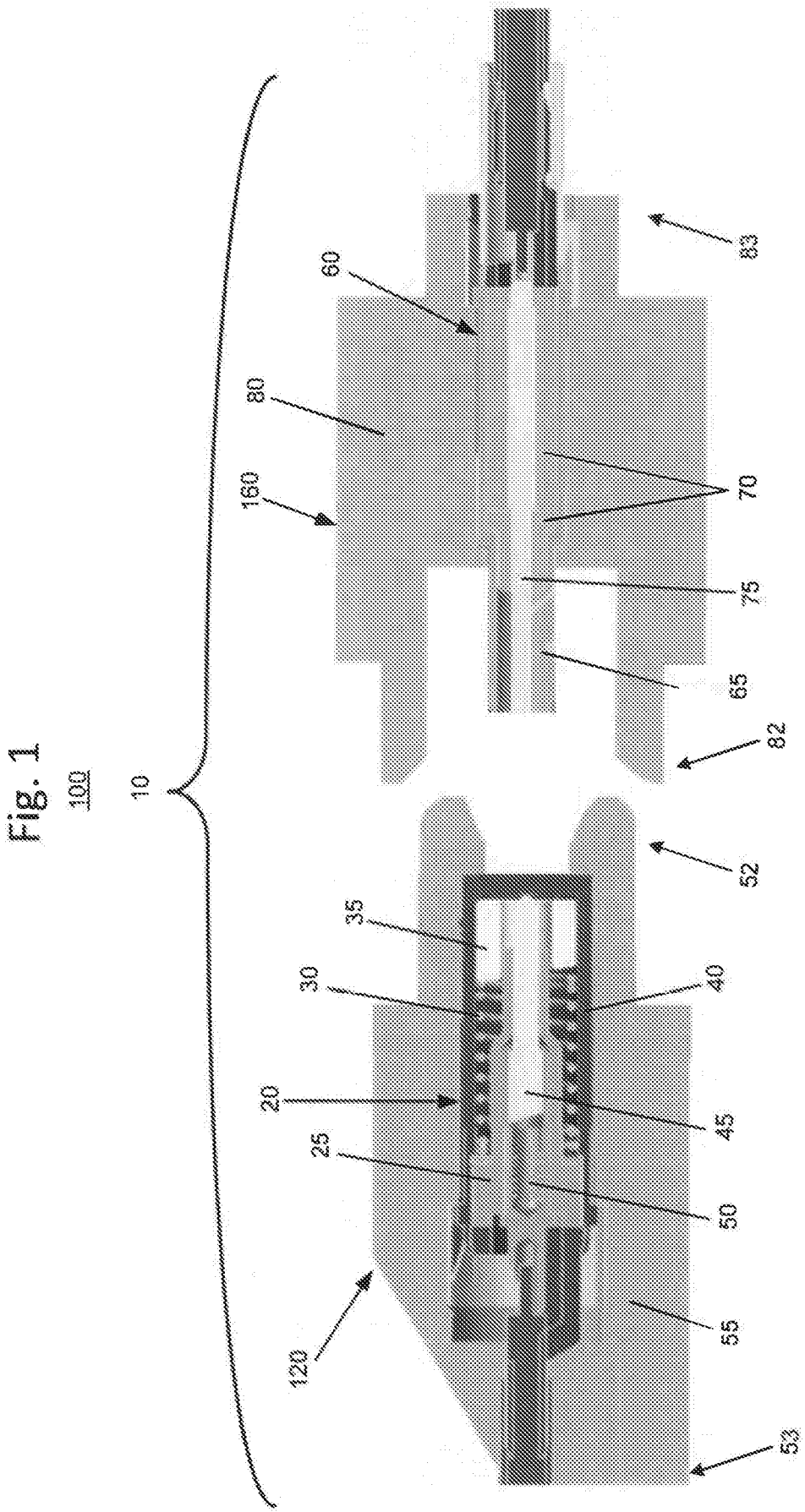


Fig. 2A

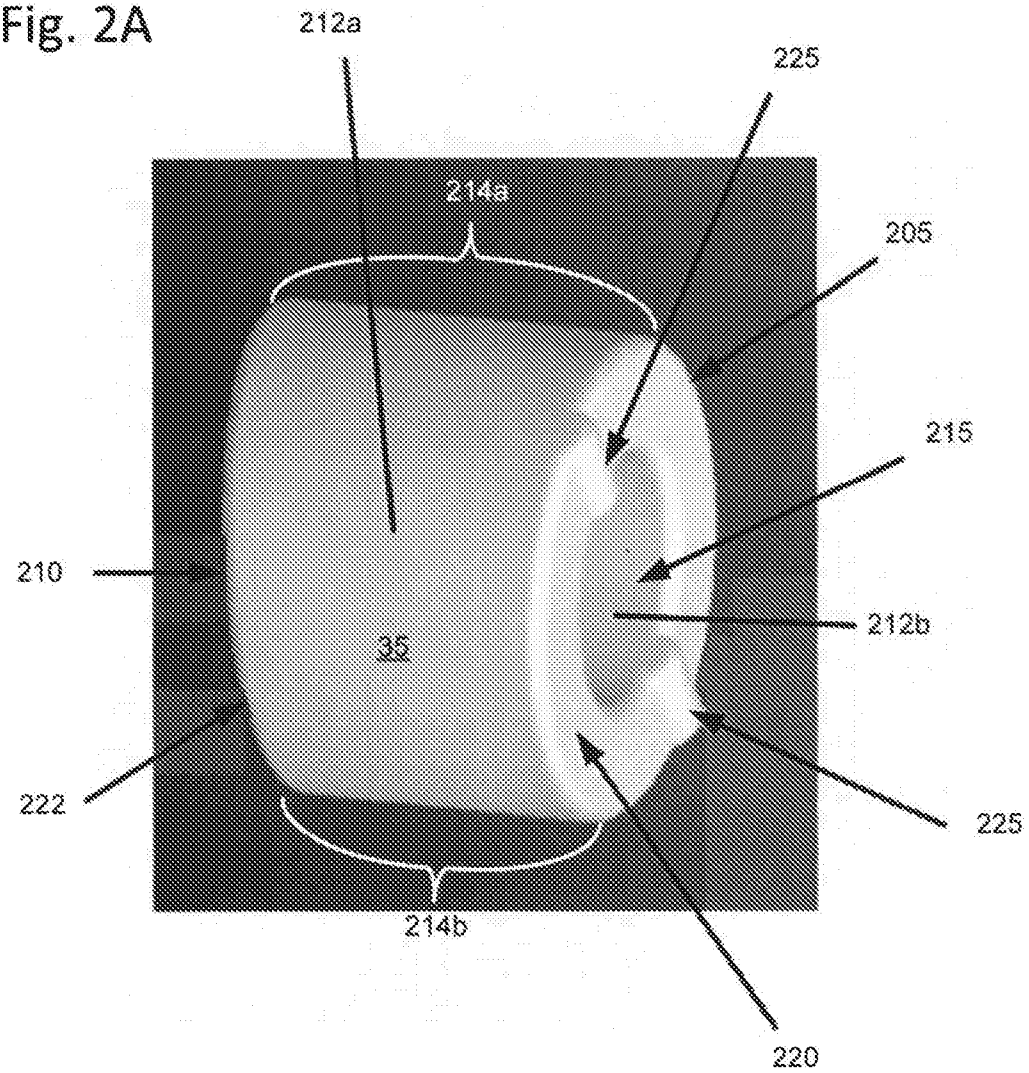


Fig. 2B

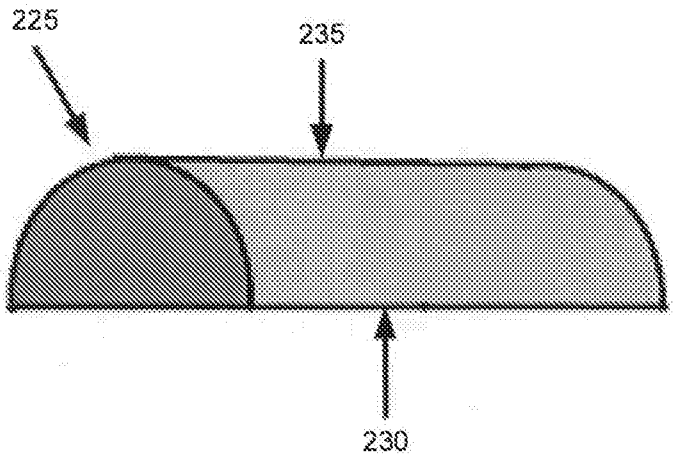


Fig. 3

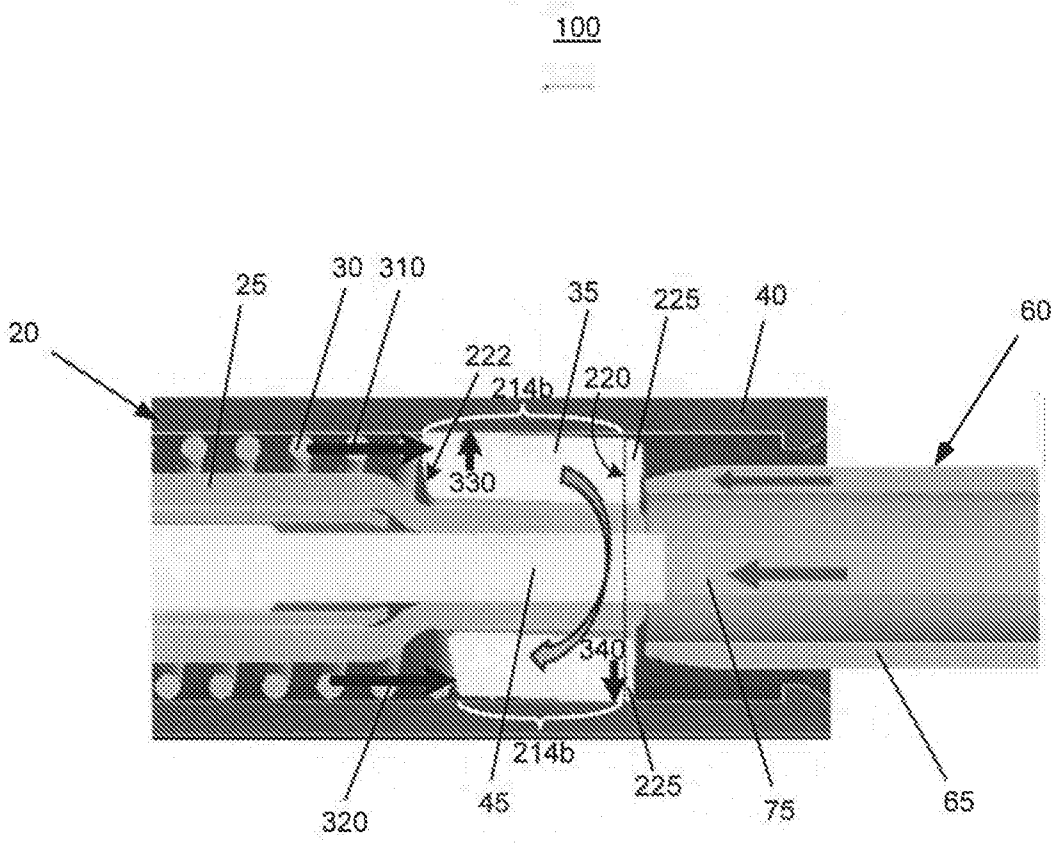

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214b
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214b
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Fig. 4

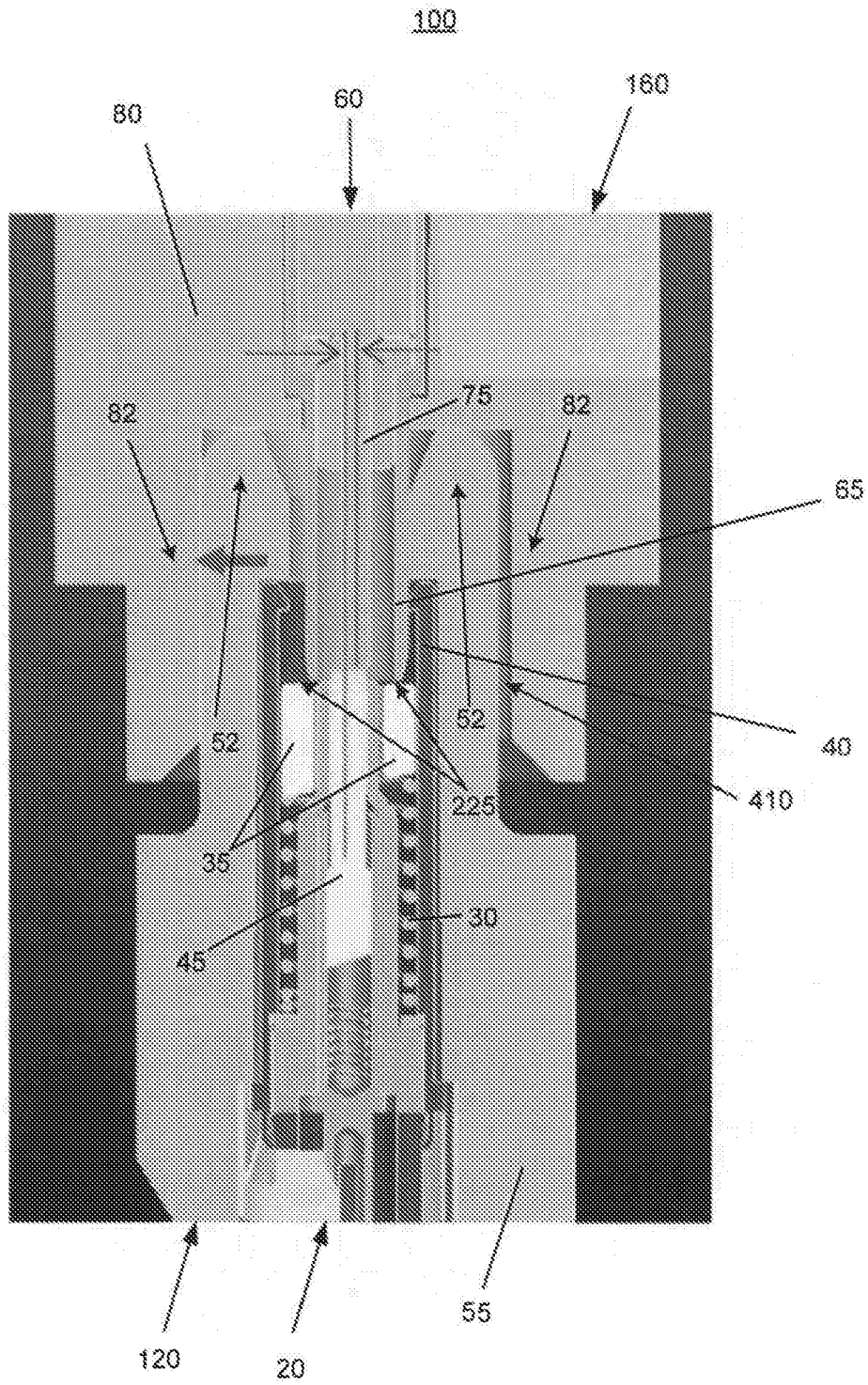


Fig. 5

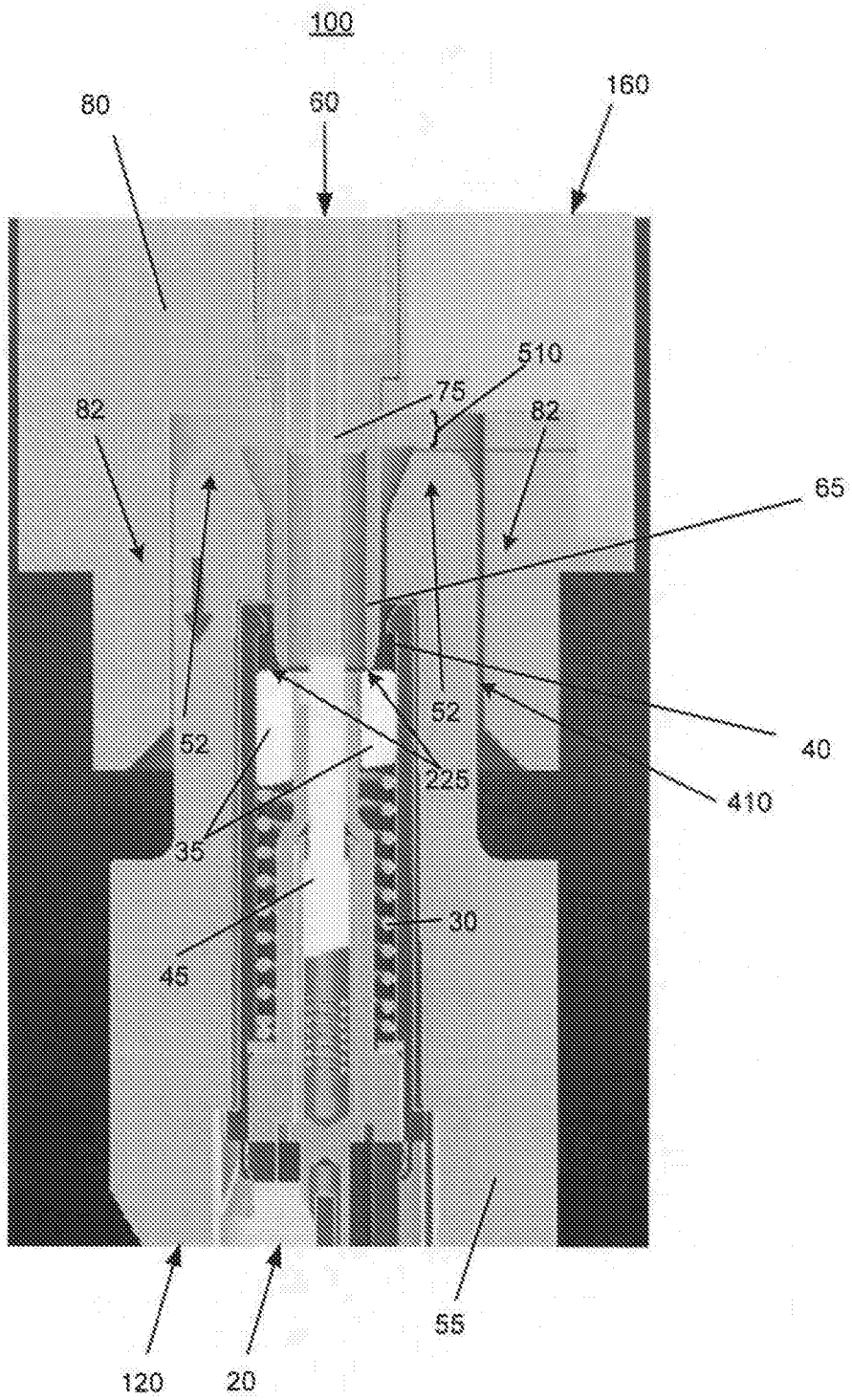


Fig. 6A

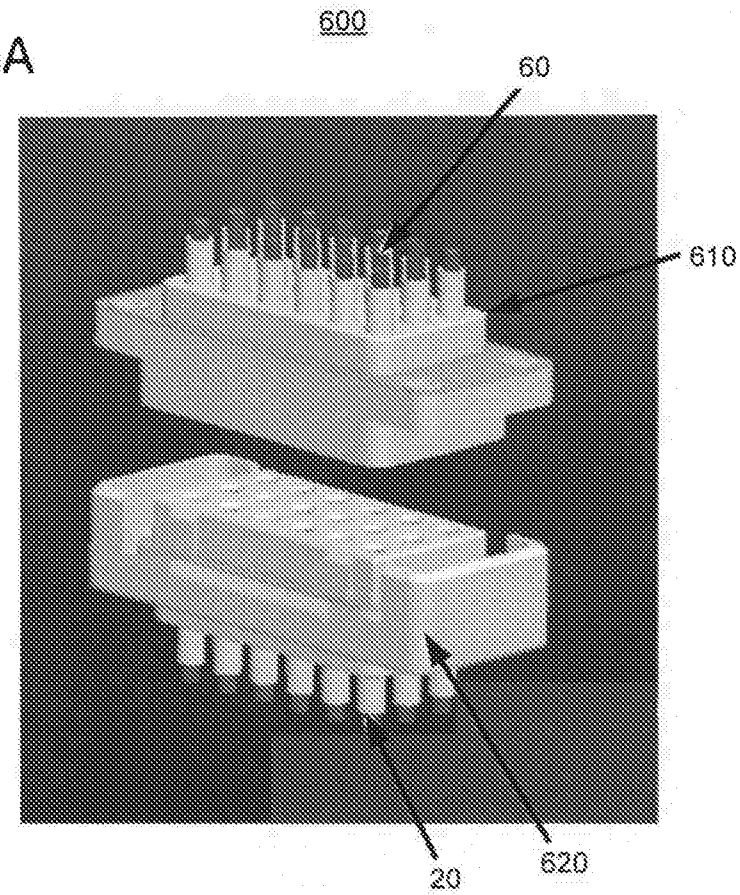


Fig. 6B

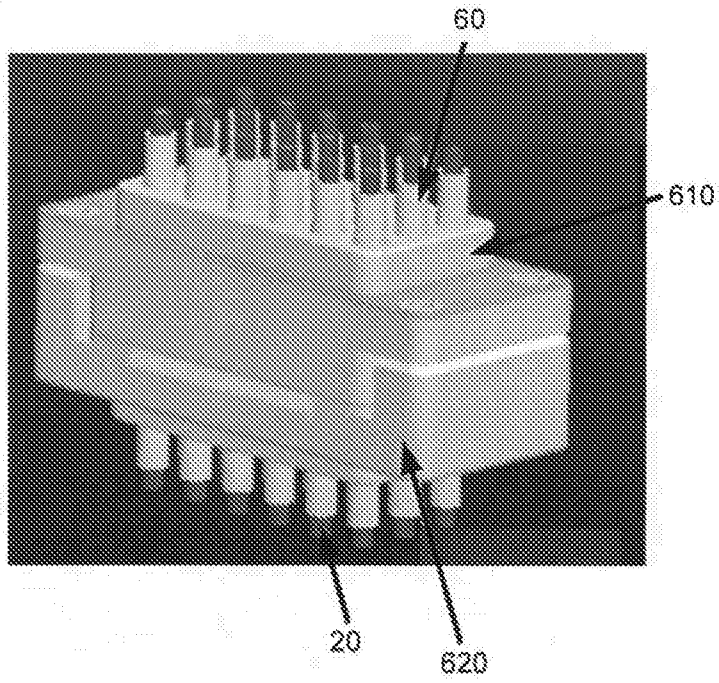


Fig. 7

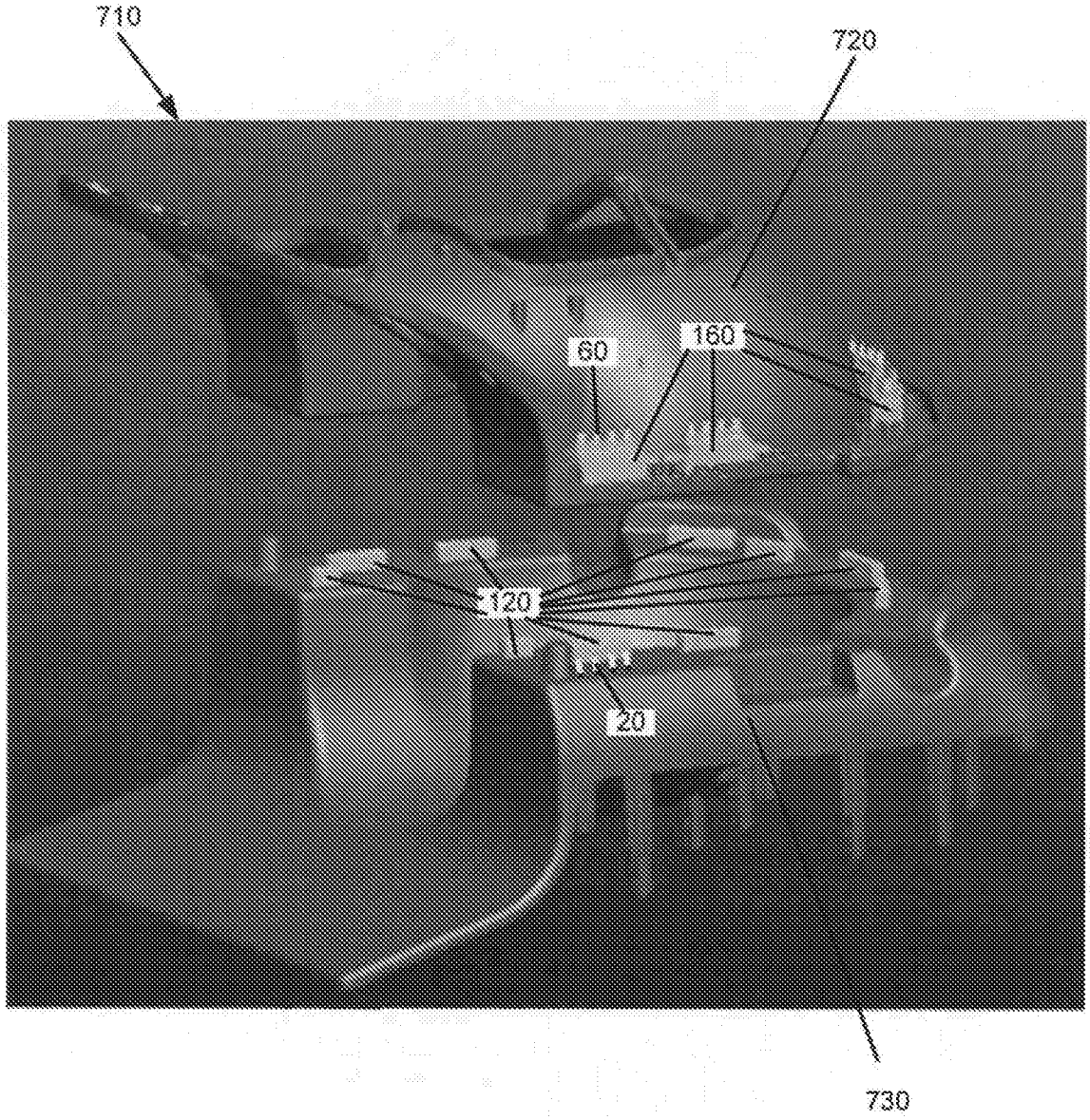


Fig. 8

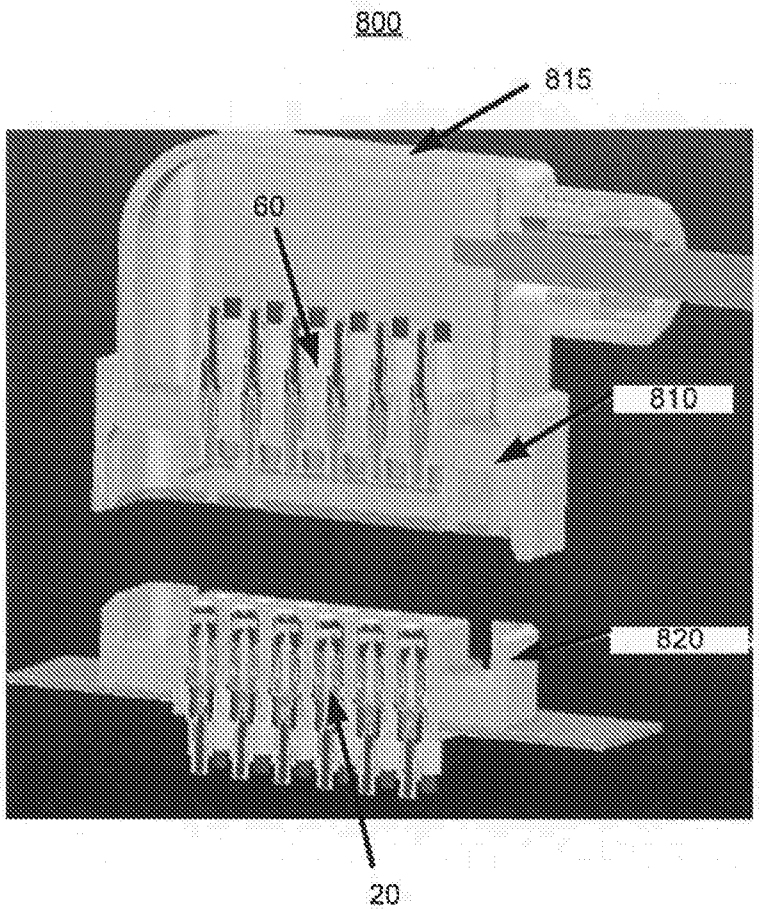


Fig. 9

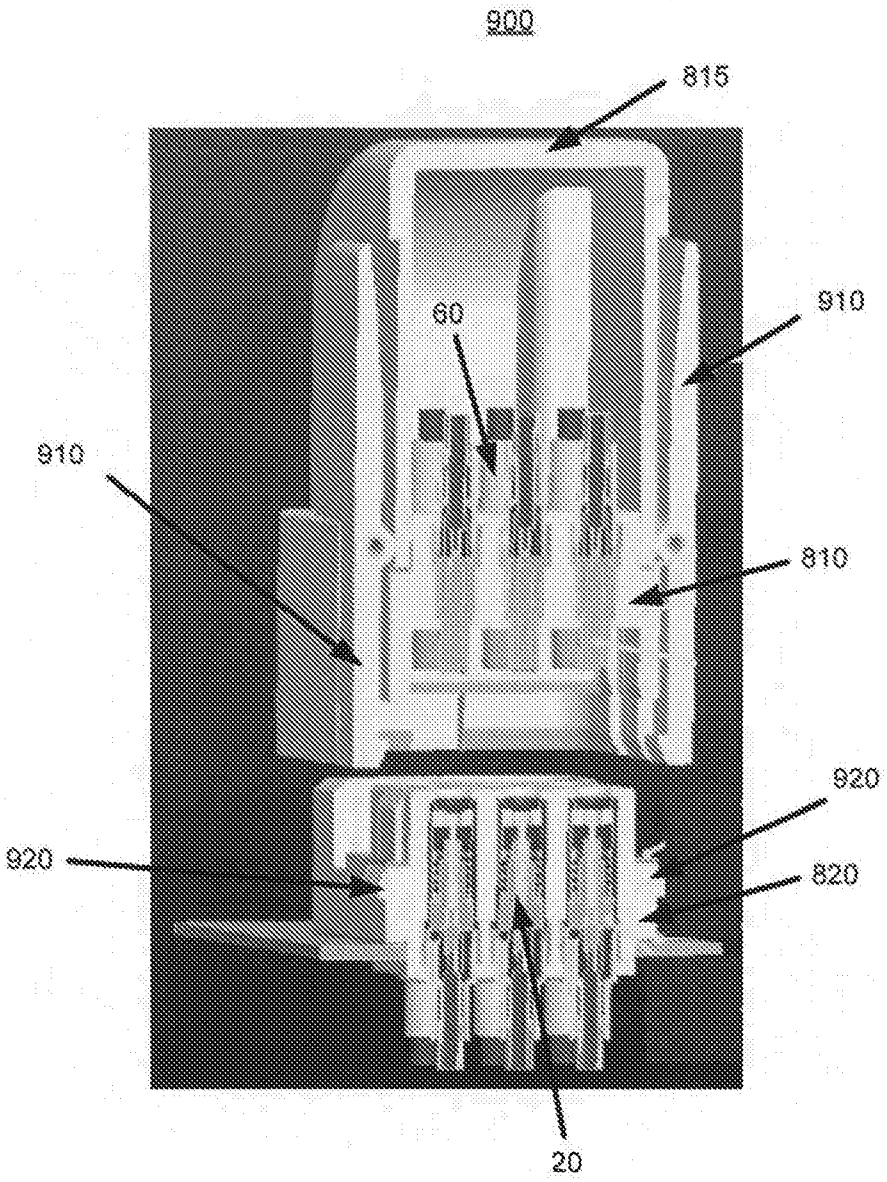
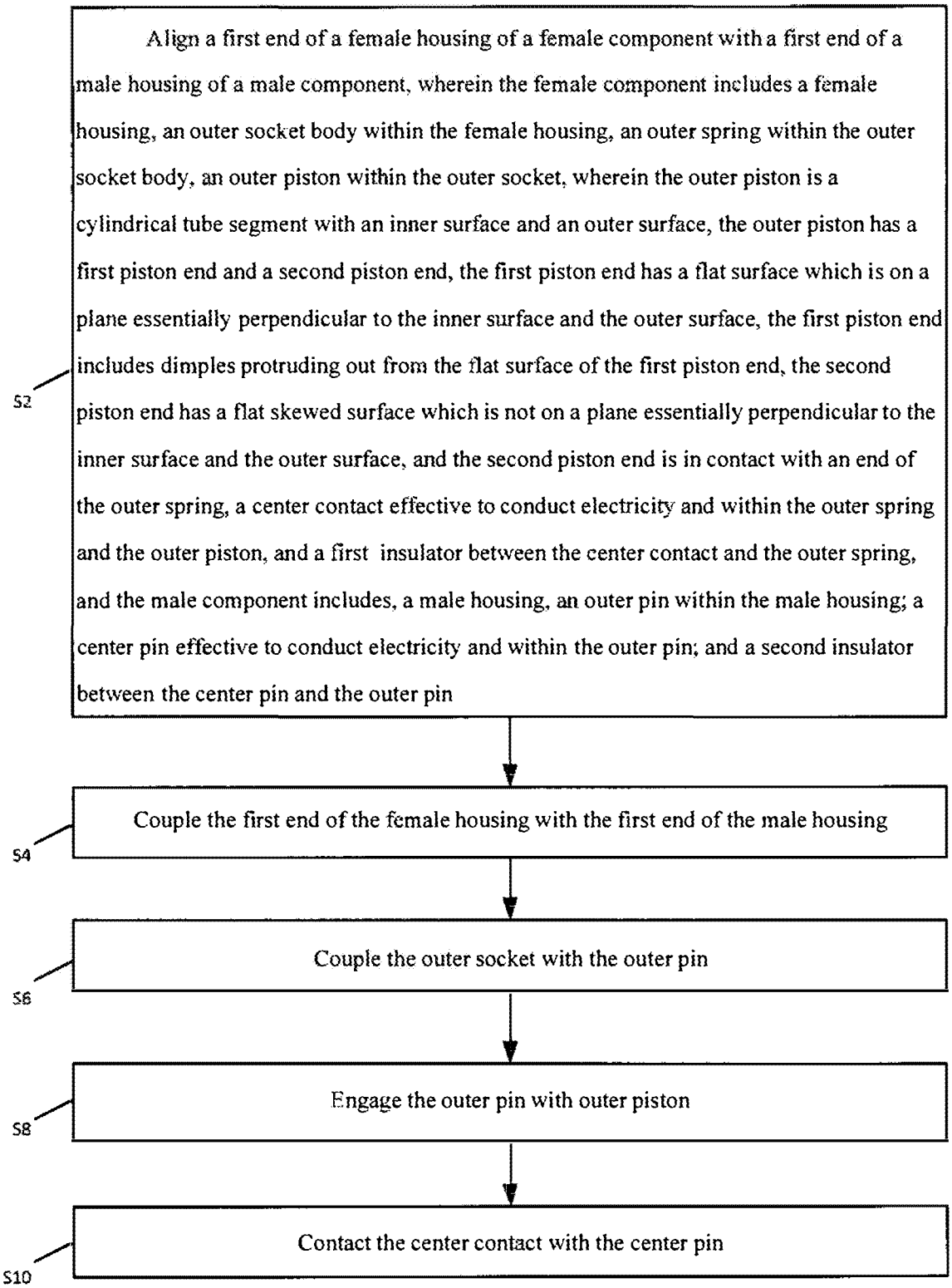


Fig. 10


Align a first end of a female housing of a female component with a first end of a male housing of a male component, wherein the female component includes a female housing, an outer socket body within the female housing, an outer spring within the outer socket body, an outer piston within the outer socket, wherein the outer piston is a cylindrical tube segment with an inner surface and an outer surface, the outer piston has a first piston end and a second piston end, the first piston end has a flat surface which is on a plane essentially perpendicular to the inner surface and the outer surface, the first piston end includes dimples protruding out from the flat surface of the first piston end, the second piston end has a flat skewed surface which is not on a plane essentially perpendicular to the inner surface and the outer surface, and the second piston end is in contact with an end of the outer spring, a center contact effective to conduct electricity and within the outer spring and the outer piston, and a first insulator between the center contact and the outer spring, and the male component includes, a male housing, an outer pin within the male housing; a center pin effective to conduct electricity and within the outer pin; and a second insulator between the center pin and the outer pin
S2
Couple the first end of the female housing with the first end of the male housing
S4
Couple the outer socket with the outer pin
S6
Engage the outer pin with outer piston
S8
Contact the center contact with the center pin
S10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 20/18209

A. CLASSIFICATION OF SUBJECT MATTER

IPC - H01R 13/02, H01R 13/24, H01R 24/38, H01R 24/40, H01R 24/44, H01R 9/05 (2020.01)

CPC - H01R 13/02, H01R 13/24, H01R 13/6474, H01R 13/648, H01R 13/658, H01R 24/40, H01R 24/44, H01R 9/05, H01R 13/2421, H01R 13/6583, H01R 13/64, H01R 13/646, H01R 13/00, H01R 24/00, H01R 9/0524, H01R 4/48

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)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018/0131153 A1 (CORNING OPTICAL COMMUNICATIONS RF LLC) 10 May 2018 (10.05.2018), entire document, especially Fig. 1A, 4A; para[0030]; para[0033]; para[0037]; para[0041]; para[0046]; para[0050]; para[0035]; para[0059];	1-20
A	US 3,609,637 A1 (Cole) 28 September 1971 (28.09.1971), entire document, especially Fig. 1, 2a, 2b; col 2, ln 30-40; col 3, ln 1-16; col 2, ln 41-45; col 3, ln 20-36;	1-20
A	US 6,776,668 B1 (Scyoc et al.) 17 August 2004 (17.08.2004), entire document, especially Fig. 1, 4; col 4, ln 10-25; col 4, ln 37-47; col 5, ln 64 to col 6, ln 24;	1-20
A	DE 44 39 852 A1 (SPINNER GMBH ELEKTROTECH) 09 May 1996 (09.05.1996), entire document	1-20
A	JP 2003-123910 A (MURATA MANUFACTURING CO) 25 April 2003 (25.04.2003), entire document	1-20
A	US 7,972,173 B1 (Hyzin et al.) 05 July 2011 (05.07.2011), entire document	1-20
A	US 2013/0244509 A1 (Holland) 19 September 2013 (19.09.2013), entire document	1-20
A	US 2004/0077215 A1 (Palinkas et al.) 22 April 2004 (22.04.2004), entire document	1-20
A	US 2006/0046565 A1 (Hosler, SR.) 02 March 2006 (02.03.2006), entire document	1-20

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
15 April 2020	07 MAY 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Lee Young Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 20/18209

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,027,373 A (Gray et al.) 22 February 2000 (22.02.2000), entire document	1-20
A	WO 1996/33530 A1 (FRAMATOME CONNECTORS INT et al.) 24 October 1996 (24.10.1996), entire document	1-20