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(54) SEALING DEVICE WITH RIDGES FOR CORRUGATED STAINLESS STEEL TUBING

ABDICHTVORRICHTUNG MIT RILLEN FÜR GEWELLTE ROHRLEITUNGEN AUS ROSTFREIEM STAHL

DISPOSITIF D'ÉTANCHÉITÉ À NERVURES POUR TUBAGE ONDULÉ EN ACIER INOXYDABLE

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Description

FIELD OF INVENTION

[0001] The present invention relates to gas and liquid piping systems, and more particularly to a device and method for forming a seal between a length of corrugated tubing and a fitting, the fitting incorporating a sealing device with ridges, and capable of controlling a sealing profile.

BACKGROUND OF THE INVENTION

[0002] Gas and liquid piping systems which utilize corrugated stainless steel tubing ("CSST") and fittings are known. Such piping systems can be designed for use in combination with elevated gas pressures of up to about 0.03 megapascals (MPa) or more, and provide advantages over traditional rigid black iron piping systems in terms of ease and speed of installation, elimination of onsite measuring, and reduction in the need for certain fittings such as elbows, tees, and couplings. Undesirably, some fittings conventionally used with CSST systems include fiber sealing gaskets which can deteriorate over time, or pre-flared tubing ends, which suffer from reliability problems.

[0003] A suitable self-aligning and self-flaring fitting assembly, which does not require the use of a sealing gasket, is disclosed in U.S. Patent No. 6,173,995 to Mau ("the '995 patent"). The '995 patent is owned by Titeflex Corporation, assignee of the present application, and discloses a self-flaring fitting assembly for use with semi-flexible, convoluted tubes or pipes, including CSST systems. The fitting assembly includes an externally-threaded adapter having a pipe receiving bore divided into a plurality of sections of different diameters, a nut threaded to a first end of the adapter, and a split bushing assembly with at least two internally spaced ribs for engaging circumferential grooves of the corrugated tubing, as shown in FIGS. 2-5 of the '995 patent. The fitting assembly disclosed in the '995 patent forms a seal by compressing an end corrugation or convolution between an internal stop shoulder of the adapter and one end of the split bushing assembly. As shown in FIGS. 3 and 4 of the '995 patent, the sealing surfaces used to form the metal-to-metal seal are substantially flat. A seal formed according to the above mechanism may be suitable for preventing leaking of gas and/or liquid through the pipe and fitting connection. However, in some instances, excessive torque may be required to create a seal on larger, stiffer tubing that may have some minor defects such as dents or weld imperfections.

[0004] It would be desirable to provide an improved sealing arrangement to ensure an adequate seal between tubing and a fitting. Such a sealing arrangement preferably could be used in conjunction with other fitting arrangements and other piping and tubing systems, particularly those designed for transporting gas and/or liquid.

[0005] In some fittings designed for use with CSST systems, an end corrugation of the tubing is compressed to form a metal-to-metal seal. Examples of such sealing arrangements include U.S. Patent 6,428,052 to Albino et al., U.S. Patent No. 6,877,781 to Edler, and U.S. Patent No. 6,908,114 to Moner. However, according to the fittings disclosed in these patents, sealing is accomplished by compressing the end corrugation against generally flat sealing surfaces.

[0006] From US 4,805,942 A a field attachable and reusable hose end fitting for a convoluted hose is known. The fitting includes a collar having threads thereon threadable to a convoluted hose end. The same collar has a smooth bore portion encircling the terminal end of the corrugated hose when the collar is threaded thereon. When the nipple of the fitting is inserted into the hose end and the socket of the fitting is threaded to the nipple, the corrugations of the hose are crushed between the inner smooth bore of the collar and the outer surface of the nipple forming a fluid tight seal. Other sealing devices are known from US 2005/285401 A1 (particularly relevant) or US 6,173,995 B1.

[0007] It would be desirable to provide an improved fitting configured for connection to a length of corrugated tubing, where the fitting incorporates a sealing device with an improved sealing geometry. The fitting and related sealing devices and methods should overcome the deficiencies of the presently available fittings and sealing arrangements, which form a seal using generally flat surfaces. Also, it would be desirable to provide a sealing device and method in which an outer diameter of one or more collapsed corrugations is controlled, such that a desirable sealing profile can be obtained.

SUMMARY OF THE INVENTION

[0008] A sealing arrangement as defined in claim 1 and a method as defined in claim 16 are provided. The dependent claims define further embodiments.

[0009] A fitting incorporating a sealing device having a plurality of ridges is provided for connecting the fitting to a length of tubing, such as corrugated stainless steel tubing (CSST), commonly used in gas and liquid piping systems. The present invention also encompasses a method for sealing the fitting to a length of tubing using the ridges. The sealing device and method of the present invention further can be used to connect two fittings.

[0010] According to the present invention, sealing ridges are formed on at least one surface of the fitting, where the ridge surfaces may replace a generally flat surface in conventional fittings. The sealing ridges preferably include annular ridges with variations in shapes, spacing, and sealing face geometry, and can be manufactured of different materials.

[0011] In various embodiments as described herein, the fitting incorporating the sealing device of the present invention can form a metal-to-metal seal with a length of tubing, where the seal preferably is formed by collapsing

or compressing at least one corrugation of the length of tubing. For example, the end corrugation of the tubing can be sealed to the fitting, thereby forming a metal-to-metal seal. As used herein, the term "end corrugation" encompasses one or more corrugations of the tubing, and may include about 1 to 3 of the endmost corrugations, such that one or more corrugations preferably are collapsed and sealed by the sealing device.

[0012] The metal-to-metal seal preferably is formed without the use of gaskets or elastomers sometimes used in conventional fittings, where the presence of gaskets or elastomers, which may be prone to deterioration, can negatively impact long-term durability by making the seal less robust and unpredictable due to polymer chain degradation and polymer material leeching (hardening and cross-sectional shrinkage). Moreover, use of a plurality of ridges forming a ridge-like geometry in the metal-to-metal seal according to the present invention can provide significant advantages over conventional sealing techniques, which utilize generally flat or smooth sealing surfaces. For example, the sealing ridges tend to form a more robust seal by presenting a feature, i.e., the ridge, which creates concentrated annular stress and/or deformation ring(s) with at least some overall tolerance for misalignment or component manufacturing variances, thereby avoiding durability and reliability problems that plague conventional fittings.

[0013] According to the present invention, the ridges used to form the metal-to-metal seal are spaced apart in a manner to maximize sealing pressure, and produce stress concentrations and/or localized deformations, in order to create at least one of: a seal at lower torques, a seal on stiffer tubing, or a seal on tubing that may have at least one minor defect such as a dent or weld. The sealing device is particularly useful for sealing an end corrugation of tubing in a fitting used in gas and liquid piping systems.

[0014] A seal can be formed by collapsing an end corrugation between first and second sealing surfaces of a fitting. At least one of the sealing surfaces preferably is formed with a plurality of ridges, including at least one end ridge and one or more internal ridges. The size, shape, geometry, and spacing between the ridges is determined to maximize sealing pressure, and can result in localized stress concentrations. Suitable ridge shapes include U-shaped, V-shaped, and various other configurations such as flat shapes, arcs, and curves. The ridges can be made of various materials such as stainless steel, brass, and plastics.

[0015] According to a first preferred embodiment of the present invention, at least one corrugation of tubing is sealed between first and second sealing surfaces, where at least one of the sealing surfaces preferably is formed with ridges. More specifically, sealing is effected between a stop shoulder of an adapter or main body, where the stop shoulder defines the first sealing surface, and the second surface constitutes at least a portion of a bushing.

[0016] According to second and third preferred embodiments of the present invention, a collapsed outer diameter of the at least one corrugation of tubing is controlled to produce a substantially circular profile or shape. In the second embodiment, an inner diameter of the main body is sized to maintain a generally circular shape of the collapsed end corrugation, where the end corrugation can contact an inner wall of the main body during sealing. In the third embodiment, an inner diameter of the bushing is sized to maintain a generally circular shape of the collapsed end corrugation, where the end corrugation can contact an inner wall of the bushing during sealing. In the second and third embodiments, the inner wall of the main body or bushing, respectively, restricts outward movement of the end corrugation, such that an inner diameter of the main body or bushing and the end corrugation essentially form an interference fit. As a result, the collapsed end corrugation has a generally circular shape, and remains substantially concentric with the remainder of the length of tubing.

[0017] Control of the outer diameter of the one or more collapsed corrugations is achieved by allowing the tubing to contact an inner wall of the main body of the fitting and/or the bushing, as provided in the second and third embodiments. By forming the one or more collapsed corrugations with a circular profile or shape, suitable sealing contact is made between the first and second sealing surfaces and the collapsed corrugations, thus providing a reliable seal.

[0018] Other aspects and embodiments of the invention are discussed below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For a fuller understanding of the nature and desired objects of the present invention, reference is made to the following detailed description taken in conjunction with the accompanying drawing figures wherein like reference characters denote corresponding parts throughout the several views and wherein:

FIG. 1 is a cross-sectional side view of a length of corrugated tubing received in a fitting, which incorporates a sealing arrangement according to a first exemplary embodiment of the present invention;

FIG. 2 is a cross-sectional view through the tubing and fitting depicted in FIG. 1.

FIG. 3 is an enlarged cross-sectional view of the tubing and fitting of FIG. 2;

FIG. 4 is a further enlarged cross-sectional view based on FIG. 3, showing the sealing ridges in greater detail;

FIG. 5 is an isolated cross-sectional side view of the fitting incorporating a sealing device according to the present invention;

FIG. 6 is an enlarged cross-sectional side view showing the sealing device of FIG. 5 in greater detail;

FIG. 7 is a perspective view of a fitting incorporating a sealing device according to the present invention;

FIG. 8 is an enlarged perspective view of the sealing device shown in FIG. 7;
FIG. 9 is a schematic view depicting a first example of sealing ridges according to the present invention;
FIG. 10 is a schematic view depicting a second example of sealing ridges according to the present invention;
FIG. 11 is a schematic view of a sealing ridge having a flat face useful in the present invention;
FIG. 12 is a schematic view of a sealing ridge having a curved face useful in the present invention;
FIGS. 13A-13B are cross-sectional views of a fitting incorporating a sealing device according to a second exemplary embodiment of the present invention;
FIG. 14 is a perspective view of a length of tubing capable of being sealed by the fitting depicted in FIGS. 13A-13B and/or other embodiments; and
FIGS. 15A-15B are cross-sectional views of a fitting incorporating a sealing device according to a third exemplary embodiment of the present invention.

DEFINITIONS

[0020] The instant invention is most clearly understood with reference to the following definitions:

As used in the specification and claims, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise.

[0021] As used herein, the terms "corrugated stainless steel tubing" and "CSST" refer to any type of semi-flexible tubing or piping, which may accommodate corrosive or aggressive gases or liquids, and includes but is not limited to semi-flexible tubing or piping made from: thermoplastics, metal or metal alloy materials such as olefin-based plastics (e.g., polyethylene (PE)), fluorocarbon polymers (e.g., polytetrafluoroethylene (PTFE)), carbon steel, copper, brass, aluminum, titanium, nickel, and alloys thereof.

DETAILED DESCRIPTION OF THE INVENTION

[0022] A fitting according to the present invention incorporates a sealing arrangement having a ridge geometry, preferably a plurality of sealing ridges provided on at least one sealing surface. The fitting can be connected to a length of tubing, such as corrugated stainless steel tubing (CSST), commonly used in gas and liquid piping systems. Alternatively, the fitting can be connected to another fitting using the ridge geometry.

[0023] In various embodiments as described herein, the fitting incorporating the sealing arrangement of the present invention forms a metal-to-metal seal with a length of tubing, where the seal preferably is formed by collapsing or compressing at least one corrugation of the length of tubing. For example, the end corrugation of the tubing can be sealed to the fitting, thereby forming a metal-to-metal seal. Use of a ridge-based geometry in the metal-to-metal seal according to the present invention can improve reliability and durability as compared to conventional sealing techniques, which utilize generally flat or smooth sealing surfaces. Moreover, a sealing arrangement having the ridge geometry can reduce the contact area in a seal, which can produce higher sealing pressures using the same applied force.

[0024] Referring to FIGS. 1-4, a first exemplary embodiment of a sealing arrangement according to the present invention is shown, whereby the sealing arrangement is incorporated into a fitting connected to a length of tubing, such as corrugated stainless steel tubing (CSST), for example, as used in gas and liquid piping systems.

[0025] As shown in FIG. 1, a fitting 20 can be connected to a length of tubing 10, where the tubing 10 optionally is jacketed, that is, covered by a smooth jacket 14 made of polyethylene or like material. Alternatively, the tubing 10 can be provided without a jacket. At least a portion of the jacket 14 may be removed prior to forming the seal connecting the tubing 10 with the fitting 20. As shown in FIG. 1, the tubing 10 includes a plurality of convolutions or corrugations 12.

[0026] Referring to FIGS. 2 and 3, the fitting 20 is connected to the tubing 10, and a seal is formed by collapsing an end corrugation of the tubing 10. The basic components of the fitting 20 are substantially the same as those described in U.S. Patent No. 6,173,995 to Mau, which is incorporated by reference herein. For example, the fitting 20 preferably includes a main body or adapter 22 having a bore for receiving the tubing 10, where the adapter 22 can include sections having different diameters. The fitting 20 also includes a nut 24 having a bore and a stop shoulder. Further, a split bushing 26 is received in the adapter 22, where the split bushing 26 can have a bore with a pair of semicircular bushing halves, and at least two spaced apart internal ribs 28a and 28b for engaging circumferential grooves in the tubing 10. At least the adapter 22 and the split bushing 26 are formed with sealing surfaces, and can be referred to as first and second components, respectively, of the fitting. Details of the interconnection of the various components to form a seal by collapsing an end corrugation of the tubing 10 is provided in U.S. Patent No. 6,173,995. Therefore, the manner in which a seal is formed will not be further described herein.

[0027] As shown in FIG. 4, when sealing is effected using the above-described components, in the manner provided in U.S. Patent No. 6,173,995, a stop shoulder 32 of the adapter 22 defines a first sealing surface, which preferably includes a plurality of sealing ridges, to be discussed in further detail below. A first end 30 of the internal rib 28a serves as a second sealing surface, where the second sealing surface can be generally flat. Although the sealing of an end corrugation is described with reference 1 to a stop shoulder and a first end of the internal rib, other types of sealing surfaces can be used, including

components that are different from those described or shown in FIGS. 1-4. The present invention encompasses any sealing mechanism, for example, for connecting tubing with a fitting, or for connecting two fittings, which utilize sealing ridges on at least one of the sealing surfaces.

[0028] Referring to FIG. 4, sealing ridges preferably are provided on either the first end 30 of the internal rib 28a or the stop shoulder 32, or can be provided on both the first end 30 and the stop shoulder 32, for example, in an accordion arrangement. For illustration purposes, the sealing ridges as described herein are provided on the stop shoulder 32. Through a mechanism described in greater detail in the '995 patent, an end corrugation 13 of the tubing 10 is compressed or collapsed between the first and second sealing surfaces to form a seal.

[0029] Referring to FIGS. 5-8, the adapter 22 of the fitting is shown in isolation, in order to illustrate details of the first sealing surface. The first sealing surface defined by the stop shoulder 32 of the adapter preferably includes at least one end ridge 40 spaced apart from a plurality of internal ridges 42. As shown e.g. in Fig. 6, internal ridges 42 comprise a first internal ridge 42 and a second internal ridge 42. The at least one end ridge 40 can include one or more ridges formed near or adjacent to an end of the stop shoulder 32, as shown in FIG. 6. To form an optimal seal, the internal ridges 42 are spaced apart by a predetermined distance from the end ridge 40, where the optimal spacing can be determined based on localized stresses in the sealing interface. In general, it is desirable to use a plurality of ridges instead of a flat sealing face in order to minimize contact area with the end corrugation, thereby increasing local contact force and resulting sealing pressure and producing areas of concentrated stresses.

[0030] For example, FIGS. 9 and 10 schematically depict stress concentrations produced by different sealing devices, including a first example of a sealing arrangement with two internal ridges 42 (see FIG. 9), and a second example of a sealing arrangement with three internal ridges 42. The use of one or more internal ridges 42 is determined based on the desired sealing pressure and anticipated stress load concentrations. Generally; a greater number of internal ridges should be used for sealing tubing with larger circumferences, for example, larger sizes of corrugated tubing. Likewise, a lesser number of internal ridges should be used for sealing circumferentially smaller sizes of tubing.

[0031] The stop shoulder 32 used as the ridge sealing surface according to the present invention is depicted in FIGS. 7 and 8. Preferably the stop shoulder 32 extends circumferentially around the adapter 22, and the ridges 40 and 42 provided in the stop shoulder 32 can extend up to 360° around the stop shoulder 32, preferably around the entire circumference of the stop shoulder.

[0032] The ridges 40 and 42 can be provided in various shapes and sizes, and with different types of faces. As shown in FIG. 11, according to one example of a ridge, the ridge 50 is V-shaped and has a generally flat face 52. In FIG. 12, according to another example, a ridge 60 is U-shaped and has a curved face 62. Various shapes can be selected depending on particular applications, such as V-shaped peaks and valleys, U-shaped peaks and valleys, mixed U and V-shaped peaks and valleys, curved peaks and valleys, and non-uniform or different peak and valley shapes, such as flat shapes, arcs, and curves. The sealing face geometry can be chosen based on a particular application, and can include a conical shape, a flat face, or a curved face.

[0033] The spacing between ridges 40 and 42 can be determined in a manner to optimize localized stress concentrations, and to achieve a design that forms an optimal seal when collapsing at least one corrugation. For example, the ridges 42, e.g. first internal ridge 42 and second internal ridge 42, can be uniformly spaced, as shown in FIG. 10, width a greater distance from the end ridge 40 to the first of the internal ridges 42, where such a configuration can apply a desired concentrated sealing pressure on a particular area of the folded end corrugation to better prevent unfolding and premature failure of the collapsed corrugation. In this way, at least one of the ridges 40 and 42 can serve as the primary sealing ridge. Alternatively, the ridges can be spaced apart in a different manner to concentrate primary sealing in another of the ridges 40 and 42.

[0034] The ridges can be made of the material used for the adapter 22, such as stainless steel, or can be made of other materials such as brass and various plastics. Sealing preferably is accomplished so as to prevent loss of gas and/or liquid from the tubing. The sealing device of the present invention can be used to connect tubing with a fitting, to connect two fittings, or to connect other types of components.

[0035] Referring again to FIGS. 9 and 10, peak stress concentrations are denoted by lines appearing closer together. For example, as expected, compressive stress concentrations are greatest near the sealing faces of the ridges. The arrangement of the ridges can be varied, and an optimal spacing determined between each of the internal ridges 42, as well as an optimal spacing from the end ridge 40 to the first of the internal ridges 42. The term "end ridge" encompasses one or more ridges spaced apart from the internal ridges 42, and oriented to achieve an optimal sealing interface. As shown in FIGS. 9 and 10, deformation or localized yielding of the ridges can create annular sealing rings, which can provide a better sealing versus planar or conical interfaces.

[0036] As shown in FIGS. 11 and 12, the exemplary ridges 50 and 60 are marked with various dimensions. Such dimensions A, B, H, and W can be varied to suit a given application. Also, as described above, ridge spacing can be varied 1 to produce optimal sealing conditions. By varying the width W of the sealing face, a flat or a sharp peak can be obtained. Referring to FIG. 12, the size of radius R can be varied, or the radius may be eliminated to be non-radial in shape.

[0037] Second and third embodiments of a fitting in-

corporating a sealing arrangement are depicted in FIGS. 13A-13B and 15A-15B, respectively. FIG. 14 depicts a length of corrugated tubing, preferably stainless steel corrugated tubing with a ridge sealing region 111 identified by the dashed line in FIG. 14. The tubing shown in FIG. 14 has a generally circular ridge sealing region configured for use in the second or third embodiments described herein, or other embodiments of the present invention. Like elements appearing in the second and third embodiments of FIGS. 13A-13B and 15A-15B having similar structures and/or functions to elements of the first embodiment are preceded by a "1" or a "2" to denote the similar structures.

[0038] Referring to the second embodiment of FIGS. 13A-13B, a fitting 120 is connected to a length of tubing 110, where the tubing 110 optionally is jacketed, and a jacket 114 can be peeled back to expose at least one corrugation of the tubing, for example, at least an end corrugation 110a. The end corrugation 110a is also depicted in FIG. 14, where a dashed line denotes the ridge sealing region 111 of the tubing 110. In particular, upon sealing of the end corrugation 110a according to the second and/or third embodiments of the present invention, the end corrugation 110a will be collapsed or compressed along the ridge sealing region 111, thus producing a generally circular profile after collapse and/or compression of the end corrugation 110a.

[0039] Referring again to FIGS. 13A-13B, the components of the fitting 120 are generally the same as those depicted in the first embodiment of FIGS. 3 and the fitting 120 includes a main body (or adapter) 122 having a bore for receiving the tubing 11 on The fitting 120 also includes a nut 124 and a split bushing 126 received in the main body 122 of the fitting. As shown in FIG. 13A, the split bushing 126 includes at least two spaced apart internal ribs 128a and 128b for engaging circumferential grooves of the tubing 110. The internal ribs 128a and 128b can engage and align the tubing 110 and/or jacket 114 within the split bushing 126, thereby centering the tubing 110 within the fitting 120 such that at least one corrugation of the tubing 110 is received between sealing surfaces of the main body 122 and the split bushing. The internal ribs 128a and 128b also provide strain relief where the outer diameter of the corrugated tubing engages the split bushing 126. Further, the split bushing 126 can include one or more additional contact points 127 with the tubing 110 and/or jacket 114 for aligning the tubing 110 within the fitting 120 and relieving strain. In other words, the split bushing includes various contact points or regions for contacting at least one of the tubing and the jacket, which can provide alignment and strain relief functions.

[0040] At least the main body 122 and the split bushing 126 are formed with sealing surfaces, where the main body 122 has a stop shoulder 132 defining a first sealing surface. In FIGS. 13A-13B, the stop shoulder 132 is formed with a plurality of ridges; alternatively, the first sealing surface can be flat.

[0041] The structure and function of the above components of the fitting 120 are generally the same as those described with reference to the first embodiment. However, in the second embodiment of FIGS. 13A-13B, the main body 122 has an inner wall 122a sized to produce a generally circular shape or profile of the end corrugation 110a of the tubing when collapsed between the first and second sealing surfaces. In other words, an inner diameter of the main body 122 is sized to maintain a generally circular shape of the collapsed end corrugation 110a, where the end corrugation 110a can contact the inner wall 122a during sealing. By virtue of this contact between the end corrugation 110a and the inner wall 122a, the end corrugation 110a is properly aligned and centered over the tubing 110, thereby producing a generally circular sealing profile of the end corrugation 110a.

[0042] As shown in FIG. 13B, the inner wall 122a of the main body 122 restricts outward movement of the end corrugation 110a when the end corrugation 110a is received between the first and second sealing surfaces. In other words, the interface between the inner wall 122a and the end corrugation 110a restricts an outer diameter of the end corrugation 110a such that an inner diameter of the main body 122 (i.e., the inner wall 122a) and the end corrugation 110a essentially form an interference fit. As a result, the collapsed end corrugation has a generally circular shape, and remains substantially concentric with the remainder of the length of tubing.

[0043] Referring to FIGS. 15A-15B, the components of the fitting 210 include a main body (or adapter) 222 having a bore for receiving a length of tubing 210. The fitting 220 also includes a nut 224 and a split bushing 226 received in the main body 222 of the fitting. In the third embodiment of FIGS. 15A-15B, the fitting 220 is formed with internal ribs 228a and 228b that can engage and align the tubing 210 and/or jacket 214 within the split bushing 226, such that at least one end corrugation of the tubing 210 is received between sealing surfaces of the main body 222 and the split bushing 226. The internal ribs 228a and 228b also provide strain relief where the outer diameter of the corrugated tubing engages the split bushing 226. Further, the split bushing 226 includes one or more additional contact points 227 with the tubing 210 and/or jacket 214 for aligning the tubing within the fitting and relieving strain. In other words, the split bushing 226 includes various contact points or regions for contacting at least one of the tubing 210 and the jacket 214, which can provide alignment and strain relief functions.

[0044] At least the main body 222 and the split bushing 226 are formed with sealing surfaces, where the main body 222 has a stop shoulder 232 defining a first sealing surface (see FIG. 15B). In the third embodiment, the stop shoulder 232 is formed with a plurality of ridges; alternatively, the first sealing surface can be flat.

[0045] The structure and function of the above components of the fitting 220 are generally the same as those described with reference to the first embodiment. However, in the third embodiment of FIGS. 15A-15B, the bushing 226 has an inner wall 226a sized to produce a

generally circular shape or profile of the end corrugation 210a of the tubing when collapsed between the first and second sealing surfaces. In other words, an inner diameter of the bushing 226 is sized to maintain a generally circular shape of the collapsed end corrugation 210a, where the end corrugation 210a can contact the inner wall 226a during sealing. By virtue of this contact between the end corrugation 210a and the inner wall 226a, the end corrugation 210a is properly aligned and centered over the tubing 210, thereby producing a generally circular sealing profile of the end corrugation 210a. The inner wall 226a also can serve as a sealing surface, such that the end corrugation 210a of the tubing is sealed against the inner wall 226a at a taper of about 0 to 10 degrees, preferably about 5 degrees.

[0046] As shown in FIG. 15B, the inner wall 226a of the bushing 226 restricts outward movement of the end corrugation 210a when the end corrugation 210a is received between the first and second sealing surfaces. In other words, the interface between the inner wall 226a and the end corrugation 210a restricts an outer diameter of the end corrugation 210a such that an inner diameter of the bushing 226 (i.e., the inner wall 226a) and the end corrugation 210a essentially form an interference fit. As a result, the collapsed end corrugation has a generally circular shape, and remains substantially concentric with the remainder of the length of tubing.

[0047] According to the second and third embodiments described in FIGS. 13A-13B and 15A-15B, respectively, a collapsed diameter of the end corrugation 110a or 210a can be controlled to produce a substantially circular profile or shape, as compared to an oval shape which may result from the collapsing and sealing of the end corrugation 10a in the first embodiment of FIGS. 3-4. Although an oval shape of the collapsed end corrugation produces a suitable sealing profile in certain applications, in other applications, it is desirable to produce a sealing profile that approximates the shape of the remaining corrugated tubing. Such a circular profile or shape also ensures that suitable contact is made between the first and second sealing surfaces and the at least one collapsed corrugation. Further, where the first and/or second sealing surfaces are provided with ridges, a circular profile can ensure adequate contact between the ridged surfaces and the collapsed tubing. In other words, by controlling an outer diameter of the collapsed tubing, the tubing can be properly aligned over the ridges (concentric), thereby producing a more reliable seal. Control of the outer diameter of the one or more collapsed corrugations is achieved by allowing the tubing to contact an inner wall of the main body of the fitting and/or the bushing, as provided in the second and third embodiments.

[0048] According to the present invention, the term "end corrugation" encompasses one or more corrugations of the tubing, for example, approximately 1-3 endmost corrugations, such that one or more corrugations can be collapsed and sealed by the sealing device.

[0049] The ridged sealing surface described herein can be formed in various profiles, as previously described. For example, a shaped cross-section may be used, where the ridges may have one or more of the following shapes: conical, toroidal, elliptical, parabolic, and spline. Also, an interface between the bushing and the main body may be straight or tapered, where a taper can be varied to suit a specific application. A suitable tapered bushing may have a conical shape, a barrel shape, or another shaped configuration.

[0050] The sealing arrangement has been described with reference to different embodiments and examples of sealing ridges, in which the number and/or type of ridges is varied. It is within the scope of the present invention to provide a sealing device including ridges having characteristics of more than one of the disclosed embodiments.

[0051] As a further alternative, in the second and third embodiments, it is possible to form the first and second sealing surfaces without ridges. In such embodiments, sealing can be adequately controlled by controlling the outer diameter of the one or more collapsed corrugations, thus producing a generally circular sealing profile.

[0052] A method for sealing a length of tubing to a fitting according to the present invention can include steps of: providing the length of corrugated tubing; providing a main body having a first sealing surface; providing a bushing received in the main body, the bushing having a second sealing surface configured to engage the first sealing surface with at least one corrugation of the tubing received between the first and second sealing surfaces; forming a plurality of ridges on at least one of the first and second sealing surfaces; and collapsing the at least one corrugation between the first and second sealing surfaces such that the ridges contact the at least one corrugation to form a seal, wherein at least one of the bushing and the main body is sized to maintain a generally circular shape of the at least one corrugation.

[0053] The present invention also encompasses methods for transporting gas and liquid through piping or tubing, in which at least a length of tubing is sealed to a fitting as provided above. The methods can include transporting the gas and liquid to a device, such as a boiler, furnace, or stove.

[0054] The present invention further encompasses a method for installing a piping or tubing system in a structure, such as a commercial or residential building, where the installation method includes installing at least a length of tubing that is sealed 1 to a fitting in the manner provided above. For example, the piping or tubing system can utilize CSST tubing and fittings.

Claims

1. A sealing arrangement for connecting a length of corrugated tubing (10; 110; 210) to a fitting (20; 120; 220), comprising:

the length of corrugated tubing (10; 110; 210);
the fitting (20; 120; 220) including a main body (22; 122; 222) having a first sealing surface (32; 132; 232);
a bushing (26; 126; 226) received in the main body (22; 122; 222), the bushing (26; 126; 226) having a second sealing surface (30) for engaging the first sealing surface with at least one corrugation (13; 110a; 210a) of the tubing (10) received between the first (32; 132; 232) and second (30) sealing surfaces; and
a plurality of ridges (40, 42; 50; 60) formed on at least one of the first (32; 132; 232) and second (30) sealing surfaces, such that the ridges (40, 42) are configured to contact the at least one corrugation (13; 110a; 210a) to form a seal, the plurality of ridges including at least one radially innermost end ridge (40) and at least first and second internal ridges (42) counted radially outwardly from said end ridge, said at least first and second internal ridges (42) being spaced apart from the adjacent end ridge (40),
characterized in that a distance between the adjacent end ridge (40) and the first internal ridge is greater than a distance between the first internal ridge and the second internal ridge to provide concentrated sealing pressure.

2. The sealing arrangement of claim 1, wherein the at least one corrugation (13; 110a; 210a) has a substantially circular profile after being collapsed and sealed between the first (32; 132; 232) and second (30) sealing surfaces.

3. The sealing arrangement of claim 1, wherein the first sealing surface is formed on a stop surface (32; 132; 232) of the main body (22; 122; 222).

4. The sealing arrangement of claim 1, wherein the second sealing surface is formed on an end of the bushing.

5. The sealing arrangement of claim 1, wherein the inner diameter of the main body (22; 122; 222) forms an interference fit with the at least one corrugation (13; 110a; 210a).

6. The sealing arrangement of claim 1, wherein the inner diameter of the bushing (26; 126; 226) forms an interference fit with the at least one corrugation (13; 110a; 210a).

7. The sealing arrangement of claim 1, wherein the inner diameter (122a) of the main body (22; 122; 222) serves as an additional sealing surface.

8. The sealing arrangement of claim 1, wherein the bushing (26; 126; 226) includes at least one internal rib (28a, 28b; 128a, 128b; 228a, 228b) for aligning the tubing (10; 110; 210) in the bushing (26; 126; 226).

9. The sealing arrangement of claim 8, wherein the at least one internal rib (28a, 28b; 128a, 128b; 228a, 228b) provides strain relief between the tubing (10; 110; 210) and the bushing (26; 126; 226).

10. The sealing arrangement of claim 1, wherein the plurality of internal ridges (50; 60) are U-shaped or V-shaped.

11. The sealing arrangement of claim 1, wherein the plurality of internal ridges (50; 60) have a flat sealing face (52).

12. The sealing arrangement of claim 1, wherein the plurality of ridges (40, 42) are annular raised ridges.

13. The sealing arrangement of claim 1, wherein the at least one corrugation (13; 110a; 210a) is an end corrugation of the tubing (10; 110; 210).

14. The sealing arrangement of claim 1, wherein the at least one corrugation (13; 110a; 210a) is generally concentric with the tubing (10; 110; 210) after being collapsed and sealed.

15. The sealing arrangement of claim 1, wherein at least one of the inner diameter of the bushing (26; 126; 226) and the inner diameter of the main body (22; 122; 222) is sized and configured to contact an outermost diameter of the at least one corrugation to maintain a generally circular shape of the at least one corrugation (13; 110a; 210a) as the seal is being formed.

16. A method for sealing a length of corrugated tubing (10; 110; 210) to a fitting (20; 120; 220), comprising the steps of:

providing the length of corrugated tubing (10; 110; 210);
providing a main body (22; 122; 222) having a first sealing surface (32; 132; 232);
providing a bushing (26; 126; 226) received in the main body (22; 122; 222), the bushing (26; 126; 226) having a second sealing surface (30) configured to engage the first sealing surface (32; 132; 232) with at least one corrugation (13; 110a; 210a) of the tubing (10; 110; 210) received between the first (32; 132; 232) and second (30) sealing surfaces;
wherein a plurality of ridges (40, 42; 50; 60) is formed on at least one of the first (32; 132; 232) and second (30) sealing surfaces, the plurality of ridges including a radially innermost end ridge

and at least first and second internal ridges counted radially outwardly from said end ridge, said at least first and second internal ridges being spaced apart from the adjacent end ridge; and

collapsing the at least one corrugation (13; 110a; 210a) between the first (32; 132; 232) and second (30) sealing surfaces such that the ridges (40, 42; 50; 60) contact the at least one corrugation (13; 110a; 210a) to form a seal,

characterized in that a distance between the adjacent end ridge and the first internal ridge is greater than a distance between the first internal ridge and the second internal ridge to provide concentrated sealing pressure.

17. The method of claim 16, wherein an inner diameter (226a) of the bushing serves as an additional sealing surface.

18. The method of claim 16, wherein at least one of the bushing (26; 126; 226) and the main body (22; 122; 222) is sized to maintain a generally circular shape of the at least one corrugation (13; 110a; 210a).

19. The method of claim 16, further comprising the step of:

engaging the tubing with at least one internal rib of the bushing.

20. The method of claim 16, wherein the inner diameter of the main body is configured to contact an outer diameter of the at least one corrugation.

21. The method of claim 16, wherein the plurality of ridges are arranged in order radially outward.

Patentansprüche

1. Dichtanordnung zum Verbinden einer Länge gewellten Rohrs (10; 110; 210) mit einem Anschlussstück (20; 120; 220), umfassend:

die Länge gewellten Rohrs (10; 110; 210);

das Anschlussstück (20; 120; 220) mit einem Hauptkörper (222; 122; 222), welcher eine erste Dichtoberfläche (32; 132; 232) aufweist,

eine in dem Hauptkörper (22; 122; 222) aufgenommene Buchse (26; 126; 226), wobei die Buchse (26; 126; 226) eine zweite Dichtoberfläche (30) zum in Eingriff gelangen mit der ersten Dichtoberfläche mit mindestens einer Wellung (13; 110A; 210A) des Rohrs (10), welche zwischen der ersten (32; 132; 232) und der zweiten (30) Dichtoberfläche aufgenommen ist, aufweist, und

eine Vielzahl von Rippen (40, 42; 50; 60), welche auf mindestens einer der ersten (32; 132; 232) und der zweiten (30) Dichtoberfläche ausgebildet sind, sodass die Rippen (40, 42) eingerichtet sind, die mindestens eine Wellung (13; 110A; 210A) zu kontaktieren, um eine Abdichtung zu bilden, wobei die Vielzahl von Rippen zumindest eine radial zuinnerst liegende Endrippe (40) und zumindest eine erste und eine zweite interne Rippe (42), gezählt von der Endrippe radial nach außen, einschließt, wobei die zumindest erste und zweite interne Rippe (42) von der benachbarten Endrippe (40) beabstandet sind,

dadurch gekennzeichnet, dass ein Abstand zwischen der benachbarten Endrippe (40) und der ersten internen Rippe größer ist als ein Abstand zwischen der ersten internen Rippe und der zweiten internen Rippe, um einen konzentrierten Dichtdruck bereitzustellen.

2. Dichtanordnung nach Anspruch 1, wobei die mindestens eine Wellung (13; 110A; 210A) ein im Wesentlichen kreisförmiges Profil aufweist, nachdem sie zwischen der ersten (32; 132; 232) und zweiten (30) Dichtoberfläche zusammengeschoben und gedichtet wurde.

3. Dichtanordnung nach Anspruch 1, wobei die erste Dichtoberfläche auf einer Anschlagoberfläche (32; 132; 232) des Hauptkörpers (22; 122; 222) ausgebildet ist.

4. Dichtanordnung nach Anspruch 1, wobei die zweite Dichtoberfläche auf einem Ende der Buchse ausgebildet ist.

5. Dichtoberfläche nach Anspruch 1, wobei der Innendurchmesser des Hauptkörpers (22; 122; 222) eine Presspassung mit der mindestens einen Wellung (13; 110A; 210A) bildet.

6. Dichtanordnung nach Anspruch 1, wobei der Innendurchmesser der Buchse (26; 126; 226) eine Presspassung mit der mindestens einen Wellung (13; 110A; 210A) bildet.

7. Dichtanordnung nach Anspruch 1, wobei der Innendurchmesser (122A) des Hauptkörpers (22; 122; 222) als eine zusätzliche Dichtoberfläche dient.

8. Dichtanordnung nach Anspruch 1, wobei die Buchse (26; 126; 226) mindestens eine interne Rippe (28A, 28B; 128A, 128B; 228A, 228B) zum Ausrichten des Rohrs (10; 110; 210) in der Buchse (26; 126; 226) umfasst.

9. Dichtanordnung nach Anspruch 8, wobei die mindestens eine interne Rippe (28A, 28B; 128A, 128B;

228A, 228B) eine Zugentlastung zwischen dem Rohr (10; 110; 210) und der Buchse (26; 126; 226) bereitstellt.

10. Dichtanordnung nach Anspruch 1, wobei die Vielzahl interner Rippen (50; 60) U-förmig oder V-förmig sind.

11. Dichtanordnung nach Anspruch 1, wobei die Vielzahl interner Rippen (50; 60) eine flache Dichtfläche (52) aufweisen.

12. Dichtanordnung nach Anspruch 1, wobei die Vielzahl von Rippen (40,42) ringförmig erhobene Rippen sind.

13. Dichtanordnung nach Anspruch 1, wobei die mindestens eine Wellung (13; 110A; 210A) eine Endwellung des Rohrs (10; 110; 210) ist.

14. Dichtanordnung nach Anspruch 1, wobei die mindestens eine Wellung (13; 110A; 210A) nach dem Zusammendrücken und Dichten im Wesentlichen konzentrisch mit dem Rohr (10; 110; 210) ist.

15. Dichtanordnung nach Anspruch 1, wobei mindestens einer des Innendurchmesser der Buchse (26; 126; 226) und des Innendurchmesser des Hauptkörpers (22; 122; 222) eine derartige Größe aufweist und derart eingerichtet ist, dass er einen äußersten Durchmesser der mindestens einen Wellung kontaktiert, um eine allgemein kreisförmige Form der mindestens einen Wellung (13; 110A; 210A) beizubehalten, während die Dichtung ausgebildet wird.

16. Verfahren zum dichten einer Länge gewellten Rohrs (10; 110; 210) an ein Anschlussstück (20; 120; 220), umfassend folgende Schritte:

Bereitstellen der Länge gewellten Rohrs (10; 110; 210),
Bereitstellen eines Hauptkörpers (22; 122; 222) mit einer ersten Dichtoberfläche (33; 132; 232),
Bereitstellen einer Buchse (26; 126; 226), welche in dem Hauptkörper (22; 122; 222) aufgenommen ist, wobei die Buchse (26; 126; 226) eine zweite Dichtoberfläche (30) aufweist, die eingerichtet ist, mit der ersten Dichtoberfläche (32; 132; 232) mit mindestens einer Wellung (13; 110A; 210A) des Rohrs (10; 110; 210), welche zwischen der ersten (32; 132; 232) und der zweiten (30) Dichtoberfläche aufgenommen ist, in Eingriff zu gelangen,
wobei auf zumindest einer der ersten (32; 132; 232) und der zweiten (30) Dichtoberfläche eine Vielzahl von Rippen (40, 42; 50; 60) ausgebildet ist, wobei die Vielzahl von Rippen eine radial zuinnerst liegende Endrippe und zumindest eine erste und eine zweite interne Rippe, gezählt von der Endrippe radial nach außen, umfasst, wobei die zumindest erste und zweite interne Rippe von der benachbarten Endrippe beabstandet sind, und
Zusammenschieben der mindestens einen Wellung (13; 110A; 210A) zwischen der ersten (32; 132; 232) und der zweiten (30) Dichtoberfläche, sodass die Rippen (40, 42; 50; 60) die mindestens eine Wellung (13; 110A; 210A) kontaktieren, um eine Dichtung zu bilden,
dadurch gekennzeichnet, dass ein Abstand zwischen der benachbarten Endrippe und der ersten internen Rippe größer ist als ein Abstand zwischen der ersten internen Rippe und der zweiten internen Rippe, um einen konzentrierten Dichtdruck bereitzustellen.

17. Verfahren nach Anspruch 16, wobei ein Innendurchmesser (226A) der Buchse als eine zusätzliche Dichtoberfläche dient.

18. Verfahren nach Anspruch 16, wobei zumindest eine der Buchse (26; 126; 226) und des Hauptkörpers (22; 122; 222) eine Größe aufweist, um eine allgemein kreisförmige Form der mindestens einen Wellung (13; 110A; 210A) beizubehalten.

19. Verfahren nach Anspruch 16, weiter umfassend folgenden Schritt:

In-Eingriff-Bringen des Rohrs mit mindestens einer internen Rippe der Buchse.

20. Verfahren nach Anspruch 16, wobei der Innendurchmesser des Hauptkörpers eingerichtet ist, einen Außendurchmesser der mindestens einen Wellung zu kontaktieren.

21. Verfahren nach Anspruch 16, wobei die Vielzahl von Rippen in einer Reihenfolge radial nach außen angeordnet sind.

Revendications

1. Agencement d'étanchéité pour raccorder une longueur de tubage ondulé (10 ; 110 ; 210) à un raccord (20 ; 120 ; 220), comprenant :

une longueur de tubage ondulé (10 ; 110 ; 210) ; le raccord (20 ; 120 ; 220) comprenant un corps principal (22 ; 122 ; 222) ayant une première surface d'étanchéité (32 ; 132 ; 232) ;
une bague (26 ; 126 ; 226) reçue dans le corps principal (22 ; 122 ; 222), la bague (26 ; 126 ; 226) ayant une seconde surface d'étanchéité (30) afin de mettre en prise la première surface

d'étanchéité avec au moins une ondulation (13 ; 110a ; 210a) du tubage (10) reçue entre la première (32 ; 132 ; 232) et la seconde (30) surface d'étanchéité ; et

une pluralité de crêtes (40, 42 ; 50 ; 60) formées sur au moins l'une des première (32 ; 132 ; 232) et seconde (30) surfaces d'étanchéité, de sorte que les crêtes (40, 42) sont configurées pour être en contact avec la au moins une ondulation (13 ; 110a ; 210a) afin de former un joint d'étanchéité, la pluralité de crêtes comprenant au moins la crête d'extrémité située radialement le plus à l'intérieur (40) et au moins des première et seconde crêtes internes (42) comptées radialement vers l'extérieur à partir de ladite crête d'extrémité, lesdites au moins première et seconde crêtes internes (42) étant espacées de la crête d'extrémité (40) adjacente,

caractérisé en ce qu'une distance entre la crête d'extrémité (40) adjacente et la première crête interne est supérieure à une distance entre la première crête interne et la seconde crête interne pour fournir une pression d'étanchéité concentrée.

2. Agencement d'étanchéité selon la revendication 1, dans lequel la au moins une ondulation (13 ; 110a ; 210a) a un profil sensiblement circulaire après avoir été repliée et rendue étanche entre les première (32 ; 132 ; 232) et seconde (30) surfaces d'étanchéité.

3. Agencement d'étanchéité selon la revendication 1, dans lequel la première surface d'étanchéité est formée sur une surface de butée (32 ; 132 ; 232) du corps principal (22 ; 122 ; 222).

4. Agencement d'étanchéité selon la revendication 1, dans lequel la seconde surface d'étanchéité est formée sur une extrémité de la bague.

5. Agencement d'étanchéité selon la revendication 1, dans lequel le diamètre interne du corps principal (22 ; 122 ; 222) forme un ajustement avec serrage avec la au moins une ondulation (13 ; 110a ; 210a).

6. Agencement d'étanchéité selon la revendication 1, dans lequel le diamètre interne de la bague (26 ; 126 ; 226) forme un ajustement avec serrage avec la au moins une ondulation (13 ; 110a ; 210a).

7. Agencement d'étanchéité selon la revendication 1, dans lequel le diamètre interne (122a) du corps principal (22 ; 122 ; 222) sert de surface d'étanchéité supplémentaire.

8. Agencement d'étanchéité selon la revendication 1, dans lequel la bague (26 ; 126 ; 226) comprend au moins une nervure interne (28a, 28b ; 128a, 128b ; 228a, 228b) pour aligner le tubage (10 ; 110 ; 210) dans la bague (26 ; 126 ; 226).

9. Agencement d'étanchéité selon la revendication 8, dans lequel la au moins une nervure interne (28a, 28b ; 128a, 128b ; 228a, 228b) fournit un réducteur de tension entre le tubage (10 ; 110 ; 210) et la bague (26 ; 126 ; 226).

10. Agencement d'étanchéité selon la revendication 1, dans lequel la pluralité de crêtes internes (50 ; 60) sont en forme de U ou en forme de V.

11. Agencement d'étanchéité selon la revendication 1, dans lequel la pluralité de crêtes internes (50 ; 60) ont une face d'étanchéité plate (52).

12. Agencement d'étanchéité selon la revendication 1, dans lequel la pluralité de crêtes (40, 42) sont des crêtes relevées annulaires.

13. Agencement d'étanchéité selon la revendication 1, dans lequel la au moins une ondulation (13 ; 110a ; 210a) est une ondulation d'extrémité du tubage (10 ; 110 ; 210).

14. Agencement d'étanchéité selon la revendication 1, dans lequel la au moins une ondulation (13 ; 110a ; 210a) est généralement concentrique avec le tubage (10 ; 110 ; 210) après avoir été repliée et rendue étanche.

15. Agencement d'étanchéité selon la revendication 1, dans lequel au moins l'un parmi le diamètre interne de la bague (26 ; 126 ; 226) et le diamètre interne du corps principal (22 ; 122 ; 222) est dimensionné et configuré pour être en contact avec le diamètre situé le plus à l'extérieur de la au moins une ondulation afin de maintenir une forme généralement circulaire de la au moins une ondulation (13 ; 110a ; 210a) lorsque le joint d'étanchéité est formé.

16. Procédé pour réaliser l'étanchéité d'une longueur de tubage ondulé (10 ; 110 ; 210) par rapport à un raccord (20 ; 120 ; 220), comprenant les étapes consistant à :

prévoir la longueur de tubage ondulé (10 ; 110 ; 210) ;

prévoir un corps principal (22 ; 122 ; 222) ayant une première surface d'étanchéité (32 ; 132 ; 232) ;

prévoir une bague (26 ; 126 ; 226) reçue dans le corps principal (22 ; 122 ; 222), la bague (26 ; 126 ; 226) ayant une seconde surface d'étanchéité (30) configurée pour mettre en prise la première surface d'étanchéité (32 ; 132 ; 232) avec au moins une ondulation (13 ; 110a ; 210a)

du tubage (10 ; 110 ; 210) reçue entre les première (32 ; 132 ; 232) et seconde (30) surfaces d'étanchéité ;
dans lequel une pluralité de crêtes (40, 42 ; 50 ; 60) est formée sur au moins l'une des première (32 ; 132 ; 232) et seconde (30) surfaces d'étanchéité, la pluralité de crêtes comprenant la crête d'étanchéité située radialement le plus à l'intérieur et au moins des première et seconde crêtes internes comptées radialement vers l'extérieur à partir de ladite crête d'extrémité, lesdites au moins première et seconde crêtes internes étant espacées de la crête d'extrémité adjacente ; et replier la au moins une ondulation (13 ; 110a ; 210a) entre les première (32 ; 132 ; 232) et seconde (30) surfaces d'étanchéité de sorte que les crêtes (40, 42 ; 50 ; 60) sont en contact avec la au moins une ondulation (13 ; 110a ; 210a) pour former un joint d'étanchéité,
caractérisé en ce qu'une distance entre la crête d'extrémité adjacente et la première crête interne est supérieure à une distance entre la première crête interne et la seconde crête interne pour fournir une pression d'étanchéité concentrée.

17. Procédé selon la revendication 16, dans lequel un diamètre interne (226a) de la bague sert de surface d'étanchéité supplémentaire.

18. Procédé selon la revendication 16, dans lequel au moins l'un parmi la bague (26 ; 126 ; 226) et le corps principal (22 ; 122 ; 222) est dimensionné pour maintenir une forme généralement circulaire de la au moins une ondulation (13 ; 110a ; 210a).

19. Procédé selon la revendication 16, comprenant en outre l'étape consistant à :

mettre en prise le tubage avec au moins une nervure interne de la bague.

20. Procédé selon la revendication 16, dans lequel le diamètre interne du corps principal est configuré pour être en contact avec un diamètre externe de la au moins une ondulation.

21. Procédé selon la revendication 16, dans lequel la pluralité de crêtes sont agencées dans l'ordre, radialement vers l'extérieur.

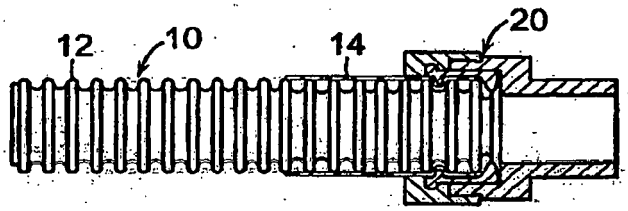

FIG. 1

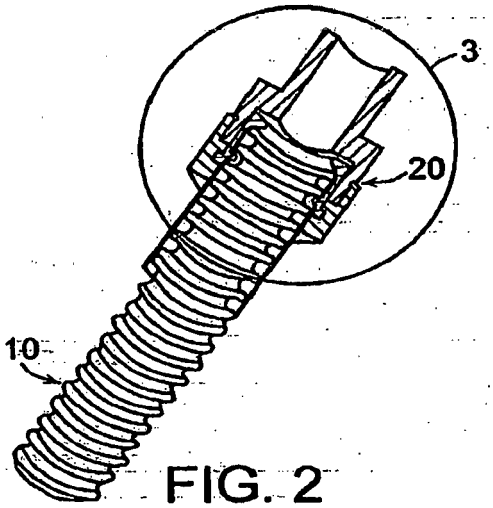

FIG. 2

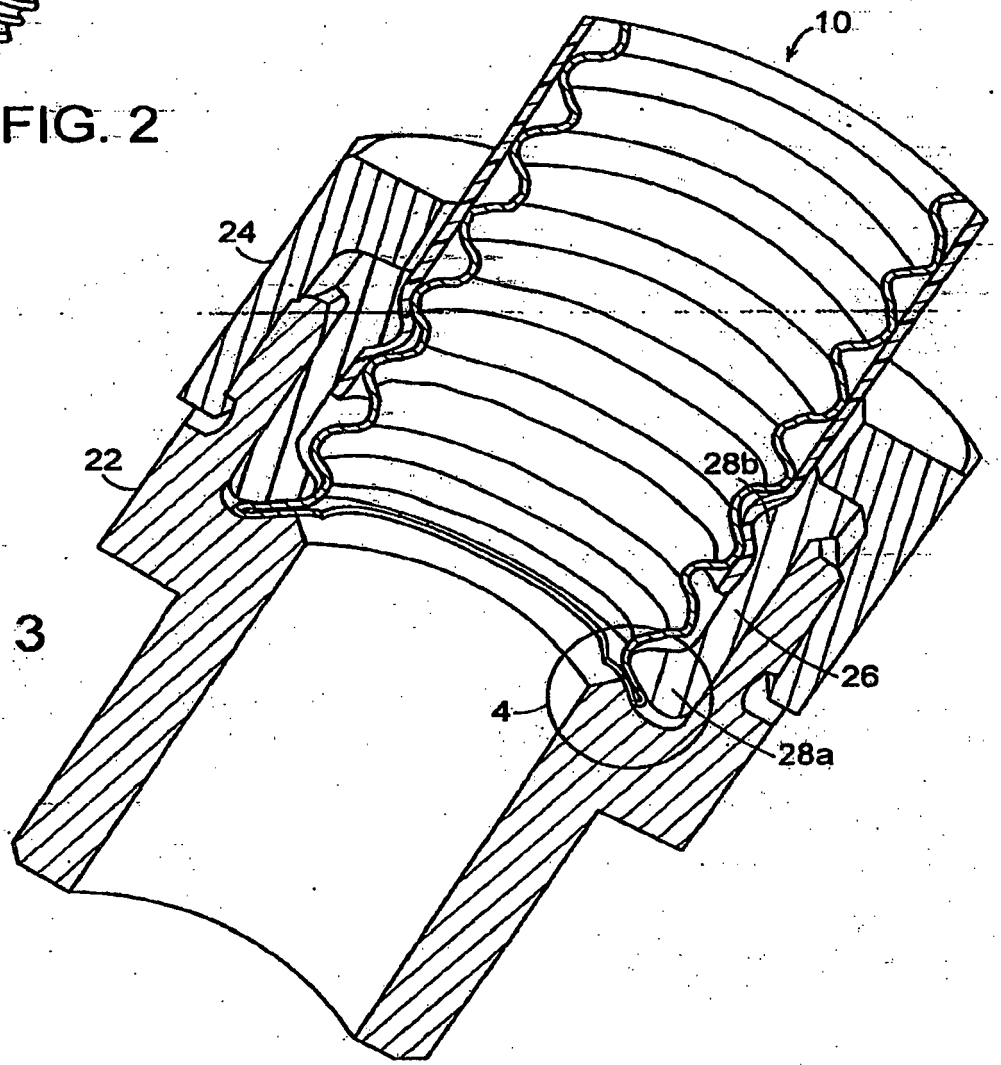

FIG. 3

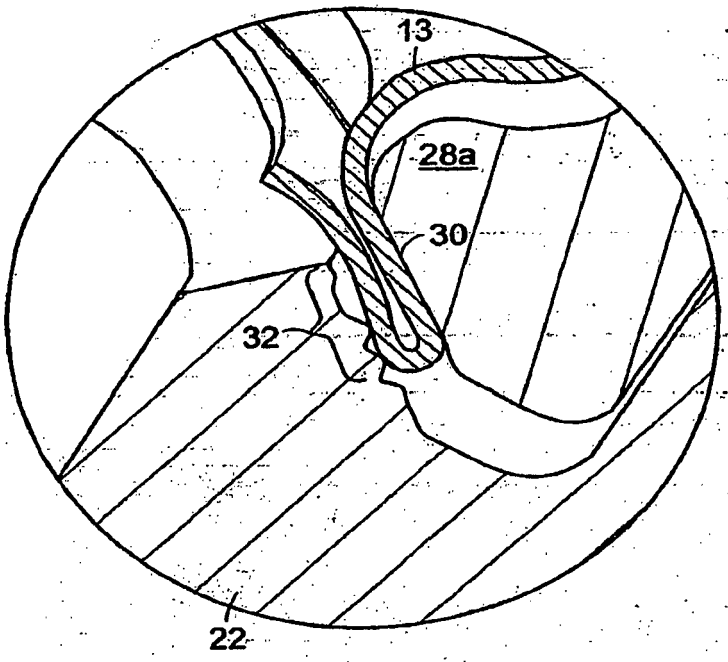

FIG. 4

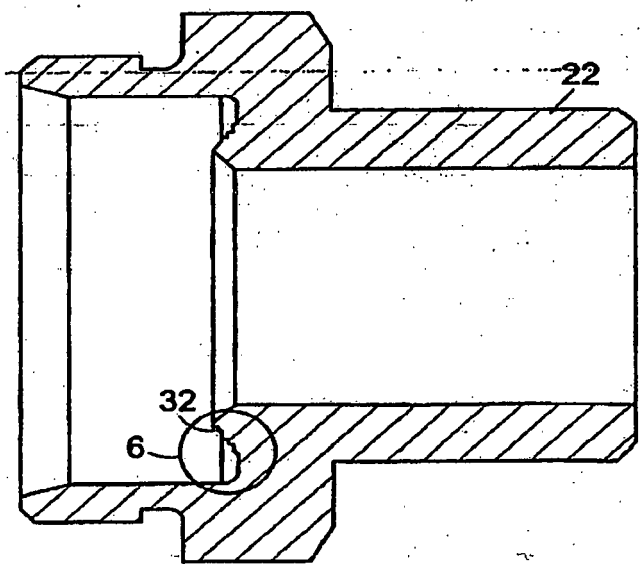

FIG. 5

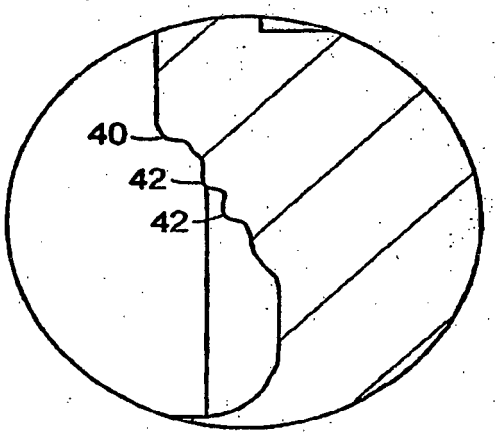

FIG. 6

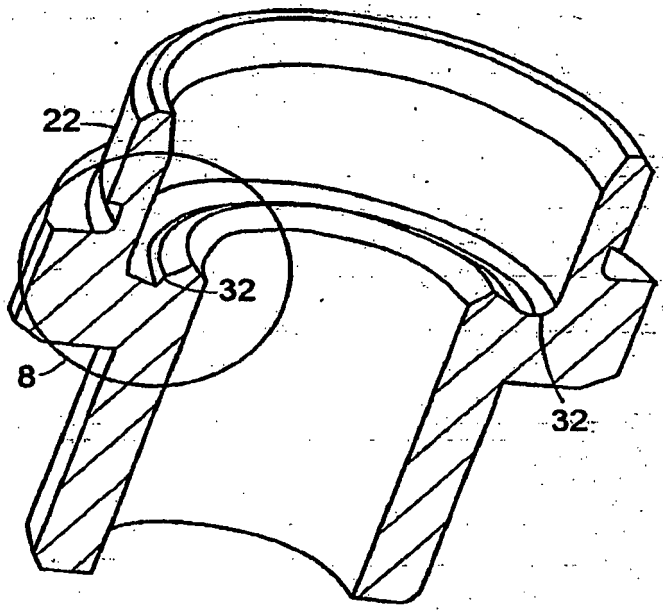

FIG. 7

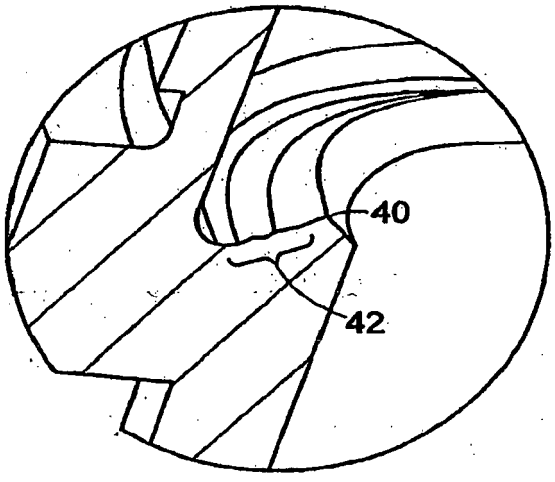

FIG. 8

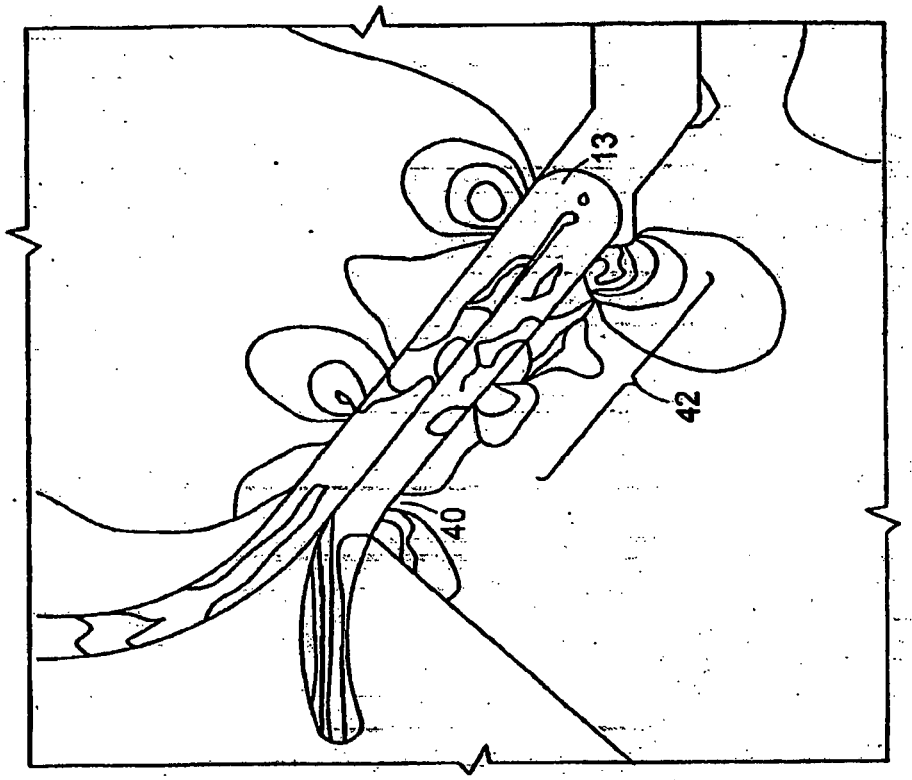

FIG. 10

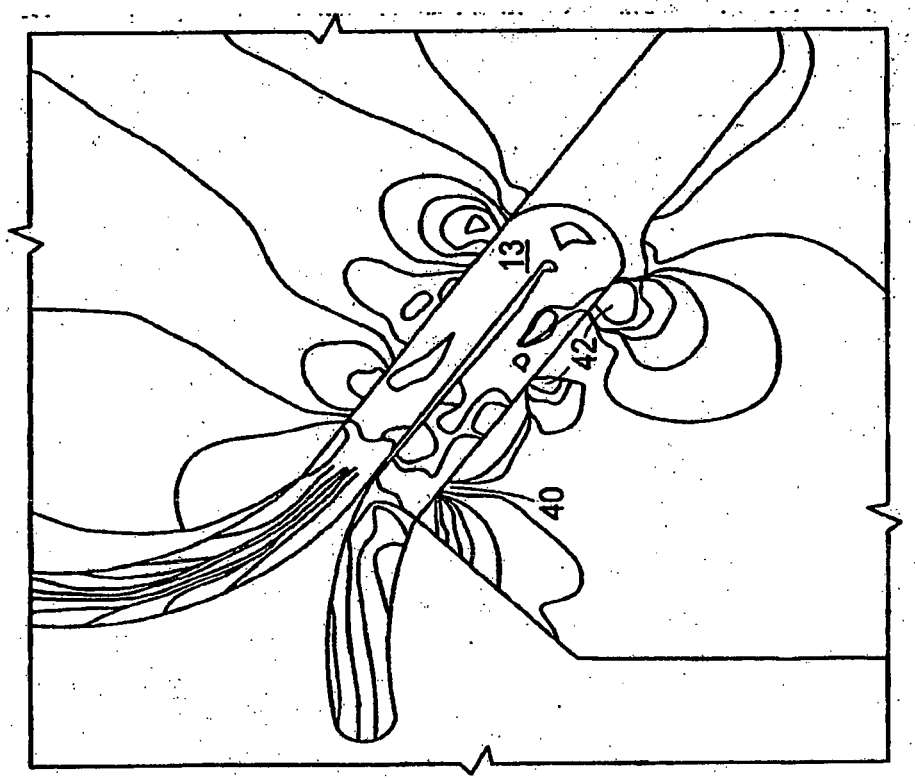

FIG. 9

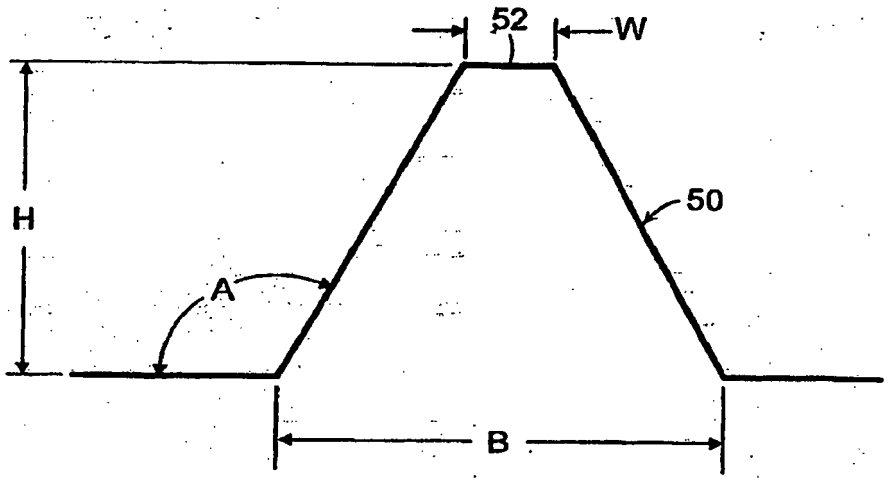

FIG. 11

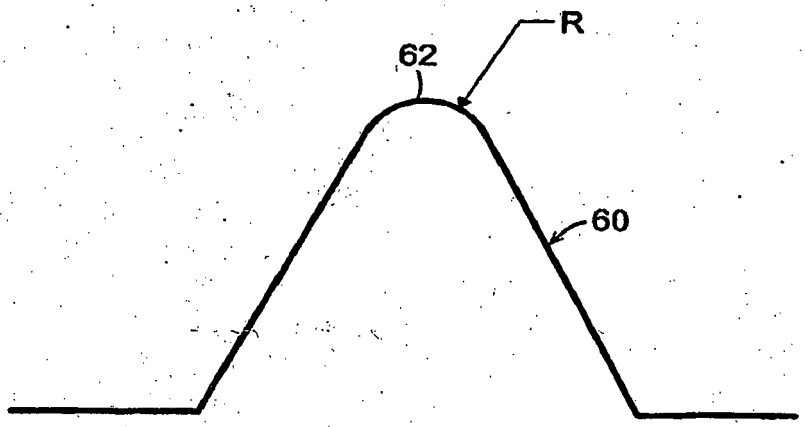

FIG. 12

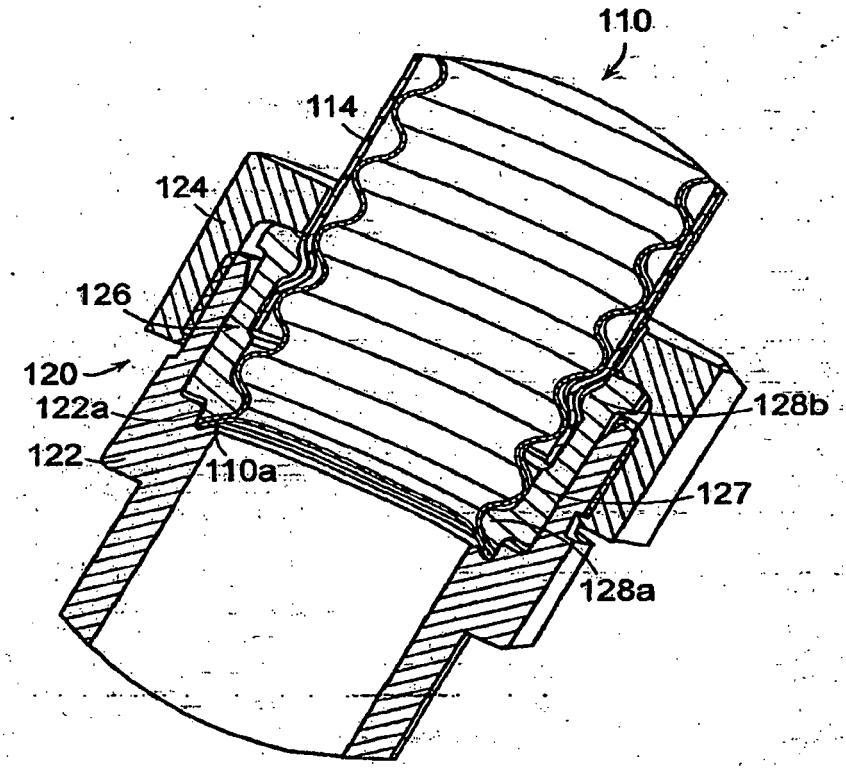

FIG. 13A

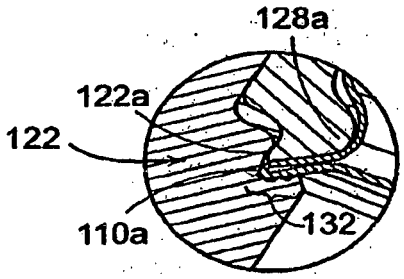

FIG. 13B

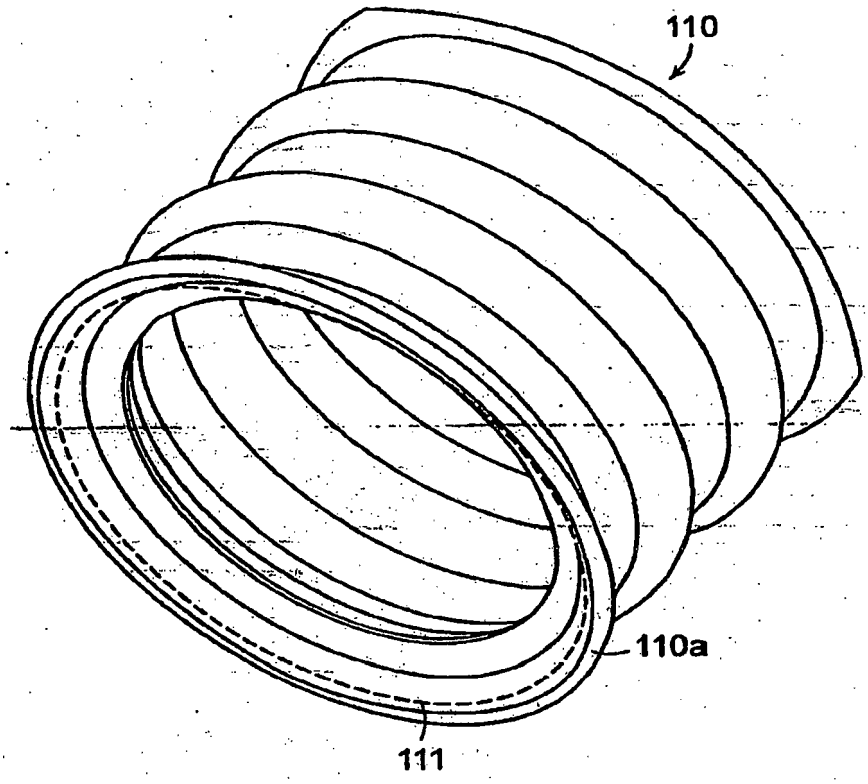

FIG. 14

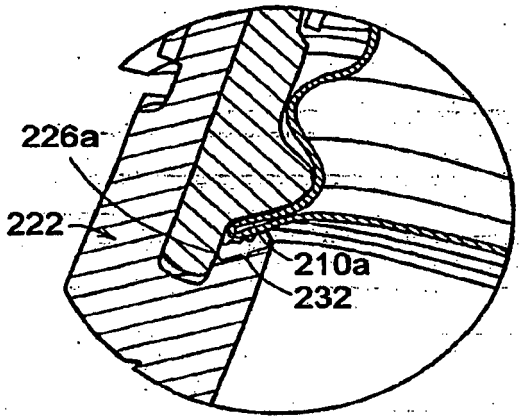

FIG. 15B

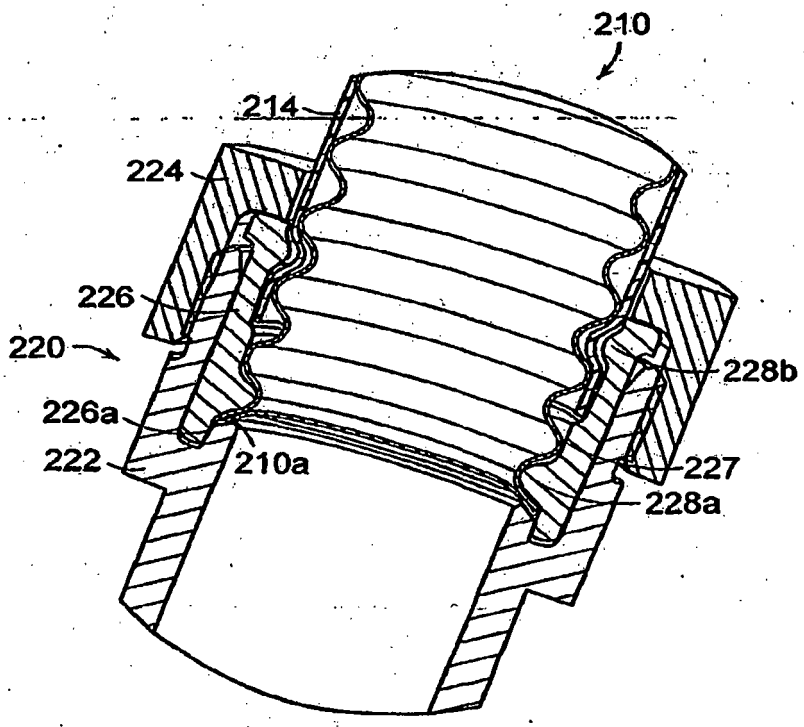

FIG. 15A

REFERENCES CITED IN THE DESCRIPTION

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