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Fluid connector including a connection verification contact

Abstract

A cartridge for a fluid connector including a connector body having a bore, and a tube, the cartridge including a first end, a second end, a first through-bore, a first radially outward facing surface, a first radially inward facing surface, and an electrical contact at least partially embedded in the first radially inward facing surface.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) The present application is the U.S. National Stage Application pursuant to 35 U.S.C. § 371 of International Patent Application No. PCT/US2020/054225, filed on Oct. 5, 2020, which application is hereby incorporated by reference in its entirety.

FIELD

(2) The present disclosure relates to fluid connectors, and, more particularly, to a fluid connector including an electrical contact that creates an electrical circuit between components therein when the fluid connector is in a fully engaged/connected state.

BACKGROUND

(3) Fluid connectors are integral components for many applications, and especially for automotive applications. Since an automotive system is made up of various components such as a radiator, transmission, and engine, fluid must be able to travel not only within each component but also between components. An example of fluid traveling between components is the transmission fluid traveling from the transmission to the transmission oil cooler in order to lower the temperature of the transmission fluid. Fluid predominantly moves between components via flexible or rigid hoses which connect to each component by fluid connectors. Such fluid connectors typically include a retaining clip, retaining ring clip, or snap ring carried on the connector body which is adapted to snap behind a raised shoulder of a tube when the tube is fully inserted into the connector body.

(4) However, during the assembly process, the raised shoulder might snap behind one of the protrusions of retaining clip and give the appearance of a full connection, when in reality there is only a partial connection. Additionally, the tube can get stuck in the in the connector body without every engaging the retaining clip, which again provides the illusion of an adequate connections. In these scenarios of poor connection, a tube blow off situation can occur resulting in leaks or other quality issues.

(5) Thus, there has been a long-felt need for a fluid connector including a connection verification contact that positively indicates a correct or an incorrect installation of the tube in the connector body.

SUMMARY

(6) According to aspects illustrated herein, there is provided a cartridge for a fluid connector including a connector body having a bore, and a tube, the cartridge comprising a first end, a second end, a first through-bore, a first radially outward facing surface, a first radially inward facing surface, and an electrical contact at least partially embedded in the first radially inward facing surface.

(7) In some embodiments, the electrical contact comprises a first section extending into the first through-bore, and a second section operatively arranged to engage the connector body. In some embodiments, the second section is arranged at the first end. In some embodiments, the second section is arranged in a groove in the first end. In some embodiments, the first section is arranged in an aperture, the aperture extending axially from the first end to the first radially inward facing surface. In some embodiments, the first section is operatively arranged to engage the tube. In some embodiments, the electrical contact comprises a first contact element hingedly connected to the first radially inward facing surface, and a second contact element engaged with the first contact element and operatively arranged to engage the connector body. In some embodiments, the cartridge further comprises a second through bore and the second contact element is slidably arranged in the second through-bore. In some embodiments, the second contact element is at least partially arranged in a groove in the first radially outward facing surface.

(8) According to aspects illustrated herein, there is provided a fluid connector, comprising a connector body, including a first through-bore, a first radially inward facing surface, and an axial surface, a non-conductive cartridge removably arranged in the first through-bore, including a first end, a second end, a second through-bore, a first radially outward facing surface, a second radially

inward facing surface, and an electrical contact at least partially embedded in the first radially inward facing surface, and a retaining clip operatively arranged in the cartridge proximate the second end, the retaining clip including at least one protrusion extending radially inward into the second through-bore.

(9) In some embodiments, the electrical contact comprises a first section extending into the second through-bore, and a second section operatively arranged to engage the connector body. In some embodiments, the second section is arranged at the first end. In some embodiments, the second section is arranged in a groove in the first end. In some embodiments, the first section is arranged in an aperture, the aperture extending axially from the first end to the second radially inward facing surface. In some embodiments, the electrical contact comprises a first contact element hingedly connected to the first radially inward facing surface, and a second contact element engaged with the first contact element and operatively arranged to engage the connector body. In some embodiments, the cartridge further comprises a third through-bore and the second contact element is slidably arranged in the third through-bore. In some embodiments, the second contact element comprises a first section engaged with the first contact element, and a second section arranged in a groove in the first radially outward facing surface. In some embodiments, in a partially engaged state, the second section is spaced apart from the first radially inward facing surface, and in a fully engaged state, the second section abuts against the first radially inward facing surface. In some embodiments, in a partially engaged state, the second contact element is arranged radially inward from the first radially outward facing surface, and in a fully engaged state, the second contact element is aligned with or arranged radially outward from the first radially outward facing surface.

(10) According to aspects illustrated herein, there is provided a fluid connector, comprising a connector body, including a first through-bore, a first radially inward facing surface, and an axial surface, a cartridge secured in the first through-bore, including a first end, a second end, a second through-bore, a first radially outward facing surface, a second radially inward facing surface, and an electrical contact extending from the second radially inward facing surface to at least one of the first end and the first radially outward facing surface, a retaining clip operatively arranged in the cartridge proximate the second end, the retaining clip including at least one protrusion extending radially inward into the second through-bore, and a tube operatively arranged to be secured in the connector body via the cartridge, wherein in a partially engaged state, the tube is not electrically connected to the connector body, and in a fully engaged state, the tube is electrically connected to the connector body via the electrical contact.

(11) According to aspects illustrated herein, there is provided a fluid connector that provides positive identification that a full connection has been made of the tube to the connector body during the production assembly process. The change in continuity of the connector body and the tube assembly provides verification that the tube has been installed completely past the retaining clip. This change in continuity can be recorded visually (e.g., indication lights), audibly (e.g., one or more sounds such as a “beep”), and/or electronically using some form of input/battery voltage and an intelligent electronic device (IED) and/or a programmable logic controller (PLC)/software program. The fluid connector provides the user a positive identification for correct installation of the tube into the connector body.

(12) The fluid connector of the present disclosure prevents the user from experiencing a tube blow off situation that can result in leaks or other quality issues. The fluid connector can provide reassurance that a full connection exists. The fluid connector of the present disclosure comprises a self-contained detection device arranged within the connector body itself and does not require a separate piece to be assembled at the tube supplier. In some embodiments, the tube and the connector body comprise a conductive material.

(13) The fluid connector of the present disclosure is a self-contained assembly solution that utilizes the contact of the tube the connector body through the conductive contact pin. The fluid connector includes isolating materials to prevent the retaining clip and tube from creating a false connection

(only when the tube shoulder contacts the conductive pin is the circuit completed between the connector body and the tube). In some embodiments, the fluid connector comprises an anodized washer and a rubber gasket operatively arranged to isolate the tube from contacting the connector body. The retaining clip is isolated from the connector body by being arranged in a plastic or non-conductive cartridge. The anodized washer is arranged adjacent to the cartridge and a flange of the connector body is crimped to secure the components therein. It should be appreciated that the fluid connector of the present disclosure can be reused in an assembly plant if a fluid line must be removed (e.g., from a vehicle) and reinstalled.

(14) In some embodiments, the fluid connector of the present disclosure comprises a plastic insert or cartridge that will house the contact pin and act as an isolator for the tube. In some embodiments, the contact pin is insert molded or pressed into the cartridge. A rubber isolator or seal is arranged in the through-bore of the connector body (e.g., an O-ring) to prevent the tube nose from contacting the connector body and a nonconductive washer or metallic washer bonded with a layer of nonconductive material (e.g., foam, cork, etc.) is arranged in the through-bore of the connector body to isolate the retaining clip and tube from the connector body to prevent a false positive connection indication. In some embodiments, the contact pin is angled and extends from the bottom or first end of the cartridge to a radially inward facing surface of the cartridge. When the tube is fully installed within the connector body (i.e., the retaining clip is snapped behind the tube shoulder), the tube will contact the pin and close the circuit between the tube and the connector body. The contact pin is now compressed and will be in constant contact with the body due to the force of the tube inserted under the retaining clip. Using a continuity tool (e.g., a voltmeter, battery powered source with a light emitting diode (LED), a PLC, a handheld device, etc.), one contact terminal of the tool is engaged with the connector body and the outer contact terminal of the tool is engaged with the tube (e.g., a radially outward facing surface thereof). The tool will indicate via a signal, vibration, sound, etc. indicating that there is continuity (i.e., that the tube is fully connected to the connector body). In some embodiments, the tool sends such verification data (i.e., voltage data) to a remote location (e.g., a computing device).

(15) These and other objects, features, and advantages of the present disclosure will become readily apparent upon a review of the following detailed description of the disclosure, in view of the drawings and appended claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

(2) FIG. **1** is a perspective view of a fluid connector, in an unsecured state;

(3) FIG. **2** is a perspective view of the fluid connector shown in FIG. **1**, in a secured state;

(4) FIG. **3** is an exploded perspective view of the fluid connector shown in FIG. **1**;

(5) FIG. **4**A is a rear perspective view of the cartridge shown in FIG. **3**;

(6) FIG. **4**B is a front perspective view of the cartridge shown in FIG. **3**;

(7) FIG. **5**A is a cross-sectional view of the fluid connector taken generally along line **5**-**5** in FIG. **1**, in a partially engaged state;

(8) FIG. **5**B is a cross-sectional view of the fluid connector taken generally along line **5**-**5** in FIG. **1**, in a fully engaged state;

(9) FIG. **6** is an exploded perspective view of the fluid connector shown in FIG. **1**;

(10) FIG. **7**A is a rear perspective view of the cartridge shown in FIG. **6**;

(11) FIG. **7**B is a front perspective view of the cartridge shown in FIG. **6**;

(12) FIG. **8**A is a cross-sectional view of the fluid connector taken generally along line **8**-**8** in FIG. **1**, in a partially engaged state; and,
(13) FIG. **8**B is a cross-sectional view of the fluid connector taken generally along line **8**-**8** in FIG. **1**, in a fully engaged state.

DETAILED DESCRIPTION

(14) At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements. It is to be understood that the claims are not limited to the disclosed aspects.
(15) Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the claims.
(16) Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure pertains. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the example embodiments.
(17) It should be appreciated that the term “substantially” is synonymous with terms such as “nearly,” “very nearly,” “about,” “approximately,” “around,” “bordering on,” “close to,” “essentially,” “in the neighborhood of,” “in the vicinity of,” etc., and such terms may be used interchangeably as appearing in the specification and claims. It should be appreciated that the term “proximate” is synonymous with terms such as “nearby,” “close,” “adjacent,” “neighboring,” “immediate,” “adjoining,” etc., and such terms may be used interchangeably as appearing in the specification and claims. The term “approximately” is intended to mean values within ten percent of the specified value.
(18) It should be understood that use of “or” in the present application is with respect to a “non-exclusive” arrangement, unless stated otherwise. For example, when saying that “item x is A or B,” it is understood that this can mean one of the following: (1) item x is only one or the other of A and B; (2) item x is both A and B. Alternately stated, the word “or” is not used to define an “exclusive or” arrangement. For example, an “exclusive or” arrangement for the statement “item x is A or B” would require that x can be only one of A and B. Furthermore, as used herein, “and/or” is intended to mean a grammatical conjunction used to indicate that one or more of the elements or conditions recited may be included or occur. For example, a device comprising a first element, a second element and/or a third element, is intended to be construed as any one of the following structural arrangements: a device comprising a first element; a device comprising a second element; a device comprising a third element; a device comprising a first element and a second element; a device comprising a first element and a third element; a device comprising a first element, a second element and a third element; or, a device comprising a second element and a third element.
(19) Moreover, as used herein, the phrases “comprises at least one of” and “comprising at least one of” in combination with a system or element is intended to mean that the system or element includes one or more of the elements listed after the phrase. For example, a device comprising at least one of: a first element; a second element; and, a third element, is intended to be construed as any one of the following structural arrangements: a device comprising a first element; a device comprising a second element; a device comprising a third element; a device comprising a first element and a second element; a device comprising a first element and a third element; a device comprising a first element, a second element and a third element; or, a device comprising a second element and a third element. A similar interpretation is intended when the phrase “used in at least one of:” is used herein. Furthermore, as used herein, “and/or” is intended to mean a grammatical conjunction used to indicate that one or more of the elements or conditions recited may be included or occur. For example, a device comprising a first element, a second element and/or a third element, is intended to be construed as any one of the following structural arrangements: a device

comprising a first element; a device comprising a second element; a device comprising a third element; a device comprising a first element and a second element; a device comprising a first element and a third element; a device comprising a first element, a second element and a third element; or, a device comprising a second element and a third element.
(20) It should be appreciated that the term “tube” as used herein is synonymous with hose, pipe, channel, conduit, tube end form, or any other suitable pipe flow used in hydraulics and fluid mechanics. It should further be appreciated that the term “tube” can mean a rigid or flexible conduit of any material suitable for containing and allowing the flow of a gas or a liquid.
(21) Adverting now to the figures, FIG. **1** is a perspective view of fluid connector **10** in an unsecured state. FIG. **2** is a perspective view of fluid connector **10** in a secured state. FIG. **3** is an exploded perspective view of fluid connector **10**. FIG. **4**A is a rear perspective view of cartridge **20**. FIG. **4**B is a front perspective view of cartridge **20**. FIG. **5**A is a cross-sectional view of fluid connector **10** taken generally along line **5**-**5** in FIG. **1**, in a partially engaged state. FIG. **5**B is a cross-sectional view of fluid connector **10** taken generally along line **5**-**5** in FIG. **1**, in a fully engaged state. Fluid connector **10** generally comprises cartridge **20**, connector body **40**, and tube **80**. In some embodiments, fluid connector **10** further comprises disk **74**. For the purposes of the present disclosure, “unsecured state” is intended to mean that flange **52** of connector body **40** has not yet been crimped over cartridge **20** or cartridge **220** (and disk **74**). “Secured state” is intended to mean that section **56** of flange **52** has been crimped over cartridge **20** or cartridge **220** (and disk **74**) thereby securing cartridge **20**, **220** and retaining clip **70** within connector body **40**. The following description should be read in view of FIGS. **1**-**5**B.
(22) Connector body **40** comprises through-bore **41** extending from end **42** to end **44**, radially inward facing surface **46**, radially inward facing surface **48**, flange **52**, head **58**, and radially outward facing surface **60**. Connector body **40** is arranged to be connected to a component that is filled with a fluid. For example, connector body **40** may be connected to a transmission via radially outward facing surface **60**, which may comprise external threading. Connector body **40** may be screwed into a threaded hole in the transmission via head **58** (e.g., using a wrench), which is then filled with transmission fluid. In some embodiments, head **58** is hexagonal; however, it should be appreciated that head **58** may comprise any geometry suitable for applying torque to connector body **40**. Another component in which fluid connector **10**, specifically connector body **40**, may be installed into is an engine block. It should be appreciated that fluid connector **10** may be used in various other components, assemblies, and subassemblies in which fluid connection is desired. Radially outward facing surface **60** may further comprise groove **64**. A seal or O-ring may be arranged in groove **64** to create a fluid tight seal between connector body **40** and the component it is connected to. Seal **62** is arranged in connector body **40**. Specifically, seal **62** is arranged in groove **50**. In some embodiments, seal **62** is an O-ring. Body **40** further comprises surface **47**, which extends between and connects radially inward facing surface **46** and radially inward facing surface **48**. Surface **47** is operatively arranged to engage cartridge **20**, as will be described in greater detail below. Flange **52** extends from head **58** in axial direction AD**2**. Flange **52** comprises section **54** and section **56**, which are shown in the figures as being separated by fold line L**1**. It should be appreciated that fold line L**1** is an imaginary line used solely for the purposes of describing the folding action of flange **52** herein. In some embodiments, connector body **40** comprises a metal. In some embodiments, connector body **40** comprises a conductive material with flange **52** comprising a suitable malleable material.
(23) Tube **80** comprises end **82**, section **83**, shoulder **87**, section **89**, end **94**, and through-bore **96**. Through-bore **96** extends through tube **80** from end **82** to end **94**. Section **83** is arranged between end **82** and shoulder **87** and comprises radially outward facing surface **84**. Radially outward facing surface **84** includes a substantially constant diameter. In some embodiments, radially outward facing surface **84** comprises a frusto-conical taper proximate end **82** (see FIGS. **5**A-B). Shoulder **87** is arranged between section **83** and section **89** and comprises radially outward facing surface **86**,

radially outward facing surface **90**, and surface **88**. As shown, radially outward facing surface **86** is a frusto-conical surface extending from radially outward surface **84** to radially outward facing surface **90**. Radially outward facing surface **86** increases in diameter is axial direction AD**2**. In some embodiments, radially outward facing surface **86** is an axial surface facing at least partially in axial direction AD**1**. Radially outward facing surface **90** extends from radially outward facing surface **86** to shoulder surface **88**. In some embodiments, radially outward facing surface **90** comprises a constant diameter. In some embodiments, radially outward facing surface **90** comprises a variable diameter. Shoulder surface **88** is an axial surface facing at least partially in axial direction AD**2**. Section **89** is arranged between shoulder **87** and end **94** and comprises radially outward facing surface **92**. Radially outward facing surface **92** includes a substantially constant diameter. Tube **80** is arranged to be inserted, specifically with end **82** first, into connector body **40** and cartridge **20**. Tube **80** is inserted into connector body **40** and cartridge **20** until retaining clip **70** snaps over shoulder **87**. It is the engagement of protrusions **72**A-B with shoulder surface **88** that secures tube **80** within connector body **40**. It should be appreciated that tube **80** may be any traditional tube comprising a bead, radially outward extending protrusion or flange, or ramp profile, which extends radially outward and axially on the outer surface of the tube, to displace a retaining ring, snap ring, or wire clip within the connector body (and cartridge) to secure the tube within the connector body. In some embodiments, tube **80** comprises a metal. In some embodiments, tube **80** comprises a conductive material.

(24) Cartridge **20** is operatively arranged to carry and enclose retaining clip **70** as well as contact elements **290** and **294**. Cartridge **20** comprises end **22**, radially outward facing surface **24**, radially outward facing surface **30**, end **32**, and through-bore **34**. Radially outward facing surface **24** is generally curvilinear and connects end **22** with radially outward facing surface **30**. Cartridge **20** further comprises radially inward facing surface **36** proximate end **32** and radially inward facing surface **38** proximal end **22**. In some embodiments, radially inward facing surface **36** comprises a constant diameter. In some embodiments, radially inward facing surface **36** comprises a variable diameter. In some embodiments, radially inward facing surface **38** comprises a variable diameter (e.g., is frusto-conical). In some embodiments, radially inward facing surface **38** comprises a constant diameter with a flange arranged to engage shoulder **87**. End **32** comprises one or more projections (e.g., projections **28**A-C) and lip **26**. Projections **28**A-C extend from end **32** in axial direction AD**2** and are generally aligned with radially inward facing surface **36** (i.e., the radially inward facing surface of projections **28**A-C are aligned with radially inward facing surface **36**). Lip **26** extends from end **32** in axial direction AD**2** and is generally aligned with radially outward facing surface **30** (i.e., the radially outward facing surface of lip **26** is aligned with radially outward facing surface **30**). Cartridge **20** is operatively arranged to be inserted, with end **22** first, into through-bore **41** at end **44** of connector body **40** and secured therein. In some embodiments, cartridge **20** comprises a non-conductive material (e.g., polymer, ceramic, etc.).

(25) Retaining clip (or retaining ring or snap clip/ring) **70** is arranged in cartridge **20**, specifically, adjacent end **32** and generally concentrically arranged within lip **26** of cartridge **20** (see FIG. **5**A). Retaining clip **70** is generally a retaining ring including one or more protrusions extending radially inward. In the embodiment shown, retaining clip **70** comprises protrusions **72**A-C. Protrusions **72**A-C extend radially inward through projections **28**A-C and into through-bore **34**. Protrusions **72**A-C are arranged to engage shoulder **87**, specifically, shoulder surface **88**, to secure tube **80** within cartridge **20** and thus connector body **40**. Retaining clip **70** may comprise any material that is capable of elastically deforming and returning to its original shape (e.g., metal, polymer, etc.).

(26) To assemble fluid connector **10**, cartridge **20** is inserted into connector body **40**. As shown in FIGS. **5**A-B, end **22** of cartridge **20** engages surface **47** of connector body **40**. End **22** thereby forms the second half of the seal or O-ring gland by enclosing seal **62** within groove **50**. Radially outward facing surface **24** and radially outward facing surface **30** are arranged proximate to or engage with radially inward facing surface **46**. Retaining clip **70** is then arranged on cartridge **20**.

Specifically, and as previously described, retaining clip **70** is arranged within lip **26** on projections **28**A-C such that protrusions **72**A-C extend into through-bore **34** of cartridge **20**. Disk **74** is then inserted into through-bore **41** of connector body. As shown in the figures, disk **74** is generally a washer-shaped element that is arranged proximate to or abuts against projections **28**A-C, which encloses retaining clip **70** (i.e., retaining clip **70** is prevented from displacement in axial direction AD**1** by end **32** and in axial direction AD**2** by disk **74**). In some embodiments, disk **74** comprises a nonconductive material. In some embodiments, disk **74** comprises an anodized metal. In some embodiments, disk **74** comprises a metal bonded with a layer of nonconductive foam or cork. It should be appreciated that disk **74** is designed to be nonconductive so as to insulate tube **80** from initiating electrical contact with connector body **40** until the fully engaged state is achieved. Flange **52** is then crimped radially inward, around disk **74**, to secure cartridge **20** within connector body **40**, as shown in FIG. **2**. Specifically, section **56** is crimped or bent radially inward about bend line L**1**, until section **56** is arranged proximate to or abuts against disk **74**. It should be appreciated that in some embodiments, when disk **74** is not present, section **56** is crimped radially inward proximate bend line L**1** until section **56** is arranged proximate to or abuts against projections **28**A-C of cartridge **20**. In the secured state, cartridge **20** is prevented from displacement in axial direction AD**1** by surface **47** and axial direction AD**2** by crimped section **56**. It should be appreciated that tube **80** is not inserted into cartridge **20** and connector body **40** until flange **52** has been crimped. FIGS. **5**A-B shows tube **80** inserted into cartridge **20** and connector body **40** in an unconnected state only to further illustrate the interaction and orientation of the components. However, tube **80** would not be present during the assembly of cartridge **20** and connector body **40**.

(27) Cartridge **20** further comprises groove **280** arranged in radially outward facing surface **30** (and radially outward facing surface **24**), groove **282** arranged in radially inward facing surface **38** (and radially inward facing surface **36**), and through-bore **284** which extends from radially inward facing surface **38**, specifically, groove **282**, in radial direction RD**1** to radially outward facing surface **46**, specifically, groove **280** (see FIGS. **4**A-**5**B).

(28) Fluid connector **10** further comprises an electrically conductive contact (e.g., contact elements **290** and **294**). Contact element **290** is operatively arranged to engage with groove **282** and comprises section **292**A and section **292**B. As best shown in FIGS. **5**A-B, section **292**A extends into a first section of groove **282** that extends in radial direction RD**1** from radially inward facing surface **36**. Section **292**A is secured within the first section of groove **282** via any suitable means, for example, interference fit, adhesives, bolts, rivets, etc. Section **292**B is engaged with a second section of groove **282** in radially inward facing surface **38**. Section **292**B is operatively arranged to be displaceable relative to section **292**A. In the partially engaged state shown in FIG. **5**A, section **292**B is arranged at angle α relative to section **292**A. However, in the fully engaged state shown in FIG. **5**B, when shoulder **87** is engaged with section **292**B, section **292** is arranged at angle β relative to section **292**A, wherein angle γ is less than angle α. In some embodiments, contact element **290** comprises a metal.

(29) Contact element **294** is operatively arranged to engage with groove **280** and through-bore **284** and comprises first section **296**A and second section **296**B. As best shown in FIGS. **5**A-B, section **296**A extends through through-bore **284** and engages section **292**B on a first end thereof. On its second end, section **296**B engages groove **280** and is connected to section **296**B. Section **296**B is operatively arranged to engage groove **280**. In the partially engaged state shown in FIG. **5**A, section **296**B is arranged in groove **280** radially inward of radially outward facing surface **30** (i.e., a radial gap exists between section **296**B and radially inward facing surface **46**). In the fully engaged state shown in FIG. **5**B, shoulder **87** engages section **292**B which thereby forces section **296**A and section **296**B radially outward in radial direction RD**2** and into contact with radially inward facing surface **46** (i.e., there no longer exists a radial gap between section **296**B and radially inward facing surface **46**). It is this connection, between tube **80**, contact element **290**, contact element **294**, and connector body **40** that creates the electrical continuity that verifies the connection. In other words,

in the fully engaged state shown in FIG. **5**B, an electrical circuit is created between tube **80**, contact element **290**, contact element **294**, and connector body **40**. In the partially engaged state shown in FIG. **5**A, there is no electrical circuit created between tube **80**, contact element **290**, contact element **294**, and connector body **40** because tube **80** is not engaged with contact element **290**.

(30) FIG. **1** is a perspective view of fluid connector **110** in an unsecured state. FIG. **2** is a perspective view of fluid connector **110** in a secured state. FIG. **6** is an exploded perspective view of fluid connector **110**. FIG. **7**A is a rear perspective view of cartridge **220**. FIG. **7**B is a front perspective view of cartridge **220**. FIG. **8**A is a cross-sectional view of fluid connector **110**, taken generally along line **8**-**8** in FIG. **1**, in a partially engaged state. FIG. **8**B is a cross-sectional view of fluid connector **110** taken generally along line **8**-**8** in FIG. **1**, in a fully engaged state. Fluid connector **110** generally comprises cartridge **220**, connector body **40**, and tube **80**. In some embodiments, fluid connector **110** further comprises disk **74**. The following description should be read in view of FIGS. **1**-**2** and **6**-**8**B.

(31) Cartridge **220** is operatively arranged to carry and enclose retaining clip **70** as well as contact **390**. Cartridge **220** comprises end **222**, radially outward facing surface **224**, radially outward facing surface **230**, end **232**, and through-bore **234**. Radially outward facing surface **224** is generally curvilinear and connects end **222** with radially outward facing surface **230**. Cartridge **220** further comprises radially inward facing surface **236** proximate end **232** and radially inward facing surface **238** proximal end **222**. In some embodiments, radially inward facing surface **236** comprises a constant diameter. In some embodiments, radially inward facing surface **236** comprises a variable diameter. In some embodiments, radially inward facing surface **238** comprises a variable diameter (e.g., is frusto-conical). In some embodiments, radially inward facing surface **238** comprises a constant diameter with a flange arranged to engage shoulder **87**. End **232** comprises one or more projections (e.g., projections **228**A-C) and lip **226**. Projections **228**A-C extend from end **232** in axial direction AD**2** and are generally aligned with radially inward facing surface **236** (i.e., the radially inward facing surface of projections **228**A-C are aligned with radially inward facing surface **236**). Lip **266** extends from end **232** in axial direction AD**2** and is generally aligned with radially outward facing surface **230** (i.e., the radially outward facing surface of lip **226** is aligned with radially outward facing surface **230**). Cartridge **220** is operatively arranged to be inserted, with end **222** first, into through-bore **41** at end **44** of connector body **40** and secured therein. In some embodiments, cartridge **220** comprises a non-conductive material (e.g., polymer, ceramic, etc.).

(32) Retaining clip (or retaining ring or snap clip/ring) **70** is arranged in cartridge **220**, specifically, adjacent end **232** and generally concentrically arranged within lip **226** of cartridge **220** (see FIG. **8**A). Retaining clip **70** is generally a retaining ring including one or more protrusions extending radially inward. In the embodiment shown, retaining clip **70** comprises protrusions **72**A-C. Protrusions **72**A-C extend radially inward through projections **228**A-C and into through-bore **234**. Protrusions **72**A-C are arranged to engage shoulder **87**, specifically, shoulder surface **88**, to secure tube **80** within cartridge **220** and thus connector body **40**. Retaining clip **70** may comprise any material that is capable of elastically deforming and returning to its original shape (e.g., metal, polymer, etc.).

(33) To assemble fluid connector **210**, cartridge **220** is inserted into connector body **40**. As shown in FIGS. **8**A-B, end **222** of cartridge **220** engages surface **47** of connector body **40**. End **222** thereby forms the second half of the seal or O-ring gland by enclosing seal **62** within groove **50**. Radially outward facing surface **224** and radially outward facing surface **230** are arranged proximate to or engage with radially inward facing surface **46**. Retaining clip **70** is then arranged on cartridge **220**. Specifically, and as previously described, retaining clip **70** is arranged within lip **226** on projections **228**A-C such that protrusions **72**A-C extend into through-bore **234** of cartridge **220**. Disk **74** is then inserted into through-bore **41** of connector body. As shown in the figures, disk **74** is generally a washer-shaped element that is arranged proximate to or abuts against projections **228**A-C, which encloses retaining clip **70** (i.e., retaining clip **70** is prevented from displacement in

axial direction AD**1** by end **232** and in axial direction AD**2** by disk **74**). Flange **52** is then crimped radially inward, around disk **74**, to secure cartridge **220** within connector body **40**, as shown in FIG. **2**. Specifically, section **56** is crimped or bent radially inward about bend line L**1**, until section **56** is arranged proximate to or abuts against disk **74**. It should be appreciated that in some embodiments, when disk **74** is not present, section **56** is crimped radially inward proximate bend line L until section **56** is arranged proximate to or abuts against projections **228**A-C of cartridge **220**. In the secured state, cartridge **220** is prevented from displacement in axial direction AD**1** by surface **47** and axial direction D2 by crimped section **56**. It should be appreciated that tube **80** is not inserted into cartridge **220** and connector body **40** until flange **52** has been crimped. FIGS. **8**A-B shows tube **80** inserted into cartridge **220** and connector body **40** in an unconnected state only to further illustrate the interaction and orientation of the components. However, tube **80** would not be present during the assembly of cartridge **220** and connector body **40**.

(34) Cartridge **220** further comprises groove **380** arranged in end **222** (and radially outward facing surface **224**), and aperture **382** which extends from radially inward facing surface **236** (and radially inward facing surface **238**) in axial direction AD**1** to end **222**, specifically, groove **380** (see FIGS. **7**A-**8**B). Groove **380** extends axially in axial direction AD**2** into end **222**. Aperture **382** is generally parallel to radially outward facing surface **230**. In some embodiments, aperture **382** is nonparallel to radially outward facing surface **230**.

(35) Fluid connector **110** further comprises an electrically conductive contact (e.g., contact **390**). Contact **390** is operatively arranged to engage with groove **380** and aperture **382** and comprises section **392**A and section **392**B. As best shown in FIGS. **8**A-B, section **392**A is arranged in groove **380** and is operatively arranged to contact surface **47**. Section **392**B extends through aperture **382** in axial direction AD**2** such that a portion thereof is exposed in through-bore **41**. Contact **390** is secured within groove **380** and/or aperture **382** via any suitable means, for example, interference fit, adhesives, bolts, rivets, etc. In some embodiments, contact **390** is slidingly secured within groove **380** and/or aperture **382** (i.e., contact **390** is “loose” within cartridge **220**). Section **392**B is arranged at an angle relative to section **392**A (e.g., 90 degrees). In the partially engaged state shown in FIG. **8**A, section **392**A is engaged with surface **47**, but shoulder **87** is not engaged with the exposed portion of section **392**B. In the fully engaged state shown in FIG. **8**B, section **392**A is engaged with surface **47** and shoulder **87** is engaged with section **392**B. It is this connection, between tube **80**, contact element **390**, and connector body **40** that creates the electrical continuity that verifies the connection. In other words, in the fully engaged state shown in FIG. **8**B, an electrical circuit is created between tube **80**, contact element **390**, and connector body **40**. In the partially engaged state shown in FIG. **8**A, there is no electrical circuit created between tube **80**, contact element **390**, and connector body **40** because tube **80** is not engaged with contact element **390**.

(36) The electrical circuit that is created (or not created) is intended to be read or indicated by another device. For example, in some embodiments, a first contact of a voltmeter is placed in contact with tube **80** and a second contact of a voltmeter is placed in contact with connector body **40**. Once tube **80** is fully engaged with connector body **40**, the voltmeter will indicate an electrically connected circuit since tube **80**, the electrical contact (e.g., contact elements **290** and **294**, or contact **390**), and connector body all comprise an electrically conductive material (e.g., a metal) and are all in contact.

(37) It will be appreciated that various aspects of the disclosure above and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

REFERENCE NUMERALS

(38) **10** Fluid connector **20** Cartridge **22** End **24** Radially outward facing surface **26** Lip **28**A

Projection **28**B Projection **28**C Projection **30** Radially outward facing surface **32** End **34** Through-bore **36** Radially inward facing surface **38** Radially inward facing surface **40** Connector body **41** Through-bore **42** End **44** End **46** Radially inward facing surface **47** Surface **48** Radially inward facing surface **50** Groove **52** Flange **54** Section **56** Section **58** Head **60** Radially outward facing surface **62** Seal **64** Groove **70** Retaining clip **72**A Protrusion **72**B Protrusion **72**C Protrusion **74** Disk **80** Tube **82** End **83** Section **84** Radially outward facing surface **86** Radially outward facing surface **87** Shoulder **88** Surface **89** Section **90** Radially outward facing surface **92** Radially outward facing surface **94** End **96** Through-bore **110** Fluid connector **220** Cartridge **222** End **224** Radially outward facing surface **226** Lip **228**A Projection **228**B Projection **228**C Projection **230** Radially outward facing surface **232** End **234** Through-bore **236** Radially inward facing surface **238** Radially inward facing surface **280** Groove **282** Aperture **284** Through-bore **290** Contact element **292**A Section **292**B Section **294** Contact element **296**A Section **296**B Section **380** Groove **382** Aperture **390** Contact **392**A Section **392**B Section L**1** Line AD**1** Axial direction AD**2** Axial direction RD**1** Radial direction RD**2** Radial direction α Angle β Angle

Claims

1. A fluid connector, comprising: a connector body, including a first through-bore, a first radially inward facing surface; a non-conductive cartridge removably arranged and secured in the first through-bore, including: a first end; a second end; a second through-bore; a first radially outward facing surface; and a second radially inward facing surface; an electrical contact at least partially embedded in the second radially inward facing surface, the electrical contact operatively arranged to engage the connector body; and a retaining clip operatively arranged in the cartridge proximate the second end, the retaining clip including at least one protrusion extending radially inward into the second through-bore.
2. The fluid connector as recited in claim 1, wherein the electrical contact comprises: a first section extending into the second through-bore; and a second section operatively arranged to engage the connector body.
3. The fluid connector as recited in claim 2, wherein the second section is arranged at the first end.
4. The fluid connector as recited in claim 2, wherein the second section is arranged in a groove in the first end.
5. The fluid connector as recited in claim 4, wherein the first section is arranged in an aperture, the aperture extending axially from the first end to the second radially inward facing surface.
6. The fluid connector as recited in claim 1, wherein the electrical contact comprises: a first contact element hingedly connected to the second radially inward facing surface; and a second contact element operatively arranged to engage the first contact element, the second contact element engaged with the connector body.
7. The fluid connector as recited in claim 6, wherein the cartridge further comprises a third through-bore and the second contact element is slidably arranged in the third through-bore.
8. The fluid connector as recited in claim 6, wherein the second contact element comprises: a first section engageable with the first contact element; and a second section arranged in a groove in the first radially outward facing surface.
9. The fluid connector as recited in claim 8, wherein: in a partially engaged state, the second section is spaced apart from the first radially inward facing surface; and in a fully engaged state, the second section abuts against the first radially inward facing surface.
10. The fluid connector as recited in claim 6, wherein: in a partially engaged state, the second contact element is arranged radially inward from the first radially outward facing surface; and in a fully engaged state, the second contact element is aligned with or arranged radially outward from the first radially outward facing surface.
11. A fluid connector, comprising: a connector body, including a first through-bore, a first radially

inward facing surface, and an axial surface; a cartridge secured in the first through-bore, including: a first end; a second end; a second through-bore; a first radially outward facing surface; a second radially inward facing surface; and an electrical contact extending from the second radially inward facing surface to at least one of the first end and the first radially outward facing surface; a retaining clip operatively arranged in the cartridge proximate the second end, the retaining clip including at least one protrusion extending radially inward into the second through-bore; and a tube operatively arranged to be secured in the connector body via the cartridge; wherein: in a partially engaged state, the tube is not electrically connected to the connector body; and in a fully engaged state, the tube is electrically connected to the connector body via the electrical contact.

12. A fluid connector, comprising: a connector body, including: a first end; a second end; a first through-bore; a first radially inward facing surface; and an axial surface; a non-conductive cartridge removably arranged in the first through-bore axially between the first end and the second end, including: a third end; a fourth end; a second through-bore; a first radially outward facing surface; and a second radially inward facing surface; an electrical contact at least partially embedded in the second radially inward facing surface; and a retaining clip operatively arranged in the cartridge proximate the fourth end, the retaining clip including at least one protrusion extending radially inward into the second through-bore.

13. The fluid connector as recited in claim 12, wherein the electrical contact comprises: a first section extending into the second through-bore; and a second section operatively arranged to engage the connector body.

14. The fluid connector as recited in claim 13, wherein the second section is arranged at the third end.

15. The fluid connector as recited in claim 13, wherein the second section is arranged in a groove in the third end.

16. The fluid connector as recited in claim 12, wherein the electrical contact comprises: a first contact element hingedly connected to the second radially inward facing surface; and a second contact element operatively arranged to engage the first contact element, the second contact element engaged with the connector body.

17. The fluid connector as recited in claim 16, wherein the cartridge further comprises a third through-bore and the second contact element is slidably arranged in the third through-bore.

18. The fluid connector as recited in claim 16, wherein the second contact element comprises: a first section engageable with the first contact element; and a second section arranged in a groove in the second radially outward facing surface.

19. The fluid connector as recited in claim 18, wherein: in a partially engaged state, the second section is spaced apart from the first radially inward facing surface; and in a fully engaged state, the second section abuts against the first radially inward facing surface.

20. The fluid connector as recited in claim 16, wherein: in a partially engaged state, the second contact element is arranged radially inward from the first radially outward facing surface; and in a fully engaged state, the second contact element is aligned with or arranged radially outward from the first radially outward facing surface.