



(43) International Publication Date
10 December 2015 (10.12.2015)

- (51) International Patent Classification:
F16L 19/06 (2006.01) *F16L 19/12* (2006.01)
- (21) International Application Number:
PCT/US2015/034208
- (22) International Filing Date:
4 June 2015 (04.06.2015)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
62/007,432 4 June 2014 (04.06.2014) US
- (71) Applicant: **PARKER-HANNIFIN CORPORATION**
[US/US]; 6035 Parkland Boulevard, Cleveland, Ohio
44124-4141 (US).
- (72) Inventor: **GIBSON, James David**; 10031 Willow Cover
Road, Huntsville, Alabama 35803 (US).
- (74) Agent: **BULSON, Don W.**; Renner, Otto, Boisselle & Sklar, LLP, 1621 Euclid Avenue, 19th Floor, Cleveland, Ohio
44115 (US).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

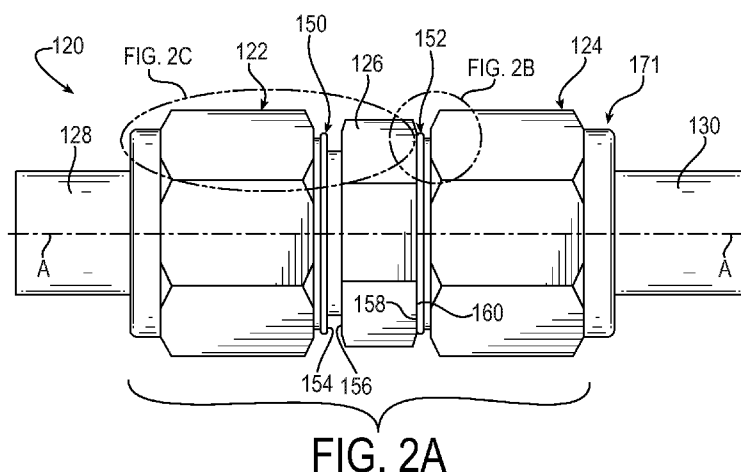
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: COMPRESSION FITTING WITH TORQUE NUT



(57) Abstract: A torque nut (122) with an axially deformable projection (150) protruding from the axially inner end face of the torque nut (122). The torque nut (122) may be assembled as part of a compression fitting (120) including one or more ferrules for engaging a tube (128) held within the torque nut (122) and a fitting body (126) onto which the torque nut (122) can be threaded. The axially deformable projection (150) will engage an opposing face on the fitting body (126) and this allows a person tightening the torque nut (122) to feel when the torque nut (122) is made up to prevent undermaking or overmaking the torque nut (122). When the axially deformable projection (150) engages the fitting body (126), there will be an abrupt increase in torque needed to tighten the torque nut (122) on the fitting body (126) after only partial axial deformation of the axially deformable projection (150) relative to the axially inner end face of the torque nut (122).



COMPRESSION FITTING WITH TORQUE NUT

Related Applications

This application claims the benefit of U.S. Provisional Application No.
5 62/007,432 filed June 4, 2014, which is incorporated herein by reference.

Technical Field

The present disclosure relates generally to tube fittings, and more particularly to compression fittings with torque nuts.

10

Background

Compression fittings are used in industrial systems to join various sections of fluid pathways together, for example to fluidly connect two separate tubes or pipes together. Fig. 1A shows a typical union compression fitting 20 including a left nut 22 and a right nut 24 attached to a body 26 to fluidly connect
15 a left tube 28 with a right tube 30. The left side of the union compression fitting 20, shown in cross-section in Fig. 1C, illustrates the position of the left nut 22 prior to assembly. The right side of the union compression fitting 20 shows the position of the right nut 24 after makeup.

Often compression fittings employ a ferrule assembly to prevent leakage of hydraulic fluid. As shown in Fig. 1C, the union compression fitting may include a ferrule assembly, such as a single ferrule 32 or a dual ferrule assembly (not shown), for sealing against an outer surface of the tube 28 after makeup of the left nut 22. In short, the left nut 22 is threaded onto the body 26, and as the
20 left nut 22 advances the ferrule 32 is pressed against the body 26. The geometry of the body 26 causes a radially inward compression of the ferrule 32 onto the outer surface of the tube 28. The right nut 24 (Fig. 1A) may be made up in a similar fashion as the left nut 22, and a ferrule assembly (not shown) similar to the ferrule 32 may seal against an outer surface of the tube 30 upon makeup
25 of the right nut 24. Typical makeup of fittings such as this requires advancing the nut 1¼ turns (or more) from the finger tight position. This usually requires marking the nut and body position or counting hex flats to insure proper initial assembly.

30

Summary

The present disclosure provides a torque nut with an axially deformable projection protruding from the axially inner end face of the torque nut. The torque nut may be assembled as part of a compression fitting including one or more ferrules for engaging a tube held within the torque nut and a fitting body onto which the torque nut can be threaded. The axially deformable projection will engage an opposing face on the fitting body and this allows a person tightening the torque nut to feel when the torque nut is made up to prevent undermaking or overmaking the torque nut. When the axially deformable projection engages the fitting body, there will be an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut. The abrupt increase in torque needed to tighten the torque nut indicates that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube. Thus, assembly time of the compression fitting may be reduced, leakage due to undermaking the compression fitting may be prevented, and component fatigue due to overmaking the compression fitting may be reduced.

A deformable portion of the torque nut may resist deformation, but deform during makeup of the torque nut. The axially deformable projection may be integral with a central body of the torque nut. For example, the axially deformable projection may be unitary (one-piece) with the central body.

In an embodiment, the axially deformable projection includes an insert that receives an axial projection of the torque nut such that the insert deforms radially as the axial projection is axially compressed.

In another embodiment, the axially deformable projection is an insert that is deformed axially between the central body and an axially inwardly facing shoulder of the fitting body.

In yet another embodiment, a sealing member is provided at a back (outer) end of the torque nut opposite the axially deformable projection at the inner end of the torque nut, the sealing member being configured to seal against an outer surface of a tube.

In a further embodiment, one or more stop collars may form the axially inwardly facing shoulder of the fitting body and the axially deformable projection. Each stop collar may protect the fitting body from damage and/or provide an indication regarding whether an associated fitting of torque nut is fully made-up or not.

Although generally illustrated as including a single ferrule-type assembly, the disclosure herein is equally applicable for multi-ferrule type assemblies, such as a dual ferrule-type ferrule assembly.

The term "finger tight" is used herein to denote a torque nut tightened to a torque value anywhere from 10 inch-pounds (in-lb) to 50 in-lb, which may be based upon the size of the torque nut.

According to one aspect of the invention, a tube fitting assembly comprising a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion, a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube, a torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body, and wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut in the same direction as the axially inwardly facing shoulder of the fitting body is radially offset from the axially inner threaded portion of the fitting body such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move

into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the torque nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube, and wherein the axially deformable projection is annularly continuous for forming a seal between the torque nut and the fitting body when the axially deformable projection is engaged with the fitting body.

According to another aspect of the invention, a tube fitting assembly comprising a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion, a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube, a torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body, and wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut in the same direction as the axially inwardly facing shoulder of the fitting body is radially offset from the axially inner threaded portion of the fitting body such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting

body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the torque nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube, and wherein the abrupt increase in the torque is at least 40% greater than the increase in torque that otherwise would occur during tightening of the torque nut in the absence of the axially deformable projection.

According to another aspect of the invention, a torque nut for a tube fitting assembly that includes a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion, and a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube, the torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body, and wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the torque nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the

ferrule assembly to the tube, and wherein the axially deformable projection is annularly continuous for forming a seal between the torque nut and the fitting body when the axially deformable projection is engaged with the fitting body.

According to another aspect of the invention, a torque nut for a tube fitting assembly that includes a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion, and a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube, the torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body, and wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the torque nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube, and wherein the abrupt increase in the torque is at least 40% greater than the increase in torque that otherwise would occur during tightening of the torque nut in the absence of the axially deformable projection.

According to another aspect of the invention, a tube fitting assembly comprising a torque nut and a fitting body, a tube with an annular outer surface embraced by the torque nut and the fitting body, and at least one ferrule engaged by the torque nut and the fitting body to seal against the annular outer surface of the tube, the fitting body comprising an annular portion having an axially inner threaded end portion, and an axially facing shoulder for engaging the torque nut, the torque nut comprising an axially inner threaded end portion configured to engage the axially inner threaded end portion of the fitting body, the axially inner threaded end portion of the torque nut helically circumscribing a central axis of the torque nut, a first end of the torque nut, wherein the first end of the torque nut is configured to receive an annular portion of the fitting body, and an axially deformable projection having a base extending from the first end of the torque nut in a first axial direction to an axially leading end of the axially deformable projection, the axially deformable projection having a first axial length from the base to the axially leading end of the axially deformable projection, the base being entirely radially offset from the axially inner threaded end portion of the torque nut and the axially inner threaded end portion of the fitting body, the axially deformable projection having a deformable portion disposed radially offset from the axially inner threaded end portion of the torque nut and radially offset from the axially inner threaded end portion of the fitting body, wherein the axially deformable projection resists deformation upon the fitting body exerting an axial compressive force against the axially leading end when the axially leading end engages the fitting body, wherein the deformable portion is configured to plastically deform when compressed by the axially facing shoulder facing in a second direction to abut the engagement end, the axially facing shoulder being axially fixed relative to the fitting body when the axially leading end engages the axially facing shoulder such that the deformable portion does not deform until the axially compressive force is at least 20% of an axial force necessary for the torque nut to axially urge the at least one ferrule into a madeup position to sealingly engage the annular outer surface of the tube, and wherein the axially deformable projection is removable from the fitting body, with the nut after the deformable portion is plastically deformed into a first position.

According to another aspect of the invention, a torque nut comprising axially inner threaded end portion configured to engage an axially inner threaded end portion of a fitting body, the axially inner threaded end portion of the torque nut helically circumscribing a central axis of the torque nut, a first end of the torque nut, wherein the first end of the torque nut is configured to receive an annular portion of the fitting body, and an axially deformable projection having a base extending from the first end of the torque nut in a first axial direction to an axially leading end of the axially deformable projection, the axially deformable projection having a first axial length from the base to the axially leading end of the axially deformable projection, the base being entirely radially offset from the axially inner threaded end portion of the torque nut, the axially deformable projection having a deformable portion disposed radially offset from the axially inner threaded end portion of the torque nut, wherein the deformable portion is axially offset from the axially leading end, and wherein the deformable portion is configured to plastically deform before any other portion of the torque nut upon an axial force being applied to the axially leading end of the axially deformable projection, wherein the axially deformable projection resists deformation upon an axial compressive force being applied to the axially leading end when the axially leading end engages the fitting body, wherein the deformable portion is configured to plastically deform when compressed by an axially facing shoulder facing in a second direction to abut the axially leading end such that the deformable portion does not deform until the axially compressive force is at least 20% of an axial force necessary for the torque nut to axially urge at least one ferrule, between the fitting body and the torque nut, into a madeup position to sealingly engage an annular outer surface of a tube held within the fitting body, and wherein the axially deformable projection is integral with the nut after the deformable portion is plastically deformed into a first position.

The foregoing and other features of the invention are hereinafter described in greater detail with reference to the accompanying drawings.

30

Brief Description of the Drawings

Fig. 1A is a front view of a prior art union compression fitting including a left nut and a right nut connected to a body.

Fig. 1B is a front view of a partial cross-section of the union compression fitting of Fig. 1A with the right nut connected to the body in a makeup position.

Fig. 1C is a front view of a partial cross-section of the union compression fitting of Fig. 1A with the left nut connected to the body in a finger tight position,
5 prior to makeup.

Fig. 2A is a front view of an exemplary union compression fitting including a left torque nut and a right torque nut, each torque nut having an exemplary axially deformable projection.

Fig. 2B is a front view of a partial cross-section of the union compression
10 fitting of Fig. 2A with a fitting body and the axially deformable projection of the right torque nut in a makeup position.

Fig. 2C is a front view of a partial cross-section of the union compression fitting of Fig. 2A with the left torque nut connected to the fitting body prior to makeup.

15 Fig. 3 is an exemplary assembly torque vs. torque nut rotation diagram of torque curves for variations of the torque nuts of Fig. 2A in dashed lines compared to torque values for traditional nuts shown in Fig. 1A.

Fig. 4 is an exemplary remake torque vs. torque nut rotation diagram of torque curves during multiple remakes for variations of the torque nuts of Fig. 2A
20 in dashed lines compared to torque curves for traditional nuts shown in Fig. 1A.

Fig. 5A is a front view of the union compression fitting of Fig. 2A with a properly assembled finger tight left torque nut and a properly assembled makeup right torque nut.

Fig. 5B is a front view of a single ferrule union compression fitting with
25 improperly assembled ferrule assemblies engaged with torque nuts.

Fig. 5C is a front view of another exemplary union compression fitting having a dual ferrule assembly, a properly assembled ferrule assembly engaged with finger tight left torque nut and a properly assembled ferrule assembly engaged with makeup right torque nut.

30 Fig. 5D is a front view of another exemplary union compression fitting having a dual ferrule assembly and improperly assembled back ferrules engaged with finger tight torque nuts.

Fig. 5E is a front view of another exemplary union compression fitting having a dual ferrule assembly and improperly assembled front ferrules engaged with finger tight torque nuts.

5 Fig. 6A is a front view of a partial cross-section of another exemplary union compression fitting in a madeup position.

Fig. 6B is a front view of a partial cross-section of yet another exemplary union compression fitting in a madeup position.

Fig. 6C is a front view of a partial cross-section of a further exemplary union compression fitting in a madeup position.

10 Fig. 6D is a front view of a partial cross-section of another exemplary union compression fitting in a madeup position.

Fig. 6E is a front view of a partial cross-section of yet another exemplary union compression fitting in a madeup position.

15 Fig. 7A is a front view of a partial cross-section of another exemplary union compression fitting having an insert in a madeup position.

Fig. 7B is a front view of a partial cross-section of yet another exemplary union compression fitting having an insert in a madeup position.

Fig. 7C is a front view of a partial cross-section of a further exemplary union compression fitting having an insert in a madeup position.

20 Fig. 7D is a front view of a partial cross-section of a still further exemplary union compression fitting having an insert in a madeup position.

Fig. 8A is a front view of a partial cross-section of another exemplary union compression fitting having a back seal for preventing fluid flow between a torque nut and a tube of the union compression fitting.

25 Fig. 8B is a front view of a partial cross-section of yet another exemplary union compression fitting having a back seal.

Fig. 8C is a front view of a partial cross-section of a further exemplary union compression fitting having a back seal.

30 Fig. 8D is a front view of a partial cross-section of a still further exemplary union compression fitting having a back seal.

Fig. 9A is a front view of a partial cross-section of another exemplary union compression fitting with a fitting body having a stop collar assembly and being in a madeup position.

Fig. 9B is a front view of a partial cross-section of yet another exemplary union compression fitting with a fitting body having a stop collar assembly and being in a makeup position.

Fig. 9C is a front view of a partial cross-section of a further exemplary union compression fitting with a fitting body having a stop collar assembly and in
5 being a position just prior to makeup.

Fig. 9D is a front view of a partial cross-section of the union compression fitting of Fig. 9C in a makeup position.

Fig. 9E is a front view of a partial cross-section of a still further exemplary union compression with a fitting body fitting having a stop collar assembly and
10 being in a makeup position.

Fig. 9F is a front view of a partial cross-section of another exemplary union compression fitting with a fitting body having a stop collar assembly and being in a makeup position.

Fig. 9G is a front view of a partial cross-section of yet another exemplary union compression fitting with a fitting body having a stop collar assembly and
15 being in a makeup position.

Fig. 9H is a front view of a partial cross-section of a further exemplary union compression fitting with a fitting body having a stop collar assembly and
20 being in a position just prior to makeup.

Fig. 9I is a front view of a partial cross-section of the union compression fitting of Fig. 9H in a makeup position.

Fig. 9J is a front view of a partial cross-section of a still further exemplary union compression fitting with a fitting body having a stop collar assembly and
25 being in a position just prior to makeup.

Fig. 9K is a front view of a partial cross-section of the union compression fitting of Fig. 9J in a makeup position.

Fig. 9L is a front view of a partial cross-section of another exemplary union compression fitting with a fitting body having a stop collar assembly and
30 being in a position just prior to makeup.

Fig. 9M is a front view of a partial cross-section of the union compression fitting of Fig. 9L in a makeup position.

Detailed Description

The principles of this present application have particular application to tube fittings that are made and remade multiple times, and thus will be described below chiefly in this context. It will be appreciated that principles of this disclosure may be applicable to other fittings where it is desirable to easily determine whether the fitting is properly made or remade. It will also be appreciated that use of the terms “left” or “right” is merely for illustrative purposes.

Referring now to the drawings and initially to Figs. 2A, an exemplary tube fitting assembly according to the invention (hereinafter referred to as a “union compression fitting”) is designated generally by reference numeral 120. The union compression fitting 120 can be provided, for example, as part of a hydraulic system (not shown) for sub-sea applications, such as sub-sea oil wells.

The union compression fitting 120 may include a left torque nut 122 and a right torque nut 124 attached to a fitting body 126 to fluidly connect a left tube 128 with a right tube 130 to the fitting body. The left torque nut 122, the right torque nut 124, the fitting body 126, the left tube 128 and the right tube 130 may be coaxial with a central axis A. For example, the tubes 128, 130 and the fitting body 126 may form a continuous fluid passage along the central axis A.

The left torque nut 122 and the right torque nut 124 may each include an axially deformable projection 150 and 152, respectively. The left torque nut 122 is illustrated in a finger tight position (i.e., the left torque nut 122 is finger tight). The finger tight position may be indicated by a space between an axially leading end 154 of the axially deformable projection 150 and an axially inwardly facing shoulder 156 of the fitting body 126. The axially inwardly facing shoulder 156 may face in a direction opposite the axially leading end 154 to directly engage the axially leading end 154 when the left torque nut 122 is made up. The fitting body may have a stop collar as shown in Fig. 9A, and the stop collar may form the axially inwardly facing shoulder of the fitting body in such embodiment, as described below.

The right torque nut 124 may be identical to the left torque nut 122, but may be oriented in a position reversed compared to the left torque nut 122 to allow an axially leading end 158 of the axially deformable projection 152 to

engage an axially inwardly facing shoulder 160 of the fitting body 126. The axially inwardly facing shoulder 160 may face in a direction opposite the axially inwardly facing shoulder 156, along the central axis A, to allow the tubes 128, 130 to be fluidly connected with a straight connection.

5 In an embodiment, the axially inwardly facing shoulders of the fitting body are not parallel to allow a non-parallel connection between the tubes, for example the axially inwardly facing shoulders may be angularly offset by 90 degrees or any other suitable angle to allow the tubes to be non-parallel to one another.

10 The right torque nut 124 is illustrated in a madeup position. Once the right torque nut 124 is finger tight (a position shown by the left nut 122), the madeup position may be reached by continuing to tighten the right torque nut 124 until the axially leading end 158 engages the axially inwardly facing shoulder 160. The torque required to tighten the right torque nut 124 may rise abruptly
15 after the axially leading end 158 engages the axially inwardly facing shoulder 160, which may indicate that the right torque nut 124 is madeup. As the axially leading end 158 axially moves into engagement with the axially inwardly facing shoulder 160 a torque needed to additionally tighten the torque nut 124 may abruptly increase after only partial axial deformation of the axially deformable
20 projection 152 relative to the axially inner end face of the torque nut.

 The abrupt increase in torque needed to tighten the right torque nut 124 may indicate that the torque nut 124 has been tightened sufficiently to make or remake the torque nut 124. For example, the corresponding ferrule assembly (not shown) may be fully madeup to seal against the tube 130 and the fitting
25 body 126. A user tightening the torque nut 124 may feel the abrupt rise in torque needed to tighten the torque nut 124, which allows the user to detect that the torque nut 124 is fully made without pre-marking the torque nut 124, use of a special tool – such as a torque wrench, or otherwise measuring torque nut 124 relative to the fitting body 126. Thus, the right torque nut 124 can be made or
30 remade by a user purely by feel without undermaking or overmaking the right torque nut 124.

 Alternatively, the rise in torque may indicate that only an additional slight rotation of the right torque nut 124 is required for makeup or remake.

The axially deformable projections 150, 152 may be made of a material that allows a user to feel the axially deformable projections 150, 152 resisting deformation. For example, the axially deformable projections 150, 152 may be made of a material with a yield strength of 60 kilopounds per square inch (KSI) or greater. In an embodiment, axially deformable projections are made of a material with a yield strength of 80 KSI or greater. In another embodiment, each torque nut is made of a material with a yield strength of at least 20 KSI, of at least 60 KSI, or at least 80 KSI.

Fig. 2B is a front view of a partial cross-section of the fitting body 126 engaged with the axially leading end 158 of the right torque nut 124. The entire right torque nut 124 may be one-piece. For example, the axially deformable projection 152 may be one-piece with an axially inner end face 169 of the right torque nut 124 and an axially outer end face 171 (shown in Fig. 2A) of the right torque nut 124.

The axially deformable projection 152 may be annularly continuous for forming a seal between the torque nut 124 and the fitting body 126 when the axially deformable projection 152 is engaged with the fitting body 126. For example, the axially deformable projection 152 may be non-permeable to fluid to allow the axially deformable projection 152 to seal against the axially inwardly facing shoulder 160. Sealing against the axially inwardly facing shoulder 160 may prevent fluid from flowing radially inwardly between the axially inwardly facing shoulder 160 and the axially inner end face 169.

The axially inner end face 169 may circumscribe a tube passage way – extending from the axially outer end face 171 to the axially inner end face 169 – for receiving the tube 130. An axially inner annular opening of the axially inner end face 169 may receive the fitting body 126 axially opposite the axially outer end face 171.

The right torque nut 124 may have a base 170 extending in a first axial direction from the axially inner end 169 of the right torque nut 124. The base 170 may extend to the axially leading end 158 an axial length L. The base 170 may be entirely radially offset from the axially inner threaded end portion 172 to allow the right torque nut 124 to be assembled with the fitting body 126 and

removed from the fitting body 126 without interference between the base 170 and axially inner threaded end portion 174 of the fitting body 126.

In an embodiment, the base or another portion of the axially deformable projection may not be offset from the corresponding axially inner threaded end portion of the fitting body after a portion of the axially deformable projection
5 plastically deforms. The lack of radial offset with the axially inner threaded end portion may prevent the right torque nut from being completely removed from the fitting body.

The axially deformable projection 152 may include a deformable portion
10 176 disposed radially offset from the axially inner threaded end portion 172. The deformable portion 176 may be axially offset from the axially leading end 158. The axial offset allows a central body 178 of the right torque nut 124 to move axially toward the axially inwardly facing shoulder 160 while the axially leading end 158 axially abuts the axially inwardly facing shoulder 160. Thus, the axial
15 length L may decrease as the right torque nut 124 is progressively tightened, such as when the right torque nut 124 is remade over and over again.

The deformable portion 176 may be configured to deform before any other portion of the axially deformable projection 152 when axially engaging the axially inwardly facing shoulder 160. For example, the deformable portion 176 may be
20 formed by a thin axially extending annular wall 180 that extends from the base 170 to a radially outwardly extending flange 182 that forms the axially leading end 158. The axially leading end 158 may have a radial thickness T_F that is greater than a thickness T_d of the deformable portion 176. For example, the radial thickness T_F may be between 0% and 150% of the thickness T_d . In an
25 embodiment, the radial thickness T_F is between 50% and 100% of the thickness T_d . Thus, the deformable portion 176 may be more easily deformed than adjacent portions of the right torque nut 124 when the axially leading end 158 abuts the axially inwardly facing shoulder 160 and the right torque nut 124 is tightened.

30 As the right torque nut 124 tightens on the fitting body 126 the deformable portion 176 may plastically deform before any other portion of the right torque nut 124 upon an axial force from the axially inwardly facing shoulder 160 being applied to the axially leading end 158. For example, the thin axially extending

annular wall 180 may allow a concentration of strain at the deformable portion 176 that is greater than each axially adjacent portion of the axially deformable projection 152.

5 The strain concentration at the deformable portion 176 may allow the axially leading end 158 to plastically deform relative to the base 170 as the right torque nut 124 is made or remade against the axially inwardly facing shoulder 160. In an alternative embodiment, axially deformable projection may be shaped such that the deformable portion is located closer to the base, at the base and/or closer to the axially leading end. For example, the deformable portion may
10 configured to be axially spaced from the base an axial distance from 30% - 80% of L. In an embodiment, the deformable portion is configured to be axially spaced from the base an axial distance from 40% - 60% of L. In another embodiment, the base may form the deformable portion.

The thickness T_d may be configured based on a desired amount of
15 remakes of the right torque nut 124. The thickness T_d may be between 5% and 50% of a radial thickness T_c of an axially central portion, such as the central body 178, of the right torque nut 124. In an embodiment, the deformable portion has a thickness of between 5% and 20% the radial thickness of an axially central portion.

20 The axial length L may be configured based on the desired amount of remakes of the torque nut 124. The axial length L may be between 100% and 400% of the thickness T_d . In an embodiment, the axial length L is between the thickness T_d and 200% of the thickness T_d . For example, the axial length L may be equal to or approximately equal to the thickness T_d . In another embodiment,
25 the axial length L is between the thickness T_d and 100% of the radial thickness T_c .

As the right torque nut 124 advances toward the axially inwardly facing shoulder 160 the axially deformable projection 152 deforms. The axially deformable projection 152 may resist deformation upon an axial compressive
30 force being applied to the axially leading end 158, which may cause an abrupt rise in torque required to continue advancing the right torque nut 124. The axially deformable projection 152 may deform first at the deformable portion 176 due to stress concentrating at the deformable portion 176. The deformation may

be entirely or almost entirely plastic deformation as the deformable portion is compressed by the axially inwardly facing shoulder 160 abutting the axially leading end 158.

The axially leading end 158 may compress axially toward the central body 178. The axially leading end 158 may also flare slightly radially outward as the right torque nut advances toward the axially inwardly facing shoulder 160 when the deformable portion first deforms. For example, an outer circumference formed by a radially outermost surface of the axially leading end 158 may be expanded radially outward. As the axially leading end 158 flares radially outward into a new position the axially leading end 158 is radially outward of the deformable portion 176. As the right torque nut 124 continues to advance, the axially leading end 158 may continue to flare radially further away from the deformable portion 176. In an embodiment, the axially leading end is configured to curl axially toward the central body as the right torque nut continues to advance against the second axially extending surface.

Referring now to Fig. 2C, the foregoing description of the right torque nut 124 and the corresponding right side of the fitting body 126 is equally applicable to the left torque nut 122 and the corresponding left side of the fitting body 126, except as noted below. The left torque nut 122 is illustrated in the finger tight position during a first makeup of the left torque nut 122 in combination with a ferrule assembly 190 and the fitting body 126. From the finger tight position an additional $1\frac{1}{4}$ tightening turns of the left torque nut 122 may makeup the torque nut 122. For example, a wrench may be used to tighten the left torque nut 122 by $1\frac{1}{4}$ additional turns (e.g., tightening by 7.5 flats of a hex-type right torque nut 124). Similarly, the right torque nut 124 may engage another ferrule assembly (not shown) that is an identical to the ferrule assembly 190 or a different type of ferrule assembly, such as a dual ferrule type ferrule assembly, to seal against an outer surface of the tube 130 (Fig. 2B).

Referring still to Fig. 2C, the ferrule assembly 190 may seal against an outer surface of the tube 128 to prevent fluid from leaking out of the tube 128 between the ferrule assembly 190 and the fitting body 126 and between the ferrule assembly 190 and the outer surface of the tube 128. For example, the ferrule assembly 190 may include a single ferrule to seal against an axially

facing sloped engaging surface at an axially inner end face 191 of the fitting body 126 and to seal radially inwardly against the outer surface of the tube 128. As the left torque nut 122 is advanced toward the axially inwardly facing shoulder 156, the left torque nut 122 may engage the ferrule assembly 190 to compress
5 the ferrule assembly into the axially facing sloped engaging surface of the fitting body 126 and thereby compress the ferrule assembly 190 into the outer surface of the tube 128.

The fitting body 126 may have a cavity opening to the axially inner end face 191 of the fitting body 126 for receiving an end of the tube 128. The fitting
10 body 126 may also have an axially inwardly facing shoulder 193 radially offset from the axially inner threaded portion 202. For example, the axially inwardly facing shoulder 193 may be radially inward of the axially inner threaded portion 202 to receive the tube 128.

The fitting body 126 may have a radially inward facing axially inner
15 surface 194 for engaging an inner end of the ferrule assembly 190 for radially inwardly compressing the ferrule assembly 190 around to tube 128 to form a seal with the tube 128. The ferrule assembly 190 may seal when the fitting body 126 and the ferrule assembly 190 are urged toward one another. For example, the left torque nut 122 may urge the ferrule assembly 190 against the fitting body
20 126 and the fitting body 126 may urge the ferrule assembly 190 radially inwardly to seal against the tube 128.

The fitting body 126 may be symmetrical, such that the fitting body has an identical geometry for engaging the tube 130, the torque nut 124, and the ferrule assembly (not shown) engaged by the torque nut 124 (Fig. 2B).

25 The ferrule assembly 190 may have a shape, size and orientation such that when the left torque nut 122 is finger tight, the ferrule assembly 190 is abutting the torque nut 122 and the fitting body 126. Also, upon a first makeup of the left torque nut 122 the ferrule assembly 190 is fully engaged with the fitting body 126 and the tube 128 – to seal against both – as the axially leading end
30 154 abuts the axially inwardly facing shoulder 156. For example, and axial gap G_{1A} between the axially leading end 154 and the axially inwardly facing shoulder 156 may be the same axial distance required for the left torque nut 122 to slide a nut end 192 of the ferrule assembly 190 to seal the ferrule assembly against the

fitting body 126 and the tube 128. The gap G_{1A} may be anywhere between .038" - .075". In an embodiment the gap G_{1A} is .062". In another embodiment, the gap G_{1A} may be up to .125". In another embodiment, the gap G_{1A} may be greater than .125".

5 In another embodiment, the ferrule assembly is any suitable sealing mechanism, such as a single or dual ferrule system shown in International Application No. PCT/US2014/043230, filed June 19, 2014 and entitled HIGH STRENGTH FLEXIBLE FERRULE, which is incorporated herein by reference.

The left torque nut 122, may be identical to the right torque nut 124 (Fig. 10 2B), and may include an axially inner threaded end portion 200 that may helically circumscribe the central axis A to engage an axially inner threaded end portion 202 of the fitting body 126. The axially inner threaded end portion 202 may circumscribe the central axis A and face radially outwardly to engage the radially inwardly facing axially inner threaded end portion 200. In an embodiment, the 15 left torque nut may have a radially outwardly facing axially inner threaded end portion to engage a radially inwardly facing axially inner threaded end portion of the fitting body.

During assembly, the left torque nut 122 may be slid onto the tube 128 and the ferrule assembly 190 may be slid onto the tube 128 to a position within 20 the left torque nut 122. An axially inner end of the tube 128 may engage the radially inner axially inwardly facing shoulder of the fitting body 126, and an annular portion of the fitting body 126 that includes the axially inner threaded end portion 202 may be received by an axially inner end face 204 of the left torque nut 122. For example, the axially inner end face 204 may define a central cavity 25 that receives the annular portion of the fitting body 126 to allow the fitting body 126 to engage the ferrule assembly 190.

The entire axially deformable projection 150 may be disposed radially outward of the axially inner threaded end portion 202 and/or the axially inner threaded end portion 200 to allow the axially deformable projection 150 to move 30 axially relative to the axially inner threaded end portion 202 prior to the first makeup. The axially deformable projection 150 and the axially inwardly facing shoulder 156 may be configured to allow the axially deformable projection 150 to deform and remain radially offset from the axially inner threaded end portion 202

and/or the axially inner threaded end portion 200. Thus, after subsequent remakes, the left torque nut 122 may be removable from the fitting body 126 along with the axially deformable projection 150.

During remake the union compression fitting 120 can be remade by removing the left torque nut 122 so that the tube 128 can be separated from the fitting body 126. The left torque nut 122 and the ferrule assembly may then be reassembled with the tube 128 and the fitting body 126 and at first finger tightened. Next, the left torque nut 122 may be tightened against the ferrule assembly 190 until the axially leading end 154 engages the axially inwardly facing shoulder 156 of the fitting body 126 which causes an abrupt increase in the torque required to turn the nut further. Each subsequent remake may cause some further deformation of the axially deformable projection 150 and the ferrule assembly 190. The deformation of the axially deformable projection 150 may match the deformation of the ferrule assembly 190.

For example, axially inwardly facing shoulder 156 may be perpendicular to the central axis A and parallel to the axially leading end 154 of the axially deformable projection 150. Thus, the axially leading end 154 may compress axially toward the central body 178. The axially leading end 158 may also flare slightly radially outwardly during makeup and/or subsequent remakes of the left torque nut 122, which prevents the axially deformable projection 150 from interfering with the axially inner threaded end portion 202 when removing the left torque nut 122. In an embodiment, the axially inwardly facing shoulder is sloped radially outward to deform the axially deformable projection radially outward further away from the axially inner threaded end portion of the fitting body during makeup or subsequent remakes. In another embodiment, the axially inwardly facing shoulder is sloped to face radially inward to deform the axially deformable projection radially inward during makeup or subsequent remakes.

Referring now to Fig 3, an exemplary torque vs. nut rotation diagram is illustrated to compare a relative torque curve required to makeup a traditional nut and relative torque curves required to makeup exemplary torque nuts of the present disclosure. The torque curves during makeup of a traditional nut is illustrated with a continuous solid line having an approximately constant rate of torque increase as the traditional nut advances from a finger tight position.

Makeup occurs when the ferrule assembly 190 is sealed to the tube 128, which is indicated by a vertical dashed line intersecting each relative torque curve at about $1\frac{1}{4}$ turns from finger tight. To reach makeup, the axially leading end 154 (Fig. 2C) of the axially deformable projection 150 axially moves into engagement with the axially inwardly facing shoulder 156 of the fitting body 126 to cause an abrupt increase in torque needed to tighten the left torque nut 122 on the fitting body 126 after only partial axial deformation of the axially deformable projection 150 relative to the axially inner end face 204 of the torque nut 122. Referring again to Fig. 3, the abrupt increase in torque needed to tighten the nut indicates that the left torque nut 122 (Fig. 2C) has been tightened sufficiently on the fitting body 126 to seal the ferrule assembly 190 to the tube 128.

Torque values for the exemplary torque nuts are represented with dashed lines and may have the same torque values as the traditional nuts until the exemplary nut abuts a corresponding body. Once the exemplary nut abuts the body the torque required to advance the nut may rise abruptly, thus forming a slope discontinuity in the illustrated graph of torque values. For example, the torque nuts 122, 124 (Figs. 2A-2C) may have an axially leading end 154, 158 that abuts a corresponding axially inwardly facing shoulder 156, 160 at or at about 1.25 turns from the finger tight position (e.g., Fig. 2C). The rate of torque increase may increase by anywhere between 40% and 100% once the axially leading end 154, 158 abuts the axially inwardly facing shoulder 156, 160. In an embodiment, the rate of torque increase may increase by 75% or more. In another embodiment, the rate of torque increase may increase by 100% or more.

A user tightening the torque nut 122, 124 is able to feel the abrupt rise in torque required to advance the nut further at an advanced position and thus stop advancing the torque nut 122, 124 to avoid overmaking the torque nut 122, 124. In an embodiment, the torque nut may be rotated $\frac{1}{4}$ - $\frac{1}{2}$ a hex flat from the advanced position to ensure the nut is madeup to prevent leakage. In an embodiment, the torque nut may be rotated 1 hex flat. In another embodiment, the torque nut may be rotated less than $\frac{1}{4}$ of a hex flat.

Referring now to Fig. 4, an exemplary torque vs. nut rotation diagram is illustrated to compare a relative torque curve required to remake a traditional nut

and relative torque curves required to remake exemplary torque nuts of the present disclosure. Torque curves are provided for a first remake, a second remake and a third remake. The torque curves for each remake are separated by a vertical dashed line and each subsequent finger tight position is represented by each "0" nut rotation position.

Remake occurs when the ferrule assembly 190 is re-sealed to the tube 128. Remake is indicated by multiple vertical dashed lines, each intersecting corresponding relative torque curves at about $\frac{3}{8}$ of a turn from finger tight. To be remade, the axially leading end 154 (Fig. 2C) of the axially deformable projection 150 axially moves into engagement with the axially inwardly facing shoulder 156 of the fitting body 126 to cause an abrupt increase in torque needed to tighten the left torque nut 122 on the fitting body 126 after only partial axial deformation of the axially deformable projection 150 relative to the axially inner end face 204 of the torque nut 122. The partial axial deformation may be less than the deformation during makeup. Referring again to Fig. 3, the abrupt increase in torque needed to tighten the nut indicates that the left torque nut 122 (Fig. 2C) has been tightened sufficiently on the fitting body 126 to seal the ferrule assembly 190 to the tube 128.

The torque curves of the traditional nut are illustrated with a continuous solid line for a first remake, a second remake and a third remake. The torque curves during each remake of the traditional nut have an approximately constant rate of torque increase as the traditional nut advances from each subsequent finger tight position, in a similar fashion to the torque curves of the initial remake illustrated in Fig. 3. The shape of each torque curve depends upon the configuration of the corresponding axially deformable projection and axially inwardly facing shoulder (illustrated by way of example in Figs. 2C as reference numerals 150 and 156, respectively). For example, the nuts 122, 124 (Fig. 2A) may correspond to the intermediate dashed lines for each subsequent remake.

The abrupt rise in torque required to continue tightening the corresponding nut for each subsequent remake allows a user to properly make the torque nuts 122, 124 - based on feeling the abrupt rise - without overmaking the torque nuts 122, 124. The user may also avoid taking the time to pre-mark the torque nuts 122, 124 and corresponding fitting body 126 (Fig. 2A).

Referring now to Fig. 5A, the union compression fitting 120 is illustrated in a partially assembled position. The right torque nut 124 is made up, as indicated by the axially leading end 158 abutting the axially inwardly facing shoulder 160. The left torque nut 122 is finger tight, as indicated by the gap G_{1A} between the axially leading end 154 and the axially inwardly facing shoulder 156. For example, the gap G_{1A} may have an axial length be between .038" and .075" to visually indicate that the left torque nut 122 is properly assembled.

Fig. 5B illustrates the union compression fitting 120, but with improperly assembled torque nuts 122, 124. The left torque nut 122 is illustrated in a finger tight position with the ferrule assembly 190 (Fig. 2C) inserted backwards. The left torque nut 122 is finger tight, but improperly assembled, as indicated by a gap G_{1B} between the axially leading end 154 and the axially inwardly facing shoulder 156. For example, the gap G_{1B} may have an axial length more than twice the axial length of the gap G_{1A} , to indicate the ferrule assembly 190 is not properly assembled prior to final assembly.

The right torque nut 124 is illustrated in a finger tight position with the corresponding ferrule assembly (not shown) not inserted. The right torque nut 124 is finger tight, but improperly assembled, as indicated by the lack of a gap between the axially leading end 158 and the axially inwardly facing shoulder 160. Thus, a visual inspection of the right torque nut 124 at the finger tight position may indicate that the corresponding ferrule assembly is not properly assembled prior to final assembly.

Turning now to Fig. 5C-5E, exemplary embodiments of the union compression fitting is shown at 320. The union compression fitting 320 is substantially the same as the above-referenced union compression fitting 120, and consequently the same reference numerals but indexed by 200 are used to denote structures corresponding to similar structures in the union compression fittings. In addition, the foregoing description of the union compression fitting is equally applicable to the union compression fitting 320 except as noted below. Moreover, it will be appreciated that aspects of the union compression fittings may be substituted for one another or used in conjunction with one another where applicable.

The union compression fitting 320 includes a dual ferrule type ferrule assembly (not shown) for each of a left torque nut 322 and a right torque nut 324. The ferrule assembly includes a back ferrule (not shown) and a front ferrule (not shown).

5 Referring briefly to Fig. 5C, the union compression fitting 320 is illustrated in a partially assembled position. The right torque nut 324 is made up, as indicated by an axially leading end 358 abutting an axially inwardly facing shoulder 360. The left torque nut 322 is finger tight, as indicated by a gap G_{2A} between an axially leading end 354 and an axially inwardly facing shoulder 356.
10 For example, the gap G_{2A} may have an axial length be between .038" - .075" to visually indicate that the corresponding ferrule assembly (e.g., ferrule assembly 190 in Fig. 2C) is properly assembled. In another embodiment, the gap G_{2A} may be up to .125". In another embodiment, the gap G_{2A} may be greater than .125".

Fig. 5D illustrates the union compression fitting 320, but with improperly
15 assembled torque nuts 322, 324. The left torque nut 322 is illustrated in a finger tight position with the back ferrule (not shown) inserted backwards. The left torque nut 322 is finger tight, but improperly assembled, as indicated by a gap G_{2B} between the axially leading end 354 and the axially inwardly facing shoulder 356. For example, the gap G_{2B} may have an axial length of at least 50% greater
20 than the axial length of the gap G_{2A} , to indicate the ferrule assembly is not properly assembled prior to final assembly.

The right torque nut 324 is illustrated in a finger tight position with the corresponding dual ferrule assembly (not shown) missing the back ferrule. The right torque nut 324 is finger tight, but improperly assembled, as indicated by the
25 gap G_{2C} between the axially leading end 358 and the axially inwardly facing shoulder 360. Thus, a visual inspection of the right torque nut 324 at the finger tight position may indicate that the corresponding ferrule assembly is not properly assembled with the right torque nut 324. For example, the gap G_{2C} may have an axial length of 50% or less than the axial length of the gap G_{2A} , to
30 indicate the ferrule assembly is not properly assembled prior to final assembly.

Fig. 5E illustrates the union compression fitting 320, but with improperly assembled nuts 322, 324. The left torque nut 322 is illustrated in a finger tight position with the front ferrule (not shown) inserted backwards. The left torque

nut 322 is finger tight, but improperly assembled, as indicated by a gap G_{2D} between the axially leading end 354 and the axially inwardly facing shoulder 356. For example, the gap G_{2D} may have an axial length of at least 100% greater than the axial length of the gap G_{2A} , to indicate the ferrule assembly is not properly assembled prior to final assembly.

The right torque nut 324 is illustrated in a finger tight position with the corresponding dual ferrule assembly (not shown) missing the front ferrule. The right torque nut 324 is finger tight, but improperly assembled, as indicated by the lack of a gap between the axially leading end 358 and the axially inwardly facing shoulder 360. Thus, a visual inspection of the right torque nut 324 at the finger tight position may indicate that the corresponding ferrule assembly is not properly assembled prior to final assembly.

Turning now to Figs. 6A-6E, exemplary embodiments of the union compression fitting are shown at 520. The union compression fittings 520 are substantially the same as the above-referenced compression fittings 120, 320, and consequently the same reference numerals but indexed by 200 are used to denote structures corresponding to similar structures in the union compression fittings. In addition, the foregoing descriptions of the union compression fittings 120, 320 are equally applicable to the union compression fittings 520 except as noted below. Moreover, it will be appreciated that aspects of the union compression fittings may be substituted for one another or used in conjunction with one another where applicable.

Fig. 6A illustrates a union compression fitting 520 that includes a fitting body 526 with a right torque nut 524 attached to the fitting body 526. The right torque nut 524 may include an axially deformable projection 552 and the fitting body 526 may include an axially inwardly facing shoulder 560 for engaging an axially leading end 558 of the axially deformable projection 552.

The axially deformable projection 552 may include a deformable portion 576 disposed radially offset from axially inner threaded end portion 572. For example, the axially leading end 558 may be and/or may extend radially inward of the deformable portion 576 prior to any deformation. The deformable portion 576 may be axially offset from the axially leading end 558. The axial offset allows a central body 578 of the right torque nut 524 to move axially toward the

axially inwardly facing shoulder 560 while the axially leading end 558 axially abuts the axially inwardly facing shoulder 560. Thus, an axial length L may decrease as the right torque nut 524 is progressively tightened, such as when the right torque nut 524 is remade over and over again.

5 The deformable portion 576 may be formed by a thin axially extending annular wall 580 that extends from a base 570 to a radially inwardly extending flange 582 that forms the axially leading end 558.

10 The base 570 may be radially offset a distance that allows the axially deformable projection 552 to fully deform radially inwardly without interfering with the axially inner threaded end portion 574 when the right torque nut 524 is removed from the fitting body 526. For example, the base 570 may be radially outwardly offset from the axially inner threaded end portion 574 a distance that is equal to or greater than a length of the axially deformable projection 552 from the base 570 to the axially leading end 558. Thus, when the axially deformable
15 projection 552 is fully deformed, the axially leading end 558 may remain radially offset from the axially inner threaded end portion 574.

20 The axially leading end 558 may have a radial thickness T_F that is greater than a thickness T_d of the deformable portion 576. For example, the radial thickness T_F may be between 0% and 150% of the thickness T_d . In an embodiment, the radial thickness T_F is between 50% and 100% of the thickness T_d .

25 The axially leading end 558 may also be radially inwardly offset from the thin axially extending annular wall 580. Thus, the deformable portion 576 may be more easily deformed than adjacent portions of the right torque nut 524 when the axially leading end 558 abuts an axially inwardly facing shoulder 560 and the right torque nut 524 is tightened.

30 The strain concentration at the deformable portion 576 may allow the axially leading end 558 to plastically deform relative to the base 570 as the right torque nut 524 is made or remade against the axially inwardly facing shoulder 560.

 The thickness T_d may be between 5% and 50% of a radial thickness T_c of an axially central portion, such as the central body 578, of the right torque nut

524. In an embodiment, the deformable portion has a thickness of between 5% and 20% the radial thickness of an axially central portion.

The axial length L may be configured based on the desired amount of remakes of the torque nut 124. The axial length L may be between 100% and 400% of the thickness T_d . In an embodiment, the axial length L is between the thickness T_d and 200% of the thickness T_d . For example, the axial length L may be equal to or approximately equal to the thickness T_d . In an embodiment, the axial length L is between the thickness T_d and 100% of the radial thickness T_c . In another embodiment, the axial length L is configured to prevent the axially leading end from deforming radially inward radially even with the axially inner threaded end portion of the fitting body and/or the axially inner threaded end portion of the torque nut.

As the right torque nut 524 advances toward the axially inwardly facing shoulder 560 the axially deformable projection 552 deforms. For example, the axially leading end 558 may be configured to constrict radially inwardly when the deformable portion 552 deforms as the right torque nut 524 is advanced after the axially leading end 558 abuts the axially inwardly facing shoulder 560. The axially deformable projection 552 may resist deformation upon an axial compressive force being applied to the axially leading end 558, which may cause an abrupt rise in torque required to continue advancing the right torque nut 524. The axially deformable projection 552 may deform first at the deformable portion 576 due to stress concentrating at the deformable portion 576. The deformation may be entirely or almost entirely plastic deformation as the deformable portion is compressed by the axially inwardly facing shoulder 560 abutting the axially leading end 558.

Fig. 6B illustrates a union compression fitting 520 that includes a fitting body 526 with a right torque nut 524 attached to the fitting body 526. The right torque nut 524 may include an axially deformable projection 552 and the fitting body 526 may include an axially inwardly facing shoulder 560 for engaging an axially leading end 558 of the axially deformable projection 552. The axially deformable projection 552 may include separate components, such as an annular insert 640 and an annular wall 642.

The annular insert 640 may include a deformable portion 576 that is press-fit to the annular wall 642 such that the annular insert 640 remains integral with the annular wall 642 during makeup and remake. The annular insert 640 may also include an L-shape cross-section. The axially leading end 558 may be
5 and/or may extend radially inward of the deformable portion 576 prior to any deformation.

The annular insert 640 may form a radially inward facing surface 644 for engaging a radially outward facing surface 646 of the annular wall 642. The radially inward facing surface 644 and the radially outward facing surface 646
10 may be non-parallel with one another. For example, the radially inward facing surface 644 may be axially sloped to face toward the annular wall 642. The angle of the axial slope may be between 1° and 10°. For example, the angle of the slope may be exactly or may be approximately 3° relative to the radially outward facing surface 646. The relative sloping allows the deformable portion
15 576 to expand radially outwardly as the annular wall 642 moves axially in toward the fitting body 526 relative to the deformable portion 576. Thus, as the right torque nut 524 advances toward the axially inwardly facing shoulder 560 the radially inward facing surface 644 and the deformable portion 576 may expand radially outward.

20 An axial length L may decrease as the right torque nut 524 is progressively tightened, such as when the right torque nut 524 is remade over and over again. As the axial length L decreases and the radially inward facing surface 644 deforms, the annular insert 640 may become press-fit to the radially outward facing surface 642. Thus, the annular insert 640 may be integral with
25 the axially deformable projection 552, which is integral with the right torque nut 524.

A radially innermost portion of the annular insert 644 may be radially outward of an axially inner threaded end portion 574 and/or the axially inner threaded end portion 572 to allow the annular insert to be removable from the
30 fitting body 526.

The strain concentration at the deformable portion 576 may allow an axially intermediate portion of the plastically deformable portion 576 to deform

relative to the annular wall 642 as the right torque nut 524 is made or remade against the axially inwardly facing shoulder 560.

The thickness T_d at a base 570 may be between 20% and 80% of a radial thickness T_c of an axially central portion, such as the central body 578, of the right torque nut 524. In an embodiment, the deformable portion has a thickness
5 of between 5% and 20% the radial thickness of an axially central portion.

The annular insert 640 may be formed of a material that has a yield strength less than the yield strength of the annular wall 642 to allow the annular insert 640 to deform before the annular wall 642. The annular insert 640 may be
10 made of a powdered metal material, a plastic material and/or another suitable material. For example, the annular insert 640 may have a yield strength of between 20% and 100% of the yield strength of the annular wall 642. In an alternative embodiment, the annular insert 640 has a yield strength of 60 KSI or greater, or 80 KSI or greater.

The axial length L may be configured based on the desired amount of remakes of the torque nut 124. The axial length L may be between 100% and 400% of the thickness T_d . In an embodiment, the axial length L is between the thickness T_d and 200% of the thickness T_d . . For example, the axial length L may be equal to or approximately equal to the thickness T_d . In an embodiment,
15 the axial length L is between the thickness T_d and 100% of the radial thickness T_c . In another embodiment, the axial length L is configured to prevent the axially leading end from deforming radially inward radially even with the axially inner threaded end portion of the fitting body and/or the axially inner threaded end portion of the torque nut.
20

As the right torque nut 524 advances toward the axially inwardly facing shoulder 560 the axially deformable projection 552 deforms. For example, the radially inward facing surface 644 may deform as the right torque nut 524 is advanced after the axially leading end 558 abuts the axially inwardly facing shoulder 560. The radially inward facing surface 644 may resist deformation
25 upon a radially outward force being applied to the radially inward facing surface 644 by the radially outward facing surface 646, which may cause an abrupt rise in torque required to continue advancing the right torque nut 524. The axially deformable projection 552 may deform first at the deformable portion 576 due to
30

stress concentrating at the deformable portion 576 and/or due to the deformable portion 576 being made of a material with a yield strength less than the annular wall 642. The deformation may be entirely or almost entirely plastic deformation as the deformable portion 576 is expanded by the radially outward facing surface 646.

Fig. 6C illustrates a union compression fitting 520 that includes a fitting body 526 with a right torque nut 524 attached to the fitting body 526. The right torque nut 524 may include an axially deformable projection 552 and the fitting body 526 may include an axially inwardly facing shoulder 560 for engaging an axially leading end 558 of the axially deformable projection 552.

The axially deformable projection 552 may include a deformable portion 576 disposed radially offset from axially inner threaded end portion 572. For example, the axially leading end 558 may be and/or may extend radially outward of the deformable portion 576 prior to any deformation. The deformable portion 576 may be axially offset from the axially leading end 558.

The deformable portion 576 may be formed by a thin radially and axially extending annular wall 580 that extends from a base 570 to the axially leading end 558. The annular wall 580 may progressively thin from the base 570 to the axially leading end 558. For example, the axially leading end 558 may have a radial thickness T_F that is less than a thickness T_d of the deformable portion 576. For example, the radial thickness T_F may be between 0% and 150% of the thickness T_d . In an embodiment, the radial thickness T_F is between 50% and 100% of the thickness T_d .

A strain concentration at the deformable portion 576 may allow the axially leading end 558 to plastically deform relative to the base 570 as the right torque nut 524 is made or remade against the axially inwardly facing shoulder 560.

The thickness T_d may be between 5% and 50% of a radial thickness T_c of an axially central portion, such as the central body 578, of the right torque nut 524. In an embodiment, the deformable portion has a thickness of between 20% and 30% the radial thickness of an axially central portion.

The axial length L may be configured based on the desired amount of remakes of the torque nut 124. The axial length L may be between 100% and 400% of the thickness T_d . In an embodiment, the axial length L is between the

thickness T_d and 200% of the thickness T_d . For example, the axial length L may be equal to or approximately equal to the thickness T_d . In an embodiment, the axial length L is between the thickness T_d and 100% of the radial thickness T_c . In another embodiment, the axial length L is configured to prevent the axially leading end from deforming radially inward radially even with the axially inner threaded end portion 574 and/or the axially inner threaded end portion 572.

Fig. 6D illustrates a union compression fitting 520 that includes a fitting body 526 with a right torque nut 524 attached to the fitting body 526. The right torque nut 524 may include an axially deformable projection 552 and the fitting body 526 may include an axially inwardly facing shoulder 560 for engaging an axially leading end 558 of the axially deformable projection 552.

The axially deformable projection 552 may include a deformable portion 576 disposed radially offset from the axially inner threaded end portion 572. The axially leading end 558 may be configured to deform radially relative to the deformation portion 576 as the deformable portion 576 initially deforms. For example, the axially leading end 558 may be and/or may extend radially inward of the deformable portion 576 prior to any deformation. The deformable portion 576 may be axially offset from the axially leading end 558.

The deformable portion 576 may be formed by a thin radially and axially extending annular wall 580 that extends from a base 570 to the axially leading end 558. The annular wall 580 may progressively thin from the base 570 to the axially leading end 558. For example, the axially leading end 558 may have a radial thickness T_F that is less than a thickness T_d of the deformable portion 576. For example, the radial thickness T_F may be 0% and 150% of the thickness T_d . In an embodiment, the radial thickness T_F is between 50% and 100% of the thickness T_d .

The base 570 may be radially offset a distance that allows the axially deformable projection 552 to fully deform radially inwardly without interfering with the axially inner threaded end portion 574 when the right torque nut 524 is removed from the fitting body 526. For example, the base 570 may be radially outwardly offset from the axially inner threaded end portion 574 a distance that is equal to or greater than a length of the axially deformable projection 552 from the base 570 to the axially leading end 558. Thus, when the axially deformable

projection 552 is fully deformed, the axially leading end 558 may remain radially offset from the axially inner threaded end portion 574.

A strain concentration at the deformable portion 576 may allow the axially leading end 558 to plastically deform relative to the base 570 as the right torque
5 nut 524 is made or remade against the axially inwardly facing shoulder 560.

The thickness T_d may be between 5% and 50% of a radial thickness T_c of an axially central portion, such as the central body 578, of the right torque nut 524. In an embodiment, the deformable portion has a thickness of between 20% and 30% the radial thickness of an axially central portion.

10 Fig. 6E illustrates a union compression fitting 520 that includes a fitting body 526 with a right torque nut 524 attached to the fitting body 526. The right torque nut 524 may include an axially deformable projection 552 and the fitting body 526 may include an axially inwardly facing shoulder 560 for engaging an axially leading end 558 of the axially deformable projection 552.

15 The axially deformable projection 552 may include a deformable portion 576 disposed radially offset from the axially inner threaded end portion 572. The deformable portion 576 may also be axially offset from the axially leading end 558.

The deformable portion 576 may be formed by a thin radially and axially
20 extending annular wall 580 that extends from a base 570 to the axially leading end 558. The annular wall 580 may have an axially sloped radially outward facing surface such that the annular wall 580 progressively thickens from the base 570 to the axially leading end 558. For example, the axially leading end 558 may have a radial thickness T_F that is less than a thickness T_d of the
25 deformable portion 576. For example, the radial thickness T_F may be between 0% and 150% of the thickness T_d . In an embodiment, the radial thickness T_F is between 50% and 100% of the thickness T_d .

A strain concentration at the deformable portion 576 may allow the axially leading end 558 to plastically deform relative to the base 570 as the right torque
30 nut 524 is made or remade against the axially inwardly facing shoulder 560.

The thickness T_d may be between 5% and 50% of a radial thickness T_c of an axially central portion, such as the central body 578, of the right torque nut

524. In an embodiment, the deformable portion has a thickness of between 20% and 30% the radial thickness of an axially central portion.

Turning now to Figs. 7A-7D, exemplary embodiments of the union compression fitting are shown at 720. The union compression fittings 720 are substantially the same as the above-referenced compression fittings 120, 320 and 520, and consequently the same reference numerals but indexed by 200 are used to denote structures corresponding to similar structures in the union compression fittings. In addition, the foregoing descriptions of the union compression fittings 120, 320 and 520 are equally applicable to the union compression fittings 720 except as noted below. Moreover, it will be appreciated that aspects of the union compression fittings may be substituted for one another or used in conjunction with one another where applicable.

Fig. 7A illustrates a union compression fitting 720 that includes a fitting body 726 with a right torque nut 724 attached to the fitting body 726. The right torque nut 724 may include an axially deformable projection 752 and the fitting body 726 may include an axially inwardly facing shoulder 760 for engaging an axially leading end 758 of the axially deformable projection 752. The axially deformable projection 752 may be initially separate from a central body 778, for example the axially deformable projection 752 may be an annular insert that may be received by the right torque nut 724. The axially deformable projection 752 may have a rectangular cross-section, and may have a radially outward facing concave surface.

The axially deformable projection 752 may include a deformable portion 776 disposed radially offset from an axially inner threaded end portion 772. The deformable portion 776 may also be axially offset from the axially leading end 758.

The deformable portion 776 may be formed by a radially and axially extending annular wall 780 that extends axially from a base 770 to the axially leading end 758.

A strain concentration at the deformable portion 776 may allow the axially leading end 758 to plastically deform relative to the base 770 as the right torque nut 724 is made or remade against the axially inwardly facing shoulder 760.

The base 770 is squeezed into an axially facing concave portion 850 of the right torque nut 724 during makeup. The base 770 may initially deform to expand radially inwardly and radially outwardly into the concave portion 850 as the right torque nut 724 advances against the axially inwardly facing shoulder 760. After deforming into the concave portion 850, the deformable portion 776 may deform further to allow further makeup or remake of a corresponding ferrule assembly (not shown). The deformation of the deformable portion 776 may be more axial deformation than radial deformation.

The concave portion 850 may open toward the axially inwardly facing shoulder 760 for receiving the axially deformable projection 752 at a position radially offset from an axially inner threaded end portion 774 and/or the axially inner threaded end portion 772. As the right torque nut 724 advances toward the axially inwardly facing shoulder 760 the base 770 may deform radially outwardly to press-fit the insert against a radially inward facing shoulder that forms a portion of the concave portion 850. Thus, the insert may be integral with the central body 778. The insert may also be fixed relative to the central body 778.

The axially deformable projection 752 may be made of any suitable material that allows the axially deformable projection 752 to deform prior to another portion of the right torque nut 724. The axially deformable projection 752 may be made from a soft powdered metal, a plastic material or a porous material. The porous material may provide a weather shield and may resist deformation.

The axially deformable projection 752 may have a yield strength of anywhere from 20% to 100% the yield strength of the central body 778.

Fig. 7B illustrates a union compression fitting 720 that includes a fitting body 726 with a right torque nut 724 attached to the fitting body 726. The right torque nut 724 may include an axially deformable projection 752 and the fitting body 726 may include an axially inwardly facing shoulder 760 for engaging an axially leading end 758 of the axially deformable projection 752. The axially deformable projection 752 may be initially separate from a central body 778, for example the axially deformable projection 752 may be an annular insert that may be received by the right torque nut 724. The axially deformable projection 752 may have an approximately rectangular cross-section, which may be a

rectangular cross-section in some embodiments, and may have a radially outward facing concave surface.

The axially deformable projection 752 may include a deformable portion 776 disposed radially offset from an axially inner threaded end portion 772. The
5 deformable portion 776 may also be axially offset from the axially leading end 758.

The deformable portion 776 may be formed by a radially and axially extending annular wall 780 that extends axially from a base 770 to the axially leading end 758.

10 A strain concentration at the deformable portion 776 may allow the axially leading end 758 to plastically deform relative to the base 770 as the right torque nut 724 is made or remade against the axially inwardly facing shoulder 760. The base 770 is squeezed into an axially facing concave portion 850 of the right torque nut 724 during makeup.

15 The base 770 may initially deform into the concave portion 850 as the right torque nut 724 advances against the axially inwardly facing shoulder 760. After deforming into the concave portion 850, the deformable portion 776 may deform to allow further makeup or remake of a corresponding ferrule assembly (not shown).

20 The concave portion 850 may open toward the axially inwardly facing shoulder 760 for receiving the axially deformable projection 752 at a position radially offset from an axially inner threaded end portion 774 and/or the axially inner threaded end portion 772. For example, the concave portion 850 may extend radially outward and axially away from the base 770.

25 As the right torque nut 724 advances toward the axially inwardly facing shoulder 760 the base 770 may deform radially outwardly to press-fit the insert against a radially inward facing shoulder that forms a portion of the concave portion 850. Thus, the insert may be integral with the central body 778. The insert may also be fixed relative to the central body 778.

30 The axially deformable projection 752 may be made of any suitable material that allows the axially deformable projection 752 to deform prior to another portion of the right torque nut 724. The axially deformable projection 752 may be made from a soft powdered metal, a plastic material or a porous

material. For example, the axially deformable projection 752 may have a yield strength of anywhere from 20% to 100% the yield strength of the central body 778.

Fig. 7C illustrates a union compression fitting 720 that includes a fitting
5 body 726 with a right torque nut 724 attached to the fitting body 726. The right torque nut 724 may include an axially deformable projection 752 and the fitting body 726 may include an axially inwardly facing shoulder 760 for engaging an axially leading end 758 of the axially deformable projection 752. The axially deformable projection 752 may be initially separate from a central body 778, for
10 example the axially deformable projection 752 may be an annular insert that may be received by the right torque nut 724. The axially deformable projection 752 may have a billowed cross-section.

The axially deformable projection 752 may include a deformable portion 776 disposed radially offset from an axially inner threaded end portion 772. The
15 deformable portion 776 may also be axially offset from the axially leading end 758.

The deformable portion 776 may be formed by a radially and axially extending annular wall 780 that extends axially from a base 770 to the axially leading end 758.

20 A strain concentration at the deformable portion 776 may allow the axially leading end 758 to plastically deform relative to the base 770 as the right torque nut 724 is made or remade against the axially inwardly facing shoulder 760.

The base 770 is squeezed into an axially facing concave portion 850 of the right torque nut 724 during makeup. The base 770 may initially deform to
25 expand radially inwardly and radially outwardly into the concave portion 850 as the right torque nut 724 advances against the axially inwardly facing shoulder 760. After deforming into the concave portion 850, the deformable portion 776 may deform to allow further makeup or remake of a corresponding ferrule assembly (not shown). The deformation of the deformable portion 776 may be
30 more axial deformation than radial deformation.

The concave portion 850 may open toward the axially inwardly facing shoulder 760 for receiving the axially deformable projection 752 at a position radially offset from an axially inner threaded end portion 774 and/or the axially

inner threaded end portion 772. As the right torque nut 724 advances toward the axially inwardly facing shoulder 760 the base 770 may deform radially outwardly to press-fit the insert against a radially inward facing shoulder that forms a portion of the concave portion 850. Thus, the insert may be integral with the central body 778. The insert may also be fixed relative to the central body 778.

The axially deformable projection 752 may be made of any suitable material that allows the axially deformable projection 752 to deform prior to another portion of the right torque nut 724. For example, the axially deformable projection 752 may have a yield strength based on a geometric shape of the deformable projection 752.

Fig. 7D illustrates a union compression fitting 720 that includes a fitting body 726 with a right torque nut 724 attached to the fitting body 726. The right torque nut 724 may include an axially deformable projection 752 and the fitting body 726 may include an axially inwardly facing shoulder 760 for engaging an axially leading end 758 of the axially deformable projection 752. The axially deformable projection 752 may be initially separate from a central body 778, for example the axially deformable projection 752 may be an annular insert that may be received by the right torque nut 724. The axially deformable projection 752 may have a billowed cross-section.

The axially deformable projection 752 may include a deformable portion 776 disposed radially offset from an axially inner threaded end portion 772. The deformable portion 776 may also be axially offset from the axially leading end 758.

The deformable portion 776 may be formed by a radially and axially extending annular wall 780 that extends axially from a base 770 to the axially leading end 758.

A strain concentration at the deformable portion 776 may allow the axially leading end 758 to plastically deform relative to the base 770 as the right torque nut 724 is made or remade against the axially inwardly facing shoulder 760. The base 770 is squeezed into an axially facing concave portion 850 of the right torque nut 724 during makeup.

The base 770 may initially deform into the concave portion 850 as the right torque nut 724 advances against the axially inwardly facing shoulder 760.

After deforming into the concave portion 850, the deformable portion 776 may deform to allow further makeup or remake of a corresponding ferrule assembly (not shown).

5 The concave portion 850 may open toward the axially inwardly facing shoulder 760 for receiving the axially deformable projection 752 at a position radially offset from an axially inner threaded end portion 774 and/or the axially inner threaded end portion 772. For example, the concave portion 850 may extend radially outward and axially away from the base 770.

10 As the right torque nut 724 advances toward the axially inwardly facing shoulder 760 the base 770 may deform radially outwardly to press-fit the insert against a radially inward facing shoulder that forms a portion of the concave portion 850. Thus, the insert may be integral with the central body 778. The insert may also be fixed relative to the central body 778.

15 The axially deformable projection 752 may be made of any suitable material that allows the axially deformable projection 752 to deform prior to another portion of the right torque nut 724. For example, the axially deformable projection 752 may have a yield strength based on a geometric shape of the deformable projection 752.

20 Turning now to Figs. 8A-8D, exemplary embodiments of the union compression fitting are shown at 920. The union compression fittings 920 are substantially the same as the above-referenced compression fittings 120, 320, 520 and 720, and consequently the same reference numerals but indexed by 200 are used to denote structures corresponding to similar structures in the union compression fittings. In addition, the foregoing descriptions of the union
25 compression fittings 120, 320, 520 and 720 are equally applicable to the union compression fittings 920 except as noted below. Moreover, it will be appreciated that aspects of the union compression fittings may be substituted for one another or used in conjunction with one another where applicable.

30 Fig. 8A illustrates a union compression fitting 920 that includes a right torque nut 924, a ferrule assembly 990 and a tube 930. The torque nut 924 may include a concave portion 1052 at a back end of the right torque nut 924. The concave portion 1052 may be partially formed by an annular radially inward facing shoulder of the right torque nut 924. A radially inwardly extending flange

at the back end may prevent provide an axially facing shoulder to partially form the concave portion 1052.

A seal 1054 may be disposed within the concave portion 1052 to seal against an outer surface of the tube 930. The seal 1054 may protect the ferrule
5 assembly 990 from an external fluid by sealing against the tube 930.

The seal 1054 may be an O-ring seal. For example, the seal 1054 may be a rubber O-ring seal. In an embodiment, the seal has another suitable cross-section. In another embodiment, the seal is any suitable elastomeric material disposed within the concave portion to seal against the concave portion and the
10 tube.

When the right torque nut 924 is madeup against a corresponding fitting body, (e.g., the fitting body 126 as shown in Fig. 2B), a seal 1054 may form between the right torque nut 924 and the corresponding fitting body. Thus, when the right torque nut 924 is madeup, external fluid may be prevented from
15 reaching interior portions of the right torque nut 924, the ferrule assembly 990 and the corresponding fitting body.

Fig. 8B illustrates a union compression fitting 920 that includes a right torque nut 924, a ferrule assembly 990 and a tube 930. The torque nut 924 may include a concave portion 1052 at a back end of the right torque nut 924. The
20 concave portion 1052 may be partially formed by an annular radially inward facing shoulder of the right torque nut 924. A radially inwardly extending flange at the back end may prevent provide an axially facing shoulder to partially form the concave portion 1052.

A seal 1054 may be disposed within the concave portion 1052 to seal
25 against an outer surface of the tube 930. The seal 1054 may protect the ferrule assembly 990 from an external fluid by sealing against the tube 930.

The seal 1054 may be an annular seal with a quadrilateral cross-section. For example, the seal 1054 may be a rubber annular seal. In an embodiment, the seal has another suitable cross-section. In another embodiment, the seal is
30 made of an elastomeric material disposed in the concave portion, such as a rubber material that is inserted into the concave portion or bonded into the concave portion.

When the right torque nut 924 is madeup against a corresponding fitting body, (e.g., the fitting body 126 as shown in Fig. 2B), a seal 1054 may form between the right torque nut 924 and the corresponding fitting body. Thus, when the right torque nut 924 is madeup, external fluid may be prevented from reaching interior portions of the right torque nut 924, the ferrule assembly 990 and the corresponding fitting body.

Fig. 8C illustrates a union compression fitting 920 that includes a right torque nut 924, a ferrule assembly 990 and a tube 930. The torque nut 924 may include a concave portion 1052 at a back end of the right torque nut 924. The concave portion 1052 may be partially formed by an annular radially inward facing shoulder of the right torque nut 924. A radially inwardly extending flange at the back end may prevent provide an axially facing shoulder to partially form the concave portion 1052.

A seal 1054 may be disposed within the concave portion 1052 to seal against an outer surface of the tube 930. The seal 1054 may protect the ferrule assembly 990 from an external fluid by sealing against the tube 930.

The seal 1054 may be an annular seal with a cross-section of a trapezium with a radially outward triangular portion removed. In an embodiment, the seal has another suitable cross-section.

The seal 1054 may be a rubber annular seal. In an embodiment, the seal is made of an elastomeric material disposed in the concave portion, such as a rubber material that is inserted into the concave portion or bonded into the concave portion.

When the right torque nut 924 is madeup against a corresponding fitting body, (e.g., the fitting body 126 as shown in Fig. 2B), a seal 1054 may form between the right torque nut 924 and the corresponding fitting body. Thus, when the right torque nut 924 is madeup, external fluid may be prevented from reaching interior portions of the right torque nut 924, the ferrule assembly 990 and the corresponding fitting body.

Fig. 8D illustrates a union compression fitting 920 that includes a right torque nut 924, a ferrule assembly 990 and a tube 930.

A seal 1054 may be disposed at a back end of the right torque nut 924 to seal against an outer surface of the tube 930. The seal 1054 may protect the ferrule assembly 990 from an external fluid by sealing against the tube 930.

The seal 1054 may be an annular seal with any suitable cross-section. For example, the seal 1054 may have a triangular cross-section with an axially deformable projection extending between a radially inward portion of the right torque nut 924 and the outer surface of the tube 930.

The seal 1054 may be a rubber annular seal. In an embodiment, the seal is made of an elastomeric material, such as a rubber material that is inserted on a back end of the torque nut or bonded to the back end of the torque nut. In another embodiment, the seal is made of a flexible tape wrapped circumferentially around the tube. For example, the torque nut may have any suitable back end and the flexible tape may seal a circumferential gap between the torque nut and the tube.

When the right torque nut 924 is made up against a corresponding fitting body, (e.g., the fitting body 126 as shown in Fig. 2B), a seal 1054 may form between the right torque nut 924 and the corresponding fitting body. Thus, when the right torque nut 924 is made up, external fluid may be prevented from reaching interior portions of the right torque nut 924, the ferrule assembly 990 and the corresponding fitting body.

Turning now to Figs. 9A-9M, exemplary embodiments of the union compression fittings are shown at 1120. The union compression fittings 1120 are substantially the same as the above-referenced compression fittings 120, 320, 520, 720 and 920, and consequently the same reference numerals but indexed by 200 are used to denote structures corresponding to similar structures in the union compression fittings. In addition, the foregoing descriptions of the union compression fittings 120, 320, 520, 720 and 920 are equally applicable to the union compression fittings 1120 except as noted below. Moreover, it will be appreciated that aspects of the union compression fittings may be substituted for one another or used in conjunction with one another where applicable.

The union compression fittings 1120 may be made and remade similar to the above compression fittings. Thus, the union compression fittings 1120 may include a torque nut that easily assembled based on feel of an abrupt increase in

torque needed to tighten the torque. During assembly the abrupt increase in torque needed to tighten the torque nut indicating that the torque nut has been tightened sufficiently.

Fig. 9A illustrates a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may be an annular stop collar with an approximately rectangular cross-section, which may be a rectangular cross-section in some embodiments.

Prior to the right torque nut 1124 being madeup, the stop collar 1260 may be rotatable about the central axis. After makeup the right torque nut 1124 (e.g., the right torque nut 124 of Fig. 2B) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axially facing surface of the stop collar 1260. The compressive force may fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Fig. 9B illustrates a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may be an annular stop collar with a rectangular cross-section.

Prior to the right torque nut 1124 being madeup, the stop collar 1260 may be rotatable about the central axis. After makeup the right torque nut 1124 (e.g., the right torque nut 524 of Fig. 6A) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axially facing surface of the stop collar 1260. The compressive force may fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Figs. 9C and 9D illustrate a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may

be an annular stop collar with an axially extending radially outward portion 1262. For example, the stop collar 1260 may have a frustoconical shape. As shown in Fig. 9C, prior to makeup of the right torque nut 1124, the axially extending radially outward portion 1262 may extend toward the right torque nut 1124. Prior to makeup, the stop collar 1260 may also be rotatable about the central axis.

Referring now to Fig. 9D, after makeup of the right torque nut 1124 (e.g., the right torque nut 524 of Fig. 6D) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axial facing surface of the axially extending radially outward portion 1262. The compressive force may deform the stop collar such that the axially extending radially outward portion 1262 may extend away from the right torque nut 1124. The deformation may be a visual indication that the right torque nut 1124 is madeup.

The compressive force may also fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Fig. 9E illustrates a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may be an annular stop collar with a rectangular cross-section.

Prior to the right torque nut 1124 being madeup, the stop collar 1260 may be rotatable about the central axis. After makeup the right torque nut 1124 (e.g., the right torque nut 524 of Fig. 6B) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axially facing surface of the stop collar 1260. The compressive force may fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Fig. 9F illustrates a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an

axially inwardly facing shoulder of the fitting body. The stop collar 1260 may be an annular stop collar with a rectangular cross-section.

Prior to the right torque nut 1124 being madeup, the stop collar 1260 may be rotatable about the central axis. After makeup the right torque nut 1124 (e.g.,
5 the right torque nut 524 of Fig. 6C) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axially facing surface of the stop collar 1260. The compressive force may fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut
10 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Fig. 9G illustrates a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may be
15 an annular stop collar with a rectangular cross-section.

Prior to the right torque nut 1124 being madeup, the stop collar 1260 may be rotatable about the central axis. After makeup the right torque nut 1124 (e.g., the right torque nut 524 of Fig. 6D) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axially facing
20 surface of the stop collar 1260. The compressive force may fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

25 Figs. 9H and 9I illustrate a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may be an annular stop collar with an axially extending radially outward portion 1262. For example, the stop collar 1260 may have a frustoconical shape. As shown in
30 Fig. 9H, prior to makeup of the right torque nut 1124, the axially extending radially outward portion 1262 may extend toward the right torque nut 1124. Prior to makeup, the stop collar 1260 may also be rotatable about the central axis.

Referring now to Fig. 9I, after makeup of the right torque nut 1124 (e.g., the right torque nut 124 of Fig. 2B) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axial facing surface of the axially extending radially outward portion 1262. The compressive
5 force may deform the stop collar such that the axially extending radially outward portion 1262 may extend away from the right torque nut 1124. The deformation may be a visual indication that the right torque nut 1124 is madeup.

The compressive force may also fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate
10 the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Figs. 9J and 9K illustrate a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming
15 an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may include a pair of annular stop collars, each with an axially extending radially outward portion 1262, 1264. For example, the stop collar 1260 may include a pair of Frustoconical shaped collars. As shown in Fig. 9J, prior to makeup of the right torque nut 1124, the axially extending radially outward portion 1262 may
20 extend toward the right torque nut 1124, and the axially extending radially outward portion 1264 may extend away from the right torque nut 1124. Opposing axially and radially outwardly facing surfaces 1270, 1272 of the axially extending radially outward portions 1262, 1264 may have a different color than adjacent portions of the axially extending radially outward portions 1262, 1264.
25 In an embodiment, the opposing axially and radially outwardly facing surfaces 1270, 1272 are colored red to indicate the right torque nut 1124 is not made up.

Prior to makeup, visibility of the opposing axially and radially outwardly facing surfaces 1270, 1272 may indicate that the right torque nut 1124 is not madeup. The stop collar 1260 may also be rotatable about the central axis to
30 indicate that the right torque nut 1124 is not madeup.

Referring now to Fig. 9K, after makeup of the right torque nut 1124 (e.g., the right torque nut 124 of Fig. 2B) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axial facing

surface of the axially extending radially outward portion 1262. The compressive force may deform the stop collar such that the axially extending radially outward portions 1262, 1264 may extend axially parallel to one another. The deformation may be a visual indication that the right torque nut 1124 is madeup. For
5 example, the opposing axially and radially outwardly facing surfaces 1270, 1272 may not be visible.

The compressive force may also fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus,
10 the stop collar 1260 may be an indicator of whether the right torque nut 1124 is madeup.

Figs. 9L and 9M illustrate a union compression fitting 1120 that includes a right torque nut 1124, and a fitting body 1126 having a stop collar 1260 forming an axially inwardly facing shoulder of the fitting body. The stop collar 1260 may
15 include a pair of annular stop collars, each with an axially extending radially outward portion 1262, 1264. For example, the stop collar 1260 include a pair of Frustoconical shaped collars. As shown in Fig. 9L, prior to makeup of the right torque nut 1124, the axially extending radially outward portion 1262 may extend toward the right torque nut 1124, and the axially extending radially outward
20 portion 1264 may extend away from the right torque nut 1124. Opposing axially and radially outwardly facing surfaces 1270, 1272 of the axially extending radially outward portions 1262, 1264 may have a different color than adjacent portions of the axially extending radially outward portions 1262, 1264. In an embodiment, the opposing axially and radially outwardly facing surfaces 1270,
25 1272 are colored red to indicate the right torque nut 1124 is not made up.

Prior to makeup, visibility of the opposing axially and radially outwardly facing surfaces 1270, 1272 may indicate that the right torque nut 1124 is not madeup. The stop collar 1260 may also be rotatable about the central axis to indicate that the right torque nut 1124 is not madeup.

30 Referring now to Fig. 9M, after makeup of the right torque nut 1124 (e.g., the right torque nut 524 of Fig. 6D) may exert an axially compressive force against an annular radially inward facing shoulder formed by an axial facing surface of the axially extending radially outward portion 1262. The compressive

force may deform the stop collar such that the axially extending radially outward portions 1262, 1264 may extend axially parallel to one another. The deformation may be a visual indication that the right torque nut 1124 is madeup. For example, the opposing axially and radially outwardly facing surfaces 1270, 1272
5 may not be visible.

The compressive force may also fix the stop collar 1260 relative to the fitting body 1126 and the right torque nut 1124. A user may be unable to rotate the stop collar 1260 relative to the nut 1124 once the nut 1124 is madeup. Thus, the stop collar 1260 may be an indicator of whether the right torque nut 1124 is
10 madeup.

Although the invention has been shown and described with respect to a certain embodiment or embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular
15 regard to the various functions performed by the above described elements (components, assemblies, devices, compositions, etc.), the terms (including a reference to a "means") used to describe such elements are intended to correspond, unless otherwise indicated, to any element which performs the specified function of the described element (i.e., that is functionally equivalent),
20 even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary embodiment or embodiments of the invention. In addition, while a particular feature of the invention may have been described above with respect to only one or more of several illustrated embodiments, such feature may be combined with one or more other features of
25 the other embodiments, as may be desired and advantageous for any given or particular application.

Claims

What is claimed is:

1. A tube fitting assembly comprising:

5 a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion;

a ferrule assembly for sealing to the tube, the ferrule assembly and fitting
10 body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube;

a torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the
15 torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is
20 tightened onto the fitting body; and

wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut in the same direction as the axially inwardly facing
25 shoulder of the fitting body is radially offset from the axially inner threaded portion of the fitting body such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting
30 body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube,

and wherein the axially deformable projection is annularly continuous for forming a seal between the torque nut and the fitting body when the axially deformable projection is engaged with the fitting body.

5 2. A tube fitting assembly comprising:

 a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion;

10 a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube;

 a torque nut having an axially inner threaded end portion in threaded
15 engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the
20 ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body; and

 wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end
25 portion of the torque nut in the same direction as the axially inwardly facing shoulder of the fitting body is radially offset from the axially inner threaded portion of the fitting body such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to
30 cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the nut indicating that the torque nut has been

tightened sufficiently on the fitting body to seal the ferrule assembly to the tube, and wherein the abrupt increase in the torque is at least 40% greater than the increase in torque that otherwise would occur during tightening of the torque nut in the absence of the axially deformable projection.

5

3. The tube fitting of any one of claims 1 or 2, wherein the torque nut can be loosened to allow for removal of the tube from the fitting body and then remade up, with the axially leading end of the axially deformable projection again moving axially into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after further axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the nut indicating that the torque nut again has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube.

15

4. The tube fitting of any one of claims 1-3, wherein the fitting body has a stop collar forming the axially inwardly facing shoulder of the fitting body.

5. A torque nut for a tube fitting assembly that includes a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion, and a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube, the torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder

20

25

30

operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body; and

wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube, and wherein the axially deformable projection is annularly continuous for forming a seal between the torque nut and the fitting body when the axially deformable projection is engaged with the fitting body.

6. A torque nut for a tube fitting assembly that includes a fitting body having an axially inner threaded end portion and a cavity opening to an axially inner end face of the fitting body for receiving an end of a tube, the fitting body having an axially inwardly facing shoulder radially offset from the axially inner threaded portion, and a ferrule assembly for sealing to the tube, the ferrule assembly and fitting body, when axially urged towards one another, having cooperating surfaces for radially inwardly compressing the ferrule assembly around to tube to form a seal with the tube, the torque nut having an axially inner threaded end portion in threaded engagement with the axially inner threaded end portion of the fitting body, the torque nut having a tube passageway extending from an axially outer end face of the torque nut to an axially inner end face of the torque nut, the tube passageway allowing for passage of a tube through the torque nut and into the fitting body, and the tube passageway having a shoulder operative to cause the ferrule assembly to be urged toward the fitting body when the torque nut is tightened onto the fitting body; and

wherein the torque nut has integral therewith an axially deformable projection protruding from the axially inner end face of the torque nut, which axially deformable projection is radially offset from the axially inner threaded end portion of the torque nut such that upon tightening of the torque nut on the fitting body, an axially leading end of the axially deformable projection will axially move into engagement with the axially inwardly facing shoulder of the fitting body to cause an abrupt increase in torque needed to tighten the torque nut on the fitting body after only partial axial deformation of the axially deformable projection relative to the axially inner end face of the torque nut, the abrupt increase in torque needed to tighten the nut indicating that the torque nut has been tightened sufficiently on the fitting body to seal the ferrule assembly to the tube, and wherein the abrupt increase in the torque is at least 40% greater than the increase in torque that otherwise would occur during tightening of the torque nut in the absence of the axially deformable projection.

15

7. A tube fitting assembly comprising:

a torque nut and a fitting body;

a tube with an annular outer surface embraced by the torque nut and the fitting body; and

at least one ferrule engaged by the torque nut and the fitting body to seal against the annular outer surface of the tube;

the fitting body comprising:

an annular portion having an axially inner threaded end portion;

and

an axially facing shoulder for engaging the torque nut;

the torque nut comprising:

an axially inner threaded end portion configured to engage the axially inner threaded end portion of the fitting body, the axially inner threaded end portion of the torque nut helically circumscribing a central axis of the torque nut;

30

a first end of the torque nut, wherein the first end of the torque nut is configured to receive an annular portion of the fitting body; and

an axially deformable projection having a base extending from the first end of the torque nut in a first axial direction to an axially leading end of the axially deformable projection, the axially deformable projection having a first axial length from the base to the axially leading end of the axially deformable projection, the base being entirely radially offset from the axially inner threaded end portion of the torque nut and the axially inner threaded end portion of the fitting body;

the axially deformable projection having a deformable portion disposed radially offset from the axially inner threaded end portion of the torque nut and radially offset from the axially inner threaded end portion of the fitting body;

wherein the axially deformable projection resists deformation upon the fitting body exerting an axial compressive force against the axially leading end when the axially leading end engages the fitting body;

wherein the deformable portion is configured to plastically deform when compressed by the axially facing shoulder facing in a second direction to abut the engagement end, the axially facing shoulder being axially fixed relative to the fitting body when the axially leading end engages the axially facing shoulder such that the deformable portion does not deform until the axially compressive force is at least 20% of an axial force necessary for the torque nut to axially urge the at least one ferrule into a madeup position to sealingly engage the annular outer surface of the tube; and

wherein the axially deformable projection is removable from the fitting body, with the nut after the deformable portion is plastically deformed into a first position.

8. A torque nut comprising:

axially inner threaded end portion configured to engage an axially inner threaded end portion of a fitting body, the axially inner threaded end portion of the torque nut helically circumscribing a central axis of the torque nut;

a first end of the torque nut, wherein the first end of the torque nut is configured to receive an annular portion of the fitting body; and

an axially deformable projection having a base extending from the first end of the torque nut in a first axial direction to an axially leading end of the axially deformable projection, the axially deformable projection having a first axial length from the base to the axially leading end of the axially deformable projection, the base being entirely radially offset from the axially inner threaded end portion of the torque nut;

the axially deformable projection having a deformable portion disposed radially offset from the axially inner threaded end portion of the torque nut, wherein the deformable portion is axially offset from the axially leading end, and wherein the deformable portion is configured to plastically deform before any other portion of the torque nut upon an axial force being applied to the axially leading end of the axially deformable projection;

wherein the axially deformable projection resists deformation upon an axial compressive force being applied to the axially leading end when the axially leading end engages the fitting body;

wherein the deformable portion is configured to plastically deform when compressed by an axially facing shoulder facing in a second direction to abut the axially leading end such that the deformable portion does not deform until the axially compressive force is at least 20% of an axial force necessary for the torque nut to axially urge at least one ferrule, between the fitting body and the torque nut, into a madeup position to sealingly engage an annular outer surface of a tube held within the fitting body; and

wherein the axially deformable projection is integral with the nut after the deformable portion is plastically deformed into a first position.

9. The tube fitting assembly or torque nut of any preceding claim, wherein the axially deformable projection is formed in one-piece with the first end of the torque nut, such that fluid cannot travel radially through any portion of the deformable portion

10. The tube fitting assembly or torque nut of any preceding claim, wherein tightening the torque nut from a finger tight position requires applying a

tightening torque that increases a first torque rate, until the axially leading end engages the axially inwardly facing shoulder; and

wherein when the axially leading end is engaged with the axially inwardly facing shoulder, a deformable portion of the axially deformable projection resists
5 axial movement of the central body such that tightening of the torque nut requires the tightening torque to increase at a second torque rate that is at least 40% greater than the first torque rate.

11. The tube fitting assembly or torque nut of any preceding claim,
10 wherein a deformable portion of the axially deformable projection does not contain a radially extending through hole, such that a radially inwardly facing surface of the axially deformable projection is fluidly separated from a radially outwardly facing surface of the axially deformable projection, when the axially leading end is engaged with the axially inwardly facing shoulder.

15

12. The tube fitting assembly or torque nut of any preceding claim, wherein when the torque nut is made up, the torque nut exerts a first axial load against at least one ferrule; and

wherein further tightening of the nut requires an additional axial load of at
20 least a 20% of the first axial load to deform a deformable portion of the axially deformable projection.

13. The tube fitting assembly or torque nut of any preceding claim, wherein a deformable portion of the axially deformable projection is axially offset
25 from the axially leading end, and wherein the deformable portion is configured to plastically deform before any other portion of the torque nut upon an axial force being applied to the axially leading end of the axially deformable projection.

14. The tube fitting assembly or torque nut of any preceding claim,
30 wherein the axially deformable projection is made from a material that has a yield strength of at least 20 KSI, optionally at least 60 KSI, and optionally at least 80 KSI.

15. The tube fitting assembly or torque nut of any preceding claim, wherein the deformable portion has a thickness of between 5% and 50% a radial thickness of an axially central portion of the torque nut.

5 16. The tube fitting assembly or torque nut of any preceding claim, wherein a deformable portion of the axially deformable projection has a thickness of between 20% and 50% a radial thickness of an axially central portion of the torque nut.

10 17. The tube fitting assembly or torque nut of any preceding claim, wherein a deformable portion of the axially deformable projection has a first axial length between a thickness of the deformable portion and a radial thickness of an axially central portion of the torque nut.

15 18. The tube fitting assembly or torque nut of any preceding claim, wherein the axially deformable projection has a first axial length that is at least the thickness of a deformable portion of the axially deformable projection.

19. The tube fitting assembly or torque nut of any preceding claim,
20 wherein the axially leading end has a thickness greater than a thickness of a deformable portion of the axially deformable projection.

20. The tube fitting assembly or torque nut of any preceding claim,
wherein axially leading end has a thickness greater than a thickness of a
25 deformable portion of the axially deformable projection.

21. The tube fitting assembly or torque nut of any preceding claim,
wherein the axially leading end has a thickness less than a deformable portion of
the axially deformable projection.

30

22. The tube fitting assembly or torque nut of any preceding claim,
wherein the axially leading end is configured to deform radially relative to the

deformation portion as a deformable portion of the axially deformable projection deforms into a first position

23. The tube fitting assembly or torque nut of any preceding claim,
5 wherein the axially leading end is configured to flare radially outward relative to a deformable portion of the axially deformable projection when the deformable portion of the axially deformable projection deforms into the first position.

24. The tube fitting assembly or torque nut of claim 23, wherein the
10 axially leading end is radially outward of the deformable portion in the first position.

25. The tube fitting assembly or torque nut of any preceding claim,
wherein the axially leading end is configured to constrict radially inwardly when a
15 deformable portion of the axially deformable projection deforms into the first position.

26. The tube fitting assembly or torque nut of claim 25, wherein the
axially leading end is radially inward of the deformable portion in the first
20 position.

27. The tube fitting assembly or torque nut of any preceding claim,
wherein the axially deformable projection includes an insert.

28. The tube fitting assembly or torque nut of claim 27, wherein the
25 insert includes a deformable portion of the axially deformable projection, and the deformable portion expands radially outwardly as the base moves axially in the first direction relative to the deformable portion.

29. The tube fitting assembly or torque nut of any one of claims 27-28,
30 wherein the insert includes a radially inwardly facing surface that engages a radially outwardly facing surface of the axially deformable projection that is non-parallel with the radially inwardly facing surface.

30. The tube fitting assembly or torque nut of any one of claims 27-29, wherein the torque nut includes a concave portion opening in the first direction for receiving the insert radially offset from the axially inner threaded end portion of the torque nut, and wherein when the deformable portion is in the first position the insert is fixed to an inner surface of the concave portion.

31. The tube fitting assembly or torque nut of any one of claims 27-30, wherein the insert comprises a ring having a billowed cross-section.

32. The tube fitting assembly or torque nut of any preceding claim, wherein the axially deformable projection is not removable with the nut after a deformable portion of the axially deformable projection is plastically deformed into a second position further deformed from the first position.

33. The tube fitting assembly or torque nut of any preceding claim, wherein the fitting body further comprises:
a stop collar configured to engage the axially leading edge of the torque nut.

34. The tube fitting assembly or torque nut of claim 33, wherein the stop collar comprises a single frustoconical shaped collar.

35. The tube fitting assembly or torque nut of any one of claims 33-34, wherein the stop collar comprises dual frustoconical shaped collars.

36. The tube fitting assembly or torque nut of any one of claims 34-35, wherein a color indicator is disposed on an axially facing surface of the frustoconical shaped collar to indicate whether the torque nut is made up.

37. The tube fitting assembly or torque nut of any preceding claim, a seal receiving portion at a back end of the torque nut, opposite the axially leading end, configured to receive a sealing member.

38. The tube fitting assembly or torque nut of any preceding claim,
wherein the torque nut includes an axially outer facing concavity configured to
receive a sealing member for sealingly engaging an annular outer surface of a
5 tube held within the torque nut.

39. The tube fitting assembly or torque nut of any preceding claim,
wherein the torque nut includes a sealing member at an axial end opposite the
axially leading end, wherein the sealing member is configured to sealingly
10 engage an annular outer surface of a tube held within the torque nut.

40. The tube fitting assembly or torque nut of any preceding claim,
wherein axial deformation of the axially deformable projection matches
deformation of a ferrule assembly, and when the torque nut is assembled with
15 the ferrule assembly and with another fitting body the axially deformable
projection indicates whether the ferrule assembly is properly remade.

41. The tube fitting assembly or torque nut of claim 40, wherein the
axially deformable projection indicates whether the ferrule assembly is properly
20 remade based on a visual indicator and/or an abrupt increase in torque needed
to tighten the torque nut.

1/18

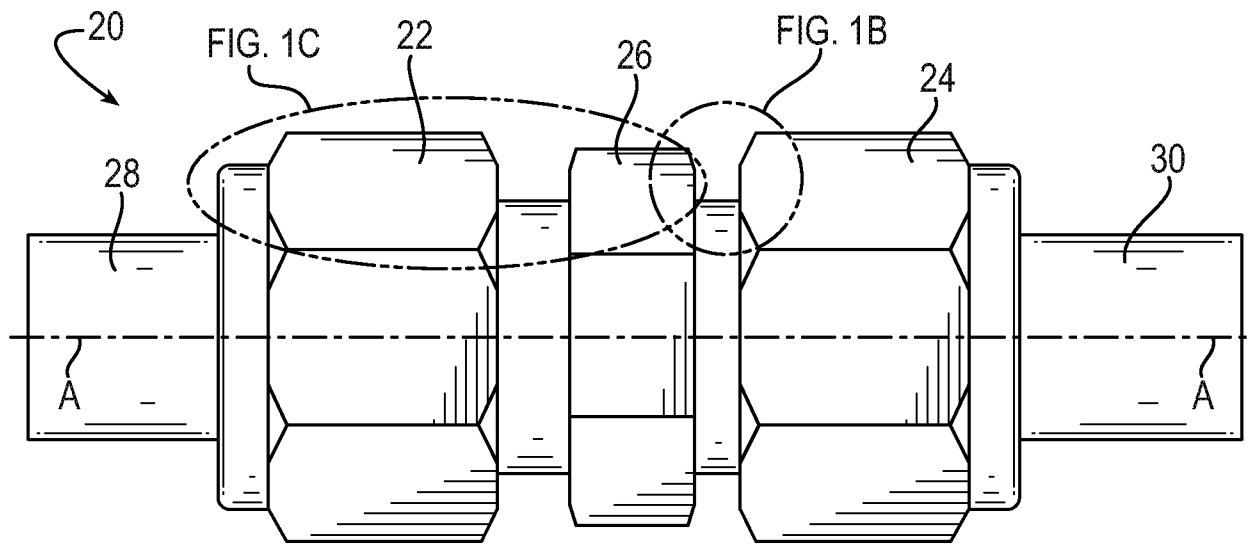


FIG. 1A
(PRIOR ART)

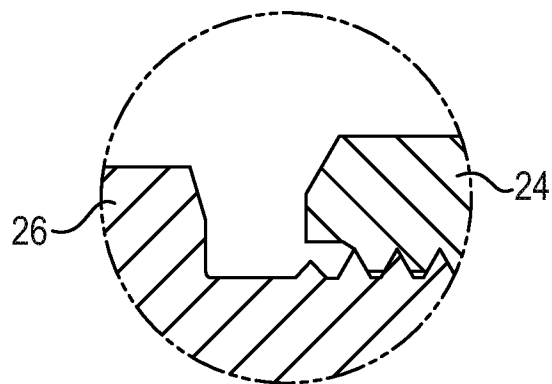


FIG. 1B
(PRIOR ART)

2/18

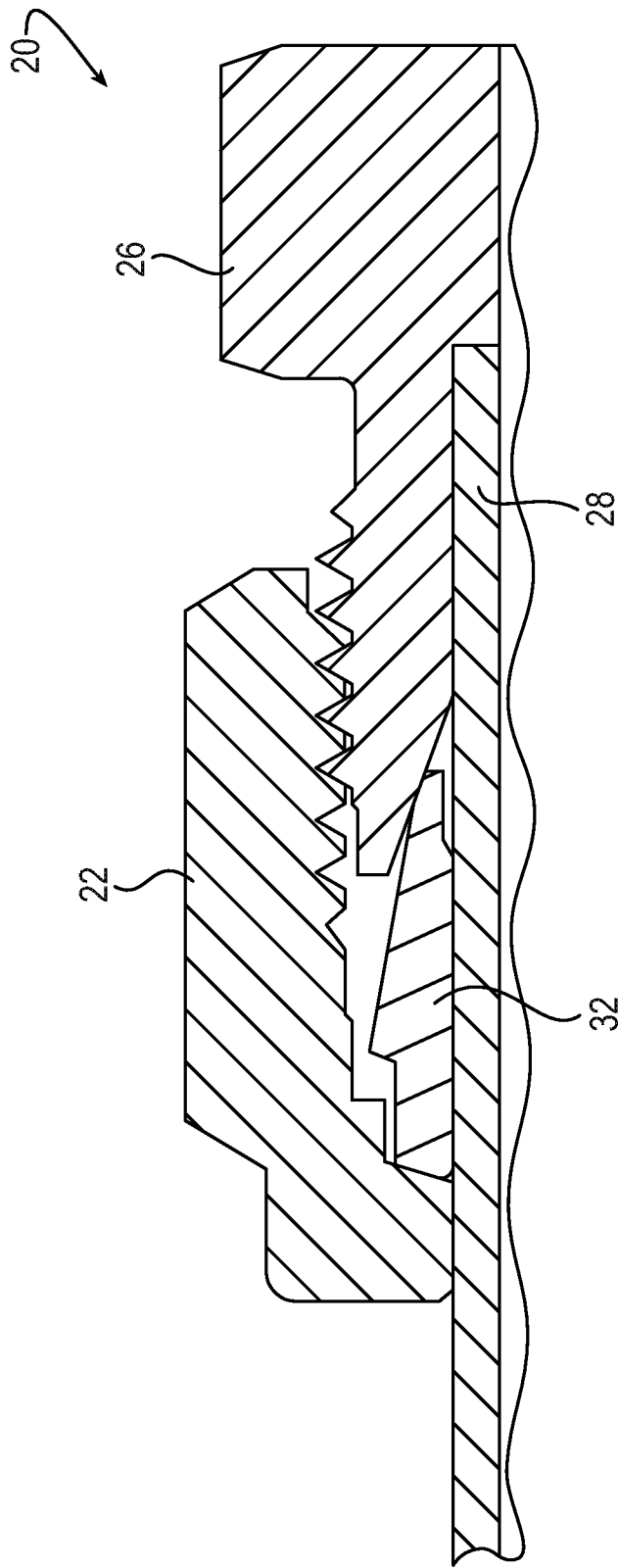
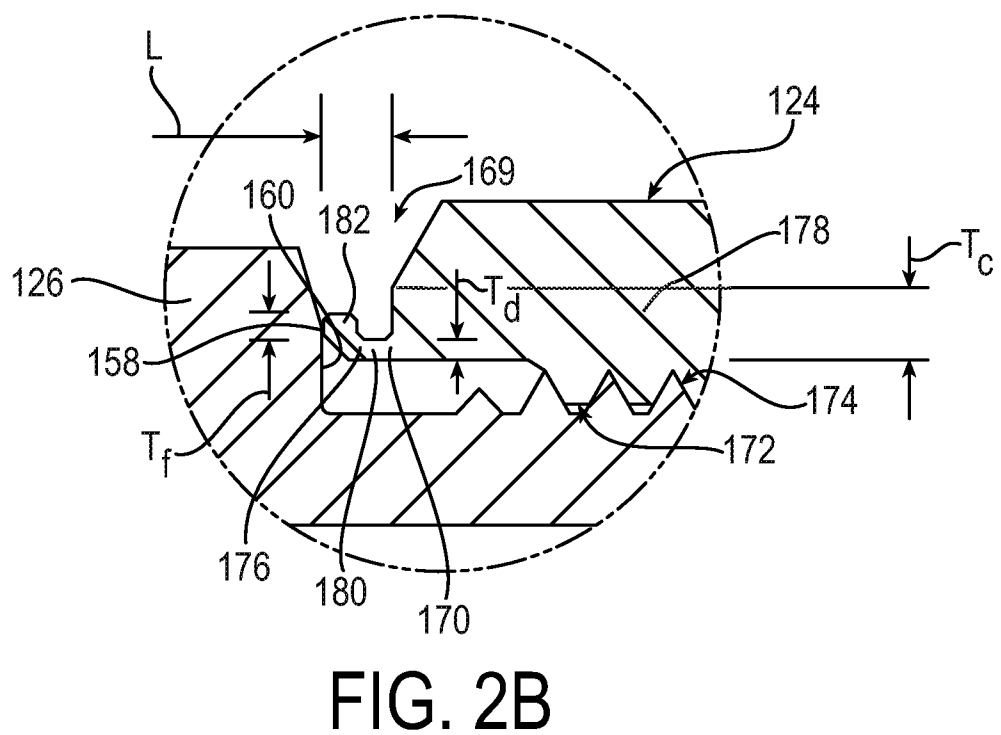
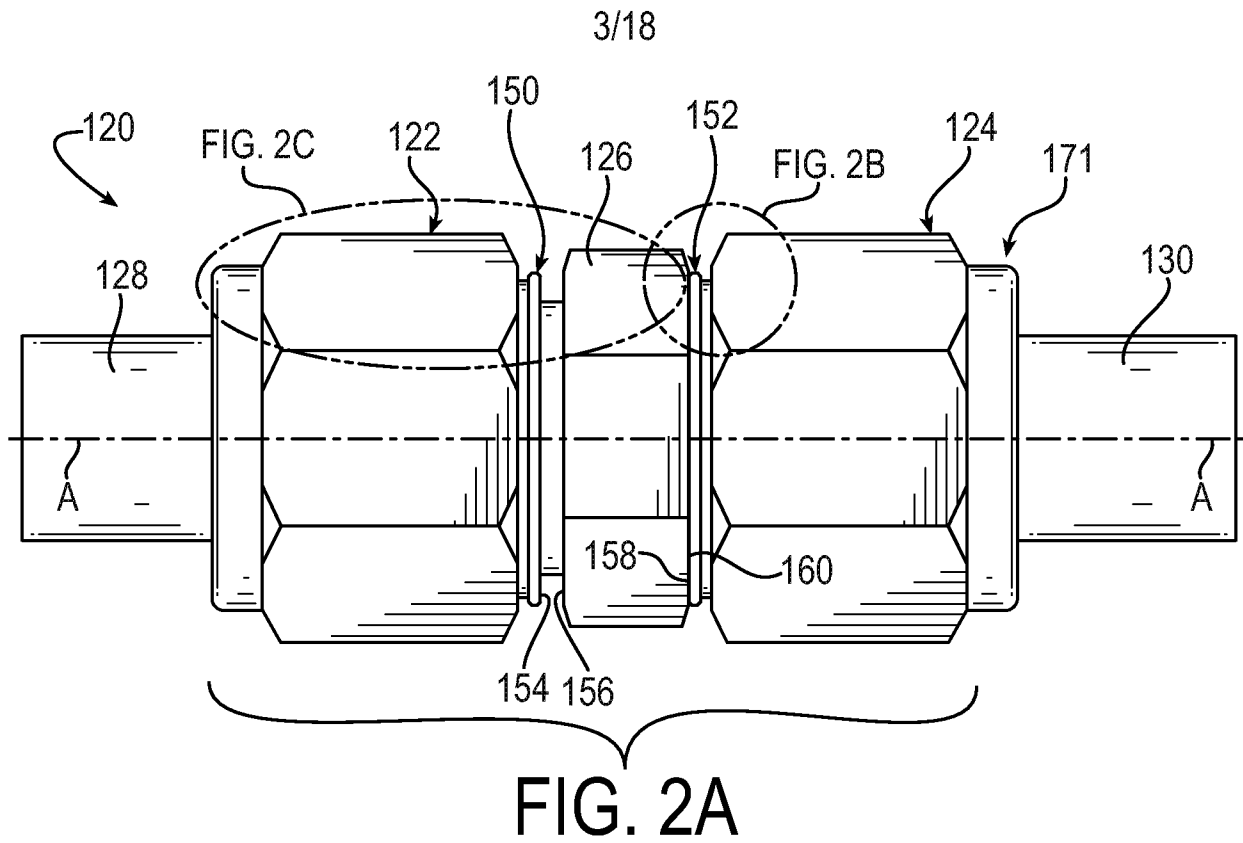


FIG. 1C
(PRIOR ART)



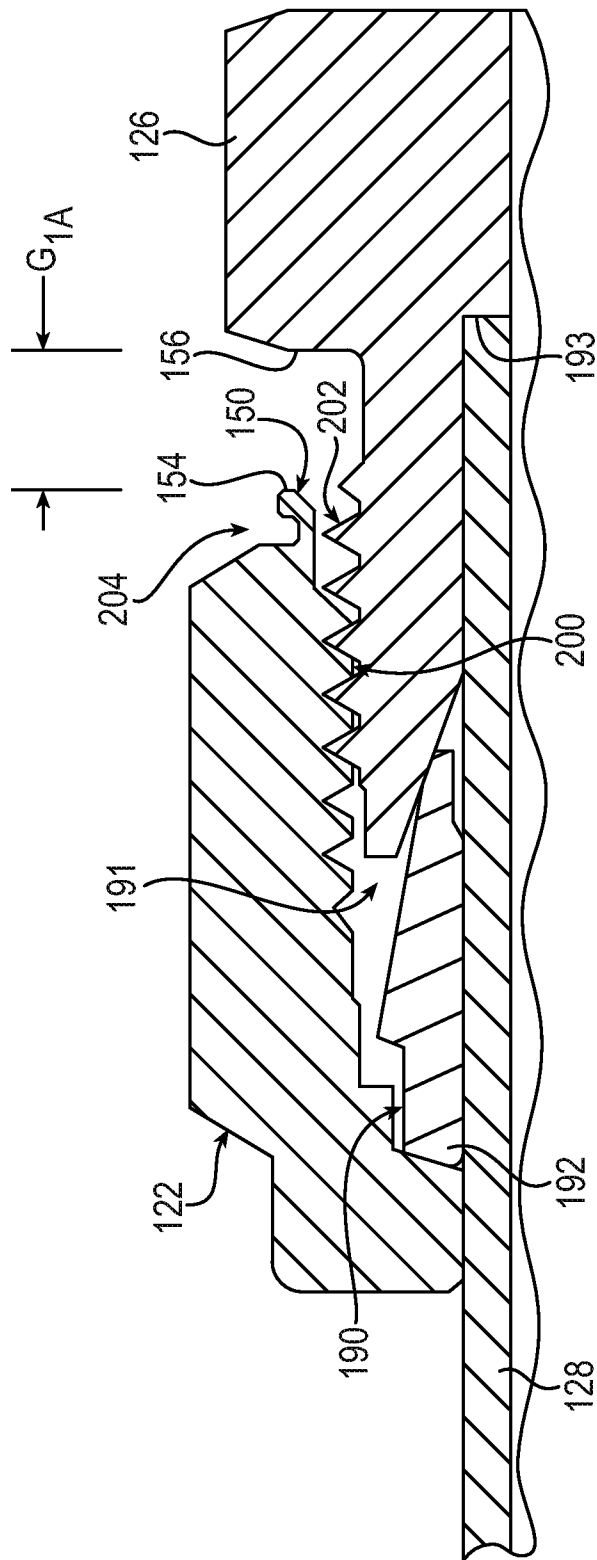


FIG. 2C

5/18

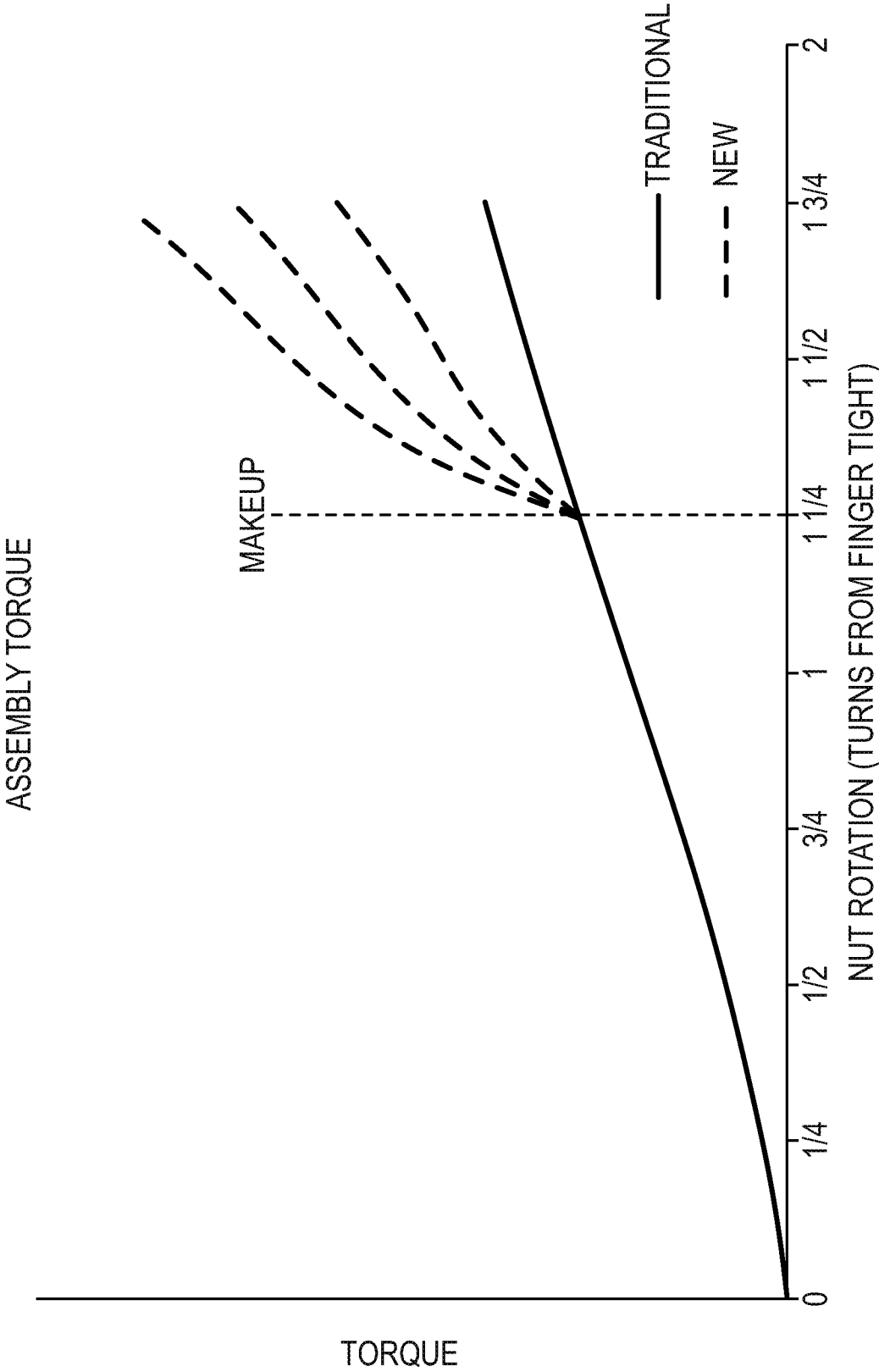


FIG. 3

6/18

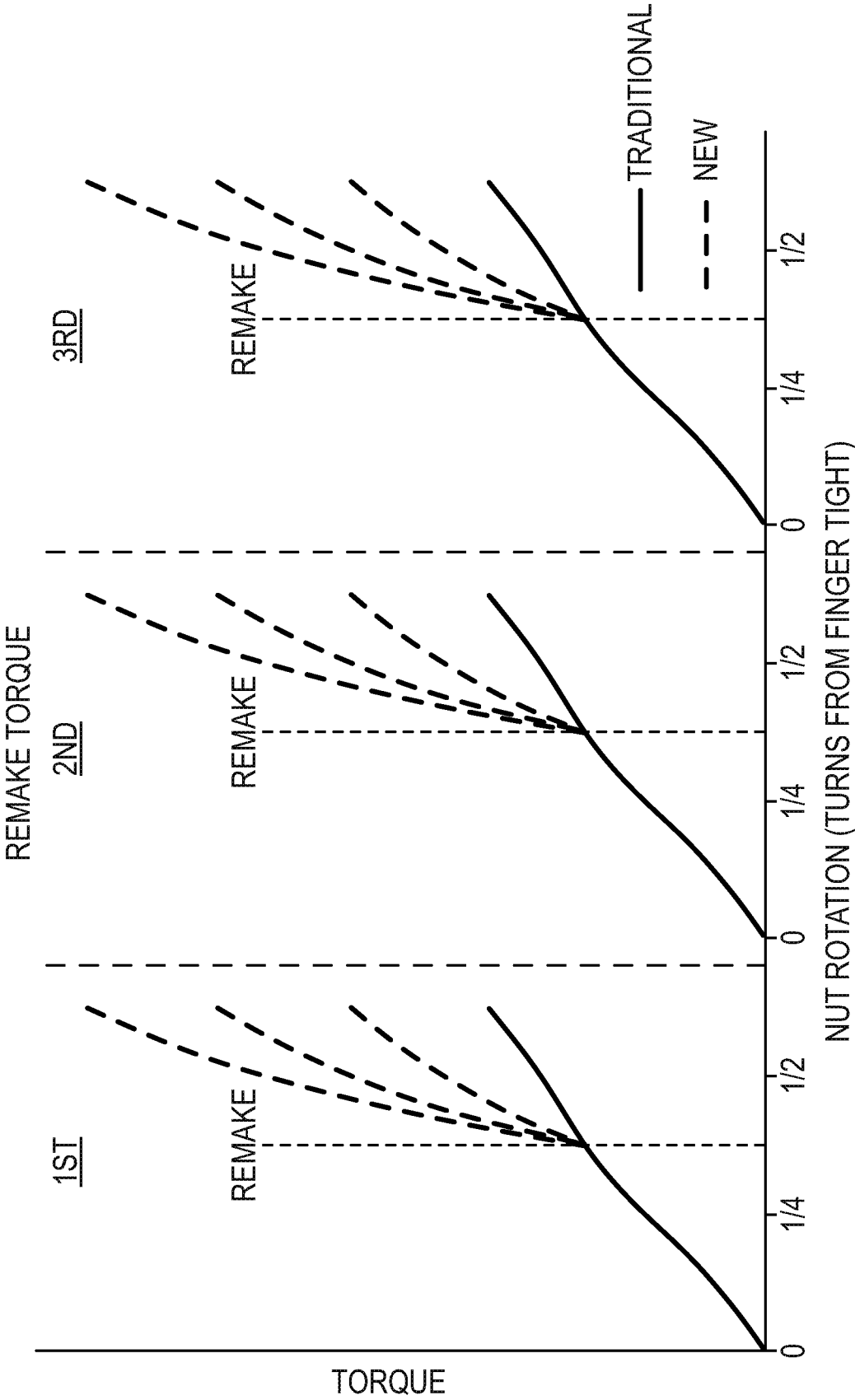


FIG. 4

7/18

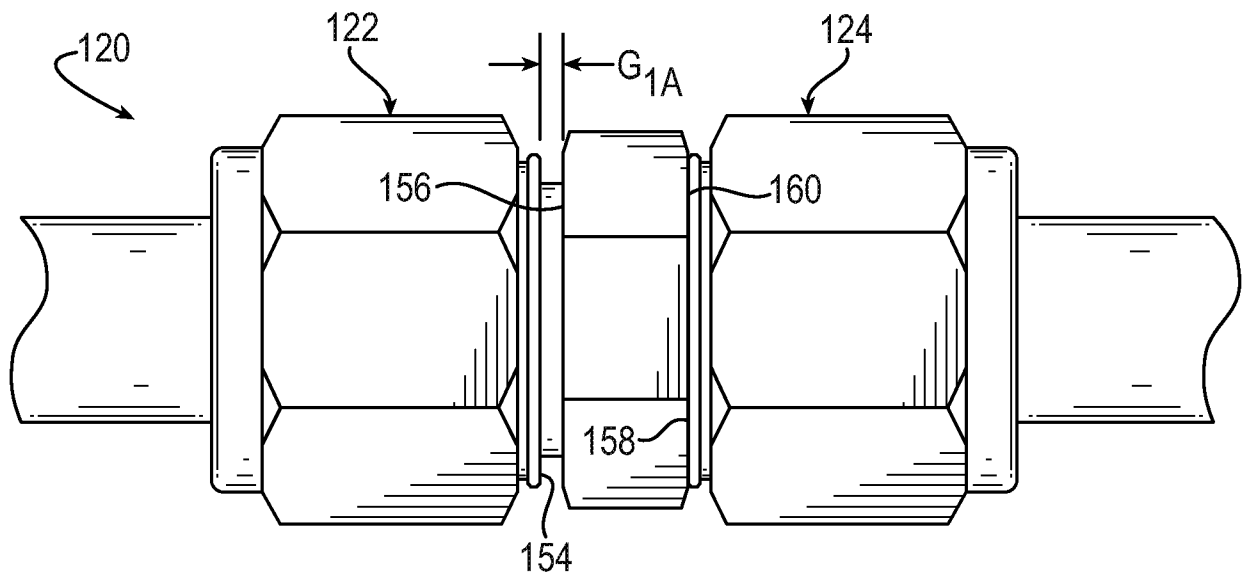


FIG. 5A

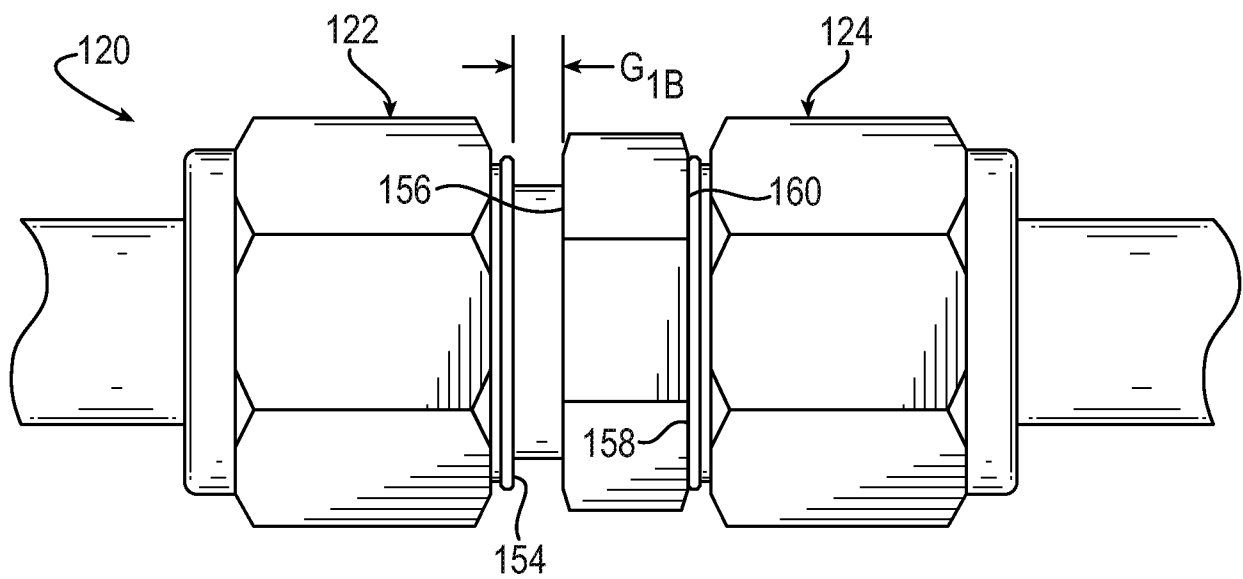


FIG. 5B

8/18

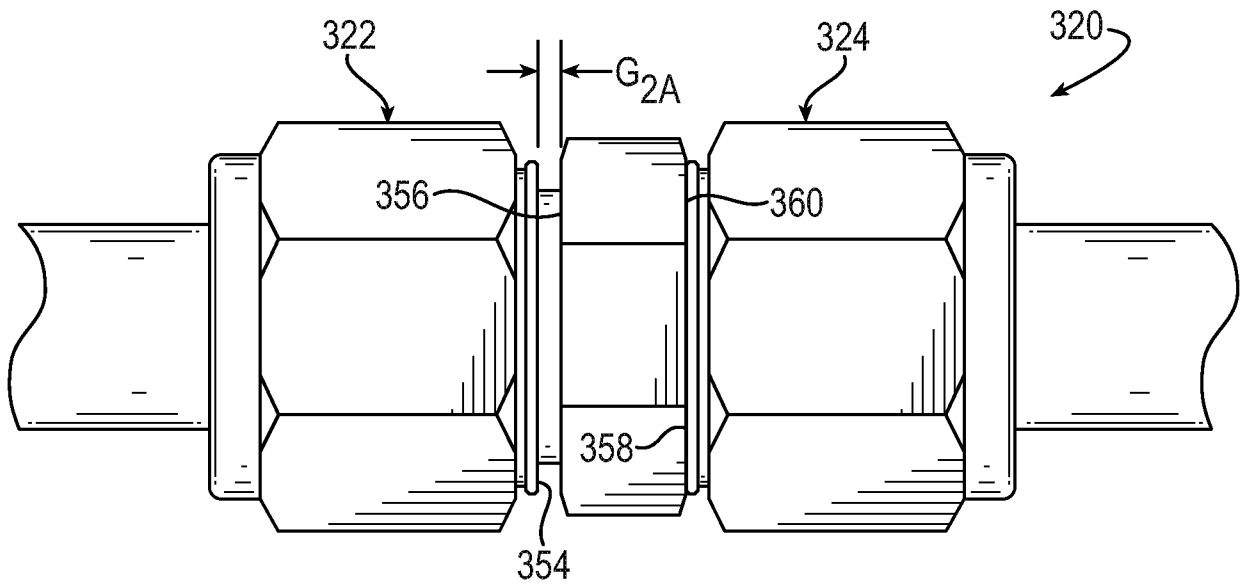


FIG. 5C

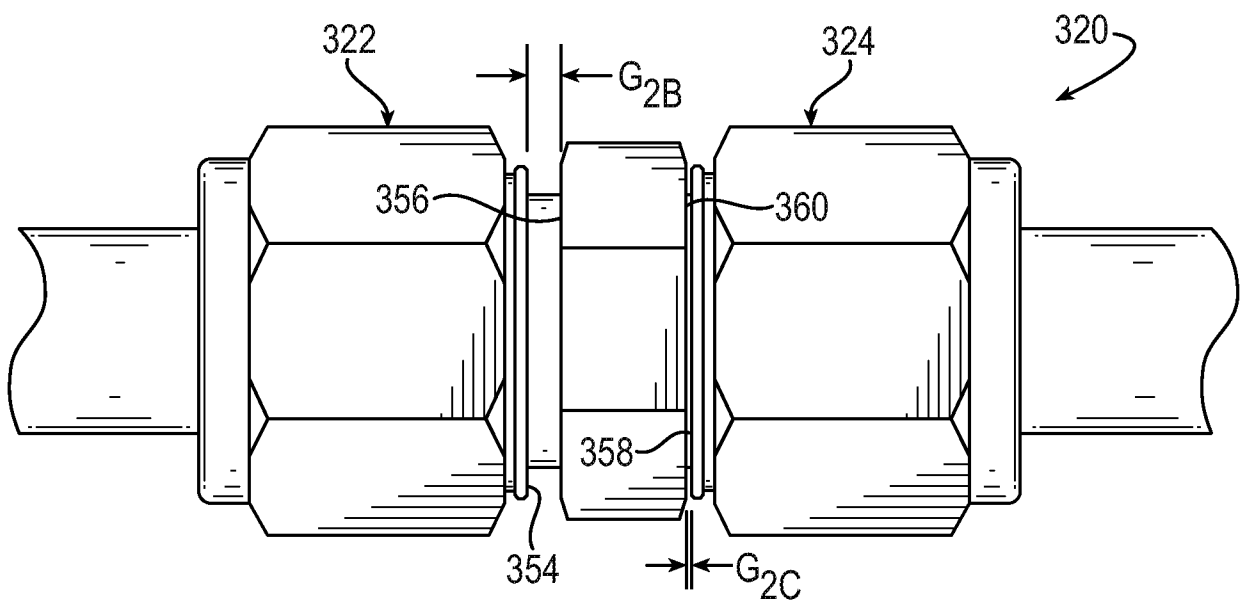


FIG. 5D

9/18

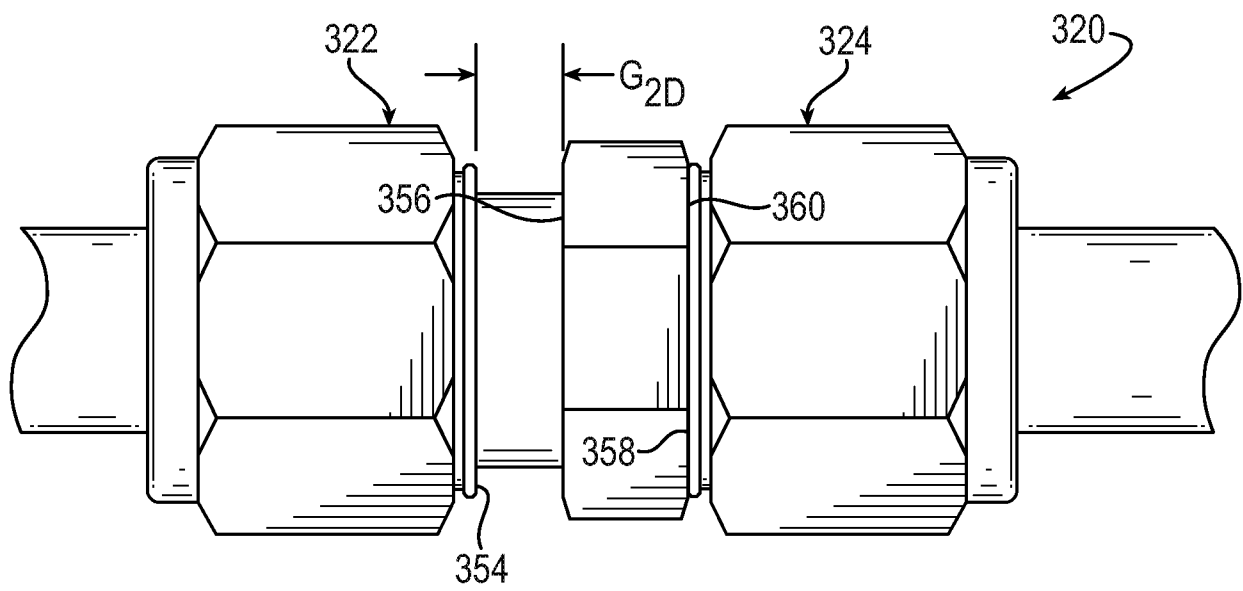


FIG. 5E

10/18

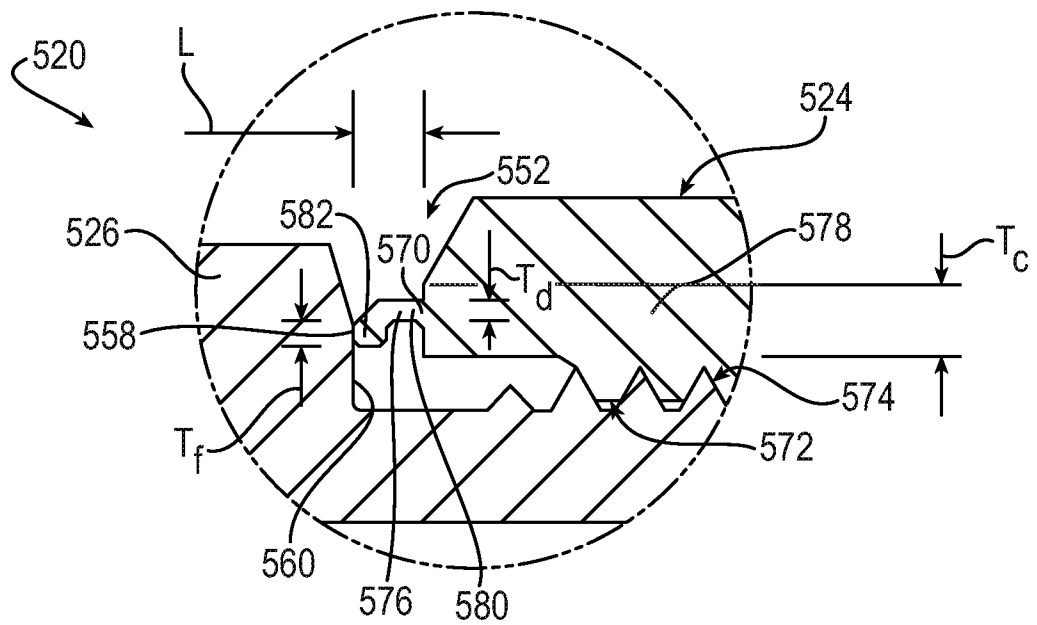


FIG. 6A

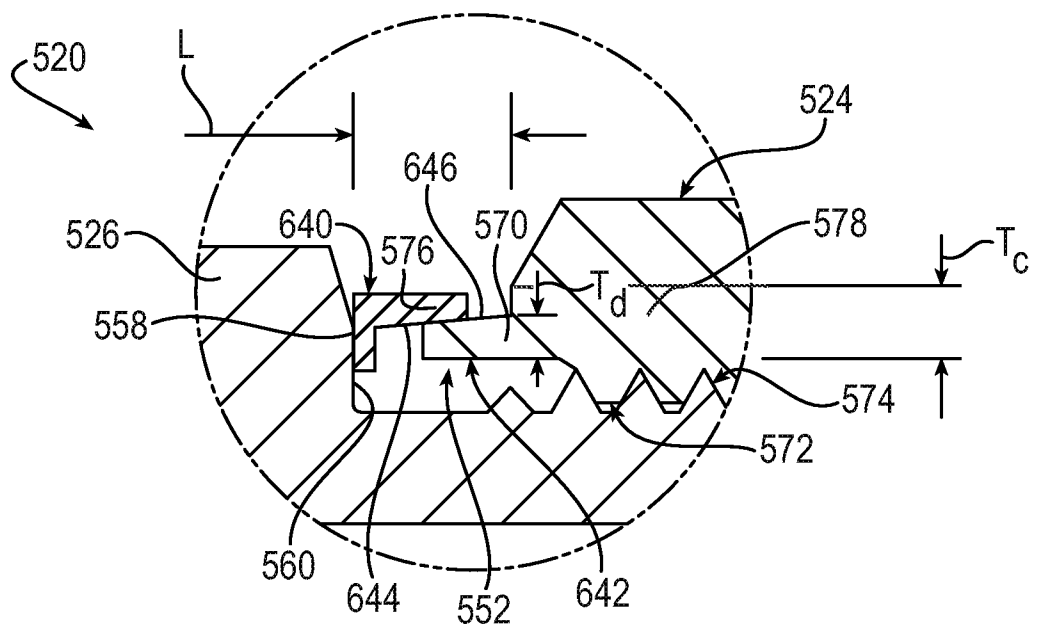


FIG. 6B

11/18

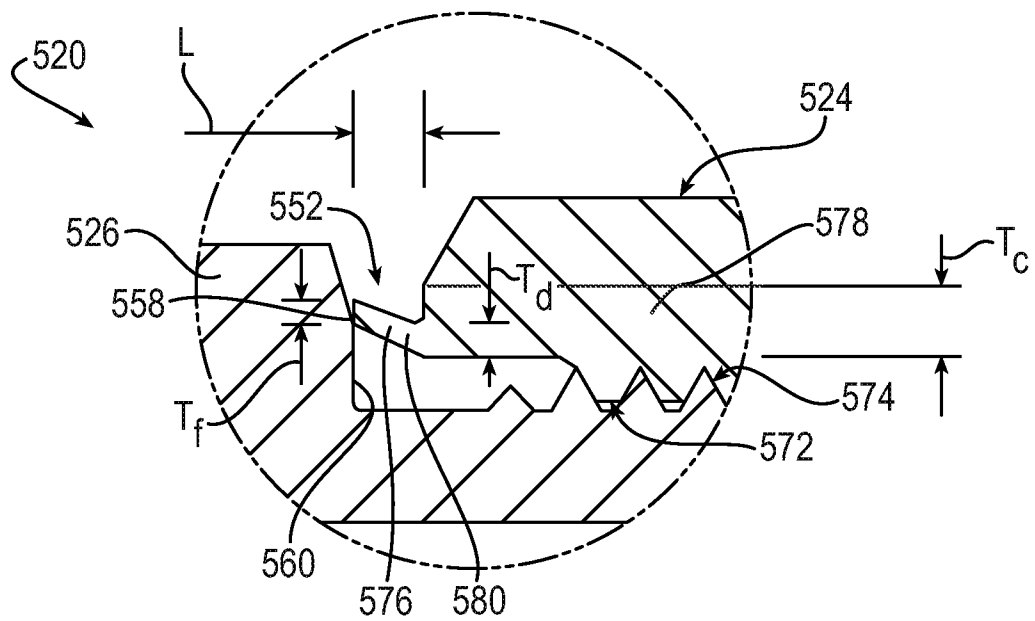


FIG. 6C

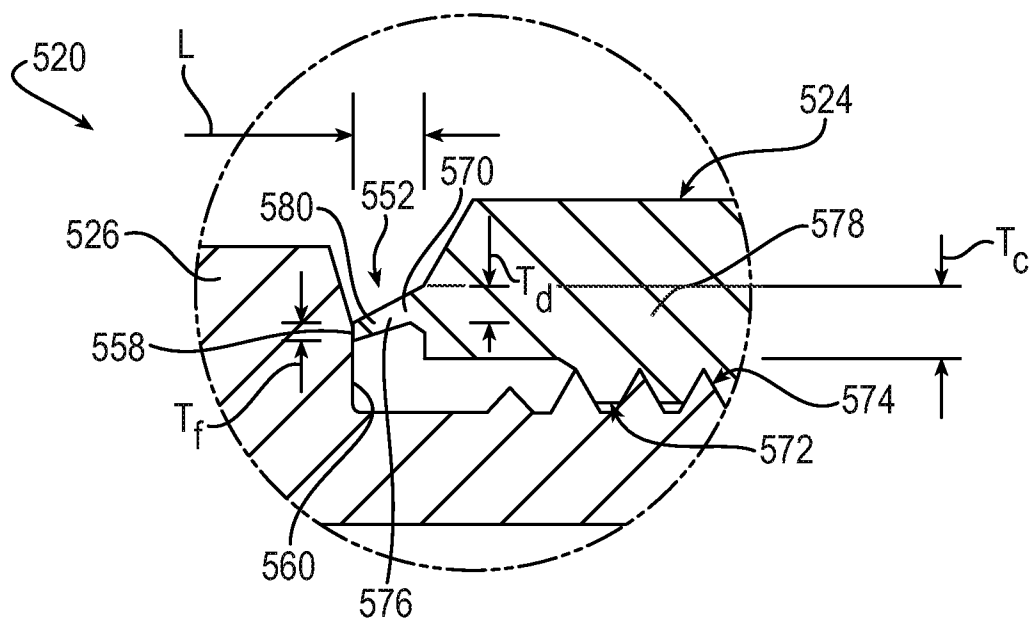


FIG. 6D

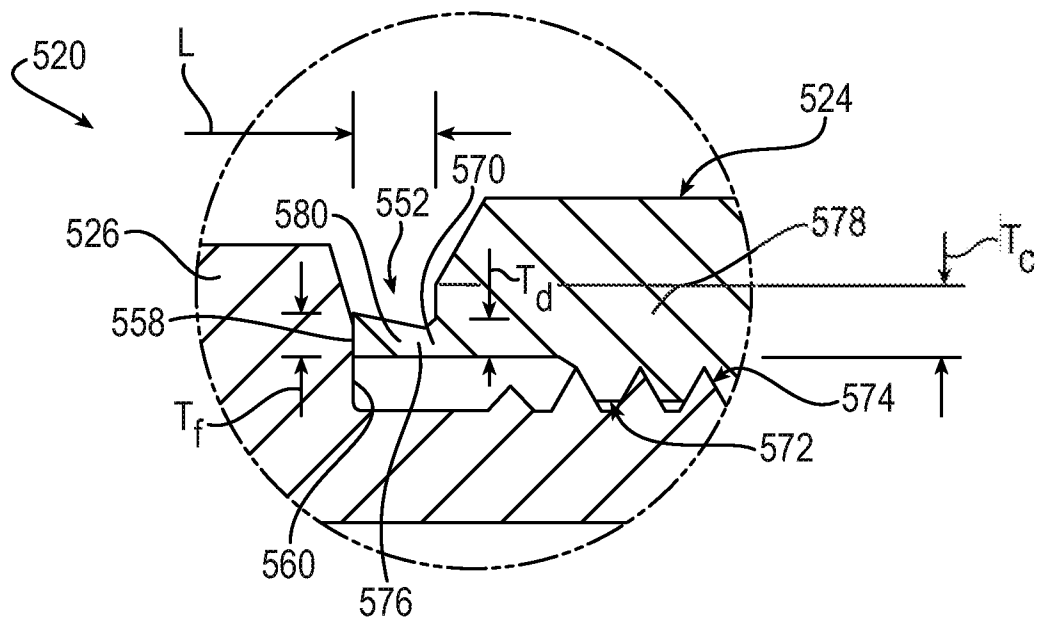


FIG. 6E

13/18

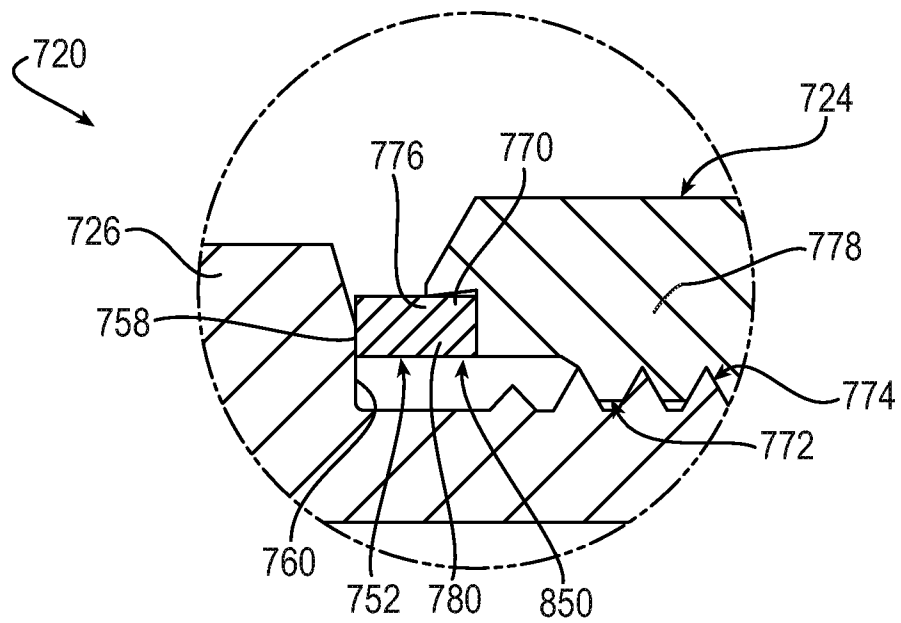


FIG. 7A

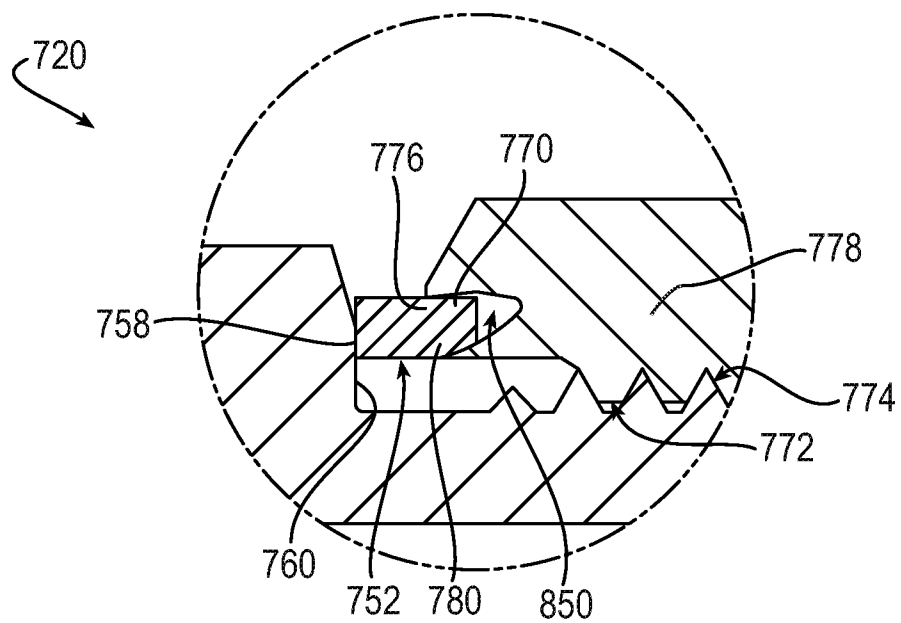


FIG. 7B

14/18

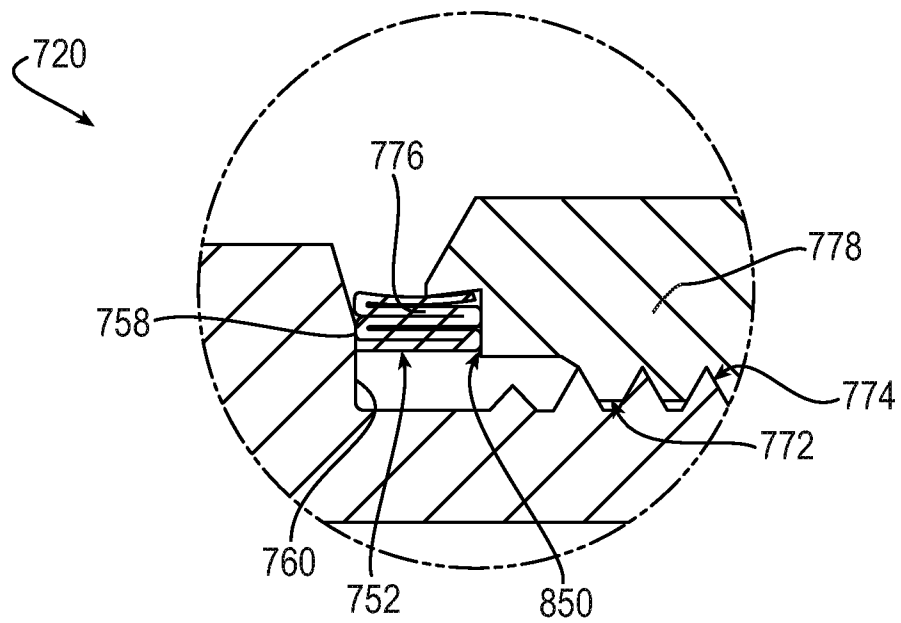


FIG. 7C

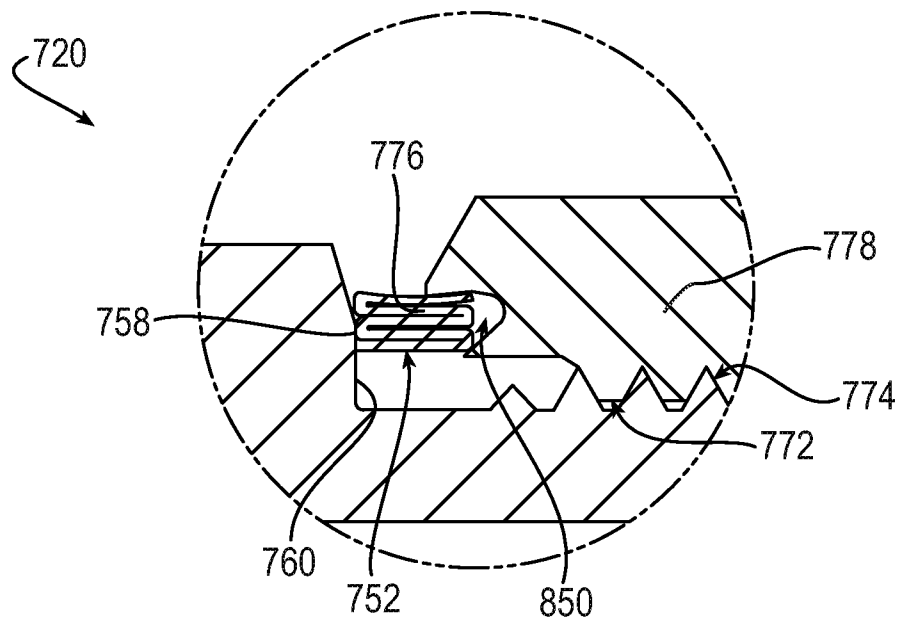
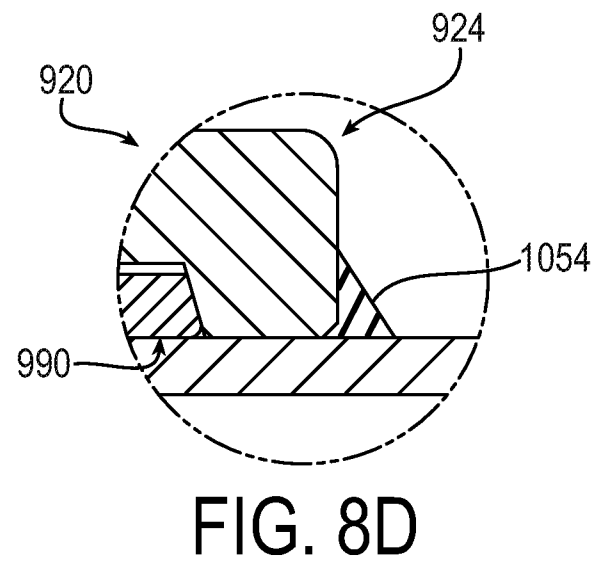
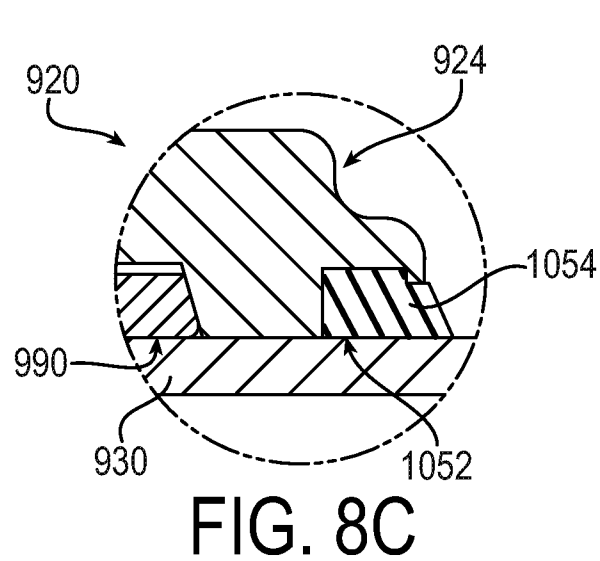
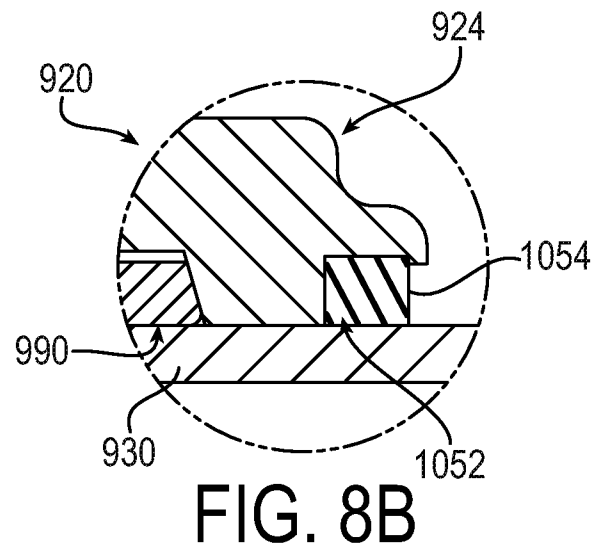
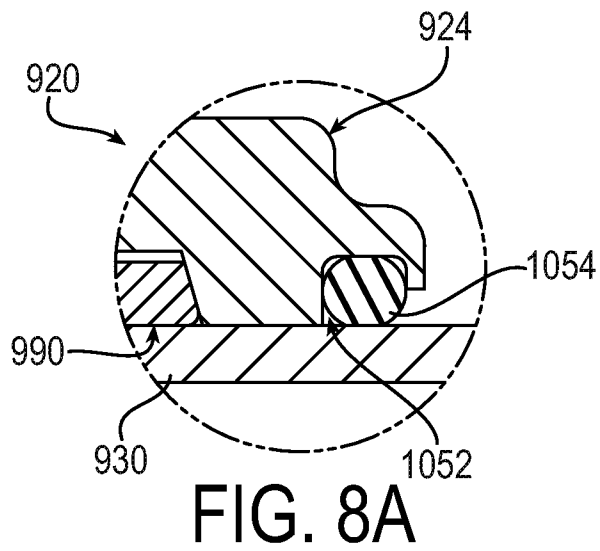


FIG. 7D

15/18



16/18

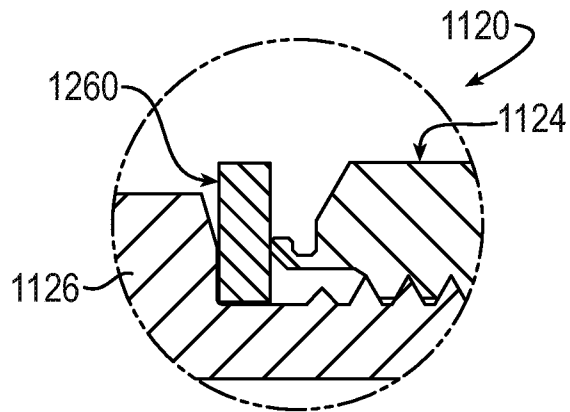


FIG. 9A

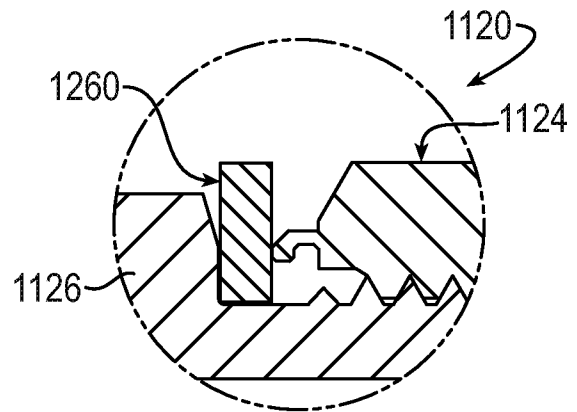


FIG. 9B

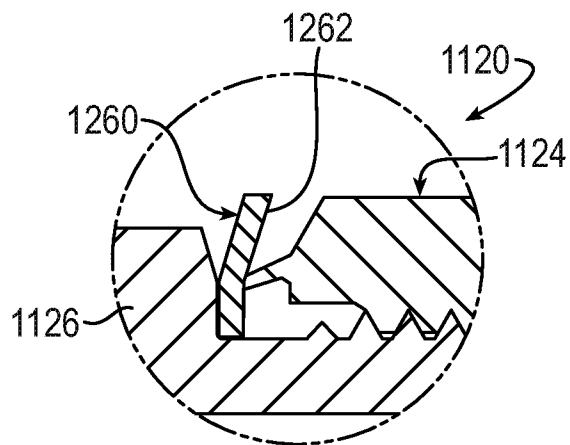


FIG. 9C

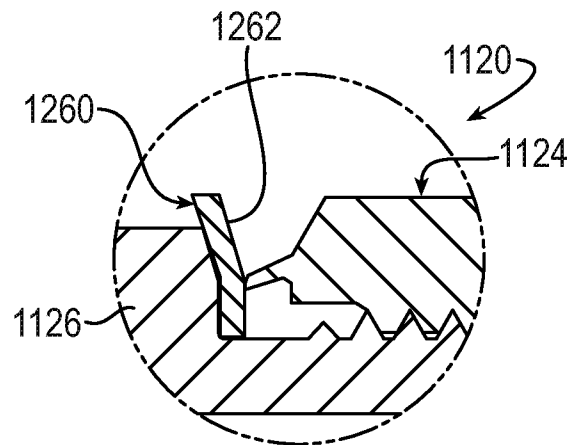


FIG. 9D

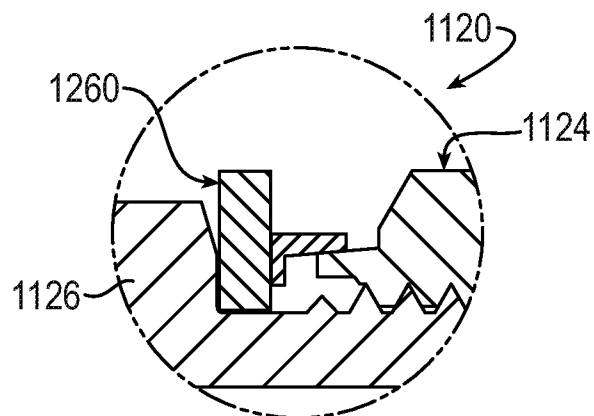


FIG. 9E

17/18

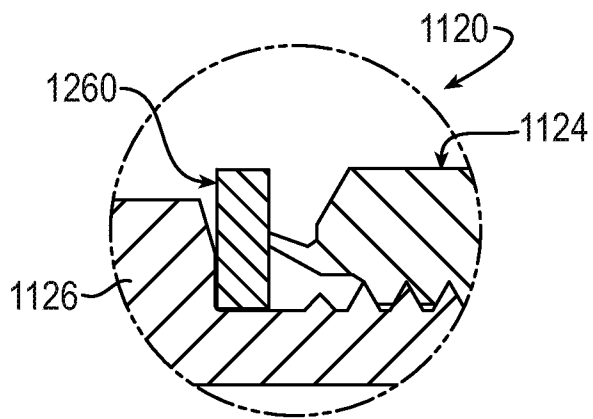


FIG. 9F

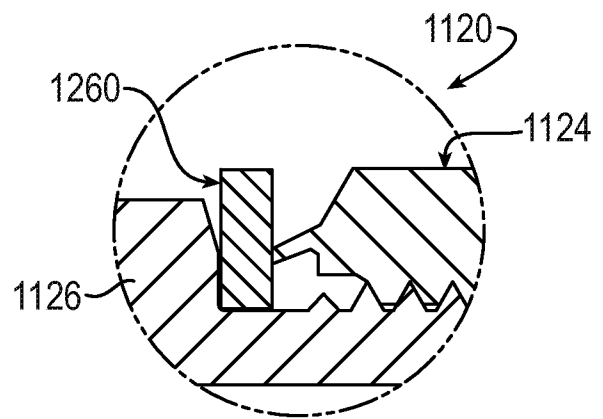


FIG. 9G

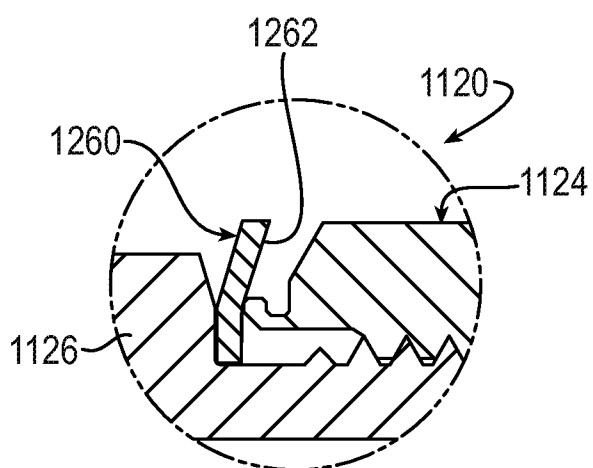


FIG. 9H

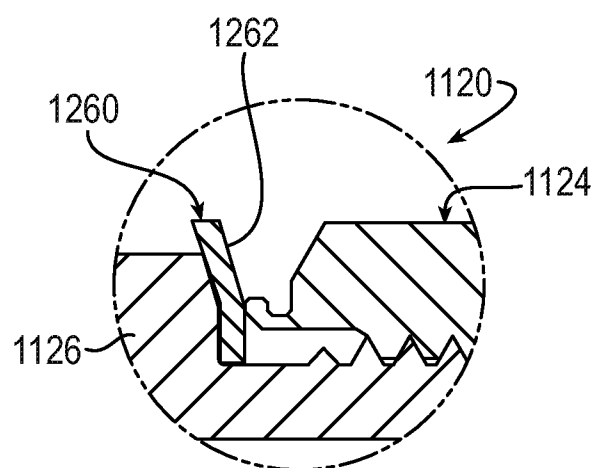


FIG. 9I

18/18

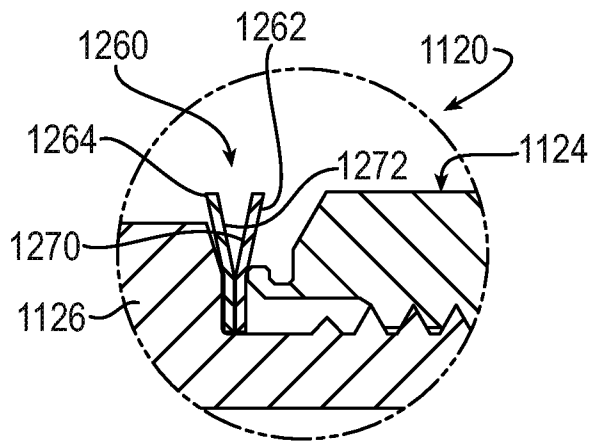


FIG. 9J

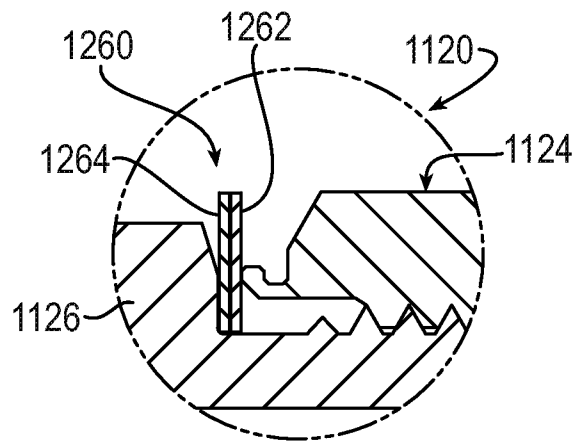


FIG. 9K

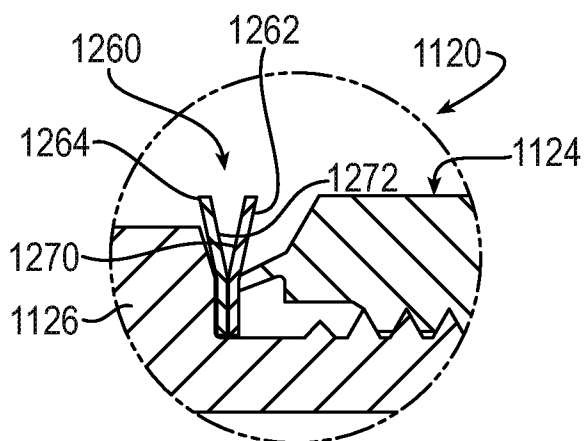


FIG. 9L

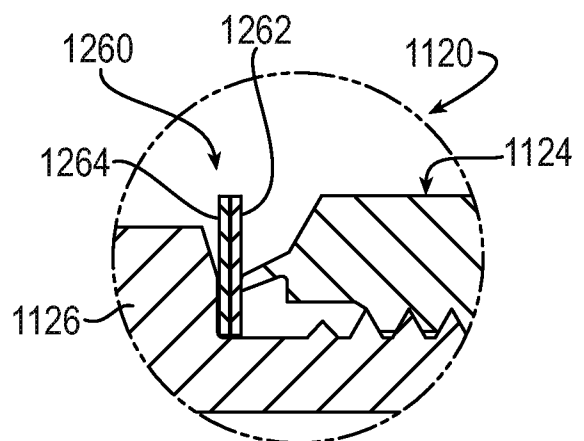


FIG. 9M

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/034208

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16L19/06 F16L19/12
ADD.

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)
F16L

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

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

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/020900 A2 (SWAGELOK CO [US]; BEARER MARK D [US]; BENNETT MARK A [US]; KARKOSIAK J) 12 February 2009 (2009-02-12)	1-9, 11-18, 21, 27-29, 33-35
Y	paragraphs [0040] - [0044], [0065] - [0069], [0082] - [0087], [0098]; figures 1,6,9a,9b,10a-10c,12	4,22-31, 36-41
X	WO 2010/129756 A1 (SWAGELOK CO [US]; WILLIAMS PETER C [US]; BROWN CAL R [US]; CLASON MARK) 11 November 2010 (2010-11-11)	1-3,5,6, 10-12, 15-20,32
Y	paragraphs [0071] - [0147]; figures 1,3a,6	22-29, 31,40,41
A	----- -/--	7,8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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

29 September 2015

Date of mailing of the international search report

09/10/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Fromentel, Henri

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/034208

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 536 175 A2 (SWAGelok CO [US]) 1 June 2005 (2005-06-01) paragraph [0088]; figures 21D-21F -----	4,22-29, 31
Y	US 5 280 967 A (VARRIN JR ROBERT D [US]) 25 January 1994 (1994-01-25) column 4, line 36 - column 5, line 2; figures 7-9 -----	31,36
Y	US 2003/197379 A1 (GLOVER DONALD S [US]) 23 October 2003 (2003-10-23) paragraphs [0019] - [0027]; figure 2 -----	37,39
Y	US 4 422 673 A (BLACKFORD JOHN E [GB] ET AL) 27 December 1983 (1983-12-27) column 2, line 24 - column 5, line 11; figures 1,2 -----	38
Y	EP 2 535 631 A1 (BMT CO LTD [KR]) 19 December 2012 (2012-12-19) paragraphs [0040] - [0041], [0072]; figures 10-12 -----	30,40,41
X	US 2004/100097 A1 (FUKANO YOSHIHIRO [JP] ET AL) 27 May 2004 (2004-05-27) paragraphs [0042], [0043], [0050] - [0055]; figures 2,5,6 -----	8
A	GB 1 361 372 A (WEATHERHEAD CO) 24 July 1974 (1974-07-24) the whole document -----	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/034208

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of Item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/ US2015/ 034208

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 9, 11, 33-39

Tube fitting assembly comprising a fitting body, a ferrule assembly for sealing a tube and a torque nut with an integral therewith axially deformable projection able to cause, by elastic deformation, wherein an abrupt increase in torque indicates a sufficient tightening of the nut on the fitting body to seal the ferrule assembly to the tube.

2. claims: 7, 8, 10, 12-32, 40, 41

Tube fitting assembly comprising a fitting body, a ferrule assembly for sealing a tube and a torque nut with an axially deformable projection having a base and a deformable portion, wherein the deformable portion of the projection is configured to plastically deform only after at least 20% of the necessary torque requested to seal the ferrule assembly to the tube has been reached and wherein the axially deformable projection is removable from the fitting body, with the nut after the deformable portion is plastically deformed into a first removable position.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/034208

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009020900 A2	12-02-2009	CN 101821541 A DE 112008002088 T5 JP 2010535989 A US 2011277309 A1 WO 2009020900 A2	01-09-2010 09-09-2010 25-11-2010 17-11-2011 12-02-2009
WO 2010129756 A1	11-11-2010	US 2012043757 A1 WO 2010129756 A1	23-02-2012 11-11-2010
EP 1536175 A2	01-06-2005	NONE	
US 5280967 A	25-01-1994	NONE	
US 2003197379 A1	23-10-2003	AU 2003262411 A1 TW 200307796 A US 2003197379 A1 WO 03089826 A2	03-11-2003 16-12-2003 23-10-2003 30-10-2003
US 4422673 A	27-12-1983	DE 3122179 A1 FR 2484050 A1 IT 1171275 B US 4422673 A	04-03-1982 11-12-1981 10-06-1987 27-12-1983
EP 2535631 A1	19-12-2012	EP 2535631 A1 JP 5654616 B2 JP 2013519848 A KR 100987334 B1 US 2012313367 A1 WO 2011099667 A1	19-12-2012 14-01-2015 30-05-2013 12-10-2010 13-12-2012 18-08-2011
US 2004100097 A1	27-05-2004	CN 1502841 A DE 10354360 A1 FR 2847646 A1 JP 3947971 B2 JP 2004176760 A KR 20040045315 A TW 1230771 B US 2004100097 A1	09-06-2004 17-06-2004 28-05-2004 25-07-2007 24-06-2004 01-06-2004 11-04-2005 27-05-2004
GB 1361372 A	24-07-1974	DE 2312478 A1 GB 1361372 A	20-09-1973 24-07-1974