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(54) **FITTING WITH ADAPTED ENGAGING SURFACES**

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(57) **ABSTRACT**

A fitting assembly is provided with a first fitting component having a stepped wall surface; and a second fitting component radially spaced from the first fitting component when the fitting assembly is in a finger tight condition prior to pull-up. When the second fitting component is displaced into contact with the stepped wall surface during fitting pull-up, the stepped wall surface assists in separating the first fitting component from the second fitting component upon fitting disassembly.

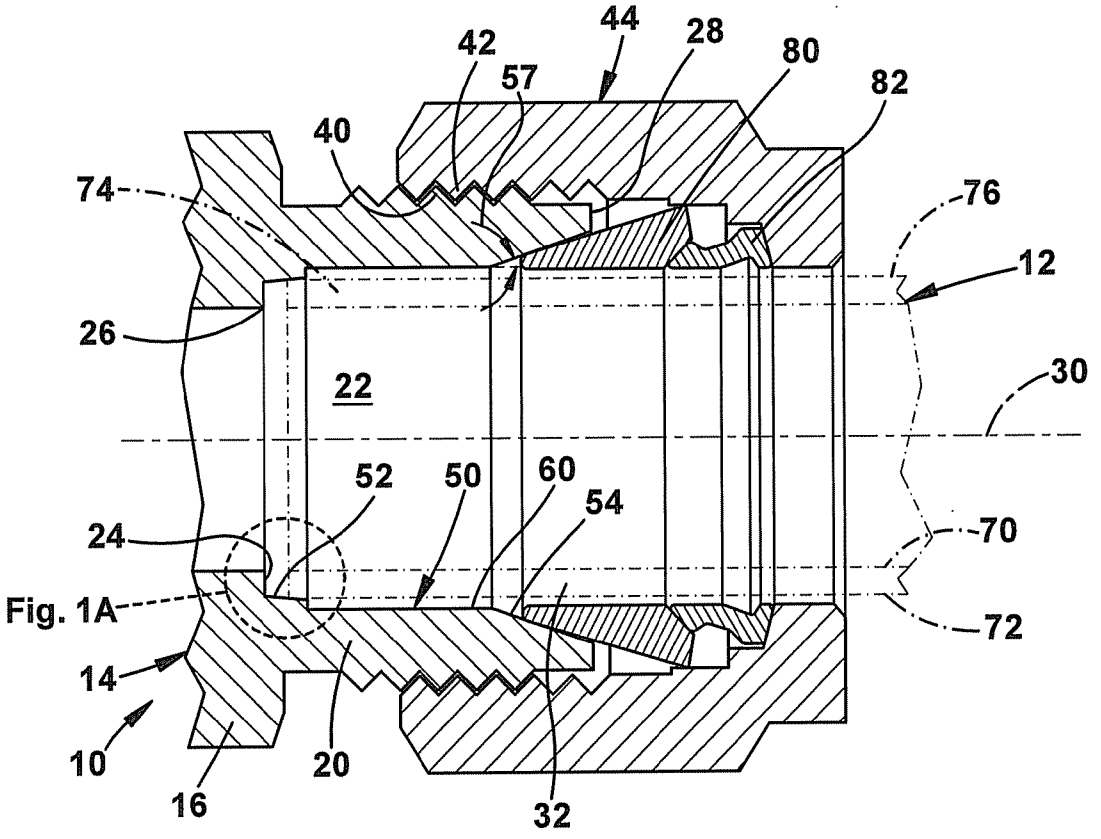


Fig. 1A

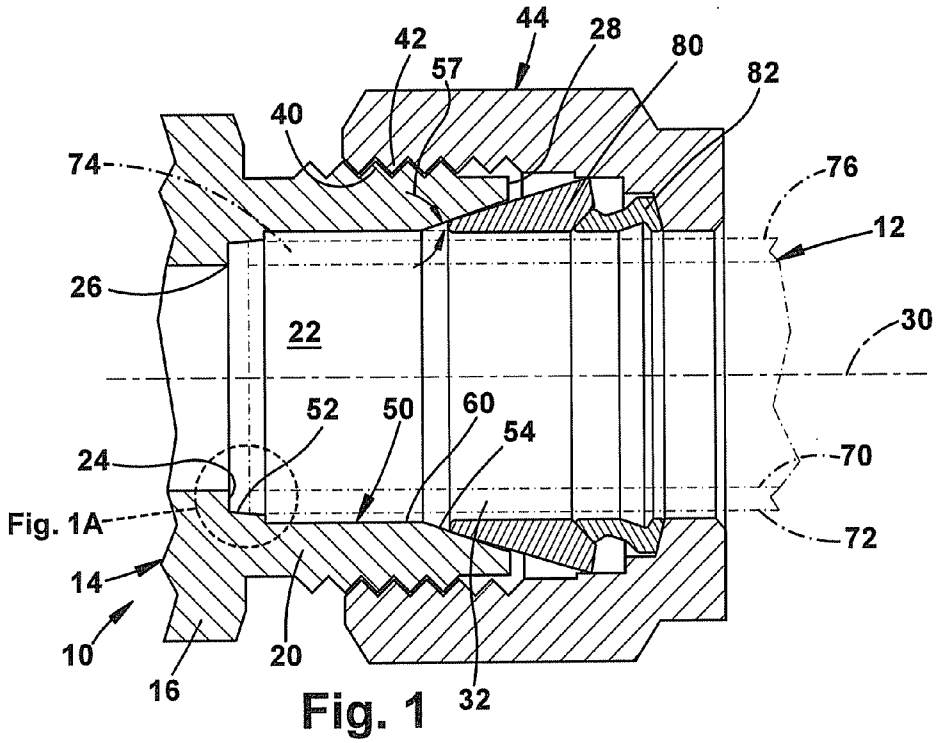

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Fig. 1A
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Fig. 1

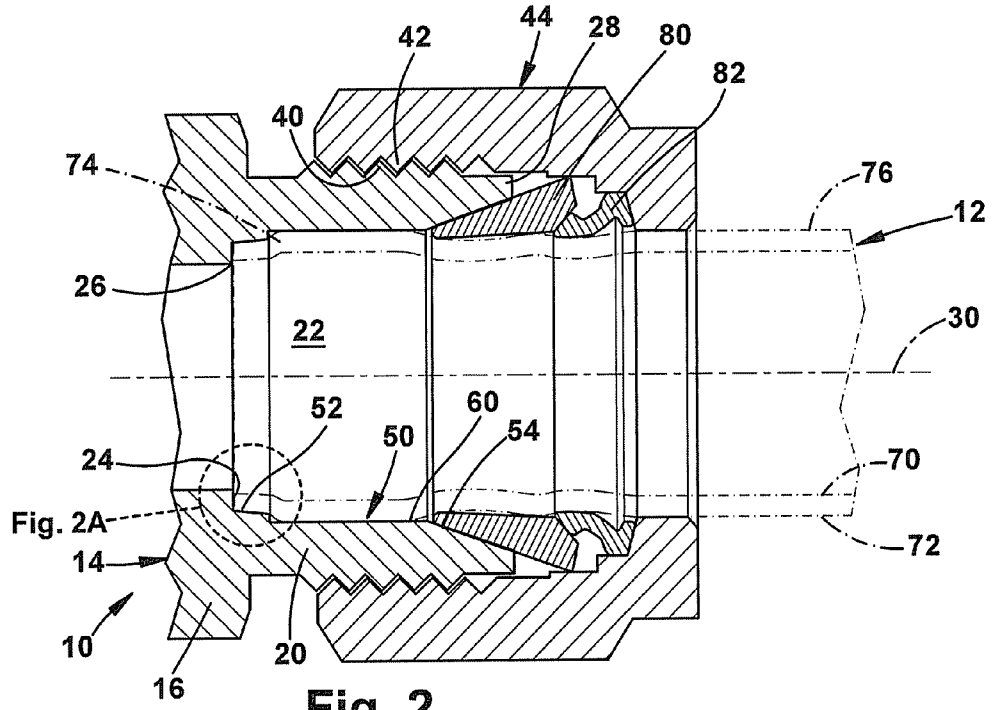

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Fig. 2A
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Fig. 2

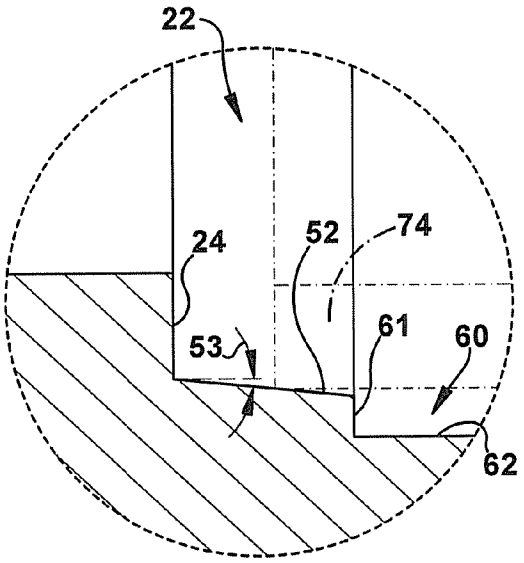


Fig. 1A

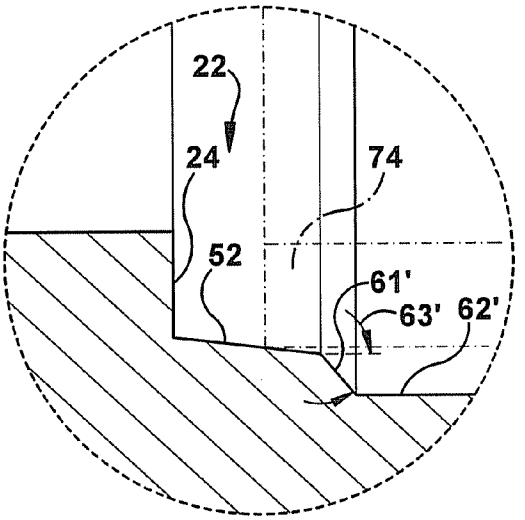


Fig. 1B

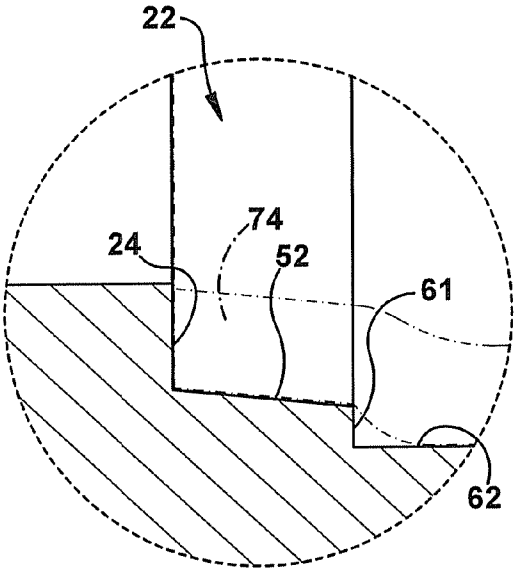


Fig. 2A

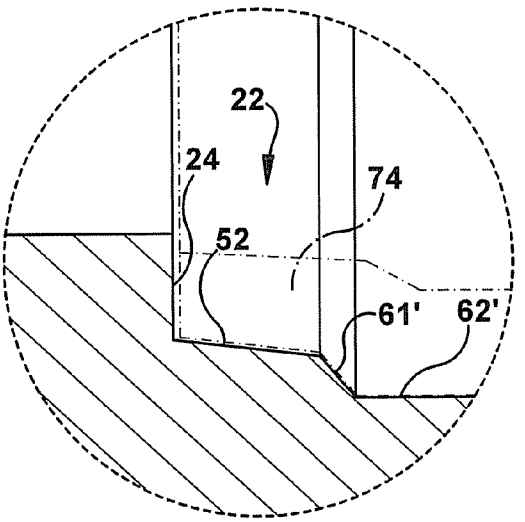


Fig. 2B

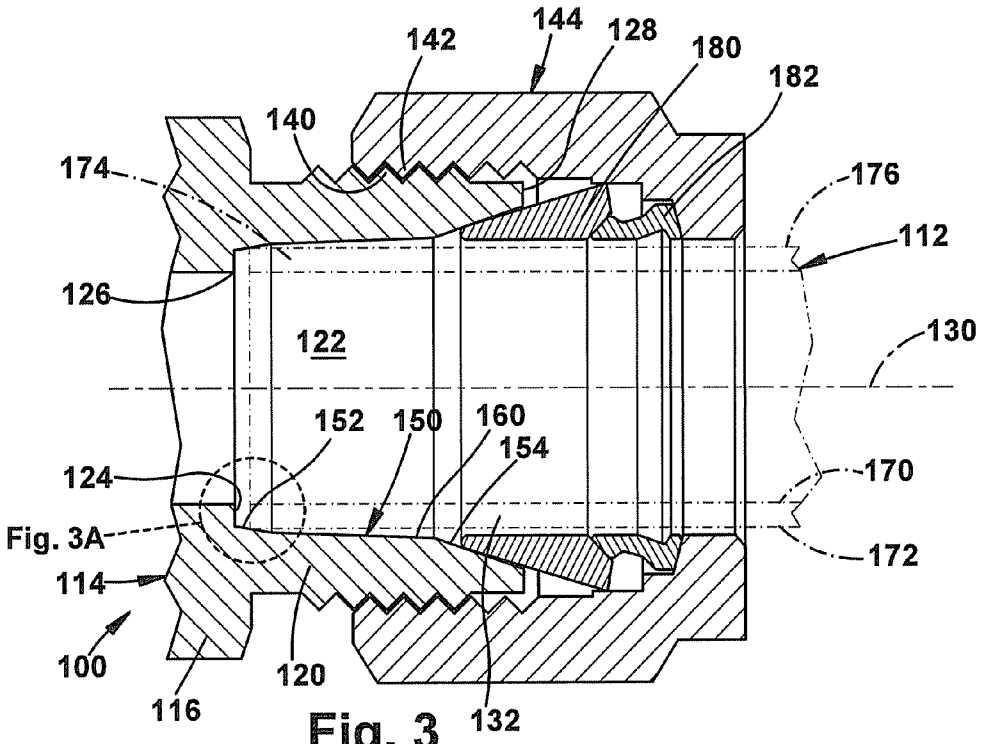

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Fig. 3A
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Fig. 3

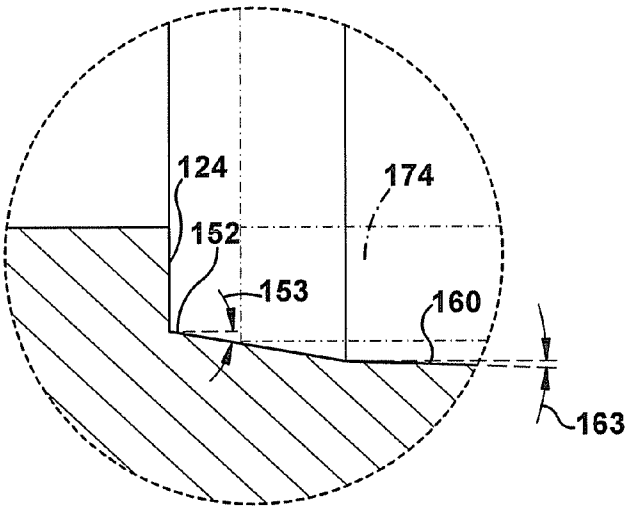

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Fig. 3A

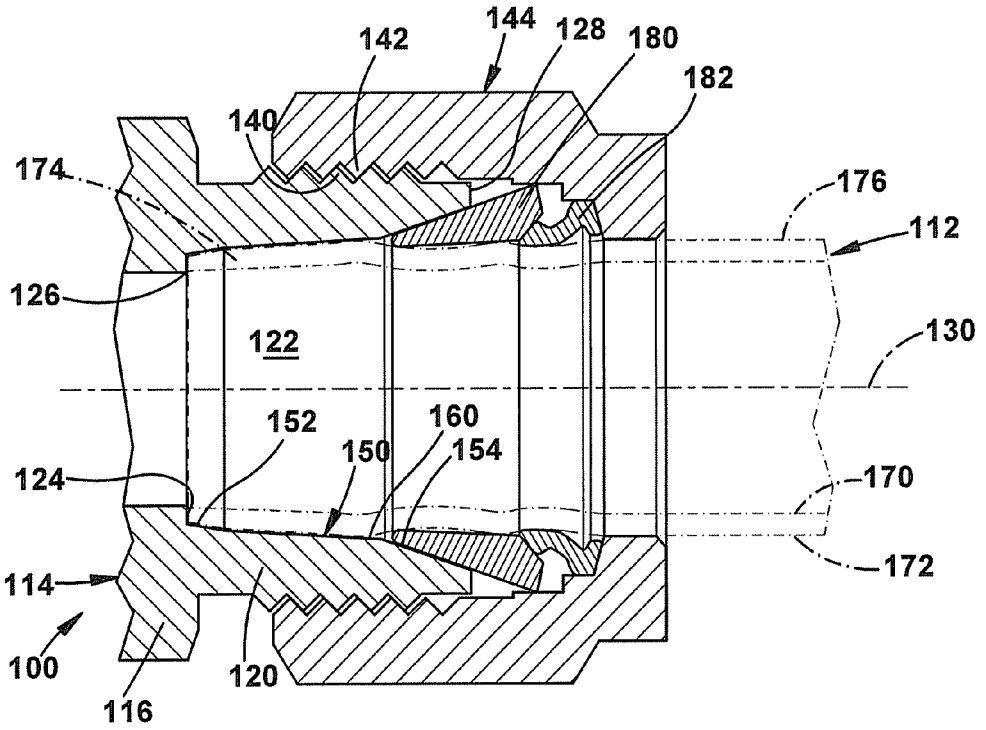

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Fig. 4

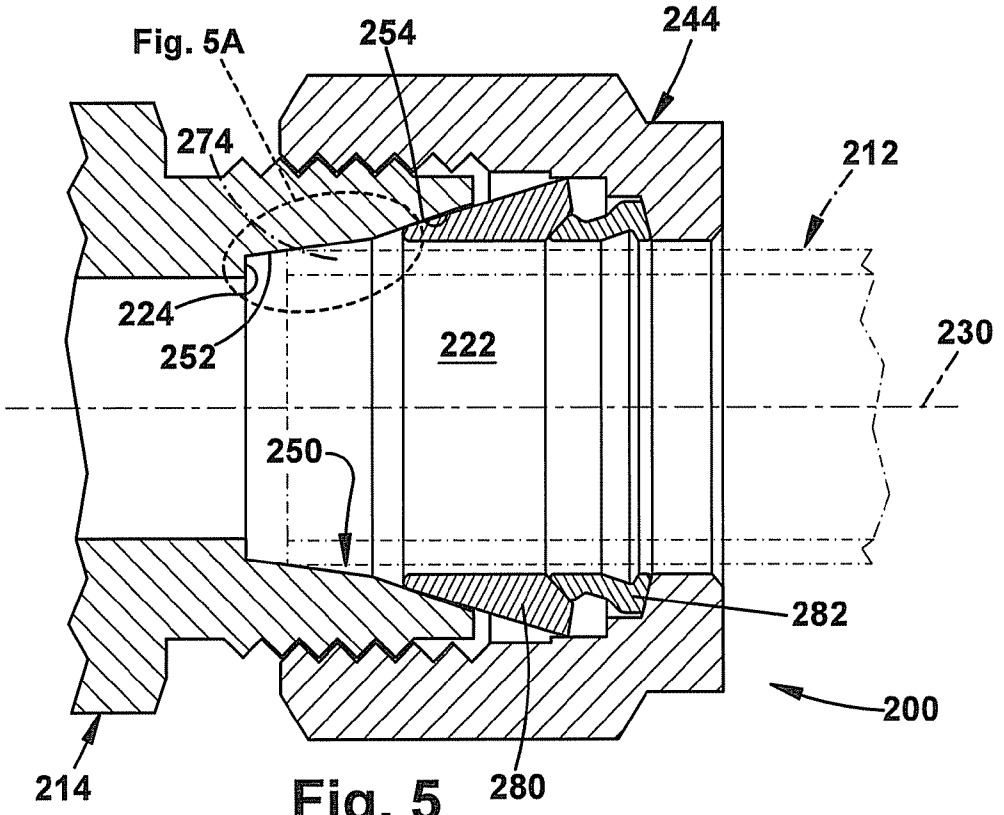

Fig. 5A
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Fig. 5

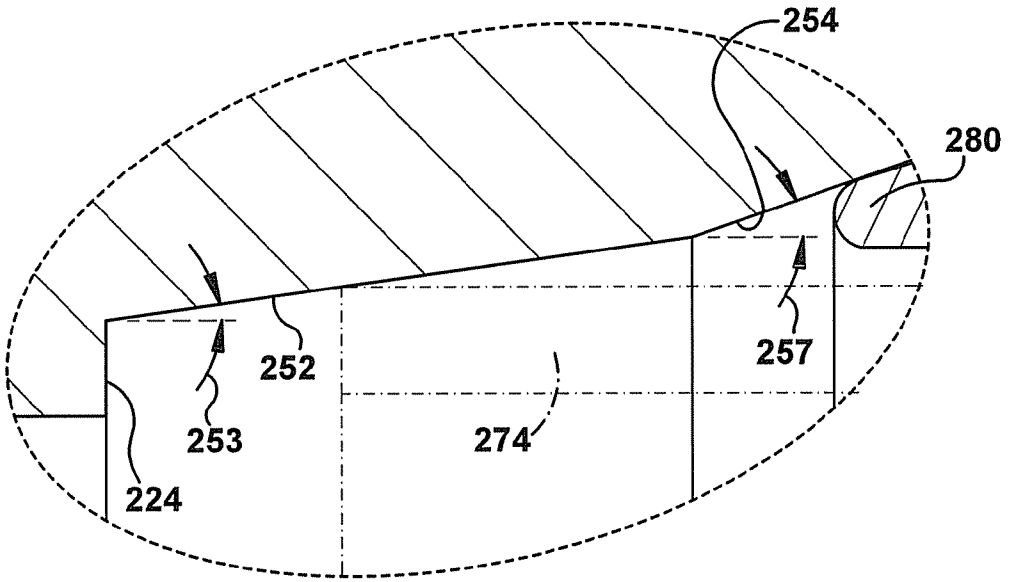

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Fig. 5A

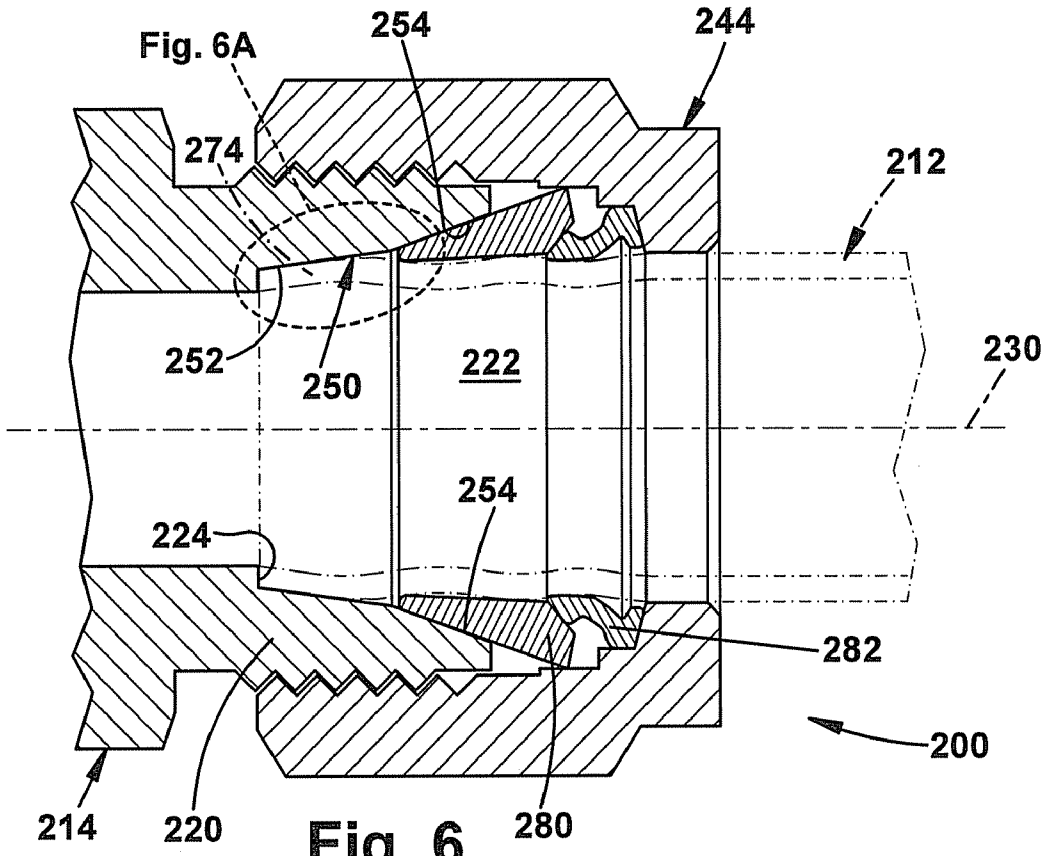

Fig. 6A
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Fig. 6

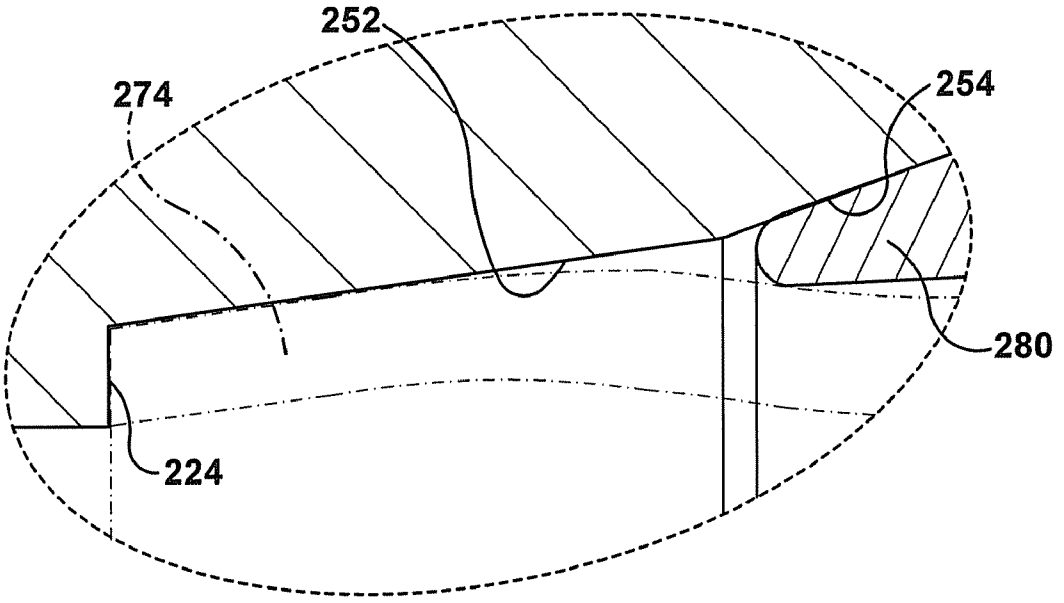

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Fig. 6A

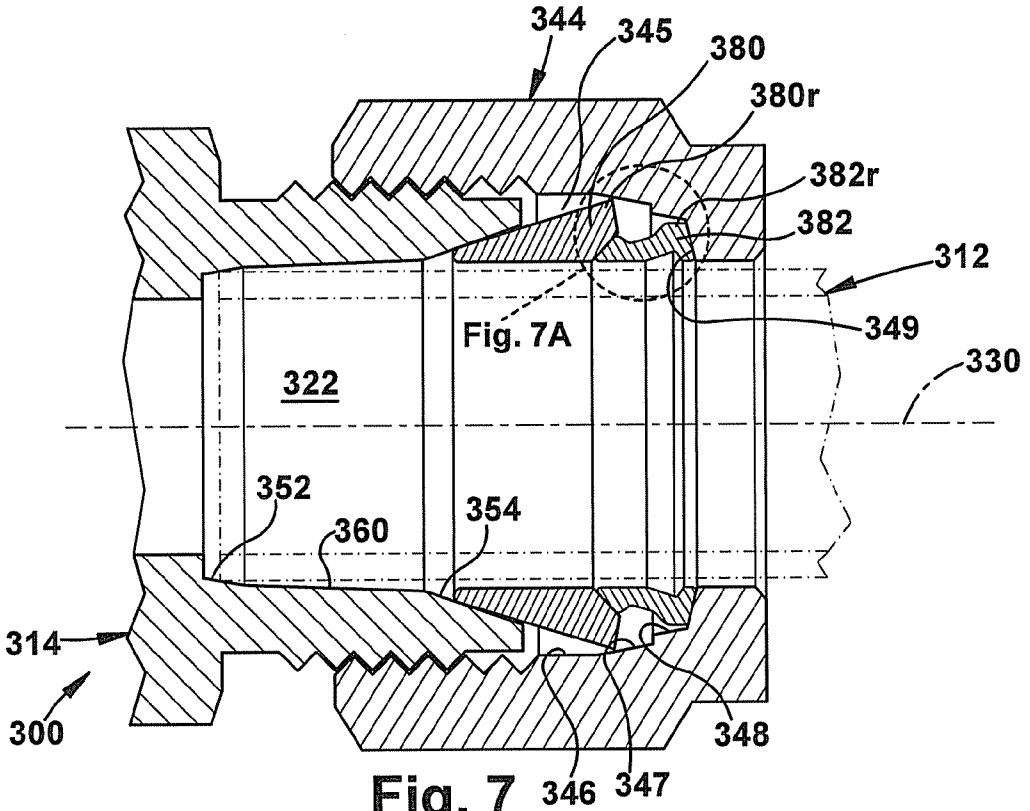

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Fig. 7A
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Fig. 7

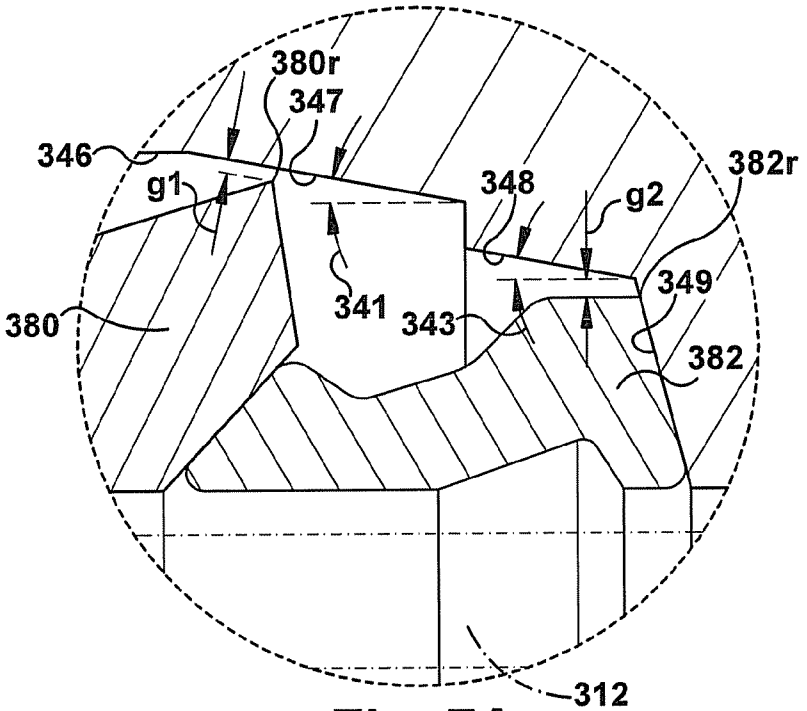

380r
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g1
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g2
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343
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Fig. 7A

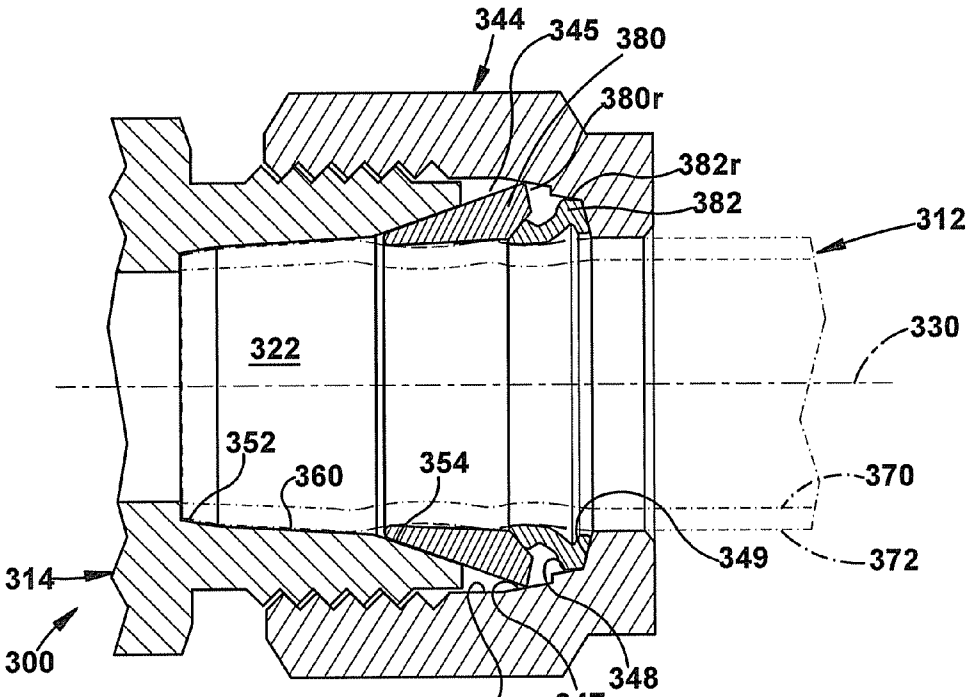

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Fig. 8

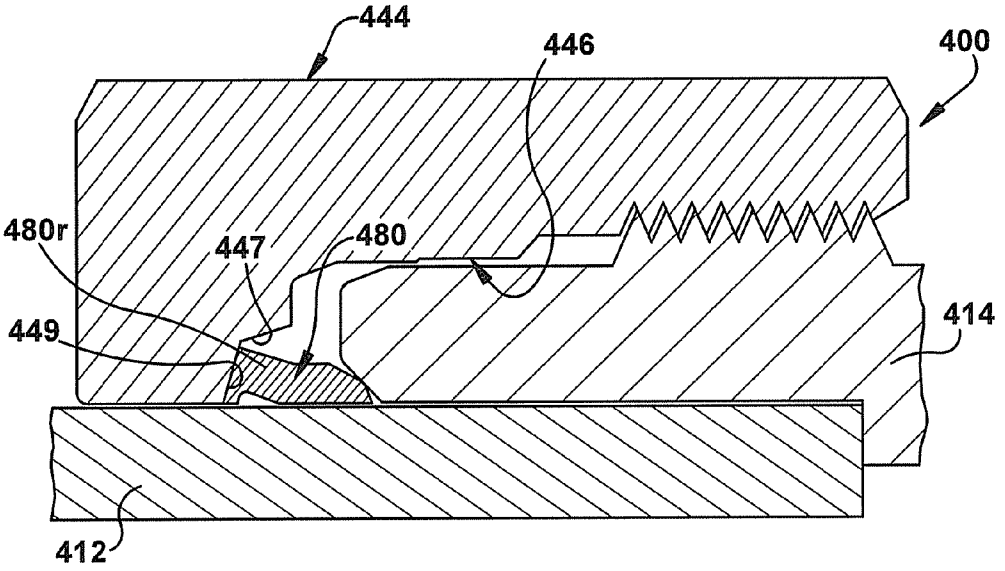

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Fig. 9

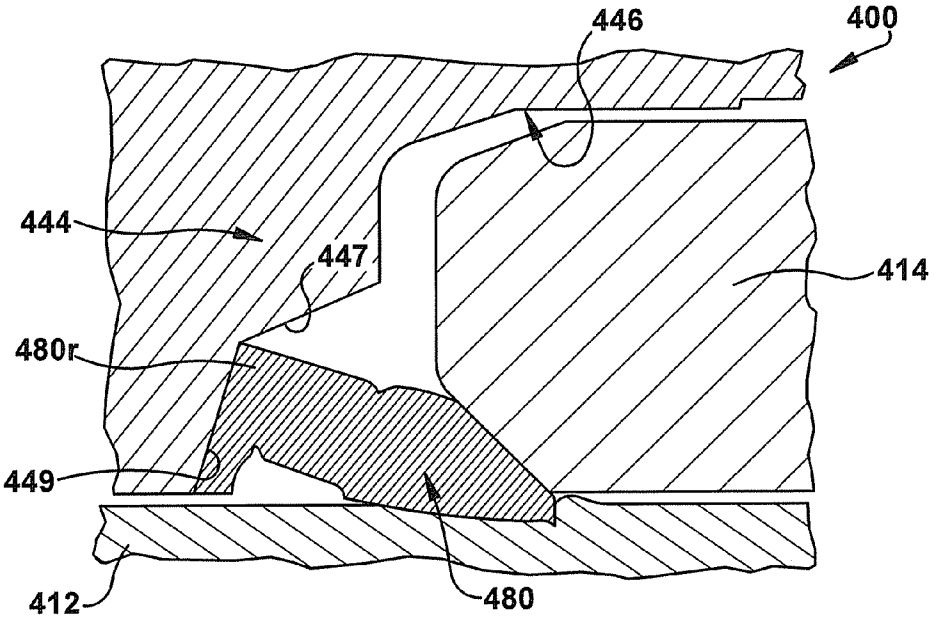

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Fig. 10

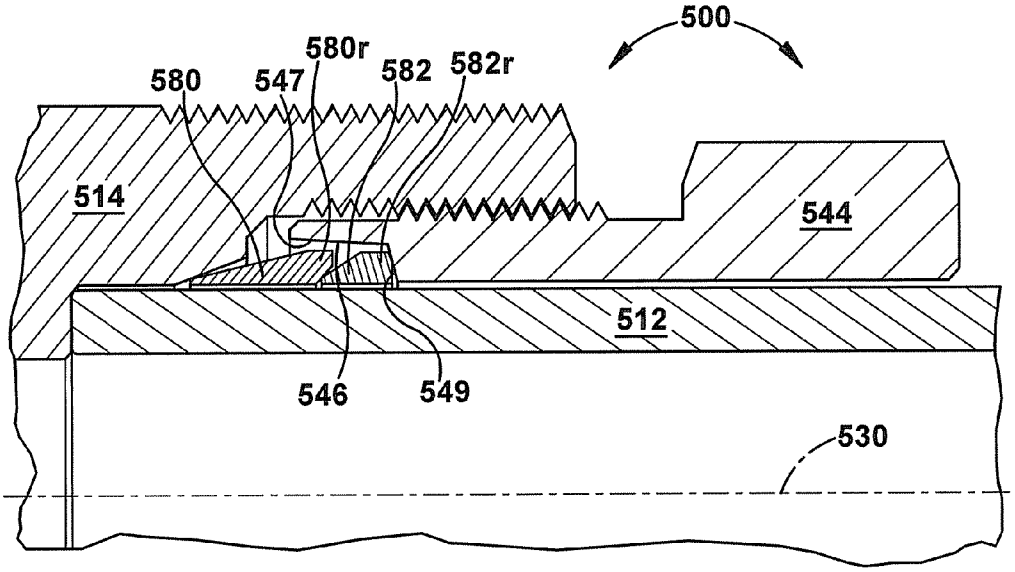

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Fig. 11

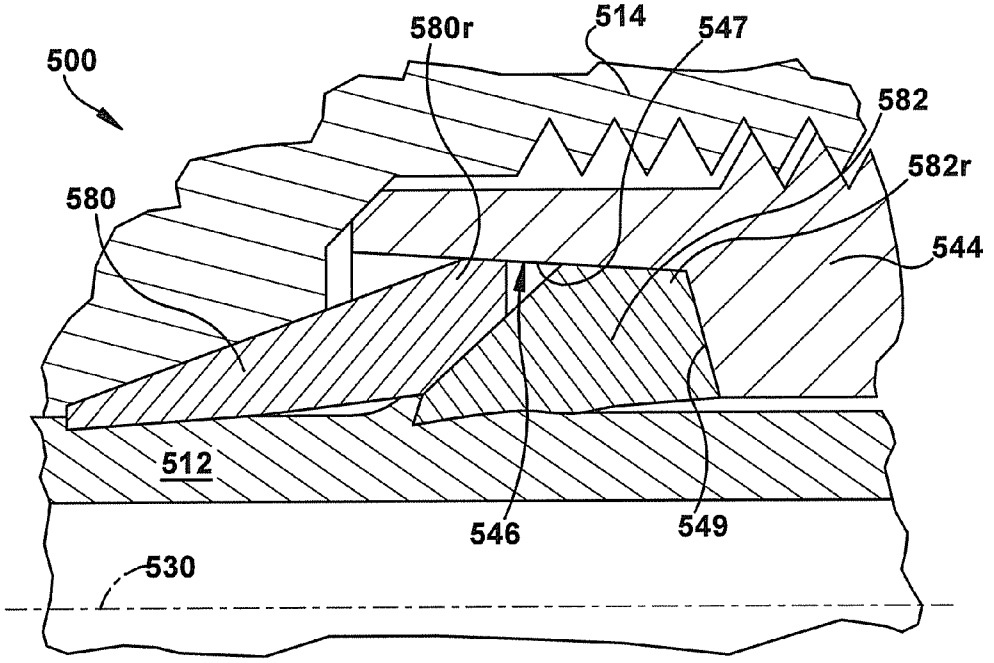

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Fig. 12

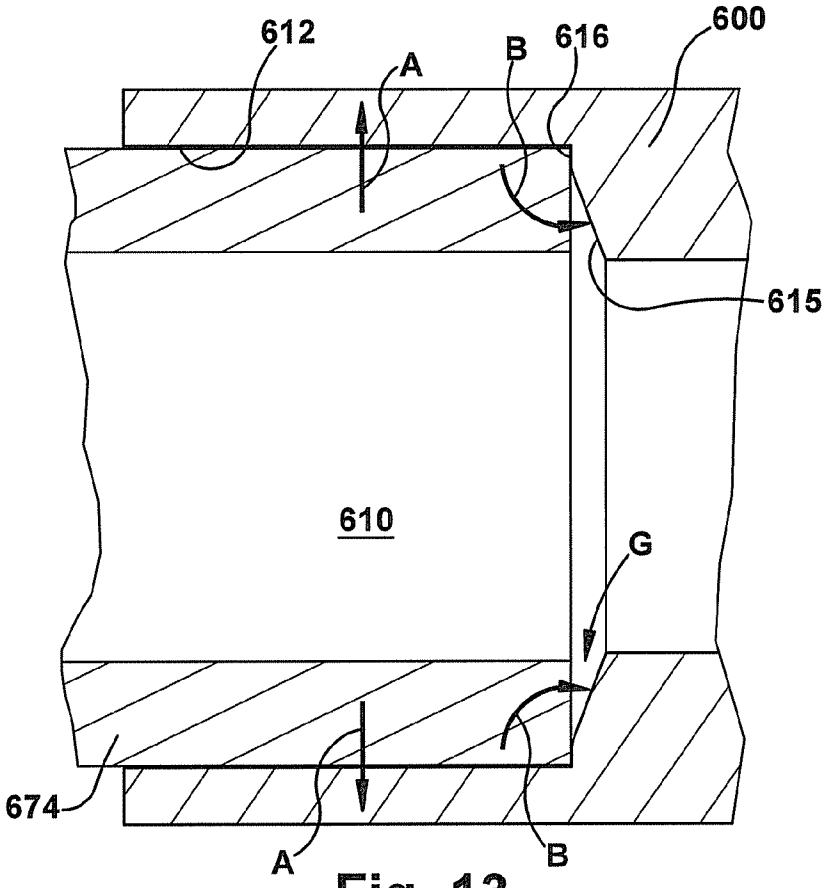

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Fig. 13

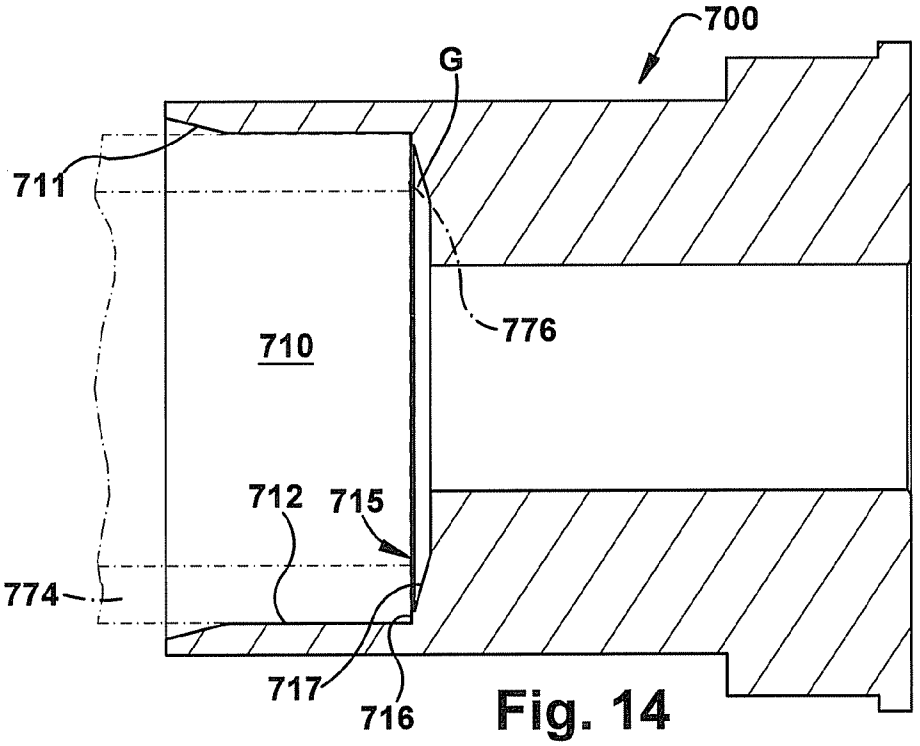

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Fig. 14

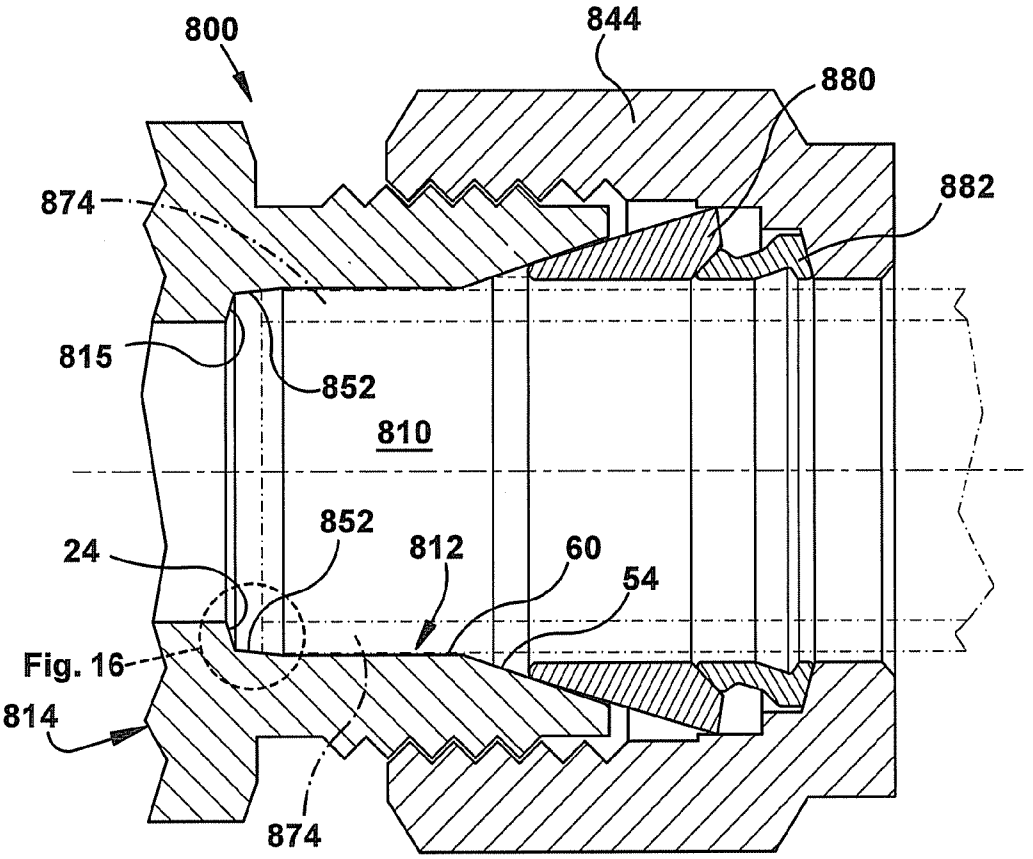

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Fig. 16
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Fig. 15

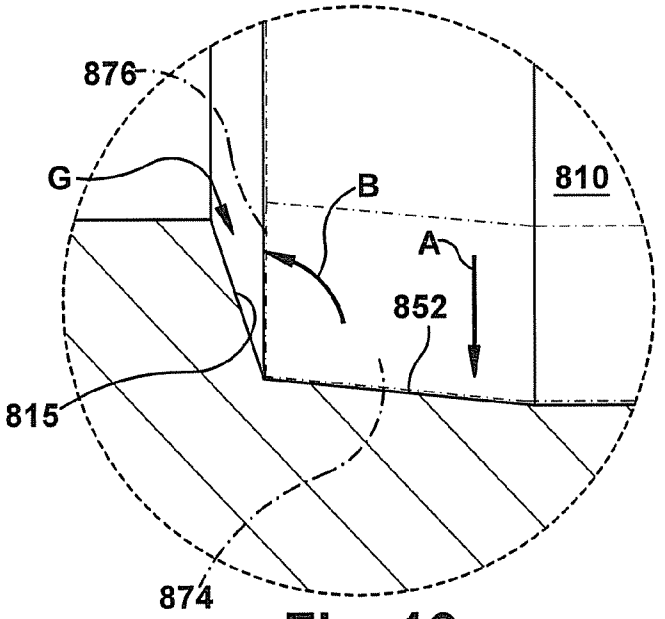

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Fig. 16

FITTING WITH ADAPTED ENGAGING SURFACES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation application of and claims priority to U.S. patent application Ser. No. 11/639,529, filed Dec. 15, 2006, entitled "Fitting for Tube or Pipe", which claims priority from U.S. provisional application Ser. No. 60/758,688, entitled "FITTING FOR TUBE OR PIPE," filed on Jan. 13, 2006, and from U.S. provisional application Ser. No. 60/834,548, entitled "FITTING FOR TUBE OR PIPE," filed on Jul. 31, 2006, the entire disclosures of which are fully incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

[0002] Fittings may be used to join or connect the end of a tube or other conduit to another member, whether that other member be another tube or conduit end such as through T-fittings and elbow fittings, for example, or a device that needs to be in fluid communication with the tube end, such as for example, a valve. One type of fitting uses a gripping arrangement including two ferrules that provide a gripping and sealing action between a tube and a body under the influence of a female threaded drive nut. Other types of fittings are also known, such as, for example, single ferrule fittings, fittings that use other types of tube gripping devices, and fittings that use male threaded drive nuts.

[0003] Tube fitting components that are radially displaced or expanded upon pull-up take up a portion of the deformation energy of pull-up and may contact radially adjacent and/or radially nearby fitting component surfaces as a result of the expansion or displacement. For example, the tubing inboard of the tube gripping member, such as, for example, the front ferrule of a two ferrule fitting or the ferrule of a single ferrule fitting, may expand radially outward during fitting pull-up and takes up a portion of the deformation energy of pull-up.

SUMMARY OF THE INVENTION

[0004] The application pertains generally to a fitting assembly that is configured to assist in separating two or more fitting components during disassembly of the fitting if and when the mating components contact each other during pull-up, for example, due to radially outward movement of a fitting component as a result of axial compression of the fitting component during fitting installation. As used herein, fitting components of a fitting assembly may include, but are not limited to, bodies, such as, for example, coupling bodies and valve bodies, drive nuts, tube gripping members, such as, for example, ferrules, tubing or other conduits, and fitting installation tools, such as, for example, tube gripping member installation tools or pre-swaging tools.

[0005] According to one inventive aspect, one or more fitting component engaging surfaces may be configured to reduce radial reaction forces between two contacting fitting components of a pulled-up fitting. For example, a surface of a first fitting component that is axially aligned with a second fitting component during fitting assembly may be radially recessed to provide reduced radial reaction forces between the recessed surface and the second component during disassembly. As used herein, two components are "axially aligned" if a portion of the first component is located at the same axial position (e.g., a position along a fitting) as a portion of the second fitting component. As another example of fitting components configured to reduce radial reaction forces resulting from contact between fitting components of a pulled-up fitting, a surface of a first fitting component that contacts a second fitting component during fitting assembly may be axially shortened to reduce a length of contact between the first and second components and, as a result, to provide reduced radial reaction forces between the first and the second components during disassembly.

[0006] Accordingly, in one exemplary embodiment, a fitting component includes a body having a tube socket that includes a recessed wall surface radially spaced from a tapered tube capture surface. Such a fitting component may be used in a fitting assembly that includes a tube having an end portion that engages the tube capture surface prior to fitting pull-up. When the fitting assembly is pulled-up, additional engagement between the tube socket and the tube end portion, for example, due to radially outward deflection or bowing of the tube end resulting from axial compression of the tube end, produces axial and radial reaction force components between the tube socket and tube end portion. By providing a recessed longitudinal surface in the tube socket, the radial force component between the first and second components may be reduced, thereby assisting in separation of the first and second components during disassembly of the fitting assembly.

[0007] According to another inventive aspect, one or more fitting component mating surfaces may additionally or alternatively be configured to produce an axial component of reaction force between two contacting fitting components of a pulled-up fitting. This axial component of elastic reaction force may assist in separating the two fitting components during disassembly of the pulled-up fitting. For example, a first fitting component may include a stepped wall surface, which may, for example, include a tapered surface, that contacts a second fitting component during fitting pull-up to produce an axial component of reaction force, which may assist in separation of the first and second fitting components when the fitting is disassembled.

[0008] Accordingly, in one exemplary embodiment, a fitting assembly has a first fitting component having a stepped wall surface and a second fitting component radially spaced from the tapered longitudinal surface when the fitting assembly is in a finger tight condition prior to pull-up. When the second fitting component is radially displaced into contact with the stepped wall surface during fitting pull-up, the stepped wall surface assists in separating the first fitting component from the second fitting component upon fitting disassembly. For example, engagement of the second fitting component with the stepped wall surface may produce an axial component of reaction force that assists in axially moving the second fitting component away from the first fitting component. As another example, the stepped wall surface may provide for a reduced radial reaction force between the first and second fitting components upon initial axial movement of the second fitting component during fitting disassembly.

[0009] In one such embodiment, a fitting body is provided with a tube socket having a stepped wall surface, such that when a tube that is assembled with the fitting body radially expands to contact the stepped wall surface, an axial component of reaction force resulting from this contact may assist in separating the tube from the fitting body upon disassembly of the fitting. Additionally, the stepped condition of the tube

socket wall may reduce the radial force between the fitting body and the tube during withdrawal of the tube from the fitting.

[0010] In an exemplary embodiment, a component of a tube fitting for a tube end includes a body having a tube end socket centered on an axis, for receiving a tube end. The tube end socket has a shoulder defining an axially inner end of the socket, a tapered tube capture surface adjacent the shoulder for engaging the tube end, a camming mouth near an axially outer end of the tube end socket, for engaging a ferrule, and a stepped wall surface disposed between the tube capture surface and the camming mouth. When the tube expands to contact the stepped wall surface during fitting pull-up, this contact between the stepped wall surface and the tube produces an axial component of elastic reaction force against the tube, which can assist in tube removal from the socket upon fitting disassembly. Additionally, the stepped condition of wall surface may reduce the radial force between the tube socket and the tube end, for example, by providing radial separation between the tube and at least a portion of the tapered surface during withdrawal of the tube from the tube socket.

[0011] In another embodiment, a fitting body may be provided with a tapered tube capture surface that is extended to assist in separation of the tube from the fitting body upon disassembly of the fitting. For example, a tapered tube capture surface in a tube socket of a fitting body may extend to a camming mouth of the tube socket, thereby eliminating any intermediary or transitional wall surface between the tube capture surface and the camming mouth. In one such exemplary embodiment, a tube fitting for a tube end includes a fitting body having a tube end socket centered on an axis, for receiving a tube end. The tube socket includes a shoulder defining an axially inner end of the socket, a tapered tube capture surface outward of the shoulder for engaging the tube end, and a camming mouth outward of and directly adjacent to the tube capture surface, for receiving at least a portion of a ferrule.

[0012] In another embodiment, a drive nut is provided with an inner wall having a tapered longitudinal surface, such that when a tube gripping member that is assembled with the drive nut and a fitting body is displaced into contact with the tapered longitudinal surface, an axial component of elastic reaction force resulting from this contact may assist in separating the tube gripping member from the drive nut upon disassembly of the fitting. Additionally, the tapered condition of the longitudinal wall may reduce the radial force between the drive nut and the tube gripping member during separation of the tube gripping member from the drive nut, for example, by providing radial separation between the tube gripping member and at least a portion of the tapered surface during fitting disassembly.

[0013] In other embodiments, multiple fitting components may be configured to reduce radial reaction forces and/or increase axial reaction forces between contacting fitting component surfaces of a pulled-up fitting, thereby assisting in disassembly of the fitting. For example, a fitting assembly may include a fitting body with a tube socket having a tapered wall to assist in separating a tube end from the fitting body during fitting disassembly, and a drive nut with an inner wall having a tapered longitudinal surface to assist in separating a tube gripping member from the drive nut during fitting disassembly.

[0014] According to still another inventive aspect of the present application, a fitting component including a tube socket configured to receive a tube end may be provided with a counter-bowing feature that reduces radially outward expansion or deflection of the tube end, including, for example, bowing or barreling of a tube end resulting from axial compression of the tube end. The reduced bowing of the tube end may result in reduced radial reaction forces between the tube end and the socket, which may assist in separation of the first fitting component and the tube end during disassembly.

[0015] In one such embodiment, a fitting component includes a socket for receiving a tube end, the socket being defined by an axial longitudinal wall surface and a shoulder including a surface extending axially and radially inward from an axially inner end of the axial longitudinal wall surface. When a tube end is inserted in the socket and axially compressed against the shoulder, the shoulder surface is configured to apply counter-bowing forces to the tube end to reduce bowing of the tube end during axial compression.

[0016] Further advantages and benefits will become apparent to those skilled in the art after considering the following description and appended claims in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** is a partial sectional view of a tube fitting having a tube socket with a recessed intermediate wall surface, shown in a finger tight condition before pull-up of the fitting;

[0018] FIG. **1**A is an enlarged sectional view of a portion of the tube socket of FIG. **1**;

[0019] FIG. **1**B is an enlarged sectional view of a portion of an alternative tube socket for the tube fitting of FIG. **1**, also shown in a finger tight condition before pull-up of the fitting;

[0020] FIG. **2** is a partial sectional view of the tube fitting of FIG. **1** in a pulled-up condition;

[0021] FIG. **2**A is an enlarged sectional view of a portion of the tube socket of FIG. **2**;

[0022] FIG. **2**B is an enlarged sectional view of a portion of the tube socket of FIG. **1**B, shown in a pulled-up condition;

[0023] FIG. **3** is a partial sectional view of a tube fitting having a tube socket with a tapered intermediate wall surface, shown in a finger tight condition before pull-up of the fitting;

[0024] FIG. **3**A is an enlarged sectional view of a portion of the tube socket of FIG. **3**;

[0025] FIG. **4** is a partial sectional view of the tube fitting of FIG. **3** in a pulled-up condition;

[0026] FIG. **5** is a partial sectional view of a tube fitting having a tube socket with no intermediate wall surface, shown in a finger tight condition before pull-up of the fitting;

[0027] FIG. **5**A is an enlarged sectional view of a portion of the tube socket of FIG. **5**;

[0028] FIG. **6** is a partial sectional view of the tube fitting of FIG. **5** in a pulled-up condition;

[0029] FIG. **6**A is an enlarged sectional view of a portion of the tube socket of FIG. **6**;

[0030] FIG. **7** is a partial sectional view of a tube fitting having a drive nut with a tapered inner wall surface, shown in a finger tight condition before pull-up of the fitting;

[0031] FIG. **7**A is an enlarged sectional view of a portion of the drive nut and ferrules of the fitting of FIG. **7**;

[0032] FIG. **8** is a partial sectional view of the tube fitting of FIG. **7** in a pulled-up condition;

[0033] FIG. **9** is a partial sectional view of a single ferrule type tube fitting having a drive nut with a tapered inner wall surface, shown in a finger tight condition before pull-up of the fitting;

[0034] FIG. **10** is an enlarged partial sectional view of the tube fitting of FIG. **9** in a pulled-up condition;

[0035] FIG. **11** is a partial sectional view of a tube fitting with a female threaded body and a male threaded drive nut with a tapered inner wall surface, shown in a finger tight condition before pull-up of the fitting;

[0036] FIG. **12** is an enlarged partial sectional view of the tube fitting of FIG. **11** in a pulled-up condition;

[0037] FIG. **13** is a partial sectional schematic view of a fitting component having a tube socket with an axially tapered shoulder surface, with a tube end installed in the tube socket in an axially compressed condition;

[0038] FIG. **14** is a partial sectional view of a fitting installation tool for tightening a tube gripping member to a tube end, the tool including a tube socket with an axially tapered shoulder surface;

[0039] FIG. **15** is a partial sectional view of a tube fitting having a tube socket with an axially tapered shoulder surface, shown in a finger tight condition before pull-up of the fitting; and

[0040] FIG. **16** is an enlarged partial sectional view of the tube fitting of FIG. **15** in a pulled-up condition.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS OF THE INVENTION

[0041] This disclosure relates to fitting components, for use with any type of fluid conduit, including tube or pipe. The exemplary embodiments are described herein with the terms "tube" and "tubing," but may be used with pipe and other conduits. The disclosure is applicable to fitting components of varying constructions, materials, sizes, and dimensions such as diameters, for example, all of which are described herein with the term "tube fitting." The tightening or preparation of a fitting connection is referred to herein as fitting "pull-up" or "make up," with both terms being used interchangeably. Fitting pull-up or make up is not limited to a specific pull-up position.

[0042] Tube fitting components that are radially displaced or expanded upon fitting pull-up may contact radially adjacent and/or radially spaced fitting component surfaces as a result of the expansion or displacement. Examples of this radially outward movement include bowing or barreling of a tube end resulting from axial compression of the tube end, or outward deflection of a tube gripping member, such as a ferrule or ferrules, during fitting pull-up. The present application contemplates providing a fitting that may be configured to assist in the separation of these contacting fitting components during disassembly of the fitting, for example, by reducing radial reaction forces (which tend to resist separation) between the components, or by increasing axial reaction forces (which tend to promote separation) between the components. According to one inventive aspect, this assistance in separating the components may be accomplished by providing a first fitting component with a recessed surface radially spaced from a surface that engages a displaced portion of a second component upon fitting pull-up. As the second component is separated from the first component during fitting disassembly, the displaced portion is axially aligned with the recessed surface, causing radial reaction forces between the first and second fitting components to be reduced, thus facilitating further separation of the first and second fitting components.

[0043] According to another inventive aspect, assistance in separating contacting first and second fitting components may be accomplished by providing the first fitting component with a tapered longitudinal surface for engagement with a displaced portion of the second fitting component. For example, a tube end socket may include a tapered longitudinal wall to assist in removal of a tube end. As another example, a drive nut may include a tapered longitudinal surface on an inner wall to assist in separation of the drive nut from a tube gripping device, such as, for example, a ferrule or ferrules. In yet another exemplary embodiment, both the tube end socket and the drive nut may include tapered longitudinal surfaces to assist in separation from the tube end and tube gripping device, respectively.

[0044] An exemplary type of fitting with which the invention can be used includes two ferrules that provide a gripping and sealing action between a tube and a body under the influence of a female threaded drive nut. While exemplary embodiments illustrated and described herein show various inventive aspects as used with this two ferrule type fitting, these inventive aspects are also applicable to other types of fittings, such as, for example, single ferrule fittings, fittings that use other types of tube gripping devices, and fittings that use male threaded drive nuts. Also, while exemplary embodiments include fittings for use with stainless steel tubing having diameters of ¼ inch, ⅜ inch and ½ inch, the inventive aspects of the present application may be provided with fittings for use with many sizes and types of tubing.

[0045] FIGS. **1** and **2** illustrate a tube fitting **10** that is an exemplary embodiment of some of the inventive aspects described herein. The tube fitting **10** is used for connection with a tube **12** and includes a fitting body **14**. The fitting body **14** is merely representative of the various different types of assemblies and fittings with which the invention is usable. For example, the fitting body can be a standalone device, or a portion of a valve, or a union, or any other type of fluid control device or fluid flow device.

[0046] The particular fitting body **14** that is illustrated has a main body portion **16** and a projecting socket wall **20**. The socket wall **20** forms the radially outer periphery of a tube end socket **22** in the fitting body **14**.

[0047] The fitting body **14** has a radially extending shoulder **24** that defines or is located at an axially inner end **26** of the socket **22**. The socket wall **20** has an outer terminal end surface **28** extending generally radially with respect to an axis **30** of the fitting body **14**. The terminal end surface **28** defines or is located at an axially outer end **32** of the socket **22**.

[0048] A male thread **40** is formed on the exterior of the socket wall **20**. The male thread **40** cooperates with a female thread **42** on a drive nut **44**. The drive nut **44** is rotatable and movable axially relative to the fitting body **14**.

[0049] The socket wall **20** has an inner wall surface **50** that partially defines the tube end socket **22**. The inner wall surface **50** extends between the axially inner end **26** of the socket **22** and the axially outer end **32** of the socket. In the illustrated embodiment, the inner wall surface **50** extends between the shoulder **24** and the terminal end surface **28**. The inner wall surface **50** may have various configurations in accordance with the inventive aspects described herein. Several embodiments are illustrated herein, and others will be readily apparent to those skilled in the art.

[0050] In the embodiment illustrated in FIGS. **1** and **2**, the inner wall surface **50** of the tube end socket **22** includes a tube capture surface **52**, a camming mouth portion **54**, and a intermediate wall surface portion **60** (the details of which may be exaggerated in the drawings for clarity) between the tube capture surface **52** and the camming mouth portion **54**. The exemplary tube capture surface **52** extends axially outward from the shoulder **24**; however, in other embodiments, the tube capture surface **52** may be axially spaced from the shoulder **24**. While the tube capture portion may take many different shapes, angles, contours, or geometries, the exemplary tube capture surface **52** of the inner wall surface **50** is a frustoconical tapered surface that tapers radially outward as it extends axially away from the shoulder **24**. In the illustrated embodiment, as shown in FIG. **1**A, the tube capture surface **52** has a taper angle **53**. In an exemplary embodiment, the taper angle **53** is approximately four degrees (4°) relative to the axis **30**. The taper angle **53** of the tube capture surface **52**, and its overall diameter, may be selected to lightly hold or capture the end of the tube **12** prior to fitting pull-up, to inhibit the tube **12** from rotating in the socket **22** during pull-up of the fitting **10**.

[0051] The exemplary camming mouth **54** is adapted to engage a ferrule (described below) that forms part of the tube fitting **10**, and to cam the ferrule radially inward, thereby to provide, in a known manner, a gripping and sealing connection between the tube **12**, the ferrule, and the fitting body **14**. The angle **57** of the camming mouth **54**, as referenced in FIG. **1**, may be selected to provide the desired gripping and sealing connection. In an exemplary embodiment, the camming mouth angle **57** is approximately 20° relative to the axis **30**.

[0052] The tube **12** that is illustrated is merely representative of the various different types and sizes of conduits with which the invention is usable. The particular tube **12** that is illustrated has a generally cylindrical configuration including parallel, cylindrical inner and outer side surfaces **70** and **72** centered on the axis **30**. The tube **12** has an inner tube end **74** and an outer portion shown broken away at **76**. When the tube fitting **10** is made up, the terminal end portion **74** of the tube **12** is located in the socket **22** of the fitting body **14**, and the tube extends axially outward therefrom, and outwardly of the fitting body **14**.

[0053] The particular tube fitting **10** that is shown in FIGS. **1** and **2** includes, in addition to the fitting body **14**, a front ferrule **80**, a rear ferrule **82**, and a drive nut **44**. The invention is applicable also to fittings including other types of tube gripping devices, including, for example, tube fittings that include only one ferrule rather than two ferrules. The invention is applicable also to tube fittings that include front and/or rear ferrules, and drive nuts, of differing constructions, many of which designs are known in the art.

[0054] FIG. **1** illustrates the fitting **10** in a finger-tight condition prior to pull-up. The tube **12** is inserted into the socket **22**. The terminal end portion of the tube **74** extends into contact with the tube capture surface **52** of the inner wall surface **50** of the fitting body **14**.

[0055] The outer surface **72** of the tube **12** is smaller in diameter than the intermediate wall surface **60** of the fitting body **14**, and is thus spaced radially inward from the intermediate wall surface **60**. The ferrules **80** and **82** are on the tube **12**, and the drive nut **44** is threadedly engaged with the fitting body **14**.

[0056] FIG. **2** illustrates the fitting **10** after pull-up. The drive nut **44** is screwed farther onto the fitting body **14**. The movement of the drive nut **44** causes the ferrules **80** and **82** to provide a gripping and sealing engagement between the tube **12** and the fitting body **14**.

[0057] Axially and radially inward movement of the nose of the front ferrule **80** causes the tube **12** to be pushed axially inward into engagement with the shoulder **24**. Axial force on the tube **12** causes the portion of the tube end **74** that is located axially inward of the front ferrule **80** to barrel radially outward. This tube portion **74** might contact the intermediate wall surface portion **60** of the fitting body **14**, for example, as shown in FIG. **2**, producing a radial component of reaction force, which may also be referred to as an interference load or a friction load.

[0058] The intermediate wall surface portion **60** of the exemplary inner wall surface **50** extends between the tube capture surface **52** and the camming mouth portion **54**. The surface **60** is centered on the axis **30**. The exemplary intermediate wall surface **60** includes a stepped portion **61** (see FIG. **1**A) axially outward of the tube capture surface **52** and a recessed portion **62** axially outward of the stepped portion **61**, such that the recessed portion **62** is radially spaced from the tube capture surface **52**. Thus, the diameter of the socket **22** is greater at the recessed portion **62** than at any point along the tube capture surface **52**. Further, the average diameter of the inner wall surface **50** of the socket **22** is increased, as compared to a fitting tube socket without such a recess. Also, while the illustrated stepped portion **61** is directly adjacent to the tube capture surface **52**, in other embodiments, the stepped portion **61** may be axially spaced from the outer edge of the tube capture surface **52**.

[0059] In the illustrated embodiment of FIGS. **1**, **1**A, **2**, and **2**A, the exemplary stepped portion **61** is substantially perpendicular to the exemplary recessed portion **62**, which is substantially cylindrical. As a result, when the tube end **74** expands during fitting pull-up and contacts the recessed portion **62**, as shown in FIG. **2**B, reaction forces between the cylindrical recessed portion **62** and the tube end **74** are substantially radial (i.e., non-axial). Also, contact between the expanded tube end **74** and the exemplary stepped portion **61** is minimal, resulting in little or no axial reaction forces from such contact. During disassembly of the exemplary fitting **10**, engagement between the tapered tube capture surface **52** and the tube end **74** will provide axial reaction forces to assist in separating the tube end from the fitting body. During separation, as the end of the tube **74**, which has experienced less expansion or displacement, axially moves into the recessed portion **62** of the tube socket, the radial reaction forces between the recessed portion **62** and the tube **12** are reduced or eliminated, thus assisting in separating the tube end **74** from the fitting body **14**. Further, by increasing the average diameter of the inner wall surface **50** of the tube socket **22**, total radial reaction forces along a length of contact between the tube **12** and the tube socket **22** are reduced.

[0060] In another embodiment, as shown in the partial views of FIGS. **1**B and **2**B, the stepped portion **61'** may be tapered, allowing for the potential for increased contact between the tube and the stepped portion **61'** upon fitting pull-up, as shown in FIG. **2**B. The potential contact between the tube **12** and the tapered stepped portion **61'** provides an axial component of reaction force between the tube and the stepped portion **61'** during fitting disassembly, which may assist in separation of the tube **12** from the fitting body **14**. While the stepped portion **61'** may be provided at many different angles and with many different surface contours, an

exemplary embodiment includes a frustoconical stepped portion **61'** at a taper angle **63'** of approximately 20° relative to the axis **30**.

[0061] In other embodiments, the stepped portion **61'** may be steeper, with a larger taper angle **63'**, resulting in an axially shorter stepped portion **61'** and a longer recessed portion **62'**, or the stepped portion **61'** may be shallower, with a smaller taper angle **63'**, resulting in an axially longer stepped portion **61'** and a shorter recessed portion **62'**. Finite element analysis and testing of a particular fitting can determine how much taper is needed, in order to achieve a system that can provide an axial elastic reaction force on the tube, to assist in tube removal, upon disassembly.

[0062] In various exemplary embodiments, a stepped or tapered intermediate wall portion of a fitting body tube socket may be discontinuous with tube capture and camming mouth portions of the tube socket; that is, the stepped or tapered intermediate wall may be provided at a different angle than the tube capture and camming mouth portions **152**, **154**, may be radially spaced from the tube capture and camming mouth portions **152**, **154**, and/or may be axially spaced from the tube capture and camming mouth portions **152**, **154**.

[0063] With reference to FIGS. **3**, **3**A and **4**, in order not to repeat the above description, it should be noted that like reference numerals are used in FIGS. **3**, **3**A and **4** for like parts described with respect to the embodiment of FIGS. **1** and **2**, but with numbering starting at **100**. For example, reference numeral **124** refers to the corresponding numeral **24** in FIGS. **1** and **2**; and numeral **180** refers to the corresponding numeral **80** in FIGS. **1** and **2**, and so on. In this embodiment, a fitting body **100** may be provided with a tube socket including a stepped portion **160** having a tapered longitudinal surface that extends to an inner edge of a camming mouth portion **154**, thereby excluding a separate recessed portion of the tube socket **122**. Engagement or contact between the stepped portion or tapered inner wall **160** and the expanded tube end **174** after fitting pull-up, when such contact occurs, produces an axial component of reaction force along the length of contact between the tube **112** and the tapered wall **160**, thus assisting in separating the tube end from the fitting body **114**. Also, while the illustrated stepped or tapered wall portion **160** is directly adjacent to the tube capture portion **152**, the stepped portion may also be axially spaced from the outer edge of the tube capture portion **152**.

[0064] The tapered condition of the wall surface **160** (as opposed to a cylindrical surface) can assist in removal of the tube **112** from the socket **122** upon disassembly. Once the tube end **174** is initially broken free from the tapered wall surface **160**, the tube **112** can be removed without any substantial force, due to the reduction or elimination of radial reaction forces between the tube end **174** and the wall surface **160**.

[0065] The tapered wall surface may be provided at a variety of taper angles and with a variety of surface contours. In one embodiment, a tapered wall surface is frustoconical and tapered to connect an outer edge of a tube capture portion with an inner edge of the camming mouth. In the illustrated embodiment of FIGS. **3**, **3**A and **4**, the tapered wall surface **160** is frustoconical with a taper angle **163**. In one exemplary embodiment, the taper angle **163** is approximately 50 minutes, or five-sixths of a degree, relative to the axis **130**. In such an embodiment, the taper angle **163** of the exemplary tapered wall surface **160** is significantly less than the taper angle **153** of the tube capture portion **152**. As described below, the taper angle **163** of the tapered wall surface **160** is selected to assist in removal of a tube end if the tube end is expanded radially outward into contact with the socket wall during fitting pull-up. One desirable range of taper angles is from 50 minutes to one degree and fifty minutes, with a tolerance of plus or minus 15 minutes.

[0066] According to another inventive aspect of the present application, separation of a tube end from a fitting body may additionally or alternatively be facilitated by reducing the length of the portion of tube contacting the tube socket upon fitting pull-up. This may reduce the total radial reaction forces between these contacting surfaces, thereby assisting the separation of the tube end from the fitting body upon disassembly. In one embodiment, the length of contact between the expanded tube end and the tube end socket may be reduced by providing a recessed or tapered longitudinal surface in the tube end socket, as described with regard to the embodiments of FIGS. **1-4** above. In another embodiment, the length of contact between the expanded tube end and the tube end socket may additionally or alternatively be reduced by reducing the length of the tube socket. FIGS. **5** and **6** illustrate a fitting **200** that is one such exemplary embodiment. In the fitting **200**, the fitting body **214** has a shallow or shortened socket **222**. The outer periphery of the socket **222** is defined by an inner wall surface **250** of the fitting body **214**. The inner wall surface **250** includes a tube capture portion **252** and a camming mouth **254**, the angles of which may be exaggerated in the drawings for clarity.

[0067] The exemplary inner wall surface **250** of FIGS. **5** and **6** does not include an intermediate wall surface like the intermediate wall surfaces **60**, **160** of the embodiments of FIGS. **1-4**. Rather, the tube capture portion **252** abuts the camming mouth **254**. That is, the camming mouth **254** is directly adjacent the tube capture surface **252** so as to provide a zero intermediate or transition length tube socket **222**. Thus, there is neither a tapered wall surface, a stepped wall surface, nor a cylindrical wall surface between the tube capture portion **252** and the camming mouth **254** of the exemplary fitting body **214**. While the taper angles **253**, **257** of the tube capture portion **252** and camming mouth **254** may be any number of different angles, as determined through testing and finite element analysis, in an exemplary embodiment, the tube capture portion **252** has a taper angle **253** of approximately 4°, and the camming mouth has a taper angle of approximately 20°.

[0068] In other embodiments, the tube socket length may be selected to provide desired radial forces between the tube socket and the tube end, both upon fitting pull-up and after disassembly of the fitting. The shallow tube socket may alternatively be provided with a cylindrical intermediate tube wall or a stepped intermediate tube wall between a tube capture surface and a camming mouth. An appropriate socket length and/or intermediate tube wall geometry could be determined by finite element analysis and testing.

[0069] In accordance with other inventive aspects, one or more tapered longitudinal surfaces may be provided on one or more other fitting assembly components. In one embodiment, a tapered longitudinal surface may be provided on an inner wall of a drive nut of a fitting assembly to engage a portion of a tube gripping device assembled with the fitting when a portion of the tube gripping device is displaced outward and into contact with the inner wall of the nut during pull-up. This contact between the tapered longitudinal surface and the tube gripping device produces an axial component of an elastic reaction force against the tube gripping device, which can

assist in separation of the nut from the tube gripping device upon fitting disassembly. FIGS. **7-12** illustrate exemplary embodiments of fittings including drive nuts having one or more of such tapered longitudinal surfaces.

[0070] According to one embodiment, FIGS. **7** and **8** illustrate a two-ferrule tube fitting **300**. The tube fitting **300** may be used for connection with a tube **312** and includes a fitting body **314**. The fitting body **314** is merely representative of the various different types of assemblies and fittings with which the invention is usable. For example, the fitting body can be a standalone device, or a portion of a valve, or a union, or any other type of fluid control device or fluid flow device. Further, the fitting body **314** may, but need not, be provided with recessed or tapered longitudinal surfaces, such as, for example, the tapered tube capture and tube end socket wall surfaces described above and illustrated in FIGS. **1-6**. The particular tube fitting **300** that is shown in FIGS. **7-8** includes, in addition to the fitting body **314**, a front ferrule **380**, a rear ferrule **382**, and a drive nut **344**.

[0071] FIGS. **7** and **7**A illustrate the fitting **300** in a finger tight condition prior to pull-up. The tube **312** is inserted through the nut **344** and into the socket **322**. The front ferrule **180** is disposed in a first portion of a recess **345** in the nut **344**, and the rear ferrule **382** is disposed in a second portion of the recess **345**. Included in the recess is a frustoconical drive surface **349** for driving the ferrules **380**, **382** into engagement with the tubing **312** during pull-up.

[0072] FIG. **8** illustrates the fitting **300** after pull-up. The drive nut **344** is screwed further onto the fitting body **314**. The movement of the drive nut **344** causes the ferrules **380** and **382** to provide a gripping and sealing engagement between the tube **312** and the fitting body **314**.

[0073] Axially and radially inward movement of a nose of the front ferrule **380** may cause an outer portion **380***r* of the front ferrule **380** to expand or deflect outward. Likewise, axially and radially inward movement of an inner, gripping portion of the rear ferrule **382** may cause an outer portion **382***r* of the rear ferrule **382** to expand or deflect outward. Under some circumstances, one or both of these outer portions of the ferrules **380**, **382** may contact an inner wall **346** of the drive nut **344** during pull-up. In the exemplary embodiment of FIGS. **7** and **8**, tapered longitudinal surfaces **347**, **348** are provided on the inner wall **346** at locations axially aligned with the front and rear ferrules **380**, **382**. It should be noted that in other exemplary embodiments, tapered longitudinal surfaces may be provided axially aligned with only one of the two ferrules, or one continuous tapered longitudinal surface on the inner wall may extend to be axially aligned with both ferrules (not shown). In the illustrated embodiment of FIGS. **7** and **8**, when the outer portions **380***r*, **382***r* of the front and rear ferrules **380**, **382** deflect during pull-up, as shown in FIG. **8**, one or both of the outer portions **380***r*, **382***r* may contact a corresponding one or both of the tapered longitudinal surfaces **347**, **348**, resulting in both a radial and an axial component of reaction force.

[0074] The tapered condition of these inner wall surfaces **347**, **348** can assist in separation of the nut **344** from one or both ferrules **380**, **382** upon disassembly. The axial component of reaction force produced by contact between the tapered surfaces **347**, **348** and the ferrule or ferrules **380**, **382** can assist in separation of the nut **344** from either or both of the ferrules **380**, **382**. Once the ferrule or ferrules **380**, **382** are initially broken free from the tapered wall surfaces **347**, **348**, the nut **344** may be separated without any substantial force, due to the resulting radial separation or reduction in radial reaction force between the ferrule or ferrules **380**, **382** and the tapered wall surfaces **347**, **348**.

[0075] To provide both sufficient radial containment of the ferrules and a sufficient axial reaction force between contacting nut and ferrule surfaces during disassembly, the taper angles **341**, **343** of the inner wall surfaces **347**, **348** of the drive nut **344**, as measured from the axis **330** of the drive nut, may, for example, each range from greater than 0° up to approximately 45°. These two angles **341**, **343** may, but need not, be the same. In an exemplary embodiment, the taper angles **341**, **343** may each range from about 5° up to about 30°, and in a more preferred, but not required embodiment, the tapered angles **341**, **343** may each range from about 10° to about 20°. In the illustrated embodiment of FIGS. **7** and **8**, the tapered wall surfaces **347**, **348** each have a taper angle **341**, **343** of about 10° relative to the axis **330**.

[0076] As described above, the taper angle of the tapered wall surface in a drive nut may be selected to assist in separation of the drive nut from the tube gripping device, such as, for example, a ferrule or ferrules, if any portion of the tube gripping device is expanded or deflected radially outward into engagement with the inner wall of the drive nut during pull-up. Additionally, a gap between the outer portion or portions of the tube gripping device and the tapered longitudinal surface or surfaces of the drive nut in the fitting's pre-tightened, finger tight condition may be selected independently or in combination with the taper angle to provide a desired radial reaction load between the outer portions of the ferrule or ferrules and the inner wall of the drive nut, to assist in tightening the tube gripping device to the tube end. In an exemplary embodiment, as shown in FIGS. **7** and **7**A, a gap g**1** is provided between the front ferrule outer portion **380***r* and the tapered longitudinal surface **347**, and a gap g**2** is provided between the rear ferrule outer portion **382***r* and the tapered longitudinal surface **348**. The dimensions of these gaps and the taper angles of the tapered longitudinal surfaces may be varied to produce desired radial reaction forces during fitting pull-up, such as, for example, to produce radial reaction forces consistent with those experienced during pull-up of the fitting **300** with a nut having cylindrical inner wall surfaces, such as the drive nuts **44**, **144**, **244** shown in FIGS. **1-6**. As such, a drive nut **344** with tapered longitudinal surfaces may be interchangeable with a nut having cylindrical inner wall surfaces, thereby allowing use of the same fitting body and tube gripping device. In one such exemplary embodiment, a tube fitting **300** for ½ inch tubing includes a gap g**1** of approximately 0.010 inches between the front ferrule **380** and the tapered longitudinal surface **347**, and a gap g**2** of approximately 0.009 inches between the rear ferrule **382** and the tapered longitudinal surface **348**.

[0077] According to another inventive aspect, tapered longitudinal surfaces may be provided on multiple components of a fitting to assist in the separation of multiple sets of contacting fitting components during fitting assembly. In one embodiment, tapered longitudinal surfaces are provided both on an inner wall of a body tube socket and on an inner wall of a drive nut, for separation from the tube end and tube gripping device, respectively, during fitting disassembly. In the illustrated exemplary embodiment of FIGS. **7** and **8**, in addition to the tapered longitudinal surfaces **347**, **348** on the nut **344**, as described above, a tapered intermediate socket wall surface **360** is provided between a tube capture portion **352** and a camming mouth **354**, consistent with the tapered wall surface

160 of FIGS. **3**, **3**A and **4**, for assisting in separation of the fitting body **314** from the tube **312** during disassembly of the pulled-up fitting **300**.

[0078] FIGS. **9** and **10** illustrate a fitting **400** that is another exemplary embodiment in which a tapered longitudinal surface **447** is provided on an inner wall of a drive nut **444**. The exemplary fitting of FIGS. **9** and **10** is a single ferrule design, similar to a single ferrule tube fitting described in co-pending application Ser. No. 10/467,241, published under Pub. No. US 2006/0049632 and entitled Tube Fitting for Stainless Steel Tubing, the entire disclosure of which is fully incorporated herein by reference.

[0079] During pull-up of the illustrated tube fitting, axially and radially inward movement of a nose of the single ferrule **480** may cause an outer portion **480***r* of the single ferrule **480** to expand or deflect outward. Under some circumstances, this outer portion **480***r* of the ferrule **480** may contact an inner wall **446** of the drive nut **444** during pull-up, causing a radial reaction load between the outer portion **480***r* of the ferrule **480** and the inner wall **446** of the drive nut **444**. In the exemplary embodiment of FIGS. **9** and **10**, a tapered longitudinal surfaces **447** is provided on the inner wall **446** at a location axially aligned with and radially spaced from the ferrule **480**. When the outer portion **480***r* of the ferrule **480** deflects during pull-up, as shown in FIG. **8**, the outer portion **480***r* may contact the tapered longitudinal surface **447**, resulting in both a radial and an axial component of reaction force. The tapered condition of the inner wall surface (as opposed to, for example, a cylindrical surface) can assist in separation of the nut **444** from the ferrule **480** upon disassembly, as the axial component of reaction force can assist in separation of the nut **444** from the ferrule **480**. Once the ferrule **480** is initially broken free from the tapered wall surfaces **447**, the nut **444** can be separated without any substantial force, because of the taper angle of the tapered longitudinal surface **447**.

[0080] FIGS. **11** and **12** illustrate a fitting **500** that is yet another exemplary embodiment in which a tapered longitudinal surface **548** is provided on an inner wall of a drive nut **544**. The exemplary fitting of FIGS. **11** and **12** is a two-ferrule fitting of the type utilizing a male threaded drive nut **544** and a female threaded fitting body **514**, similar to a tube fitting with male threaded drive nut described in co-pending application Ser. No. 11/112,800, published under Pub. No. US 2005/0242582 and entitled Fitting for Tube and Pipe, the entire disclosure of which is fully incorporated herein by reference.

[0081] During pull-up of the illustrated tube fitting, axially and radially inward movement of a nose of the front ferrule **580** may cause an outer portion **580***r* of the front ferrule **580** to expand or deflect outward. Likewise, axially and radially inward movement of the inner, gripping portion of the rear ferrule **582** may case an outer portion **582***r* of the rear ferrule to expand or deflect outward. Under some circumstances, one or both of these outer portions **580***r*, **582***r* of the ferrules **580**, **582** may contact an inner wall **546** of the drive nut **544** during pull-up, causing a radial reaction load between the outer portion **580***r*, **582***r* of the ferrule or ferrules **580**, **582** and the inner wall **546** of the drive nut **544**. In the exemplary embodiment of FIGS. **11** and **12**, a tapered longitudinal surface **547** is provided on the inner wall **546** at a location axially aligned with and radially spaced from the ferrules **580**, **582**. When the outer portions **580***r*, **582***r* of the ferrules **580**, **582** deflect during pull-up, as shown in FIG. **12**, one or both of the outer portions **580***r*, **582***r* may contact the tapered longitudinal surface **547**, resulting in both a radial and an axial component of reaction force between the contacting surfaces. The tapered condition of the inner wall surface **547** (as opposed to, for example, a cylindrical surface) can assist in separation of the nut **544** from the ferrules **580**, **582** upon disassembly, as the axial component of reaction force can assist in separation of the nut **544** from the ferrule or ferrules **580**, **582**. Once the ferrule or ferrules **580**, **582** are initially broken free from the tapered wall surfaces **547**, the nut **544** can be separated without any substantial force, because of the taper angle of the tapered longitudinal surface.

[0082] According to still another inventive aspect, assistance in separating first and second fitting components may be accomplished by reducing radially outward deflection of the second fitting component during axial compression of the second fitting component, to reduce radial reaction forces between the first and second fitting components. For example, a counter-bowing feature may be provided on a fitting body to reduce outward deflection or bowing of a tube end during fitting assembly. In one embodiment having a counter-bowing feature, a fitting component with a socket for receiving a tube end may be provided with an axially receding shoulder surface, or a shoulder having a surface that extends axially and radially inward from an axially inner end of an axial longitudinal wall surface of the socket.

[0083] FIG. **13** illustrates a fitting component **600** having a socket **610** with an annular longitudinal wall surface **612** and an axially receding shoulder surface **615** that extends axially and radially inward of an axially inner end of the longitudinal wall surface **612**. When a tube end **674** is axially compressed in the tube socket **610** against an outer portion **616** of the shoulder surface **615**, an outward bowing force illustrated by arrows A tends to cause the tube end **674** to bow or barrel outward into engagement with the longitudinal wall surface **612**. By axially receding the shoulder surface **615** inward from the outer portion **616** that engages the tube end **674**, a gap G between an inner portion **676** of the tube end **674** and the shoulder **615** allows an inward pivoting force illustrated by arrows B to at least partially counteract the bowing force A, thereby reducing radial expansion of the tube end **674** due to bowing or barreling. This reduced radial expansion of the tube end **674** may facilitate separation of the tube end **674** from the fitting component **600** during disassembly.

[0084] Many different types of axially receding shoulder surfaces may be provided in a fitting component, including, for example, frustoconical, concave, convex, or stepped surfaces, or combinations of different contours or geometries, extending from (either directly or radially spaced from) the annular longitudinal wall surface. In the illustrated embodiment, the axially receding shoulder surface **615** includes a frustoconical surface extending from a substantially flat outer portion **616** of the shoulder surface **615**, which extends to the longitudinal wall surface **612**. This flat outer portion may, for example, provide a tube end engaging surface against which the tube end **674** bottoms out before or during axial compression of the tube end.

[0085] This counter-bowing feature may be provided with many different types of fitting components, including any fitting component having a socket for receiving another fitting component, such as a tube end, that experiences axial compression while inserted in the socket, including, for example, a fitting installation tool that pre-assembles or swages a tube gripping member, such as a ferrule or ferrules, to a tube end prior to fitting assembly. One example of such a fitting instal-

lation tool to which these inventive aspects may be applied is a manually operated hydraulic swaging unit described in U.S. Pat. No. 6,463,778 (the "'778 patent"), entitled "Apparatus for Swaging Ferrules," the entire disclosure of which is incorporated herein by reference.

[0086] FIG. **14** illustrates an exemplary tightening or swaging die **700** for use with a swaging tool, such as, for example, the exemplary hydraulic swaging unit of the '778 patent. The swaging die **700** includes a socket **710** having an axially outer camming surface **711**, an annular longitudinal wall surface **712**, and an axially receding shoulder surface **715**, that extends axially and radially inward from an inner end of the longitudinal wall surface **712**. When a tube end **774** is axially compressed in the socket **710**, for example, due to axial advancement of the die **700**, a gap G between the axially receding shoulder surface **715** and an inner portion **776** of the tube end **774** allows an inward pivoting force on the axially compressed tube end **774** to at least partially counteract a bowing force, thereby reducing radial expansion of the tube end **774** due to bowing or barreling.

[0087] The gap G between the shoulder surface **715** and the inner portion **776** of the tube end **774** may be sized to limit inward pivoting of the tube end **774** during axial compression, and/or to provide additional axial support for the axially compressed tube end **774**, by allowing at least part of the inner portion **776** of the tube end **774** to engage the shoulder surface upon axial compression of the tube end **774**. For example, in one embodiment, the shoulder surface **715** includes a tapered portion **717** that extend from an outer portion **716** at an angle of approximately 75° with respect to an axial center line of the die **700**.

[0088] Additionally, the surfaces of the socket **710** may, but need not, be further configured to facilitate separation of the tube end from the tool or swaging die **700** using one or more of the other features described herein, such as, for example, a stepped or tapered annular longitudinal surface to reduce radial reaction forces and/or increase axial reaction forces between the tube end **774** and the die **700**. For example, in the illustrated swaging die **700**, the annular longitudinal wall surface **712** may be provided with an intermediate tapered portion **713**, to reduce radial reactions force and/or increase axial reaction forces between the tube end **774** and the die **700**. The angle of the tapered portion **713** may, but need not, be relatively slight or over a relatively short axial distance; for example, in one embodiment, for tubing having an outer diameter of approximately 1.1 inches (28 mm), an intermediate portion **713** is tapered at angle of approximately 0.67° over an axial length of approximately 0.088 inches (2.2 mm).

[0089] A counter-bowing feature may also be provided in a fitting body to reduce radial reaction forces between a tube end and the fitting body, thereby assisting in separation of the tube end from the fitting body during fitting disassembly. FIGS. **15** and **16** illustrate an exemplary fitting assembly **800** including a counter-bowing feature. The fitting assembly **800** includes a fitting body **814** having a socket **810** for receiving a tube end **874**. The socket includes an annular longitudinal wall surface **812** and an axially receding shoulder surface **815** that extends axially and radially inward from an axially inner end of the longitudinal wall surface **812**. The fitting **800** may further include a drive nut **844** and ferrules **880**, **882**, which may, but need not, be consistent with the nut **44** and ferrules **80**, **82** of the fitting **10** of FIG. **1**.

[0090] The fitting body **814** may be configured to receive the tube end **874** such that the tube end **874** engages or bottoms out against an outer portion of the shoulder **815** in the fitting's finger-tight condition, or prior to axial compression of the tube end **874**. In another embodiment, the tube end **874** may engage a tapered tube capture surface **852** in the fitting's finger tight condition, resulting in a space between the shoulder surface **815** and the end of the tube **874**, as illustrated in FIG. **15**. When the fitting **800** is pulled up, as illustrated in FIG. **16**, the tube end **874** is axially compressed into engagement with the shoulder surface **815**, at which point a gap G between the axially receding shoulder surface **815** and an inner portion **876** of the tube end **874** allows further axial compression of the tube end **874** to produce inward pivoting forces B, which at least partially counteract outward bowing forces A to reduce the radial reaction forces between the fitting body **814** and the tube end **874**, thereby assisting in separation of the tube end **874** from the fitting body **814** during fitting disassembly. As with the fitting installation tool die **700** of FIG. **14**, the gap G may be limited such that axial compression of the tube end **874** results in additional axial support of the inner portion **876** of the tube end **874**.

[0091] As with the tool die **700** described above, a socket **810** of a fitting body **814** may, but need not, be further configured to facilitate separation of the tube end **874** from the fitting body **814** using one or more of the other features described herein, such as, for example, a stepped, tapered, or recessed annular longitudinal surface to reduce radial reaction forces and/or increase axial reaction forces between the tube end **874** and the fitting body **814**, as shown, for example, in the exemplary embodiments of FIGS. **1-6**.

[0092] While various inventive aspects, concepts and features of the inventions may be described and illustrated herein as embodied in combination in the exemplary embodiments, these various aspects, concepts and features may be used in many alternative embodiments, either individually or in various combinations and sub-combinations thereof. Unless expressly excluded herein all such combinations and sub-combinations are intended to be within the scope of the present inventions. Still further, while various alternative embodiments as to the various aspects, concepts and features of the inventions—such as alternative materials, structures, configurations, methods, circuits, devices and components, software, hardware, control logic, alternatives as to form, fit and function, and so on—may be described herein, such descriptions are not intended to be a complete or exhaustive list of available alternative embodiments, whether presently known or later developed. Those skilled in the art may readily adopt one or more of the inventive aspects, concepts or features into additional embodiments and uses within the scope of the present inventions even if such embodiments are not expressly disclosed herein. Additionally, even though some features, concepts or aspects of the inventions may be described herein as being a preferred arrangement or method, such description is not intended to suggest that such feature is required or necessary unless expressly so stated. Still further, exemplary or representative values and ranges may be included to assist in understanding the present disclosure; however, such values and ranges are not to be construed in a limiting sense and are intended to be critical values or ranges only if so expressly stated. Moreover, while various aspects, features and concepts may be expressly identified herein as being inventive or forming part of an invention, such identification is not intended to be exclusive, but rather there may be inventive aspects, concepts and features that are fully described herein without being expressly identified as such or

as part of a specific invention, the inventions instead being set forth in the appended claims. Descriptions of exemplary methods or processes are not limited to inclusion of all steps as being required in all cases, nor is the order that the steps are presented to be construed as required or necessary unless expressly so stated.

1. A fitting body having a longitudinal axis, comprising:

a tube end socket comprising a tube capture surface that extends in an axial direction and a ferrule camming surface,

said tube capture surface comprising a first end bounded by a shoulder and a second end bounded by said ferrule camming surface, said ferrule camming surface being tapered radially outwardly in a direction away from said shoulder,

said tube capture surface being tapered radially outwardly in a direction away from said shoulder.

2. The fitting body of claim **1** wherein said tube capture surface tapers continuously from said shoulder to said ferrule camping surface.

3. The fitting body of claim **2** wherein said tube capture surface tapers at a first angle and said ferrule camping surface tapers at a second angle relative to the longitudinal axis, said first angle and said second angle being different from one another.

4. The fitting body of claim **3** wherein said first angle is about four degrees and said second angle is about 20 degrees.

5. The fitting body of claim **1** wherein said ferrule camming surface is frustoconical.

6. The fitting body of claim **5** wherein said tube capture surface is frustoconical.

7. The fitting body of claim **1** wherein said shoulder extends on a radial line with respect to the longitudinal axis.

8. The fitting body of claim **2** wherein said tube capture surface tapers at a single angle from said shoulder to said ferrule camping surface.

9. A fitting assembly, comprising:

a fitting body comprising a tube end socket,

a fitting nut that can be threadably joined with said fitting body,

a first ferrule and a second ferrule, said first and second ferrules that are disposed between said fitting body and said fitting nut when the fitting assembly is in a finger tight condition,

said tube end socket comprising a tube capture surface that extends in an axial direction and a ferrule camming surface,

a ferrule camming surface, said tube capture surface comprising a first end bounded by a shoulder and a second end bounded by said ferrule camming surface, said ferrule camming surface being tapered radially outwardly in a direction away from said shoulder,

said tube capture surface being tapered radially outwardly in a direction away from said shoulder.

10. The fitting assembly of claim **9** wherein said first ferrule engages said ferrule camming surface when the fitting assembly is pulled up.

11. The fitting assembly of claim **10** wherein said first ferrule comprises a rounded front end.

12. The fitting assembly of claim **9** wherein said tube capture surface tapers continuously from said shoulder to said ferrule camping surface.

13. The fitting assembly of claim **12** wherein said tube capture surface tapers at a first angle and said ferrule camping surface tapers at a second angle relative to the longitudinal axis, said first angle and said second angle being different from one another.

14. The fitting assembly of claim **13** wherein said first angle is about four degrees and said second angle is about 20 degrees.

15. The fitting assembly of claim **9** wherein said ferrule camming surface is frustoconical.

16. The fitting assembly of claim **15** wherein said tube capture surface is frustoconical.

17. The fitting assembly of claim **9** wherein said shoulder extends on a radial line with respect to the longitudinal axis.

18. The fitting assembly of claim **9** wherein said tube capture surface tapers at a single angle from said shoulder to said ferrule camping surface.

19. The fitting assembly of claim **9** in combination with a tube end inserted into said tube end socket with the fitting assembly in a finger tight condition, an end portion of said tube end conduit being in contact with said tube capture surface when the fitting assembly is in a finger tight condition prior to pull-up, wherein during fitting pull-up a portion of said tube end is radially displaced into contact with said tube capture surface.

20. The fitting assembly of claim **19** wherein said portion of said tube end is radially displaced into contact with said tube capture surface with an axial component of an elastic reaction force against said tube end for separating said fitting body from said tube end upon fitting disassembly.

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