

[DESCRIPTION]

[Invention Title]

PIPE CONNECTION DEVICE

[Technical Field]

- [01] The present invention relates to a pipe connection device.

[Background Art]

- [02] A pipe is widely used as a part of piping or a structure for leak-free transfer of fluids and the like due to ease of production and a structural advantage. A joining method of the pipe may be a mechanical joint method or a welding/fusion method.
- [03] Among them, the mechanical joint method may be divided into a decomposable (separable) coupling method and a permanent coupling method. Screwed bonding and bolted bonding using a flange, etc., provide decomposable coupling of the former, while press bonding and swaging provide permanent coupling of the latter.
- [04] On the other hand, welding/fusion is regarded as a technique for extending the continuity of pipes, and thus is recognized as an excellent coupling method that is permanent and its performance is verified. For example, in the case of permanently connecting pipes having the same outer diameter, welding bonding includes butt welding and socket welding. Among them, butt welding is the most commonly used welding method, and the change or branch of the pipeline is solved by using parts (welding fittings) such as butt-welding elbows, tees, and reducers, or by bending the pipes themselves. However, in the case of such a welding/fusion method, there are difficult quality control factors in the construction process, and the skill of the constructor also affects the quality, and thus a lot of costs tend to be required to obtain a reliable joint.

- [05] Due to the difficulty of the welding/fusion method, there have been attempts to provide consistent and reliable quality while ultimately exhibiting performance equivalent to welding/fusion through the permanent coupling method of the mechanical joint method. One of these attempts is the adoption and refinement of a swaging method.
- [06] FIGS. 1A and 1B are cross-sectional views schematically illustrating before and after swaging of a conventional pipe connection device.
- [07] Referring to FIGS. 1A and 1B, a conventional device for connecting pipes using a swaging principle includes a body 330 that cylindrically surrounds a predetermined area from end portions of pipes 210 and 220, and swage rings 310, 320 that linearly move in a longitudinal direction toward the center of the body 330 to guide the outer diameter of the body to be decreased.
- [08] While the outer diameter of the body 330 is reduced due to the movement of the swage rings 310 and 320, a gap between the inner surface of the body 330 and the outer surfaces of the pipes 210 and 220 is removed, thereby preventing the leakage of a fluid and strongly fixing the pipe 220 to the body 330.
- [09] The conventional device for connecting the pipes 210 and 220 using the swaging principle is commercialized in a direction of slightly varying the detailed shapes of the body and the ring while fulfilling the two basic purposes of preventing the leakage of the fluid and fixing the pipe.
- [10] A background art of the present invention is disclosed in Korea Patent Registration No. 1365539.

[Disclosure]

[Technical Problem]

- [11] An object of the present invention is to provide a pipe connection device that can reduce

the weight and size and lower the manufacturing cost through a form and a coupling method different from a conventional configuration while maintaining the advantages of a swaging method.

- [12] Another object of the present invention is to provide a pipe connection device that can enhance a mechanical coupling force compared to a conventional pipe connection device, lower manufacturing cost, and reduce the weight and size thereof while maintaining the advantages of a pipe connection device using a swaging method.

[Technical Solution]

- [13] In order to achieve the objects, according to a first aspect of the present invention, there is provided a pipe connection device including: an outer body into which an end portion of a first pipe is inserted from the rear side and an end portion of a second pipe is inserted from the front side; and a swage ring which surrounds, contacts, and presses an outer circumference of the outer body, in which the contact and pressing of the swage ring are performed with respect to a middle portion except for a rear introducing portion which contacts the swage ring only upon introduction of the swage ring and a front end portion which does not contact the swage ring in the outer body, and an initial inner diameter of the swage ring before the swaging is smaller than an initial outer diameter of the outer body before the swaging.

- [14] According to a second aspect of the present invention, there is provided a pipe connection device including: an outer body into which an end portion of a first pipe is inserted from the rear side and an end portion of a second pipe is inserted from the front side; and a swage ring which surrounds, contacts, and presses an outer circumference of the outer body, in which an initial inner diameter of the swage ring before swaging is smaller than an initial outer diameter of the outer body before swaging, the contact and

pressing of the swage ring are performed with respect to a middle portion except for a rear introducing portion which contacts the swage ring only upon introduction of the swage ring and a front end portion which does not contact the swage ring in the outer body, and the outer circumferential surface of the front end portion of the outer body has a fastening groove, the swage ring includes a front part provided with a fastening protrusion that protrudes obliquely toward the front inner side and is fastened to the fastening groove, and the fastening protrusion is deformed into a restrained state to be fastened to the fastening groove from an initial state of protruding so as not to interfere with the outer circumferential surface of the outer body by the axial compressive force thereto.

- [15] According to a third aspect of the present invention, there is provided a pipe connection device including: an outer body into which an end portion of a first pipe is inserted from the rear side and an end portion of a second pipe is inserted from the front side; and a swage ring which surrounds, contacts, and presses an outer circumference of a rear part of the outer body, in which an initial inner diameter of the swage ring before swaging is smaller than an initial outer diameter of the outer body before swaging, the contact and pressing of the swage ring are performed with respect to a middle portion except for a rear introducing portion which contacts the swage ring only upon introduction of the swage ring in the rear part and a front end portion which does not contact the swage ring, and the outer circumferential surface of the front end portion of the rear part has a fastening groove, the swage ring includes a front part provided with a fastening protrusion that protrudes obliquely toward the front inner side and is fastened to the fastening groove, and the fastening protrusion is deformed into a restrained state to be fastened to the fastening groove from an initial state of protruding so as not to interfere

with the outer circumferential surface of the outer body by the axial compressive force thereto.

- [16] The above-mentioned aspects are merely exemplary and should not be construed as limiting the present disclosure. In addition to the above-described exemplary embodiments, additional embodiments may exist in the drawings and detailed description of the invention.

[Advantageous Effects]

- [17] According to at least one of the aspects of the present invention described above, unlike the related art, the outer body is provided without a structure protruding from the outer circumferential surface (for example, a protruding structure for mounting the fastening tool) or an outer protrusion, and thus the outer body becomes a form that can be produced by processing as little as possible the raw material in the form of a pipe, thereby greatly reducing the manufacturing cost.
- [18] Further, since all middle portions of the outer body are swaged, it is possible to secure mechanical strength equal to or higher than that of the related art while having a shorter body length than the related art, reduce the weight of the fastening tool, the pipe fitting, and the like, and facilitate construction even in a narrower space.
- [19] Further, in the related art, a frictional configuration at a constant contact surface is provided between the swage ring and the outer body to prevent the swage ring from being separated from the outer body. However, according to at least one of the aspects of the present invention, the outer diameter at the middle portion of the outer body is decreased and the outer diameter of the front end portion of the outer body may be relatively larger than that of the middle portion by the swaging. Accordingly, it is possible to implement a pipe connection device in which a limiting jaw limiting the

forward movement of the swage ring pressing and surrounding the outer circumference of the middle portion of the outer body is automatically formed by swaging without any additional configuration.

- [20] Further, according to at least one of the aspects of the present invention, it is possible to implement a pipe connection device having advantages that with only forward movement to the middle portion of the outer body of the swage ring, the end portions of each of the two pipes are swaged and connected to each other while ensuring a predetermined mechanical strength, thereby reducing construction time.
- [21] Further, according to at least one of the aspects of the present invention, as the fastening protrusion of the swage ring and the fastening groove of the outer body are fastened to each other, the swage ring and the outer body may be mechanically coupled to each other. As a result, unlike a conventional method which has prevented detachment of the swage ring from the outer body using frictional coupling, it is possible to secure a high detachment stop force and thus to secure a greater mechanical coupling force against vibration and shock.
- [22] Further, unlike the related art, the outer body is provided without a structure protruding from the outer circumferential surface (for example, a protruding structure for mounting the fastening tool) or an outer protrusion, and thus the outer body becomes a form that can be produced by processing as little as possible the raw material in the form of a pipe, thereby greatly reducing the manufacturing cost.
- [23] Further, since all middle portions of the outer body are swaged, it is possible to secure mechanical strength equal to or higher than that of the related art while having a shorter body length than the related art, reduce the weight of the fastening tool, the pipe fitting, and the like, and facilitate construction even in a narrower space.

- [24] Further, according to at least one of the aspects of the present invention, the outer diameter at the middle portion of the outer body is decreased and the outer diameter of the front end portion of the outer body may be relatively larger than that of the middle portion by the swaging. Accordingly, it is possible to implement a pipe connection device in which a limiting jaw limiting the forward movement of the swage ring pressing and surrounding the outer circumference of the middle portion of the outer body is automatically formed by swaging without any additional configuration.
- [25] Further, according to at least one of the aspects of the present invention, it is possible to implement a pipe connection device having advantages that with only forward movement to the middle portion of the outer body of the swage ring, the end portions of each of the two pipes are swaged and connected to each other while ensuring a predetermined mechanical strength, thereby reducing construction time.
- [26] Further, according to at least one of the aspects of the present invention, as the fastening protrusion of the swage ring and the fastening groove of the outer body are fastened to each other, the swage ring and the outer body may be mechanically coupled to each other. As a result, unlike a conventional method which has prevented detachment of the swage ring from the outer body using frictional coupling, it is possible to secure a high detachment stop force and thus to secure a greater mechanical coupling force against vibration and shock.
- [27] Further, unlike the related art, the outer body is provided without a structure protruding from the outer circumferential surface (for example, a protruding structure for mounting the fastening tool) or an outer protrusion, and thus the outer body becomes a form that can be produced by processing as little as possible the raw material in the form of a pipe, thereby greatly reducing the manufacturing cost.

- [28] Further, since all middle portions of the front part and the rear part of the outer body are swaged, it is possible to secure mechanical strength equal to or higher than that of the related art while having a shorter body length than the related art, reduce the weight of the fastening tool, the pipe fitting, and the like, and facilitate construction even in a narrower space.
- [29] Further, according to at least one of the aspects of the present invention, the outer diameter at the middle portion of the front part and the rear part of the outer body is decreased and the outer diameter of the front end portion of the outer body or the front end portion of the front part or the rear part may be relatively larger than that of the middle portion by the swaging. Accordingly, it is possible to implement a pipe connection device in which a limiting jaw limiting the backward movement of another swage ring pressing and surrounding the outer circumference of the middle portion of the front part of the outer body and a limiting jaw limiting the forward movement of the swage ring pressing and surrounding the outer circumference of the middle portion of the rear part of the outer body are automatically formed by swaging without any additional configuration.

[Description of Drawings]

- [30] FIGS. 1A and 1B are cross-sectional views schematically illustrating before and after swaging of a conventional pipe connection device.
- [31] FIG. 2 is a schematic cross-sectional view of a pipe connection device according to a first embodiment of the present invention.
- [32] FIG. 3 is a schematic cross-sectional view for describing that a swage ring of the pipe connection device according to the first embodiment of the present invention is introduced into a rear introducing portion for swaging.

- [33] FIG. 4 is a schematic cross-sectional view illustrating a state in which both front and rear ends of an outer body are in contact with a fastening tool during the forward movement of the swage ring in the pipe connection device according to the first embodiment of the present invention.
- [34] FIG. 5 is a schematic cross-sectional view and a partially enlarged view for describing a swaging completion state (before the fastening tool is removed) in which both the front and rear ends of the swage ring are in contact with the fastening tool in the pipe connection device according to the first embodiment of the present invention.
- [35] FIG. 6 is a schematic cross-sectional view of one embodiment of a pipe connection device including an insert ring according to the first embodiment of the present invention.
- [36] FIG. 7 is a schematic cross-sectional view for describing that a swage ring of one embodiment of the pipe connection device including the insert ring according to the first embodiment of the present invention is introduced into a rear introducing portion for swaging.
- [37] FIG. 8 is a schematic cross-sectional view of another embodiment of the pipe connection device including an insert ring according to the first embodiment of the present invention.
- [38] FIG. 9 is a schematic cross-sectional view for describing that a swage ring of another embodiment of the pipe connection device including the insert ring according to the first embodiment of the present invention is introduced into a rear introducing portion for swaging.
- [39] FIG. 10 is a schematic cross-sectional view of a pipe connection device according to a second embodiment of the present invention.

- [40] FIG. 11 is a schematic cross-sectional view for describing that a swage ring of the pipe connection device according to the second embodiment of the present invention is introduced into a rear introducing portion for swaging.
- [41] FIG. 12 is an enlarged view of A of FIG. 10.
- [42] FIG. 13 is a schematic conceptual cross-sectional view for describing that a fastening protrusion of the pipe connection device according to the second embodiment of the present invention is in contact with a first ring contact circumferential surface.
- [43] FIG. 14 is a schematic conceptual cross-sectional view for describing that a fastening protrusion with a pre-formed fastening groove of the pipe connection device according to the second embodiment of the present invention is in contact with a first ring contact circumferential surface.
- [44] FIG. 15 is a schematic cross-sectional view of a pipe connection device according to a third embodiment of the present invention.
- [45] FIG. 16 is a schematic cross-sectional view illustrating that a swage ring of the pipe connection device according to the third embodiment of the present invention is introduced into a rear introducing portion for swaging.
- [46] FIG. 17 is an enlarged view of A of FIG. 15.
- [47] FIG. 18 is a schematic cross-sectional view of another embodiment of a pipe connection device according to the third embodiment of the present invention.
- [48] FIG. 19 is an enlarged view of B of FIG. 18.
- [49] FIG. 20 is a schematic cross-sectional view illustrating that a swage ring of another embodiment of the pipe connection device according to the third embodiment of the present invention is introduced into a rear introducing portion for swaging.
- [50]

[Best Mode]

- [51] Hereinafter, exemplary embodiments of the present invention will be described in detail so as to be easily implemented by those skilled in the art, with reference to the accompanying drawings. However, the present invention may be embodied in many different forms and are limited to embodiments described herein. In addition, a part not related with a description is omitted in order to clearly describe the present invention in the drawings and throughout the specification, like reference numerals designate like elements.
- [52] Further, throughout the specification, when it is described that a certain part is “connected” with another part, it means that the certain part may be “directly connected” with the other part and a third part may be interposed therebetween as well.
- [53] Throughout this specification, it will be understood that when a member is referred to as being “on”, “above”, “upper”, “under”, “below”, or “lower” another member, it can be directly on the other member or intervening members may also be present.
- [54] Throughout the specification, a case where a part “comprises” an element will be understood to imply the inclusion of stated elements but not the exclusion of any other elements unless explicitly described to the contrary.
- [55] In addition, in this application, a longitudinal direction (length direction) of a pipe is defined and described as a front-to-back direction. For example, a 3 o'clock direction (right direction) may be forward and a 9 o'clock direction (left direction) may be backward based on FIG. 2. However, the longitudinal direction of the pipe does not depend only on the front-to-back direction in the actual displacement of the pipe. In other words, the pipe may be disposed in various directions (e.g., an up-to-down direction, an oblique direction, etc.) as well as the front-to-back direction, depending on

the need of the pipe displacement.

[56] Hereinafter, a pipe connection device according to a first embodiment of the present invention (hereinafter, referred to as 'a first pipe connection device') will be described. For reference, reference numerals used in the following description of the first pipe connection device may be understood as reference numerals corresponding to the reference numerals shown in FIGS. 1 to 9.

[57] FIG. 2 is a schematic cross-sectional view of a pipe connection device according to a first embodiment of the present invention and FIG. 3 is a schematic cross-sectional view for describing that a swage ring of the pipe connection device according to the first embodiment of the present invention is introduced into a rear introducing portion for swaging. For reference, it is preferred to understand the description of the present invention in consideration of at least some of the plastic deformation caused by swaging in the figures of the present invention, which may be simplified or omitted.

[58] Referring to FIG. 2, the first pipe connection device relates to a device for connecting facing end portions of two pipes 210 and 220 to each other.

[59] Referring to FIG. 2, the first pipe connection device includes an outer body 11. The outer body 11 is configured such that an end portion of the first pipe 210 is inserted from the rear thereof (9 o'clock direction based on FIG. 2) and an end portion of the second pipe 220 is inserted from the front thereof (3 o'clock direction based on FIG. 2). Referring to FIG. 2, the outer body 11 may be disposed in such a manner that a portion of a rear introducing portion 11b and a middle part 11a surrounds an end portion (front end portion) of the first pipe 210. In addition, the outer body 11 may be disposed in a form in which a portion of a front end portion 11c and the middle part 11a surrounds an end portion (rear end portion) of the second pipe 220. For reference, referring to FIG.

2, the outer body 11 may be divided into the front end portion 11c, the middle part 11a, and the rear introducing portion 11b in a longitudinal direction (3 o'clock to 9 o'clock directions based on FIG. 2). Here, the rear introducing portion 11b may mean a portion into which a swage ring 15 to be described later is introduced. In addition, the middle part 11a may be a middle portion except for the rear introducing portion 11b and the front end portion 11c. In addition, the front end portion 11c may basically include a portion where the swage ring 15 does not reach and does not contact. In addition, the front end portion 11c may also include a portion which is in contact with the swage ring 15 to perform predetermined swaging, but swaging is gradually relaxed by a tapered portion so that the inner diameter is gradually increased toward the front thereof, not swaging by the portion having the smallest constant inner diameter of the swage ring 15. That is, the front end portion 11c may refer to a front portion in which no maximum swaging is made by the portion having the minimum inner diameter of the swage ring 15 (the front portion with smaller swaging lessened than maximum swaging and the front portion with a swage ring uncontacted or unreached).

- [60] The middle part 11a of the outer body 11 may have its minimum thickness larger than the thickness of the first pipe 210 and the thickness of the second pipe 220 so as to have a strength that exceeds the strength of the first pipe 210 and the strength of the second pipe 220. For example, the minimum thickness of the middle part 11a may be a minimum thickness measured based on a portion where an inner protrusion 116 and a stopper 117 to be described below of the middle part 11a are not formed. The outer body 11 is a configuration which is pressed by the swage ring 15 to be described later to come into close contact with outer circumferential surfaces of the first pipe 210 and the second pipe 220 which are located therein. The outer body 11 may connect the first

pipe 210 and the second pipe 220 mechanically while preventing the leakage of materials inside the first pipe 210 and the second pipe 220 and the fastening separation (detachment) of the first pipe 210 and the second pipe 220. For this purpose, the outer body 11 needs to have a mechanical strength equal to or higher than that of the first pipe 210 and the second pipe 220. In order to ensure such a mechanical strength, as described above, the minimum thickness of the outer body 11 may be set to be larger than the thickness of the first pipe 210 and the thickness of the second pipe 220.

[61] In addition, the minimum thickness of the middle part 11a of the outer body 11 may be set to be larger than a larger value of a half of the difference between the maximum outer diameter and the minimum outer diameter in consideration of the tolerance of the first pipe 210 or the second pipe 220 and the minimum thickness of the first pipe 210.

[62] First, the fact that the minimum thickness of the middle part 11a of the outer body 11 is set to be thicker than a half of the difference between the maximum outer diameter and the minimum outer diameter of the pipe in consideration of the pipe tolerance is setting considering simultaneously a condition capable of ensuring the airtightness by the pressure of the swage ring 15 regardless of the outer diameter of the pipe (the first pipe 210 or the second pipe 220) and a condition to be disposed (set) so that the swage ring 15 surrounds the outer circumferential surface of the pipe (the first pipe 210 and the second pipe 220).

[63] Specifically, it is assumed that when the swage ring 15 swages the outer body 11, the outer diameter C of the outer body 11 is reduced in correspondence with the inner diameter B of the swage ring, and if the thickness of the outer body 11 is D , the outer diameter of the pipe after swaging becomes $B - 2D$. However, a minimum outer diameter $A_{\min}$ of the pipe needs to be larger than $B - 2D$ so that the outer circumferential

surface of the pipe after swaging is always pressed by the swage ring 15 regardless of the tolerance of the pipe. That is, Equation 1 may be referred to as a condition for securing airtightness regardless of the outer diameter of the pipe (the first pipe 210 or the second pipe 220).

[64] [Equation 1]

[65] $B - 2D < A_{\min}$

[66] In addition, as a precondition before swaging, the inner diameter B of the swage ring 15 needs to be larger than the maximum outer diameter $A_{\max}$ of the pipe considering the pipe tolerance so that the swage ring 15 may be disposed to surround the outer circumferential surface of the pipe.

[67] [Equation 2]

[68] $B > A_{\max}$

[69] In consideration of Equation 1 and Equation 2 above, $A_{\max} - 2D < B - 2D < A_{\min}$, so that a relationship of Equation 3 below may be derived.

[70] [Equation 3]

[71] $(A_{\max} - A_{\min})/2 < D$

[72] Here, as described above, $A_{\max}$ is a maximum outer diameter of the pipe in consideration of the tolerance of the pipe (the first pipe 210 or the second pipe 220), $A_{\min}$ is a minimum outer diameter of the pipe in consideration of the tolerance of the pipe (the first pipe 210 or the second pipe 220), and D is a thickness of the outer body 11.

[73] That is, according to Equation 3, it is preferred that the thickness of the outer body 11, in particular, the minimum thickness of the middle part 11a of the outer body 11 is set to be larger than a half of the difference between the maximum outer diameter and the

minimum outer diameter of the pipe in consideration of the tolerance of the pipe.

- [74] Next, the fact that the minimum thickness of the middle part 11a of the outer body 11 is set to be larger than the minimum thickness of the pipe is a setting considering a condition that the outer body 11 has the same strength as the pipe (the first pipe 210 or the second pipe 220) with respect to an axial force applied to the pipe (the first pipe 210 or the second pipe 220).
- [75] For example, when the first pipe 210 (or the second pipe 220) has a standard outer diameter of 60 mm, a thickness of 2 mm, an outer diameter tolerance of ± 1 mm, and a thickness tolerance of ± 0.5 mm, a minimum outer diameter of the first pipe 210 (or the second pipe 220) is 59 mm, a maximum outer diameter thereof is 61 mm, and a minimum value of the thickness thereof is 1.5 mm. At this time, it is preferred that the minimum thickness of the outer body 11 is set to 1.5 mm or more which is a larger value of 1 mm, a half of 2 mm which is a difference of the maximum value and the minimum value of the outer diameter of the first pipe 210 (or the second pipe 220) and 1.5 mm which is the minimum thickness of the first pipe 210 (or the second pipe 220).
- [76] Also, referring to FIG. 3, it is preferable that the middle part 11a of the outer body 11 is provided with a smooth round surface (circumferential surface) without the formation of projections or protrusions outward on the outer circumferential surface of the outer body 11 so as to enable smooth movement to reduce frictional resistance in the longitudinal direction (the length direction of the pipe) of the swage ring 15. For example, referring to FIG. 3, when viewed based on a thickness except for an inner protrusion 116, the thickness of at least a portion of the middle part 11a may be set to be constant in the longitudinal direction (length direction). In addition, as be described later, the rear introducing portion 11b of the outer body 11 has an outer diameter less than or equal to

the outer diameter of the middle part 11a so that initial introduction into the outer body 11 of the swage ring 15 may be easier. In addition, the front end portion 11c of the outer body 11 refers to a portion where the swage ring 15 does not reach and does not contact and may be provided to have an outer diameter greater than or equal to the outer diameter of the middle part 11a.

[77] Referring to FIG. 2, the first pipe connection device includes the swage ring 15. An initial inner diameter of the swage ring 15 before swaging may be smaller than an initial outer diameter of the outer body 11 (in particular, the middle part 11a) before swaging. Referring to FIG. 3, the swage ring 15 may be introduced from the rear introducing portion 11b to move forward and the outer body 11 is swaging. Referring to FIG. 2, the swage ring 15 contacts and presses the outer body 11 by surrounding the outer circumference of the outer body 11. The contact and pressing of the swage ring 15 to the outer body 11 are performed with respect to the middle part 11a except for the rear introducing portion 11b which contacts the swage ring 15 only upon introduction of the swage ring 15 and the front end portion 11c which does not contact the swage ring 15 in the outer body 11. However, when a front tapered portion 152 to be described later is formed in the swage ring 15, the front tapered portion 152 of the swage ring 15 may also contact the front end portion 11c. A portion of the front end portion 11c which comes into contact with the front tapered portion 152 may be a portion where swaging is gradually relaxed along an increasingly expanding inner diameter of the front tapered portion as compared to the swaging by the portion having a constant minimum inner diameter of the swage ring 15. That is, the middle part 11a may mean a portion where swaging is performed by a constant minimum inner diameter of the swage ring 15, and the front end portion 11c basically includes a portion where the swage ring 15 is not

reached as a front portion of such a middle part 11a. If the swage ring 15 has a front tapered portion, the swage ring 15 may include a portion where the front tapered portion swages. To this end, the swage ring 15 may have a shorter length than that of the outer body 11 to surround the outer circumference of the middle part 11a of the outer body 11. In other words, the length of the swage ring 15 may be set to a length capable of contacting only the outer circumference of the middle part 11a of the outer body 11 to press the middle part 11a.

[78] When comparing FIGS. 2 and 3, the outer body 11 may be in a state in which at least a part thereof is plastically deformed by swaging. For example, referring to FIG. 2, the middle part 11a of the outer body 11 may be deformed in a direction in which the outer diameter is reduced by swaging. In addition, the rear introducing portion 11b of the outer body 11 is deformed in a direction in which the outer diameter is reduced by swaging of the swage ring 15, and then at least a portion of the outer body 11 is elastically restored after the swage ring 15 passes, or the outer circumferential surface side thereof may be pulled forward at least a portion according to the movement of the swage ring 15 to be deformed in a direction in which the outer diameter becomes relatively larger than that of the middle part 11a. This will be described below in more detail.

[79] FIG. 4 is a schematic cross-sectional view illustrating a state in which both front and rear ends of an outer body are in contact with a fastening tool during the forward movement of the swage ring in the pipe connection device according to the embodiment of the present invention and FIG. 5 is a schematic cross-sectional view and a partially enlarged view for describing a swaging completion state (before the fastening tool is removed) in which both the front and rear ends of the swage ring are in contact with the

fastening tool in the pipe connection device according to the embodiment of the present invention.

- [80] Referring to FIGS. 2 and 5, by swaging of the swage ring 15 which deforms the middle part 11a in a direction in which the outer diameter is reduced, at least a part of the inner circumferential surface of the middle part 11a may press the outer circumferential surface of the first pipe 210 and the outer circumferential surface of the second pipe 220.
- [81] When comparing FIGS. 3 and 5, the middle part 11a has an outer diameter smaller than that of the front end portion 11c due to the swaging of the swage ring 15 which deforms the middle part 11a in the direction in which the outer diameter is reduced. In other words, due to swaging, the front end portion 11c has a relatively larger outer diameter than that of the middle part 11a. Referring to FIGS. 3 to 5, as described above, since the swage ring 15 has a shorter length than the outer body 11, the swage ring 15 may press the middle part 11a of the outer body 11 without reaching the front end portion 11c. Accordingly, the front end portion 11c of the outer body 11 may have an outer diameter relatively larger than that of the middle part 11a of the outer body 11 having the reduced outer diameter.
- [82] Referring to FIGS. 2 and 5 (particularly, an enlarged diagram of a right part of FIG. 5), the front end portion 11c may prevent the swage ring 15 from being separated forward by the outer diameter relatively larger than the middle part 11a. In other words, the front end portion 11c naturally having a relatively larger outer diameter than the middle part 11a by the swaging method of pressing only the middle part 11a of the outer body 11 of the present invention may serve as a limiting jaw (limiter) that restricts further advancement in the direction in which the swage ring 15 has advanced after the swaging is completed.

- [83] Further, referring to FIG. 3, the rear introducing portion 11b may include a rear end portion 113 of which an outer diameter size is less than the outer diameter size of the middle part 11a and equal to or larger than the inner diameter size of the swage ring 15 based on before being deformed by swaging and an inclined connection portion 114 obliquely connecting the rear end portion 113 and the middle part 11a. The outer body 11 having such a rear introducing portion 11b has the smallest outer diameter of the rear end portion 113 of the rear introducing portion 11b and may have a shape in which the outer diameter is continuously increased along an inclined surface by the inclined connection portion 114 extending forward from the rear end portion 113 and then the outer diameter is constantly maintained from the middle part 11a. Accordingly, the outer diameter of the rear introducing portion 11b may be smaller than the outer diameter of the front end portion 11c.
- [84] In addition, since the outer diameter of the rear end portion 113 of the rear introducing portion 11b is set to be equal to or larger than the inner diameter of the swage ring 15, the swage ring 15 is introduced through the rear end portion 113 of the rear introducing portion 11b and then the swage ring 15 may not be easily separated from the rear introducing portion 11b by frictional resistance due to pressing. Specifically, referring to FIG. 3, introduction of the swage ring 15 through the rear end portion 113 of the rear introducing portion 11b may be performed while the front end portion of the swage ring 15 is overlaid on at least a portion of the rear introducing portion 11b. As described above, when the outer diameter of the rear end portion 113 of the rear introducing portion 11b is set to be equal to or larger than the inner diameter of the swage ring 15, in the introduction of the swage ring 15 through the rear end portion 113 of the rear introducing portion 11b, the swage ring 15 may be forcibly fitted and coupled to the rear

end portion 113 of the rear introducing portion 11b by a predetermined level or more of force, and then may not be easily separated or detached backward through the rear introducing portion 11b when swaging by moving forward.

- [85] Although not clearly illustrated in the drawings, the rear introducing portion 11b is deformed by the swage ring 15, and then at least a portion of the rear introducing portion 11b is restored after the swage ring 15 passes, or the outer circumferential surface side thereof may be pulled forward at least a portion according to the movement of the swage ring 15 to have the outer diameter relatively larger than that of the middle part 11a. That is, the rear introducing portion 11b may serve as a limiting jaw (limiter) on the rear side to prevent the swage ring 15 from being separated or detached backward through at least one of such deformation restoration and an outer diameter change due to the pulling force. Specifically, referring to FIG. 4, when the swage ring 15 is introduced into the outer body 11, the swage ring 15 moves forward while pressing the outer circumferential surface of the rear introducing portion 11b. In this process, when the swage ring 15 presses the outer circumferential surface of the rear introducing portion 11b temporarily while a part of the outer circumferential surface is elastically deformed, and then moves forward, the elastically deformed portion is elastically restored again to be restored to an outer diameter larger than the outer diameter when pressed. Moreover, when the swage ring 15 which has an outer diameter smaller than the outer diameter of the rear introducing portion 11b is moved forward while pressing the outer circumferential surface (surface) of the rear introducing portion 11b at a predetermined pressure, a pulling force for pulling the outer circumferential surface side forward may be applied to the outer circumferential surface (surface) of the rear introducing portion 11b, and predetermined deformation may be made in which the rear

introducing portion 11b is lifted (rolled up) in a direction in which the outer diameter is extended by the pulling force. By at least one of the two actions described above, the rear introducing portion 11b can have a relatively larger outer diameter than the middle part 11a. The rear introducing portion 11b may prevent the swage ring 15 from being detached backward by an outer diameter relatively larger than the middle part 11a.

[86] Referring to FIGS. 3 to 5, the rear introducing portion 11b has an annular groove 111 formed on its inner circumferential surface (*see* FIG. 3), and an outer circumferential surface portion corresponding to the groove 111 may have a bead 112 formed to convexly protrude outward to have a larger outer diameter than the middle part 11a.

[87] When the swage ring 15 moves forward by the fastening tool 2, as illustrated in FIG. 4, both end surfaces of the outer body 11 in the longitudinal direction come into contact with the fastening tool 2 and then when a force for additionally moving the swage ring 15 forward is applied by the moving of the fastening tool 2, a compressive force in an axial direction (length direction) may be applied to the groove 111 formed to be recessed on the inner circumferential surface of the rear introducing portion 11b of the outer body 11. When comparing FIGS. 4 and 5, the bead 112 is deformed to shorten the length of the rear introducing portion 11b when a compressive force in an axial direction (length direction) is applied to the rear introducing portion 11b and the deformation to increase the outer diameter may be induced by the groove 111. The thickness of a portion where the groove 111 of the rear introducing portion 11b is formed is thinner than other portions due to the formation of the groove 111, and the groove 111 may have a shape which is recessed outward from the inner circumferential surface of the rear introducing portion 11b. With this groove, when the axial compressive force is applied, the portion in which the groove 111 is formed naturally

protrudes outward, not inward, and the deformation to extend the outer diameter of the rear introducing portion 11b may be easily induced. That is, according to the groove 111, the bead 112 serving as the limiting jaw may be very easily formed to more effectively prevent the swage ring 15 from being detached backward even by a predetermined compression by the fastening tool.

[88] For reference, referring to FIG. 3, the groove 111 may be formed in an annular shape at a point spaced apart from the rear end surface (rear end surface) of the rear introducing portion 11b. For example, referring to FIG. 3, the groove 111 may be formed over a portion of the rear end portion 113 of the rear introducing portion 11b and a portion of the inclined connection portion 114, but is not limited thereto. As described above, the groove 111 may be preferred to be formed on the inner circumferential side of the rear introducing portion 11b and have a thickness thinner than other portions of the rear introducing portion 11b such that the groove 111 may be deformed to protrude outward while the groove 111 is folded or distorted when the axial (longitudinal or length direction) compressive force is applied by the fastening tool.

[89] Referring to FIGS. 2 and 3, the inner circumferential surface of the middle part 11a has an inner protrusion 116 which comes into contact with the first pipe 210 and the second pipe 220 during swaging of the swage ring 15. In the swaging process, the middle part 11a may be plastically deformed in a direction in which the inner diameter and the outer diameter are reduced. Accordingly, the portion of the inner protrusion 116 formed on the inner circumferential surface of the middle part 11a corresponding to the outer circumferential surface of the first pipe 210 is in contact with the outer circumferential surface of the first pipe 210 and at least a part may be deformed by pressing the outer circumferential surface of the first pipe 210. A portion of the inner protrusion 116

corresponding to the outer circumferential surface of the second pipe 220 may come into contact with the outer circumferential surface of the second pipe 220 and press the outer circumferential surface of the second pipe 220 to be at least partially deformed. Also, referring to FIGS. 2 and 5, each of the first pipe 210 and the second pipe 220 may be deformed by the pressure of the inner protrusion 116. Accordingly, a portion of the inner protrusion 116 may be coupled to the first pipe 210 in the form of penetrating the outer circumferential surface of the first pipe 210. In addition, another portion of the inner protrusion 116 may be coupled to the second pipe 220 in the form of penetrating the outer circumferential surface of the second pipe 220.

[90] Also, referring to FIGS. 2 and 3, the inner protrusion 116 is preferably formed in a symmetrical shape with respect to the center point between the first pipe 210 and the second pipe 220 in the longitudinal direction such that the same or similar physical deformation or fastening may be made to each of the first pipe 210 and the second pipe 220.

[91] Specifically, the inner protrusion 116 may include a sealing-type protrusion which seals between the middle part 11a and the first pipe 210 or between the middle part 11a and the second pipe 220 and resists an axial force applied to the first pipe 210 or the second pipe 220. A plurality of inner protrusions 116 is provided, and some of the plurality of inner protrusions 116 press the first pipe 210 and some of the plurality of the inner protrusions 116 press the second pipe 220 during swaging of the swage ring 15 to seal between the outer body 11 and the first pipe 210 and between the outer body 11 and the second pipe 220. For example, the sealing-type protrusion may be provided in an annular structure that extends continuously in a circumferential direction. In addition, a plurality of sealing-type protrusions may be provided at intervals in the longitudinal

direction.

- [92] The sealing-type protrusion may be a lattice-type protrusion in which if there is a defect on the outer circumferential surface of the first pipe 210 or the second pipe 220, lattices adjacent to the defect form a closed space of the local area and are repeatedly arranged in the circumferential direction on the inner circumferential surface of the middle part 11a so as to resist torsion together. In other words, the sealing-type protrusion may be provided to protrude in the form of a lattice. For example, the lattice shape may be provided as an axial symmetric structure, but is not limited thereto. Accordingly, the sealing-type protrusion, such a lattice-type protrusion, may protrude in a lattice form in the circumferential direction on the inner circumferential surface so that if there is a defect on the surfaces of the first pipe 210 and the second pipe 220, lattices adjacent to the defect form a closed space of the local area and prevent torsion of the first pipe 210 and the second pipe 220. As such, when the sealing-type protrusion is provided in the form of a lattice, each lattice acts as a kind of partition wall that partitions an area inside the lattice with an area outside the lattice, thereby more enhancing a higher anti-leakage capability. That is, when the sealing is made in the form of a lattice, leakage from the defect may be limited to only a predetermined lattice area and additional leakage to the outside of the lattice area may be blocked. In addition, the lattice shape may serve to resist the torsion applied to the pipe as well as to resist the axial force applied to the pipe due to the structure.
- [93] In addition, the inner protrusion 116 may include a torsion resistant protrusion that resists the torsion acting on the first pipe 210 or the second pipe 220.
- [94] For example, the torsion resistant protrusion may have a knurling shape (spline). In other words, the torsion resistant protrusion has a tooth form elongated in the

longitudinal direction (continuously extending in the longitudinal direction) which is repeatedly disposed along the circumferential direction on the inner circumference of the outer body 11 (internal gear shape). In other words, the inner protrusion 116 may be provided to have a tooth form when viewing the inner circumference of a longitudinal cross-section of the outer body 11. The torsion resistant protrusion may be provided to extend from the middle part 11a of the outer body 11 to the rear introducing portion 11b or the front end portion 11c. By arranging such a torsion resistant protrusion, a structure in which the torsion resistant protrusion is more effectively resistant also to a bending deformation moment applied to the pipe may be provided. Further, the torsion resistant protrusion may be applied in combination with the above-mentioned sealing-type protrusion. In another example, the inner protrusion 116 may be formed in an annular shape having an oblique inclination (an acute angle inclination of less than 90 degrees with respect to the axial direction of the pipe), or formed as a lattice protrusion as described above to serve as both the sealing-type protrusion and the torsion resistant protrusion. As such, the inner protrusion 116 may be provided in various forms in consideration of sealing, axial force resistance, torsion resistance, and the like.

- [95] In addition, the inner protrusion 116 may be configured to be integrally formed on the inner surface of the outer body 11. Alternatively, as another example, the inner protrusion 116 may be implemented by inserting a ring-shaped part processed separately from the outer body 11. When the inner protrusion 116 is formed through the ring-shaped part processed separately, since the airtightness needs to be satisfied with respect to both the inner surface of the outer body 11 and the outer surface of the pipe (first pipe 210 or second pipe 220), it is preferable that the projections are formed on a portion

contacting each surface (both an outer end and an inner end in a radial direction in the form of separately processed rings). In addition, when the inner protrusion 116 is a ring-shaped part separately processed, the strength and hardness of the ring-shaped part may be set to be higher than the strength and hardness of the outer body 11 and higher than the strength and hardness of the first and second pipes 210 and 220. According to such strength and hardness setting, the inner protrusion 116 may be formed to penetrate deeper into the inner surface of the outer body and the outer surface of the pipe, thereby improving the airtightness and mechanical strength of the first pipe connection device.

[96] In addition, the length of the outer body 11 may be set to a length that satisfies the minimum number of inner protrusions 116 capable of withstanding the axial external force on the pipe that is expected or actually acted upon in the pipe connection design. Since the length of the outer body 11 is related to the structural strength of the inner protrusion 116 and the strength of the first pipe 210 and the second pipe 220, the length of the outer body 11 is preferably set differently according to each case and conditions based on the material and shape of the inner protrusion 116, the material and thickness of the first pipe 210 and the second pipe 220, etc. For example, when the first pipe connection device is applied to connect the first pipe 210 and the second pipe 220 having insufficient strength, an insert ring 13 (a configuration inserted into the pipe to support the pipe in the radial direction, which will be described in more detail later) covering the length range or more in the axial direction in which the inner protrusion 116 is formed may be additionally provided to reinforce the strength of the first pipe 210 and the second pipe 220, and in this case, the outer body 11 may ensure a predetermined or more of sufficient strength without excessively increasing its length.

[97] For reference, the outer body 11 may be provided in the form of omitting the above-

described inner protrusion 116 for an ultra high purity (UHP) piping, a very thin piping, etc. which are required to use the insert ring 13. In this case, the insert ring 13 may be provided to form a sealing portion at a contact point between the outer circumferential surface of the insert ring 13 and the inner circumferential surface of the first pipe 210 (or the second pipe 220).

[98] In addition, referring to FIG. 2, the inner circumferential surface of the middle part 11a corresponding to the center of the outer body 11 may have a stopper 117 which limits forward movement of the first pipe 210 and limits backward movement of the second pipe 220. Referring to FIG. 2, the stopper 117 may be formed on the inner circumference of the middle part 11a of the outer body 11. The stopper 117 may limit the forward movement of the first pipe 210 and the backward movement of the second pipe 220. In other words, each of the first pipe 210 and the second pipe 220 may be inserted into the outer body 11 to a position in contact with the stopper 117. By disposing the stopper 117 at the center of the middle part 11a, the symmetrical arrangement of the first pipe and the second pipe with respect to the outer body 11 may be facilitated. The inner protrusion 116 described above may be symmetrically formed with respect to the stopper 117.

[99] In addition, the stopper 117 may be provided in the same as or similar to the inner protrusion 116. For example, the stopper 117 may be configured to be integrally formed on the inner surface of the outer body 11. Alternatively, as another example, the stopper 117 may be implemented in a form in which a ring-shaped part (for example, a C-shaped ring) processed separately from the outer body 11 is inserted into the outer body 11.

[100] Meanwhile, in order to adjust and align a gap between the first pipe 210 and the second

pipe 220 before the fastening operation (swaging), it may be easier for the stopper 117 not to be provided. In addition, in the case of an operation for repairing the pipe (the first pipe 210 or the second pipe 220), it may be more preferable that there is no stopper 117, and thus the stopper 117 may be selectively provided in some cases.

[101] Referring to FIGS. 3 and 5, the inner circumferential surface of the swage ring 15 is formed so that a middle portion thereof has a predetermined inner diameter, and the front tapered portion 152 is formed at the front end portion thereof and a rear tapered portion 151 may be formed at the rear end portion thereof. The introduction of the swage ring 15 into the rear introducing portion 11b may be smoothly and easily made by the front tapered portion 152. In addition, referring to an enlarged view of the right part of FIG. 5, a part of the outer circumferential surface of the front end portion 11c may be provided in the form of gradually securing an outer diameter while coming into contact with the front tapered portion 152. Thus, the frictional resistance due to the contact may be organically combined in the role of the limiting jaw of the front end portion 11c. That is, the front end portion 11c may serve as a limiting jaw that restricts the forward detachment of the swage ring 15 by the outer diameter relatively larger than the middle part 11a and the frictional resistance with the front tapered portion 152. As such, when the front tapered portion 152 is formed in the swage ring 15, a portion (the front tapered portion) of the swage ring 15 may also come into contact with the front end portion 11c of the outer body 11 as described above. That is, the swage ring 15 swages by pressing the middle part 11a of the outer body 11 by the inner circumferential surface having the largest inner diameter, whereas may be subjected to swaging which is gradually relaxed forward by pressing a portion of the front end portion 11c of the outer body 11 by the front tapered portion 152 of which the inner diameter is gradually

extended.

- [102] In addition, the swage ring 15 may be provided in a single part form in which another portion other than the portion where the front tapered portion 152 and the rear tapered portion 151 are formed has a predetermined inner diameter.
- [103] In addition, the minimum thickness of the swage ring 15 may be larger than a value obtained by adding a maximum thickness before the plastic deformation of the first pipe 210 or the second pipe 220 and a maximum thickness before the plastic deformation of the middle part 11a of the outer body 11. This prevents the outer diameter of the swage ring 15 from increasing more than the amount of decreasing the inner diameter of the outer body 11 during the swaging process, so that a compressive force acts in the inward direction of the outer body 11, the first pipe 210, and the second pipe 220 and the swaging is performed.
- [104] Meanwhile, the maximum thickness of the swage ring 15 is not particularly limited, but when the insert ring 13 such as a UHP piping is used, the plastic deformation of the insert ring 13 should be avoided. In this case, the maximum thickness of the swage ring 15 may be set to be smaller than a value obtained by adding the thickness (e.g., the minimum thickness) of the outer body 11, the thickness of the first pipe 210 (or the thickness of the second pipe 220), and the thickness of the insert ring 13 (e.g., the maximum thickness of the insert ring).
- [105] In addition, the outer body 11 and the swage ring 15 may be preferably made of the same material as the first pipe 210 and the second pipe 220. In addition, the insert ring 13 to be described later is also preferably made of the same material as the first pipe 210 and the second pipe 220. This is to minimize a change in the physical bonding force between the first pipe 210 and the outer body 11 and between the second pipe 220 and

the outer body 11 due to an influence of a surrounding environment of the first pipe 210 and the second pipe 220, such as a temperature change. In addition, when metals having the same material as the first pipe 210 and the second pipe 220 are used in the outer body 11 and the swage ring 15, there is also an advantage that potential corrosion due to a potential difference between metals in contact with each other may be minimized.

[106] In addition, each of the outer circumferential surface of the outer body 11 and the inner circumferential surface of the swage ring 15 may be lubricated and coated with a lubricant or a material having good lubricity. This is to lower the need to use unnecessarily strong fastening tools. However, a material that is coated on the outer circumferential surface of the outer body 11 and the inner circumferential surface of the swage ring 15 for lubricating coating has corrosion resistance of corrosion resistance surface treatment or less applied to the first pipe 210 and the second pipe 220, it is preferred that corrosion resistant surface treatment is first performed on the outer body 11 and the swage ring 15 before lubrication coating to ensure corrosion resistance equal to or greater than that of the material of the pipe (first pipe 210 and second pipe 220).

[107] FIG. 6 is a schematic cross-sectional view of one embodiment of a first pipe connection device including an insert and FIG. 7 is a schematic cross-sectional view for describing that a swage ring of one embodiment of the first pipe connection device including the insert is introduced into a rear introducing portion for swaging. FIG. 8 is a schematic cross-sectional view of another embodiment of the first pipe connection device including an insert and FIG. 9 is a schematic cross-sectional view for describing that a swage ring of another embodiment of the first pipe connection device including the insert is introduced into a rear introducing portion for swaging.

- [108] The first pipe connection device may include an insert ring 13. The insert ring 13 may complement the function of the outer body 11 and exhibit a variety of effects, and may be provided in various forms depending on the required effect. Hereinafter, it will be described in detail.
- [109] Referring to FIGS. 6 and 7, the insert ring 13 is provided longer than the outer body 11 (in particular, the middle part 11a of the outer body 11) to be disposed at a position including a length section of the outer body 11 (the length section of the middle part 11a of the outer body 11) of the inside of the first pipe 210 and the second pipe 220. In addition, the insert ring 13 may support the inner circumferential surfaces of the first pipe 210 and the second pipe 220 when swaging the swage ring 15. Accordingly, the insert ring 13 may prevent the first pipe 210 and the second pipe 220 from being bent and deformed by a bending component external force. The first pipe connection device may be configured with a minimum length necessary to resist an axial force and a torsion component external force in order to pursue a simple and light configuration, and has an insert ring 13 supporting the pipe inside the pipe to ensure a sufficient mechanical strength while reducing the size of the outer body 11 so that the outer body 11 occupies only a small space. In particular, when the thicknesses of the first pipe 210 and the second pipe 220 are small, it is more preferred to reinforce the mechanical strength of the connection portion of the first pipe 210 and the second pipe 220 through the insert ring 13. As such, when the insert ring 13 is included, the pipe (the first pipe 210 or the second pipe 220) may be disposed and connected so that an end thereof is interposed between the outer body 11 and the insert ring.
- [110] Meanwhile, referring to FIGS. 8 and 9, the outer circumferential surface of the insert ring 13 has an outer protrusion 131 which comes into contact with the first pipe 210 and

the second pipe 220 during swaging of the swage ring 15. The outer protrusion 131 may be formed at a position corresponding to the inner protrusion 116 of the outer body 11 and the length direction (the longitudinal direction) of the pipe. For example, referring to FIG. 8, when any one of the plurality of inner protrusions 116 is deformed by the swaging of the swage ring 15 to press the outer circumferential surface of the pipe (the first pipe 210 or the second pipe 220), any one of the plurality of outer protrusions 131 may be configured to support the pipe against the pressure at a position corresponding to the one of the inner protrusions 116 of the inner circumferential surface of the pipe. These outer protrusions 131 are continuously formed along the periphery (for example, annularly formed) to support the pipe, thereby sealing the pipe (the first pipe 210 or the second pipe 220) and the insert ring 13. This sealing prevents foreign matters (contaminants), such as pipe processing residues, which may remain at the end portion (cut surface) of the pipe (first pipe 210 or second pipe 220) from being introduced into a space inside the pipe, so as to be effectively applied to piping structures (semiconductor piping, etc.) where a significantly high level of internal cleanliness is required.

- [111] More specifically, as illustrated in FIG. 8, an engagement groove recessed inward with respect to the radial direction of the pipe may be formed in a circumferential direction in the middle of the outer protrusion 131 of the insert ring 13. Referring to FIG. 8, the engagement groove may be engaged with at least a portion of the inner protruding portion of the pipe deformed inward by the pressing of the inner protrusion 116 of the outer body 11 during swaging. At this time, the protrusions on both sides of the outer protrusion 131 may fix the pipe while penetrating both inner circumferential surfaces of the inner protruding portion of the pipe. As such, the projection of the outer protrusion

131 and the engaging groove are organically coupled with respect to the inner protrusions 116 of the outer body 11, so that the permanent fixing of the pipes by swaging becomes more cohesive, and the airtightness between the pipe and the outer body 11 and the airtightness between the pipe and the insert ring 13 may be implemented more completely.

- [112] As another example, the outer protrusion 131 of the insert ring 13 may be provided in a similar form to the inner protrusion 116 of the outer body 11 described above. For example, the outer protrusion 131 may include a sealing-type protrusion which seals between the insert ring 13 and the first pipe 210 or between the insert ring 13 and the second pipe 220 and resists an axial force applied to the first pipe 210 or the second pipe 220. In addition, the outer protrusion 131 may include a torsion resistant protrusion that resists the torsion acting on the first pipe 210 or the second pipe 220. The torsion resistant protrusion may be provided to partially protrude from the outer circumferential surface of the insert ring 13 to the front and rear of the outer body 11. Referring to FIG. 6, when the torsion resistant protrusion partially protrudes to the front and rear of the outer body 11, the first pipe 210 and the second pipe 220 may be bent and deformed by the bending component external force so that a bending resistance capability of the insert ring 13 may be further improved. The sealing-type protrusion may be a lattice-type protrusion in which if there is a defect on the inner circumferential surface of the first pipe 210 or the second pipe 220, lattices adjacent to the defect form a closed space of the local area and are repeatedly arranged along the circumferential direction on the outer circumferential surface of the insert ring 13 so as to resist torsion together. Since the configuration of the outer protrusion 131 may be understood by applying equally and similarly the description of the inner protrusion 116 of the outer

body 11 described above, the detailed description thereof will be omitted.

[113] In addition, the inner circumferential surface of the insert ring 13 may be coated with a protective material so as to be protected from materials flowing in the first pipe 210 and the second pipe 220 as necessary. For example, fluids, gases, etc. flowing in the pipe (the first pipe 210 and the second pipe 220) may easily corrode the pipe, or pipes may be installed under chemical conditions that materials forming the pipe are eluted into the pipe. In this case, the insides of the first pipe 210 and the second pipe 220 may be coated with a protective material. However, when the first pipe 210 or the second pipe 220 is inevitably cut to correct the path of the pipe, an internal pipe material forming the pipe may be exposed on the cut surface thereof. In this case, the insert ring 13 coated with the protective material is disposed inside the first pipe 210 and the second pipe 220, so that sealing between the cut surface of the pipe and the insert ring 13 may be made to solve above problem.

[114] This first pipe connection device may be applied with various applications in fields requiring high cleanliness as well as airtightness, such as high clean gas pipings (UHP pipings) in industries such as semiconductors, bio, and pharmaceutical where clean rooms are used. In this case, the inner circumferential surface of the insert ring 13 may ensure smoothness equal to or higher than that of the pipe (the first pipe 210 and the second pipe 210) by electropolishing, etc., and may be chemically stable and not contaminated.

[115] As described above, in the first pipe connection device, the insert ring 13 may complement (reinforce) the outer body 11 through an effect such as structural strength reinforcement and chemical resistance reinforcement special environments response.

[116] In addition, the thickness of the insert ring 13 is preferably smaller so as not to cause

flow resistance of materials (fluids, gases, etc.) in the first pipe 210 and the second pipe 220, but it is preferred to ensure the minimum mechanical strength according to the use and to ensure the minimum thickness necessary to maintain airtightness. In particular, when the first pipe 210 and the second pipe 220 are gas pipes with little influence of flow resistance due to a change in the inner diameter, the thickness of the insert ring 13 may be larger than that of each of the first pipe 210 and the second pipe 220. In addition, when the first pipe 210 and the second pipe 220 are high clean pipes, the insert ring 13 is preferably thicker than the first pipe 210 and the second pipe 220.

[117] Referring to FIGS. 3 and 5, the first pipe connection device may include a fastening tool 2. The fastening tool 2 may be a temporary configuration in which the swage ring 15 is fastened to surround the middle part 11a and then removed.

[118] As an example, the fastening tool 2 may include a rear support unit 21 coming into contact with the rear end surface of the swage ring 15, and a front support unit 22 coming into contact with the front end surface of the front end portion 11c of the outer body 11.

[119] In addition, the fastening tool 2 may include a driving unit which provides an axial compressive force by a driving force and the driving force by which the rear support unit 21 and the front support unit 22 move to face each other so that the swage ring 15 moves from the rear side of the outer body 11 to a position surrounding the middle part 11a, for example, a driving force by which the rear support unit 21 relatively moves to the front support unit 22 side. For example, the driving unit may relatively pull the rear support unit 21 with respect to the front support unit 22 and move the rear support unit 21 and the front support unit 22 to be close to each other. Since various driving devices such as a driving unit (actuator) using hydraulic pressure may be applied to the

driving unit, a more detailed description thereof will be omitted.

[120] Referring to FIGS. 4 and 5, the rear support unit 21 has a first ring contact circumferential surface 211 coming into contact with the rear end surface of the swage ring 15, and a first body contact recessed surface 212 formed to be recessed backward from the first ring contact circumferential surface 211 by a first step a and coming into contact with the rear end surface of the rear introducing portion 11b of the outer body 11. Here, the first step a may be set to correspond to the length of the rear introducing portion 11b that is shorter than the length before the formation of the bead 112 while the bead 112 is formed. Referring to a partially enlarged view of the left side of FIG. 5, it may be understood that the fact that the first step a is set to correspond to the length of the rear introducing portion 11b means setting a size of the first step a to be equal to the length of the rear introducing portion 11b when the rear tapered portion 151 is not formed at the rear end of the swage ring 15 unlike the drawings. However, when the rear tapered portion 151 is formed at the rear end of the swage ring 15 as shown in the drawing, it may be understood that the fact that the first step a is set to correspond to the length of the rear introducing portion 11b means setting a size obtained by adding a longitudinal length of the rear tapered portion 151 to the size of the first step a to be equal to the length of the rear introducing portion 11b.

[121] Referring to FIGS. 4 and 5, the front support unit 22 has a second ring contact circumferential surface 221 coming into contact with the front end surface of the swage ring 15, and a second body contact recessed surface 222 formed to be recessed forward from the second ring contact circumferential surface 221 by a second step c and coming into contact with the front end surface of the front end portion 11c of the outer body 11. Here, the second step c may be set to correspond to the length of the front end portion

11c. Referring to a partially enlarged view of the right side of FIG. 5, it may be understood that the fact that the second step c is set to correspond to the length of the front end portion 11c means setting a size of the second step c to be equal to the length of the front end portion 11c when the front tapered portion 152 is not formed at the front end of the swage ring 15 unlike the drawings. However, when the front tapered portion 152 is formed at the front end of the swage ring 15 as shown in the drawing, it may be understood that the fact that the second step c is set to correspond to the length of the front end portion 11c means setting a size obtained by adding a longitudinal length of the front tapered portion 152 to the size of the second step c to be equal to the length of the front end portion 11c.

[122] By the first step a and the second step c, the rear introducing portion 11b and the front end portion 11c of the outer body 11 are not covered by the swage ring 15, and the position of the swage ring 15 may be set so that the contact and pressing by the swage ring 15 are made only to the middle part 11a of the outer body 11.

[123] Referring to FIG. 4, in a state (hereinafter, referred to as 'a first state') where each of the longitudinal end surfaces of the outer body 11 comes into contact with the first body contact recessed surface 212 of the rear support unit 21 and the second body contact recessed surface 222 of the front support unit 22, the swage ring 15 is in a state where only the rear end surface thereof comes into contact with the first ring contact circumferential surface 211 of the rear support unit 21 and the front end surface thereof does not still come into contact with the second ring contact circumferential surface 221 of the front support unit 22. That is, in the first state, the outer body 11 is in a state in which both end surfaces are in contact with the fastening tool 2, but the front end surface of the swage ring 15 is still spaced apart b from the fastening tool 2. As the

fastening tool 2 is driven in a direction of further narrowing a gap by such a spacing gap b, the groove 111 is formed to induce the formation of the bead 112 that protrudes outward while a major deformation occurs in the forming portion of the groove 111 of the rear introducing portion 11b of the outer body 11, which is the thinnest portion thereof.

[124] As such, the outer body 11 is provided to have an initial length longer by a predetermined size b than the length finally formed by compression by the fastening tool 2, and the swage ring 15 is provided to have a length LR subtracted from the initial length of the outer body 11 by the first step a and the second step c which are both side steps of the fastening tool 2 and the predetermined size b. As described above, according to the driving of the fastening tool 2, a compressive force may be applied to the outer body 11 due to a movement (movement from the state of FIG. 4 to the state of FIG. 5) by the predetermined size b. In addition, since the compressive force is organically interlocked with the groove 111 formed on the inner circumferential surface of the rear introducing portion 11b of the outer body 11, the formation of the beads 112 protruding outward from the groove 111 may be induced. The rear detachment of the swage ring may be effectively limited by the bead 112 without an additional configuration. At this time, the first step a and the second step c of the fastening tool 2 may serve to ensure the rear section (rear introducing portion) and the front section (front end portion) where the swage ring 15 is not covered. Furthermore, the first step a is used alone or in combination with the rear tapered portion 151 of the swage ring 15 to secure a space in which the bead 112 is formed. Referring to the partially enlarged view of the left side of FIG. 5, in order to secure the space for forming the bead 112, the first body contact recessed surface 212 of the rear support unit 21 may be formed with a

width (diameter or radius) larger than the outer diameter of the rear introducing portion 11b of the outer body 11. Specifically, it is preferred that the first body contact recessed surface 212 is provided to have a width enough not to interfere with the bead 112 protruding outward by compression.

[125] In the above-described first pipe connection device, the outer body 11 is provided without a structure protruding to the outer surface and an outer protrusion in the middle part 11a unlike the related art, so that the outer body 11 may be manufactured with as little processing as possible from raw materials in the form of pipes, thereby greatly reducing manufacturing cost. In addition, since the middle part 11a of the outer body 11 swages as a whole, the same mechanical strength as in the related art may be ensured even with a shorter body length than the related art. As a result, it is possible to reduce the weight of the first pipe connection device, a pipe joint by the first pipe connection device, and the fastening tool 2 and to be easily constructed even in a narrow space.

[126] Further, conventionally, a friction configuration at a constant contact surface is provided between the swage ring and the outer body to prevent the swage ring from being detached from the outer body. On the other hand, in the first pipe connection device, the front end portion 11c and the rear introducing portion 11b of the outer body 11 have a larger outer diameter than the middle part 11a where the swage ring 15 is naturally disposed by swaging the swage ring 15 to limit the movement of the swage ring 15 in the front and rear direction, and as a result, it is possible to implement a rigid pipe joint against vibration, shock, and the like.

[127] Further, according to the first pipe connection device, it is possible to minimize the number of parts and reduce the cause of defects, and unlike the related art, it is possible to perform connection of the two pipes 210 and 220 by one tool operation (for example,

in the related art, a tool operation for swaging the front and rear ends of the outer body was required, but according to the first pipe connection device, one tool operation for the forward movement of the swage ring 15 is required), thereby significantly reducing a construction time by more than half.

[128] Hereinafter, a pipe connection method (hereinafter, referred to as 'a first pipe connection method') according to a first embodiment of the present invention will be described. However, the first pipe connection method shares the same or corresponding technical features and configurations as or to the above-described first pipe connection device. Therefore, descriptions overlapping with those described in the first pipe connection device will be simplified or omitted, and the same reference numerals will be used for the same or similar components.

[129] The first pipe connection method relates to a method for connecting facing end portions of two pipes 210 and 220 to each other.

[130] The first pipe connection method includes preparing a pipe for an outer body forming the outer body 11. The pipe for the outer body may have the middle part 11a, the front end portion 11c, and the rear introducing portion 11b described above. In addition, the pipe for the outer body may have a groove 111, an inner protrusion 116, and a stopper 117.

[131] In addition, the first pipe connection method includes inserting an end portion of the first pipe 210 into the outer body 11 from the rear and inserting an end portion of the second pipe 220 from the front of the outer body 11 (first step).

[132] In addition, the first pipe connection method includes disposing the swage ring 15 to be located at the rear of the pipe for the outer body with respect to the outer circumferential surface of the first pipe 210 (second step). The second step may be performed after the

first step and if necessary, may also be performed before the first step.

[133] The first pipe connection method includes disposing the fastening tool 2 (third step). The fastening tool 2 may include a rear support unit 21 coming into contact with the rear end surface of the swage ring 15, and a front support unit 22 coming into contact with the front end surface of the front end portion 11c of the outer body 11. In addition, the fastening tool 2 may include a driving unit which provides an axial compressive force by a driving force and the driving force to relatively move the rear support unit 21 to the front support unit 22 side.

[134] The first pipe connection method includes disposing (fastening) the swage ring 15 to perform swaging and surround the middle part 11a of the outer body 11 (fourth step). In addition, the first pipe connection method may include removing the fastening tool 2 (fifth step) after fastening the swage ring 15 to surround the middle part 11a.

[135] Hereinafter, a pipe connection device according to a second embodiment of the present invention (hereinafter, referred to as 'a second pipe connection device') will be described. For reference, reference numerals used in the following description of the second pipe connection device may be understood as reference numerals corresponding to the reference numerals shown in FIGS. 10 to 14.

[136] FIG. 10 is a schematic cross-sectional view of a second pipe connection device, FIG. 11 is a schematic cross-sectional view for describing that a swage ring of the second pipe connection is introduced into a rear introducing portion for swaging, FIG. 12 is an enlarged view of A of FIG. 10, FIG. 13 is a schematic conceptual cross-sectional view for describing that a fastening protrusion of the second pipe connection is in contact with a first ring contact circumferential surface, and FIG. 14 is a schematic conceptual cross-sectional view for describing that a fastening protrusion with a pre-formed

fastening groove of the second pipe connection is in contact with a first ring contact circumferential surface. For reference, FIG. 10 illustrates a state in which the fastening tool is not removed. Further, it is preferred to understand the description of the present invention in consideration of at least some of the plastic deformation caused by swaging in the figures of the present invention, which may be simplified or omitted.

[137] Referring to FIG. 10, the second pipe connection device relates to a device for connecting facing end portions of two pipes 210 and 220 to each other.

[138] Referring to FIG. 10, the second pipe connection device includes an outer body 11. The outer body 11 is configured such that an end portion of the first pipe 210 is inserted from the rear thereof (9 o'clock direction based on FIG. 10) and an end portion of the second pipe 220 is inserted from the front thereof (3 o'clock direction based on FIG. 10). Referring to FIG. 10, the outer body 11 may be disposed in such a manner that a portion (rear portion) of a rear introducing portion 11b and a middle part 11a surrounds an end portion (front end portion) of the first pipe 210. In addition, the outer body 11 may be disposed in a form in which a portion (front portion) of a front end portion 11c and the middle part 11a surrounds an end portion (rear end portion) of the second pipe 220. For reference, referring to FIG. 10, the outer body 11 may be divided into the front end portion 11c, the middle part 11a, and the rear introducing portion 11b in a longitudinal direction (3 o'clock to 9 o'clock directions based on FIG. 10). Here, the rear introducing portion 11b may mean a portion into which a swage ring 15 to be described later is introduced. In addition, the middle part 11a may mean a swaging portion to have a predetermined outer diameter by the swage ring 15 and may be a middle portion except for the rear introducing portion 11b and the front end portion 11c. In addition, the front end portion 11c may basically include a portion where the swage ring 15 does

not reach and does not contact. In addition, the front end portion 11c may also include a portion which is in contact with the swage ring 15 to perform predetermined swaging, but swaging is gradually relaxed by a tapered portion so that the inner diameter is gradually increased toward the front thereof, not swaging by the portion having the smallest constant diameter of the swage ring 15. That is, the front end portion 11c may refer to a front portion in which no maximum swaging is made by the portion having the minimum inner diameter of the swage ring 15 (the front portion with smaller swaging lessened than maximum swaging and the front portion with a swage ring uncontacted or unreached).

[139] The outer body 11 is a configuration which is pressed by the swage ring 15 to be described later to come into contact with outer circumferential surfaces of the first pipe 210 and the second pipe 220 which are located therein. The outer body 11 may connect the first pipe 210 and the second pipe 220 mechanically while preventing the leakage of materials inside the first pipe 210 and the second pipe 220 and the separation (detachment) of the first pipe 210 and the second pipe 220. For this purpose, the outer body 11 needs to have a mechanical strength equal to or higher than that of the first pipe 210 and the second pipe 220.

[140] Referring to FIG. 10, the second pipe connection device includes a swage ring 15. Referring to FIG. 11, an initial inner diameter of the swage ring 15 before swaging may be smaller than an initial outer diameter of the outer body 11 (in particular, the middle part 11a) before swaging. Referring to FIG. 11, the swage ring 15 may be a configuration which is introduced from the rear introducing portion 11b to move forward and swages the outer body 11.

[141] Referring to FIG. 10, the swage ring 15 contacts and presses the outer body 11 by

surrounding the outer circumference of the outer body 11. The contact and pressing of the swage ring 15 to the outer body 11 are performed with respect to the middle part 11a except for the rear introducing portion 11b which contacts the swage ring 15 only upon introduction of the swage ring 15 and the front end portion 11c which does not contact the swage ring 15 in the outer body 11. However, when a front tapered portion 152 to be described later is formed in the swage ring 15, the front tapered portion 152 of the swage ring 15 may also contact the front end portion 11c. A portion of the front end portion 11c which comes into contact with the front tapered portion 152 may be a portion where swaging is gradually relaxed along an increasingly expanding inner diameter of the front tapered portion as compared to the swaging by the portion having a constant minimum inner diameter of the swage ring 15. That is, the middle part 11a may mean a portion where swaging is performed by a constant minimum inner diameter of the swaging ring 15, and the front end portion 11c basically includes a portion where the swage ring 15 is not reached as a front portion of such a middle part 11a. If the swage ring 15 has a front tapered portion, the swage ring 15 may include a portion where the front tapered portion swages. Accordingly, the swage ring 15 may have a shorter length than that of the outer body 11 to surround the outer circumference of the middle part 11a of the outer body 11.

- [142] When comparing FIGS. 10 and 11, the outer body 11 may be in a state in which at least a part thereof is plastically deformed by swaging. For example, referring to FIG. 10, the middle part 11a of the outer body 11 may be deformed in a direction in which the outer diameter is reduced by swaging. In addition, the rear introducing portion 11b of the outer body 11 is deformed in a direction in which the outer diameter is reduced by swaging of the swage ring 15, and then at least a portion of the outer body 11 is

elastically restored after the swage ring 15 passes, or the outer circumferential surface side thereof may be pulled forward at least a portion according to the movement of the swage ring 15 to be deformed in a direction in which the outer diameter becomes larger than that of the middle part 11a.

[143] When comparing FIGS. 10 and 11, by swaging of the swage ring 15 which deforms the middle part 11a in a direction in which the outer diameter is reduced, at least a part of the inner circumferential surface of the middle part 11a may press the outer circumferential surface of the first pipe 210 and the outer circumferential surface of the second pipe 220.

[144] In addition, the movement of the swage ring 15 may be made by the fastening tool 2. For example, referring to FIGS. 10 and 11, the fastening tool 2 may include a rear support unit 21 coming into contact with a rear end surface of the swage ring 15, a front support unit 22 coming into contact with a front end portion of the front end portion 11c of the outer body 11, and a driving unit which provides an axial compressive force by a driving force and the driving force by which the rear support unit 21 is moved relatively toward the front support unit 22 so that the swage ring 15 moves from the rear of the outer body 11 to a position surrounding the middle part 11a.

[145] Referring to FIGS. 10 and 12, a fastening groove 111 is formed on an outer circumferential surface of the front end portion 11c of the outer body 11. In addition, the swage ring 15 includes a front part 151 provided with a fastening protrusion 1513 that obliquely protrudes toward the front inward and fastened to the fastening groove 111. That is, according to the second pipe connection device, a restrained state in which the fastening protrusion 1513 is fastened to the fastening groove 111 may be implemented. This restrained state may mean a state in which the rear movement of

the swage ring 15 is prevented by fastening the fastening protrusion 1513 and the fastening groove 111. By the restrained state, the swage ring 15 and the outer body 11 may be coupled to each other such that the backward movement of the swage ring 15 is limited. Accordingly, a structure (fastening protrusion 1513) for coupling with the outer body 11 may be formed in the front part 151 of the swage ring 15. For reference, referring to FIGS. 13 and 14, the fact that the fastening protrusion 1513 protrudes obliquely toward the front inside may mean that the fastening protrusion 1513 protrudes toward the front of the swage ring 15 but extends obliquely toward the inside.

[146] Further, for example, the fastening protrusion 1513 may have an annular shape that continuously extends in the circumferential direction, and the fastening groove 111 may continuously extend in the circumferential direction corresponding to the annular fastening protrusion 1513.

[147] In addition, the fastening protrusion 1513 is deformed into a restrained state to be fastened to the fastening groove 111 in an initial state protruding so as not to interfere with the outer circumferential surface of the outer body 11 by the axial compressive force thereto. In other words, the fastening protrusion 1513 has an initial state so as not to interfere with respect to the outer circumferential surface of the outer body 11 before the axial compressive force is applied thereto and moves forward on the outer body of the swage ring 15 according to the forward movement. In addition, if the axial compressive force is applied, the fastening protrusion 1513 may be deformed to be fastened to the fastening groove 111 formed on the outer circumferential surface of the outer body 11. For reference, when the fastening protrusion 1513 has an annular shape, a minimum inner diameter in the initial state of the fastening protrusion 1513 may be larger than the outer diameter of the outer body 11 so as not to interfere with the outer

circumferential surface of the outer body 11 of the fastening protrusion 1513. In addition, the axial compressive force may be applied by the fastening tool 2 described above. For reference, the axial compressive force may mean a compressive force applied to the front and rear sides (longitudinal direction). Since the fastening protrusion 1513 protrudes forward, the axial compressive force may be a pressure applied to the rear side so that the fastening protrusion 1513 is deformed while being compressed.

[148] More specifically, referring to FIGS. 13 and 14, a recessed surface 1512 recessed with a step toward the rear side (9 o'clock based on FIGS. 13 and 14) may be formed below a front end surface 1511 of the front part 151. In addition, the fastening protrusion 1513 may be provided to protrude forward ahead of the front end surface 1511 of the front part 151 from the recessed surface 1512 in the initial state.

[149] Also, referring to FIGS. 10 and 12, the front support unit 22 may include a first ring contact circumferential surface 221 which comes into contact with a portion corresponding to the front end surface 1511 of the front part 151 of the swage ring and the front end surface 1511 of the front part 151 of the fastening protrusion 1513 in the restrained state. The first ring contact circumferential surface 221 may limit the forward movement of the swage ring 15. In other words, the swage ring 15 may be moved until the front end surface 1511 is in full contact with the first ring contact circumferential surface 221.

[150] In addition, when in the initial state a portion protruding forward ahead of the front end surface 1511 of the front part 151 is pressed backward to a position corresponding to the front end surface 1511 of the front part 151 by the axial compressive force, the fastening protrusion 1513 may be provided in a shape that is induced to be protruding-deformed

inward ahead of the outer circumferential surface of the outer body 11.

[151] For example, referring to FIGS. 13 and 14, the fastening protrusion 1513 in the initial state may protrude obliquely toward the front inside. This may mean that the fastening protrusion 1513 protrudes toward the front side (3 o'clock direction based on FIGS. 13 and 14), but is formed toward the inner side (6 o'clock direction side based on FIGS. 13 and 14) obliquely (in a direction between 3 o'clock and 6 o'clock based on FIGS. 13 and 14). If the fastening protrusion 1513 protrudes obliquely toward the front outer side (the direction side between the 12 o'clock direction and the 3 o'clock direction based on FIGS. 13 and 14), the fastening protrusion 1513 may not be fastened to the fastening groove 111 to be deformed and induced outward at the time of the back pressing. Therefore, the fastening protrusion 1513 of the initial state may be preferably provided with a shape (for example, a shape protruding obliquely toward the front inner side) which is induced to be deformed inward from the outer circumferential surface of the outer body 11 when the surface is pressed by the front support unit to the rear side.

[152] Referring to FIGS. 13 and 14, when the swage ring 15 moves forward, the portion protruding forward from the front end surface 1511 of the fastening protrusion 1513 may come into contact with the first ring contact circumferential surface 221 of the front support unit 22 earlier than the front end surface 1511. Further, referring to FIG. 12, the swage ring 15 may be moved until the front end surface 1511 comes into contact with the first ring contact circumferential surface 221, and in this moving process, the fastening protrusion 1513 contacting the first ring contact circumferential surface 221 earlier than the front end surface 1511 may be pressed back to a position corresponding to the front end surface 1511 of the front part 151. Accordingly, the fastening protrusion 1513 may be deformed in a form in which at least a portion is bent or

plastically deformed in the downward direction, the rear downward direction, or the like to penetrate (press) the outer circumferential surface of the outer body 11. In other words, by pressing the surface of the first ring contact circumferential surface 221 to the rear side, the fastening protrusion 1513 may be deformed to protrude inwardly from the outer circumferential surface of the outer body 11. Accordingly, referring to FIG. 12, the fastening protrusion 1513 may be deformed to be fastened to the fastening groove 111 while non-protruding forward from the front end surface 1511 of the front part 151 in the restrained state. For reference, whether or not non-protrude forward from the front end surface may be determined to be non-protruded forward from the front end surface when it is within an error range considering in designing even if the fastening protrusion protrudes slightly forward ahead of the front end surface in consideration of an error, deformation of the front support unit, or the like.

[153] When comparing FIGS. 12 and 13, the fastening groove 111 may be a groove formed by pressing the outer circumferential surface of the front end portion of the outer body 11 while the fastening protrusion 1513 is deformed from an initial state to a restrained state. As described above, the fastening protrusion 1513 may be deformed in the form of being pressed back and plastically deformed to penetrate (press) the outer circumferential surface of the outer body 11. The fastening groove 111 may be formed on the outer circumferential surface of the outer body 11 by pressing according to the deformation of the fastening protrusion 1513. Accordingly, the fastening protrusion 1513 may be naturally engaged with and fastened to the fastening groove 111 formed by pressing of the fastening protrusion.

[154] Alternatively, as another example, referring to FIG. 14, the fastening groove 111 may be a groove pre-formed on the outer circumferential surface of the front end portion of the

outer body 11 before swaging the swage ring 15. In this case, less external force may be required to fasten the fastening protrusion 1513 and the fastening groove 111. The pre-formed groove may be previously formed on the outer circumferential surface of the outer body 11 before fastening the fastening groove 111 and the fastening protrusion 1513 in consideration of a position, a depth, and a width of the fastening groove 111 in the restrained state. Alternatively, the pre-formed groove may be previously formed only to guide the deformation of the fastening protrusion 1513 to be induced to the inside thereof, and may be extended to have a greater depth, width, and the like in the restrained state. As such, it may be understood in a wide concept that the pre-formed groove is formed only to guide, and then when the fastening protrusion 1513 is inserted, a groove formed wider or deeper is included.

[155] Referring to FIG. 12, the fastening groove 111 may be formed on the outer circumferential surface of the outer body 11 to be positioned between the front end surface 1511 and the recessed surface 1512 of the front part 151 of the swage ring 15 in a restrained state. Accordingly, when the front support unit 22 presses the fastening protrusion 1513 backward while contacting the front end surface 1511 of the swage ring 15, the fastening protrusion 1513 formed to obliquely protrude to the front inside is naturally deformed, and a part of the fastening protrusion 1513 may be inserted to the fastening groove 111 to engage with the fastening groove 111.

[156] In addition, the front support unit 22 has a first body contact recessed surface 222 recessed forward ahead of the first ring contact circumferential surface 221 so as to contact the front end surface of the front end portion 11c of the outer body 11 in a restrained state. Referring to FIG. 12, the first body contact recessed surface 222 may be recessed to come into contact with the front end surface of the front end portion 11c

of the outer body 11 when the first ring contact circumferential surface 221 of the front support unit 22 comes into contact with the front end surface 1511 of the front part 151 of the swage ring 15. For example, referring to FIG. 12, a distance (an amount of recession of the first body contact recessed surface) in the front-rear direction between the first ring contact circumferential surface 221 and the first body contact recessed surface 222 may be set to correspond to a length between the front end surface of the front end portion 11c of the outer body 11 and the front end of the fastening groove 111.

[157] Referring to FIG. 10, the front end portion 11c may have an outer diameter relatively larger than that of the middle part 11a due to the swaging of the swage ring 15 which deforms the middle part 11a in a direction of decreasing the outer diameter. Referring to FIG. 10, as described above, since the swage ring 15 has a shorter length than the outer body 11, the swage ring 15 may press the middle part 11a of the outer body 11 without reaching the front end portion 11c. Accordingly, the front end portion 11c of the outer body 11 may have an outer diameter relatively larger than that of the middle part 11a of the outer body 11 having the reduced outer diameter.

[158] Referring to FIG. 10, the front end portion 11c may prevent the swage ring 15 from being detached forward by an outer diameter relatively larger than the middle part 11a. In other words, the front end portion 11c naturally having a relatively larger outer diameter than the middle part 11a by the swaging method of pressing only the middle part 11a of the outer body 11 of the present invention may serve as a limiting jaw (limiter) that restricts further advancement in the direction in which the swage ring 15 has advanced after the swaging is completed.

[159] Referring to FIGS. 10 and 11, at the front end portion of the inner circumferential surface of the swage ring 15, the front tapered portion 152 may be formed to come into

contact with a part of the outer circumferential surface of the front end portion 11c which has an outer diameter relatively larger than that of the middle part 11a by swaging of the swage ring 15 which deforms the middle part 11a in a direction of decreasing the outer diameter. The inner diameter of the front tapered portion 152 may increase toward the front side. The introduction of the swage ring 15 into the rear introducing portion 11b may be smoothly and easily made by the front tapered portion 152. In addition, a part of the outer circumferential surface of the front end portion 11c of the outer body 11 may be provided in the form of gradually enlarging (extending) an outer diameter while coming into contact with the front tapered portion 152 by the front tapered portion 152. Thus, the frictional resistance due to the contact may be organically combined in the role of the limiting jaw of the front end portion 11c. That is, the front end portion 11c may serve as a limiting jaw that restricts the forward detachment of the swage ring 15 by the outer diameter relatively larger than the middle part 11a and the frictional resistance with the front tapered portion 152. As such, when the front tapered portion 152 is formed in the swage ring 15, a portion (the front tapered portion) of the swage ring 15 may also come into contact with the front end portion 11c of the outer body 11 as described above. That is, the swage ring 15 swages by pressing the middle part 11a of the outer body 11 to the inner circumferential surface having the largest inner diameter, whereas may be subjected to swaging which is gradually relaxed forward by pressing a portion of the front end portion 11c of the outer body 11 by the front tapered portion 152 of which the inner diameter is gradually extended.

[160] Referring to FIGS. 10 and 12, the front tapered portion 152 may be formed to connect the front part 151 and the middle portion formed to have a constant inner diameter in the swage ring 15. In addition, the fastening protrusion 1513 may be provided to be

fastened with the fastening groove 111 formed on the outer circumferential surface of the front end portion 11c of which an outer diameter is relatively larger than that of the middle part 11a by swaging of the swage ring 15 in the restrained state. In addition, the swage ring 15 may include a middle portion formed to have a constant inner diameter, thereby acting and pressing a constant external force against the middle part 11a of the outer body 11.

- [161] The inner diameter of the front part of the swage ring 15 (the front part of the front tapered portion 152) may have an inner diameter capable of being fitted to the outer body 11 (particularly, the rear introducing portion 11b) so that the swage ring 15 is introduced (assembled) into the outer body 11 so as not to be easily detached from the outer body 11 before movement to the front side of the swage ring 15 is made (before fastening starts by the fastening tool 2). The front tapered portion 152 connected to the front part of the swage ring 15 may be formed to be inclined to have an inner diameter that gradually decreases backward from the inner diameter corresponding to the outer diameter of the outer body 11 to be fitted. As such, the inner diameter of the rear end of the front tapered portion 152 (the portion connected to the middle portion of the swage ring as the most end portion) is set to be smaller than the outer diameter of the outer body 11, so that a part of the front end portion 11c of the outer body 11 may serve as a limiting jaw that causes frictional resistance and shear resistance with respect to the front tapered portion 152. At this time, in the case of the inner diameter of the rear end of the front tapered portion 152, within the range set smaller than the outer diameter of the outer body 11, the inner diameter may be preferably determined to a proper numerical value considering a mechanical coupling requirement value of the pipe connection device and a manufacturing tolerance of the pipe (tube).

[162] In addition, although not illustrated in the drawings, a rear tapered portion may be formed at the rear end of the inner circumferential surface of the swage ring 15. The rear tapered portion may have a shape in which the inner diameter increases toward the rear side. As described above, the rear introducing portion 11b of the outer body 11 is deformed in a direction in which the outer diameter is reduced by swaging of the swage ring 15, and then at least a portion of the outer body 11 is elastically restored after the swage ring 15 passes, or at least a portion of the outer circumferential surface side thereof may be pulled forward according to the movement of the swage ring 15 to be deformed in a direction in which the outer diameter becomes larger than that of the middle part 11a. At this time, the rear tapered portion is in contact with a part of the rear introducing portion 11b having an outer diameter relatively larger than the middle part 11a of the outer body 11, so that the rear introducing portion 11b serves as a limiting jaw for preventing backward movement of the swage ring 15, thereby exhibiting friction resistance due to a contact. That is, the rear introducing portion 11b of the outer body 11 may serve as a limiting jaw that limits the backward movement of the swage ring 15 as the outer diameter is relatively larger than that of the middle part 11a. In the case where the rear tapered portion is formed at the swage ring 15, resistance by friction with the rear tapered portion may be organically combined to act more strongly as a limiting jaw.

[163] In the second pipe connection device, referring to FIGS. 12 to 14, the inner circumferential surface of the front end portion 11c of the outer body 11 may have a front end support member 1191 which protrudes inward to maintain an outer diameter relatively larger than the intermediate portion 11a. According to the front end support member 1191, the influence of deformation in which the outer diameter of the outer

body 11 is reduced by swaging by the swage ring 15 may be more minimized with respect to the front end portion 11c of the outer body 11. Referring to FIGS. 12 to 14, at least a portion of the front end support member 1191 may be provided between the front tapered portion 152 and the front end surface of the outer body 11.

[164] In addition, the outer body 11 and the swage ring 15 may be made of the same material as the first pipe 210 and the second pipe 220. This is to minimize a change in the physical bonding force between the first pipe 210 and the outer body 11 and between the second pipe 220 and the outer body 11 due to an influence of a surrounding environment of the first pipe 210 and the second pipe 220, such as a temperature change. In addition, when metals having the same material as the first pipe 210 and the second pipe 220 are used in the outer body 11 and the swage ring 15, there is also an advantage that potential corrosion due to a potential difference between metals in contact with each other may be minimized

[165] In addition, each of the outer circumferential surface of the outer body 11 and the inner circumferential surface of the swage ring 15 may be preferably lubricated and coated with a lubricant or a material having good lubricity. This is to lower the need to use unnecessarily strong fastening tools. However, a material that is coated on the outer circumferential surface of the outer body 11 and the inner circumferential surface of the swage ring 15 for lubricating coating has corrosion resistance of corrosion resistance surface treatment or less applied to the first pipe 210 and the second pipe 220, it is preferred that corrosion resistant surface treatment is first performed on the outer body 11 and the swage ring 15 before lubrication coating to ensure corrosion resistance equal to or greater than that of the material of the pipe (the first pipe 210 and the second pipe 220).

- [166] Referring to FIGS. 10 and 11, the inner circumferential surface of the outer body 11 may have an inner protrusion 116 which comes into contact with the first pipe 210 and the second pipe 220 during swaging of the swage ring 15. In the swaging process, the outer body 11 may be plastically deformed in a direction in which the inner diameter and the outer diameter are reduced. Accordingly, a portion of the inner protrusion 116 formed on the inner circumferential surface of the outer body 11 corresponding to the outer circumferential surface of the first pipe 210 is in contact with the outer circumferential surface of the first pipe 210 and at least a part may be deformed by pressing the outer circumferential surface of the first pipe 210. A portion of the inner protrusion 116 corresponding to the outer circumferential surface of the second pipe 220 comes into contact with the outer circumferential surface of the second pipe 220 and press the outer circumferential surface of the second pipe 220 to be at least partially deformed. Also, each of the first pipe 210 and the second pipe 220 may be deformed by the pressing of the inner protrusion 116. Accordingly, a portion of the inner protrusion 116 may be coupled to the first pipe 210 in the form of penetrating the outer circumferential surface of the first pipe 210. In addition, another portion of the inner protrusion 116 may be coupled to the second pipe 220 in the form of penetrating the outer circumferential surface of the second pipe 220.
- [167] In addition, a minimum inner diameter of the inner protrusion 116 may have a larger value than the maximum outer diameter considering the tolerances of the first pipe 210 and the second pipe 220 in consideration of the manufacturing tolerance of the first pipe 210 and the second pipe 220.
- [168] Also, referring to FIGS. 10 and 11, the inner protrusion 116 is preferably formed in a symmetrical shape with respect to the center point between the first pipe 210 and the

second pipe 220 in the longitudinal direction such that the same or similar physical deformation or fastening may be made to each of the first pipe 210 and the second pipe 220.

[169] In addition, the inner protrusion 116 may include a sealing-type protrusion which seals between the middle part 11a and the first pipe 210 or between the middle part 11a and the second pipe 220 and resists an axial force applied to the first pipe 210 or the second pipe. A plurality of inner protrusions 116 is provided, and some of the plurality of inner protrusions 116 press the first pipe 210 and some of the plurality of inner protrusions 116 press the second pipe 220 during swaging of the swage ring 15 to seal between the outer body 11 and the first pipe 210 and between the outer body 11 and the second pipe 220. For example, the sealing-type protrusion may be provided in an annular structure that extends continuously in a circumferential direction. In addition, a plurality of sealing-type protrusions may be provided at intervals in the longitudinal direction.

[170] The sealing-type protrusion may be a lattice-type protrusion in which if there is a defect on the outer circumferential surface of the first pipe 210 or the second pipe 220, lattices adjacent to the defect form a closed space of the local area and are repeatedly arranged in the circumferential direction on the inner circumferential surface of the middle part 11a so as to resist torsion together. In other words, the sealing-type protrusion may be provided to protrude in the form of a lattice. For example, the lattice shape may be provided as an axial symmetric structure, but is not limited thereto. Accordingly, the sealing-type protrusion, such a lattice-type protrusion, may protrude in a lattice form in the circumferential direction on the inner circumferential surface so that if there is a defect on the surfaces of the first pipe 210 and the second pipe 220, lattices adjacent to

the defect form a closed space of the local area and prevent torsion of the first pipe 210 and the second pipe 220. As such, when the sealing-type protrusion is provided in the form of a lattice, each lattice acts as a kind of partition wall that partitions an area inside the lattice with an area outside the lattice, thereby more enhancing a higher anti-leakage capability. That is, when the sealing is made in the form of a lattice, leakage from the defect may be limited to only a predetermined lattice area and additional leakage to the outside of the lattice area may be blocked. In addition, the lattice shape may serve to resist the torsion applied to the pipe as well as to resist the axial force applied to the pipe due to the structure.

[171] In addition, the inner protrusion 116 may include a torsion resistant protrusion that resists the torsion acting on the first pipe 210 or the second pipe 220.

[172] For example, the torsion resistant protrusion may have a knurling shape (spline). In other words, the torsion resistant protrusion has a tooth form elongated in the longitudinal direction (continuously extending in the longitudinal direction) which is repeatedly disposed along the circumferential direction on the inner circumference of the outer body 11 (internal gear shape). In other words, the inner protrusion 116 may be provided to have a tooth form when viewing the inner circumference of a longitudinal cross-section of the outer body 11. The torsion resistant protrusion may be provided to extend from the middle part 11a of the outer body 11 to the rear introducing portion 11b or the front end portion 11c. By arranging such a torsion resistant protrusion, a structure in which the torsion resistant protrusion is more effectively resistant also to a bending deformation moment applied to the pipe may be provided. Further, the torsion resistant protrusion may be applied in combination with the above-mentioned sealing-type protrusion. In another example, the inner protrusion

116 may be formed in an annular shape having an oblique inclination (an acute angle inclination of less than 90 degrees with respect to the axial direction of the pipe), or formed as a lattice protrusion as described above to serve as both the sealing-type protrusion and the torsion resistant protrusion. As such, the inner protrusion 116 may be provided in various forms in consideration of sealing, axial force resistance, torsion resistance, and the like.

[173] In addition, the inner protrusion 116 may be configured to be integrally formed on the inner surface of the outer body 11. Alternatively, as another example, the inner protrusion 116 may be implemented by inserting a ring-shaped part processed separately from the outer body 11. When the inner protrusion 116 is formed through the ring-shaped part processed separately, since the airtightness needs to be satisfied with respect to both the inner surface of the outer body 11 and the outer surface of the pipe (first pipe 210 or second pipe 220), it is preferable that the projections are formed on a portion contacting each surface (both an outer end and an inner end in a radial direction in the form of separately processed rings). In addition, when the inner protrusion 116 is a ring-shaped part separately processed, the strength and hardness of the ring-shaped part may be set to be higher than the strength and hardness of the outer body 11 and higher than the strength and hardness of the first and second pipes 210 and 220. According to such strength and hardness setting, the inner protrusion 116 may be formed to penetrate deeper into the inner surface of the outer body and the outer surface of the pipe, thereby improving the airtightness and mechanical strength of the second pipe connection device.

[174] In addition, the length of the outer body 11 may be set to a length that satisfies the minimum number of inner protrusions 116 capable of withstanding the axial external

force on the pipe that is expected or actually acted upon in the pipe connection design. Since the length of the outer body 11 is related to the structural strength of the inner protrusion 116 and the strength of the first pipe 210 and the second pipe 220, the length of the outer body 11 is preferably set differently according to each case and conditions based on the material and shape of the inner protrusion 116, the material and thickness of the first pipe 210 and the second pipe 220, etc.

[175] In addition, referring to FIG. 10, the inner circumferential surface of the middle part 11a corresponding to the center of the outer body 11 may have a stopper (not illustrated) which limits forward movement of the first pipe 210 and limits backward movement of the second pipe 220. For example, the stopper may be formed on the inner circumference of the middle part 11a of the outer body 11. The stopper may limit the forward movement of the first pipe 210 and the backward movement of the second pipe 220. In other words, each of the first pipe 210 and the second pipe 220 may be inserted into the outer body 11 to a position in contact with the stopper. By disposing the stopper at the center of the middle part 11a, the symmetrical arrangement of the first pipe and the second pipe with respect to the outer body 11 may be facilitated. The inner protrusion 116 described above may be symmetrically formed with respect to the stopper.

[176] In addition, the stopper may be provided in the same as or similar to the inner protrusion 116. For example, the stopper may be configured to be integrally formed on the inner surface of the outer body 11. Alternatively, as another example, the stopper may be implemented in a form in which a ring-shaped part (for example, a C-shaped ring) processed separately from the outer body 11 is inserted into the outer body 11.

[177] Meanwhile, in order to adjust and align a gap between the first pipe 210 and the second

pipe 220 before the fastening operation (swaging), it may be easier for the stopper 117 not to be provided. In addition, in the case of an operation for repairing the pipe (the first pipe 210 or the second pipe 220), it may be more preferable that there is no stopper, and thus the stopper may be selectively provided in some cases.

[178] Referring to FIGS. 11 and 13, the second pipe connection device may include a fastening tool 2. The fastening tool 2 may be a temporary configuration in which the swage ring 15 is fastened to surround the middle part 11a and then removed.

[179] As described above, the fastening tool 2 may include a rear support unit 21, a front support unit 22, and a driving unit. For example, the driving unit may relatively pull the rear support unit 21 with respect to the front support unit 22 and move the rear support unit 21 and the front support unit 22 to be close to each other. Since various driving devices such as a driving unit (actuator) using hydraulic pressure may be applied to the driving unit, a more detailed description thereof will be omitted.

[180] Referring to FIGS. 10 and 11, the rear support unit 21 may have a second ring contact circumferential surface 211 coming into contact with the rear end surface of the swage ring 15, and a second body contact recessed surface 212 formed to be recessed backward ahead of the second ring contact circumferential surface 211 by a step and coming into contact with the rear end surface of the rear introducing portion 11b of the outer body 11. Here, the recession amount (step amount) of the second body contact recessed surface 212 may be set to correspond to the length of the rear introducing portion 11b, that is, equally. Alternatively, as another example, the recession amount (step amount) of the second body contact recessed surface 212 is set to be shorter than the length of the rear introducing portion 11b, so that while the rear introducing portion 11b is compressed by a difference between the recession amount (step amount) and the

length of the rear introducing portion 11b, deformation in which a part thereof protrudes outward may occur and a bead for limiting the backward movement of the swage ring 15 may be formed by the protruding deformation. In addition, in order to induce such bead formation, a groove for inducing beads to be recessed outward may be formed in the inner circumferential surface of the rear introducing portion 11b. That is, according to the groove for inducing beads formed on the inner circumferential surface of the rear introducing portion 11b, when the rear introducing portion 11b is compressed, deformation in a direction in which a part thereof protrudes outward may be induced more naturally.

[181] In the second pipe connection device, the outer body 11 is provided without a structure protruding to the outer surface and an outer protrusion in the middle part 11a unlike the related art, so that the outer body 11 may be manufactured with as little processing and material as possible from raw materials in the form of pipes and only the material amount, thereby greatly reducing manufacturing cost. In addition, since the mechanical coupling of the swage ring 15 and the outer body 11 may be made by plastic deformation of the fastening protrusion 1513, by using a friction coupling configuration between the swage ring and the outer body 11 in the related art or an elastic deformation configuration of a member, a high detachment stopping force may be secured compared to a method for preventing the detachment from the outer body of the swage ring. Accordingly, in the pipe connection device, greater mechanical coupling performance against vibration and shock may be ensured.

[182] In addition, since a direct mechanical coupling is made between the swage ring 15 and the outer body 11, a function of the protrusion of the middle part 11a of the outer body in the related art (mounting of the fastening tool and fixing the swage ring) is

unnecessary. As a result, since the length of the outer body 11 may be reduced compared to the conventional outer body, it is possible to greatly reduce the weight and perform construction in a narrower space.

[183] Hereinafter, a pipe connection method (hereinafter, referred to as 'a second pipe connection method') according to a second embodiment of the present invention will be described. However, the second pipe connection method shares the same or corresponding technical features and configurations as or to the above-described second pipe connection device. Therefore, descriptions overlapping with those described in the second pipe connection device will be simplified or omitted, and the same reference numerals will be used for the same or similar components.

[184] The second pipe connection method relates to a method for connecting facing end portions of two pipes 210 and 220 to each other.

[185] The second pipe connection method includes preparing a pipe for an outer body forming the outer body 11. The pipe for the outer body may have the middle part 11a, the front end portion 11c, and the rear introducing portion 11b described above. In addition, the pipe for the outer body may have an inner protrusion 116 and a stopper.

[186] In addition, the second pipe connection method includes inserting an end portion of the first pipe 210 into the outer body 11 from the rear side and inserting an end portion of the second pipe 220 from the front side of the outer body 11 (first step).

[187] In addition, the second pipe connection method includes disposing the swage ring 15 to be located at the rear of the pipe for the outer body with respect to the outer circumferential surface of the first pipe 210 (second step). The second step may be performed after the first step and if necessary, may also be performed before the first step.

- [188] The second pipe connection method includes disposing the fastening tool 2 (third step). The fastening tool 2 may include a rear support unit 21 coming into contact with the rear end surface of the swage ring 15, and a front support unit 22 coming into contact with the front end surface of the front end portion 11c of the outer body 11. In addition, the fastening tool 2 may include a driving unit which provides an axial compressive force by a driving force and the driving force to move the rear support unit 21 relatively to the front support unit 22 side.
- [189] The second pipe connection method includes disposing (fastening) the swage ring 15 to perform swaging and surround the middle part 11a of the outer body 11 (fourth step). In the fourth step, the fastening groove 111 of the outer body 11 and the fastening protrusion 1513 of the swage ring 15 are fastened to each other to become a restrained state. For reference, the fastening groove 111 may be a groove previously formed before the fourth step, or may be a groove formed by the deformation of the fastening protrusion 1513 in the fourth step.
- [190] In addition, the second pipe connection method may include removing the fastening tool 2 (fifth step) after fastening the swage ring 15 to surround the middle part 11a.
- [191] Hereinafter, a pipe connection device according to a third embodiment of the present invention (hereinafter, referred to as 'a third pipe connection device') will be described. For reference, reference numerals used in the following description of the third pipe connection device may be understood as reference numerals corresponding to the reference numerals shown in FIGS. 15 to 20.
- [192] FIG. 15 is a schematic cross-sectional view of a third pipe connection device, FIG. 16 is a schematic cross-sectional view illustrating that a swage ring of the third pipe connection device is introduced into a rear introducing portion for swaging, and FIG. 17

is an enlarged view of A of FIG. 15. For reference, it is preferred to understand the description of the present invention in consideration of at least some of the plastic deformation caused by swaging in the figures of the present invention, which may be simplified or omitted.

[193] Referring to FIG. 15, the third pipe connection device relates to a device for connecting facing end portions of two pipes 210 and 220 to each other.

[194] Referring to FIG. 15, the third pipe connection device includes an outer body 11. The outer body 11 is configured such that an end portion of the first pipe 210 is inserted from the rear thereof (9 o'clock direction based on FIG. 15) and an end portion of the second pipe 220 is inserted from the front thereof (3 o'clock direction based on FIG. 15).

[195] Referring to FIG. 15, the outer body 11 may be disposed in such a manner that a rear part 11b surrounds an end portion (front end portion) of the first pipe 210. In addition, the outer body 11 may be disposed in a form in which a front part 11c surrounds an end portion (rear end portion) of the second pipe 220. For reference, referring to FIG. 15, the outer body 11 may be divided into the front part 11c and the rear part 11b in a longitudinal direction (3 o'clock to 9 o'clock directions based on FIG. 15).

[196] In addition, the front part 11c and the rear part 11b of the outer body 11 may be symmetrical based on the center. Here, a space between the front part 11c and the rear part 11b may mean, for example, a space between the first pipe 210 and the second pipe 220 or a center portion of the outer body 11. Since the front part 11c and the rear part 11b are symmetrical with each other, in the description of the third pipe connection device, even if there is no further detailed description of the front part 11c, the configuration, operation, effects and the like of the front part 11c may be understood to be the same as or similar to those of the rear part 11b.

- [197] Referring to FIG. 15, the rear part 11b of the outer body 11 may be divided into a front end portion 11b-3, a middle portion 11b-1, and a rear introducing portion 11b-2. Here, the rear introducing portion 11b-2 may mean a portion into which a swage ring 15 to be described later is introduced. In addition, the middle portion 11b-1 may mean a portion that is swaged by the swage ring 15 to have a constant outer diameter, and the middle portion 11b-1 may be a middle portion except for the rear introducing portion 11b-2 and the front end portion 11b-3. In addition, the front end portion 11b-3 may basically include a portion where the swage ring 15 does not reach and does not contact. In addition, the front end portion 11b-3 may also include a portion which is in contact with the swage ring 15 to perform predetermined swaging, but swaging is gradually relaxed by a tapered portion so that the inner diameter is gradually increased toward the front thereof, not swaging by the portion having the smallest constant inner diameter of the swage ring 15. That is, the front end portion 11b-3 may refer to a front portion in which no maximum swaging is made by the portion having the minimum inner diameter of the swage ring 15 (the front portion with smaller swaging lessened than maximum swaging and the front portion with a swage ring uncontacted or unreached).
- [198] In addition, referring to FIG. 15, the front part 11c of the outer body 11 is symmetrical with the rear part 11b described above, and may be divided into the rear end portion 11c-3, the middle portion 11c-1 and the front introducing portion 11c-2. The rear end portion 11c-3, the middle portion 11c-1 and the front introducing portion 11c-2 are configured symmetrically with the front end portion 11b-3, the middle portion 11b-1, and the rear introducing portion 11b-2 of the rear part 11b, and may have the same as or similar configurations and effects, and thus detailed description thereof will be omitted.
- [199] Referring to FIG. 15, the outer body 11 is a configuration which is pressed by the swage

ring 15 and another swage ring 16 to be described later to come into contact with outer circumferential surfaces of the first pipe 210 and the second pipe 220 which are located therein. The outer body 11 may connect the first pipe 210 and the second pipe 220 mechanically while preventing the leakage of materials inside the first pipe 210 and the second pipe 220 and the separation (detachment) of the first pipe 210 and the second pipe 220. For this purpose, the outer body 11 needs to have a mechanical strength equal to or higher than that of the first pipe 210 and the second pipe 220.

[200] Referring to FIG. 15, the third pipe connection device includes a swage ring 15. An initial inner diameter of the swage ring 15 before swaging may be smaller than an initial outer diameter of the outer body 11 (in particular, the middle portion 11b-1 of the rear part 11b) before swaging. Referring to FIG. 16, the swage ring 15 may be introduced from the rear introducing portion 11b-2 to move forward and swage the rear part 11b of the outer body 11.

[201] Referring to FIG. 15, the swage ring 15 contacts and presses the outer body 11 by surrounding the outer circumference of the rear part 11b of the outer body 11. The contact and pressing of the swage ring 15 to the rear part 11b are performed with respect to the middle portion 11b-1 except for the rear introducing portion 11b-2 which contacts the rear part 11b only upon introduction of the swage ring 15 and the front end portion 11b-3 which does not contact the swage ring 15 in the rear part 11b. However, when a front tapered portion 152 to be described later is formed in the swage ring 15, the front tapered portion 152 of the swage ring 15 may also contact the front end portion 11b-3. A portion of the front end portion 11b-3 of the rear part 11b which comes into contact with the front tapered portion may be a portion where swaging is gradually relaxed along an increasingly expanding inner diameter of the front tapered portion as compared

to the swaging by the portion having a constant minimum inner diameter of the swage ring 15. That is, the middle portion 11b-1 of the rear part 11b may mean a portion where swaging is performed by a constant minimum inner diameter of the swage ring 15, and the front end portion 11b-3 of the rear part 11b basically includes a portion where the swage ring 15 is not reached as a front portion of such a middle portion 11b-1. If the swage ring 15 has a front tapered portion, the swage ring 15 may include a portion where the front tapered portion swages. Accordingly, referring to FIG. 15, the swage ring 15 may have a shorter length than that of the rear part 11b of the outer body 11 to surround the outer circumference of the middle portion 11b-1 of the rear part 11b.

[202] When comparing FIGS. 15 and 16, the rear part 11b of the outer body 11 may be in a state in which at least a part thereof is plastically deformed by swaging. For example, referring to FIG. 15, the middle portion 11b-1 of the rear part 11b may be deformed in a direction in which the outer diameter is reduced by swaging. In addition, the rear introducing portion 11b-2 of the rear part 11b is deformed in a direction in which the outer diameter is reduced by swaging of the swage ring 15, and then at least a portion of the rear introducing portion 11b-2 is elastically restored after the swage ring 15 passes, or at least a portion of the outer circumferential surface side thereof may be pulled forward according to the movement of the swage ring 15 to be deformed in a direction in which the outer diameter relatively becomes larger than that of the middle portion 11b-1.

[203] In addition, the third pipe connecting device may include another swage ring 16 which surrounds and contacts and presses the outer circumference of the front part 11c of the outer body 11, and is provided symmetrically with the swage ring 15 based on a space between the rear part 11b and the front part 11c. Referring to the drawing, a space

between the rear part 11b and the front part 11c may refer to, for example, a space between the first pipe 210 and the second pipe 220 or a center portion of the outer body 11. For reference, in the third pipe connection device, when another swage ring 16 is included, the swage ring 15 corresponding to reference numeral 15 may also be referred to as a first swage ring and another swage ring 16 corresponding to reference numeral 16 may also be referred to as a second swage ring. In addition, since the other swage ring 16 (the second swage ring 16) provided in the front part 11c is configured to be symmetrical with the swage ring 15 (the first swage ring 15), in the description of the third pipe connection device, even if there is no further detailed description of another swage ring 16 provided in the front part 11c, it can be understood that the structure, function, effect, etc. of another swage ring 16 provided in the front part 11c are the same as or similar to those of the swage ring 15 provided in the rear part 11b.

[204] For example, it can be understood that a rear part 161, a rear end surface 1611, a fastening protrusion 1613, a rear tapered portion 162, etc. of another swage ring 16 may be the same as or similar to the front part 151, the front end surface 1511, the fastening protrusion 1513, the front tapered portion 152, etc. of the swage ring 15. As another example, the contact and pressing of the front part 11c of another swage ring 16 may be performed with respect to the middle portion 11c-1 except for the front introducing portion 11c-2 coming into contact with another swage ring only in the introduction of another swage ring 16 and the rear end portion 11c-3 not coming into contact with another swage ring 16 in the front part 11c so as to be symmetrical with the contact and pressing of the rear part 11b of the swage ring 15. It can be understood that the configuration, function, effect, etc., in the case where the rear tapered portion 162 is formed on another swage ring 16 to be described later may be the same as or similar to

those in the case in which the swage ring 15 has the front tapered portion 152 formed thereon. In addition, it can be understood that the deformation by the swaging of the front part 11c of the outer body 11 may be the same as or similar to the deformation by the swaging of the front part 11b of the outer body 11 (for example, the middle portion 11c-1 of the front part 11c may be deformed in a direction in which the outer diameter is reduced by swaging, the front introducing portion 11c-2 of the front part 11c is deformed in a direction in which the outer diameter is reduced by swaging of another swage ring 16 and then at least partially elastically restored after another swage ring 16 passes. The outer circumferential surface side thereof is pulled backward at least partially according to the movement of another swage ring 16, and is deformed in a direction in which the outer diameter becomes larger than that of the middle portion 11c-1, so that at least a part may be plastically deformed the same as or similar to the deformation of the front part 11b.

[205] Accordingly, hereinafter, configurations and effects related with the swage ring 15 and the rear part 11b of the outer body 11 swaging by the swage ring 15 will be described below, rather than the configurations and effects related with another swage ring 16 and the front part 11c of the outer body 11 swaging by another swage ring 16.

[206] Referring to FIGS. 15 and 16, by swaging of the swage ring 15 which deforms the middle portion 11b-2 of the rear part 11b in a direction in which the outer diameter is reduced, at least a part of the inner circumferential surface of the middle portion 11b-2 may press the outer circumferential surface of the first pipe 210. In addition, by swaging another swage ring 16 which deforms the middle portion 11c-2 of the front part 11c in the direction of decreasing outer diameter, at least a part of the inner circumferential surface of the middle portion 11c-2 may press the outer circumferential

surface of the second pipe 220.

[207] Referring to FIGS. 15 and 17, a fastening groove 111 is formed on an outer circumferential surface of the front end portion 11b-3 of the rear part 11b. In addition, the swage ring 15 includes a front part 151 provided with a fastening protrusion 1513 that obliquely protrudes toward the front inward and fastened to the fastening groove 111. That is, according to the third pipe connection device, a restrained state in which the fastening protrusion 1513 is fastened to the fastening groove 111 may be implemented. For reference, the fact that the fastening protrusion 1513 protrudes obliquely toward the front inside may mean that the fastening protrusion 1513 protrudes toward the front side of the swage ring 15, but extends obliquely toward the inside. This restrained state may mean a state in which the backward movement of the swage ring 15 is prevented by fastening the fastening protrusion 1513 and the fastening groove 111. By the restrained state, the swage ring 15 and the outer body 11 may be coupled to each other such that the backward movement of the swage ring 15 is limited. Accordingly, a structure (fastening protrusion 1513) for coupling with the outer body 11 may be formed in the front part 151 of the swage ring 15.

[208] Further, for example, the fastening protrusion 1513 may have an annular shape that continuously extends in the circumferential direction, and the fastening groove 111 may continuously extend in the circumferential direction corresponding to the annular fastening protrusion 1513.

[209] Referring to 15 and 17, a fastening groove 111 may be formed on the outer circumferential surface of the rear end portion 11c-3 of the front part 11c to correspond to a fastening protrusion 1613 of another swage ring 16. The coupling of the fastening protrusion 1613 of the other swage ring 16 provided with respect to the front part 11c

and the fastening groove 111 of the front part 11c is similar to the coupling of the fastening protrusion 1513 of the swage ring 15 provided with respect to the rear part 11b and the fastening groove 111 of the rear part 11b in configuration, function, effect, and the like, and thus detailed description thereof will be omitted.

[210] In addition, the fastening protrusion 1513 is deformed into a restrained state to be fastened to the fastening groove 111 in an initial state protruding so as not to interfere with the outer circumferential surface of the outer body 11 by the axial compressive force thereto. In other words, the fastening protrusion 1513 has an initial state so as not to interfere with respect to the outer circumferential surface of the outer body 11 before the axial compressive force is applied thereto and moves forward according to the forward movement of the swage ring 15. In addition, if the axial compressive force is applied, the fastening groove 111 may be deformed to be fastened to the fastening groove 111 formed on the outer circumferential surface of the outer body 11. For reference, when the fastening protrusion 1513 has an annular shape, a minimum inner diameter in the initial state of the fastening protrusion 1513 may be larger than the outer diameter of the outer body 11 so as not to interfere with the outer circumferential surface of the outer body 11 of the fastening protrusion 1513. For reference, the axial compressive force may mean a compressive force applied to the front and rear sides (longitudinal direction). Since the fastening protrusion 1513 protrudes forward, the axial compressive force may be a pressure applied to the rear side so that the fastening protrusion 1513 is deformed while being compressed.

[211] More specifically, referring to FIGS. 16 and 17, a recessed surface 1512 recessed backward with a step may be formed below the front end surface 1511 of the front part 151. In addition, the fastening protrusion 1513 may be provided to protrude forward

ahead of the front end surface 1511 of the front part 151 from the recessed surface 1512 in the initial state.

[212] In addition, when in the initial state a portion protruding forward ahead of the front end surface 1511 of the front part 151 is pressed backward to a position corresponding to the front end surface 1511 of the front part 151 by the axial compressive force, the fastening protrusion 1513 may be provided in a shape that is induced to be protruding-deformed inward ahead of the outer circumferential surface of the outer body 11.

[213] For example, referring to FIG. 16, the fastening protrusion 1513 in the initial state may protrude obliquely toward the front inside. This may mean that the fastening protrusion 1513 protrudes forward, but is formed obliquely toward the inside. If the fastening protrusion 1513 protrudes obliquely toward the front outside, the fastening protrusion 1513 may be induced to be deformed toward the outside at the time of the back pressing and may not be fastened to the fastening groove 111. Therefore, the fastening protrusion 1513 of the initial state may be preferably provided with a shape (for example, a shape protruding obliquely toward the front inside) which is induced to be deformed to protrude inward ahead of the outer circumferential surface of the outer body 11 in the back pressing.

[214] In addition, upon moving forward of the swage ring 15, the swage ring 15 may move forward until the front end surface 1513 comes into contact with an object located in the front of the swage ring 15 (e.g., may be another swage ring or a front support unit, which will be described below in detail).

[215] In the process of moving forward, a portion protruding forward ahead of the front end surface 1511 of the fastening protrusion 1513 may come into contact with an object earlier than the front end portion 1511. An axial compressive force is applied to the

protruding portion of the fastening protrusion 1513 to be pressed backward until a position corresponding to the front end portion 1511 of the front part 151. Accordingly, the fastening protrusion 1513 may be deformed to be at least partially bent or plastically deformed in a lower direction, a rear lower direction, or the like to penetrate (press) the outer circumferential surface of the outer body 11. In other words, the fastening protrusion 1513 may be deformed to protrude inwardly ahead of the outer circumferential surface of the outer body 11 by the back pressing by the object. Accordingly, referring to FIG. 17, the fastening protrusion 1513 may be deformed to be fastened to the fastening groove 111 while non-protruding forward ahead of the front end surface 1511 of the front part 151 in the restrained state. For reference, whether or not non-protrude forward ahead of the front end surface may be determined to be non-protruded forward ahead of the front end surface when it is within an error range considered in designing even if the fastening protrusion protrudes slightly forward ahead of the front end surface in consideration of an error, deformation of the object, or the like.

- [216] Referring to FIG. 17, the front end surface 1511 of the swage ring 15 may come into contact with the rear end surface 1611 of another swage ring 16 in a restrained state, and the fastening protrusion 1513 of the swage ring 15 may come into contact with the fastening protrusion 1613 of another swage ring 16 in a restrained state. For example, the swage ring 15 may be moved to a position where its front end surface 1511 may be in full contact with the rear end surface 1611 of another swage ring 16. For example, if the object is the front support unit of the fastening tool, the swage ring 15 may move until its front end surface 1511 is in contact with the front support unit to move to a position which may come into full contact with the rear end surface 1611 of another

swage ring 16. At this time, after the swage ring 15 moves to the position, another swage ring 16 may move until the rear end surface 1611 thereof comes into contact with the front end surface 1511 of the swage ring 15. As another example, if the object is another swage ring 16, the swage ring 15 may be moved until its front end surface 1511 comes into contact with the rear end surface 1611 of another swage ring 16. In this case, another swage ring 16 may be installed to swage the front part 11c of the outer body 11 earlier than the swage ring 15, and may be installed while symmetrically moving toward a central portion of the outer body 11 at the same time as the swage ring 15.

[217] In the installation process of the swage ring 15 and another swage ring 16 in the outer ring 11, the fastening protrusion 1513 of the swage ring 15 and the fastening protrusion 1613 of another swage ring 16 apply an external force (reaction force) to face each other to induce deformation into the restrained state of at least one of both fastening protrusions 1513 and 1613. Accordingly, in the restrained state, the front end surface 1511 of the swage ring 15 may come into contact with the rear end surface 1611 of another swage ring 16, and the fastening protrusion 1513 of the swage ring 15 may come into contact with the fastening protrusion 1613 of another swage ring 16.

[218] In addition, referring to FIG. 17, the fastening groove 111 of the rear part 11b is disposed between the front end surface 1511 of the swage ring 15 and the recessed surface 1512 of the swage ring 15 in the restrained state. Further, the fastening groove 111 of the front part 11c may be formed between the rear end surface 1611 of another swage ring 16 and the recessed face 1612 of another swage ring 16 in the restrained state. Accordingly, in the restrained state, the fastening protrusion 1513 of the swage ring 15 of the rear part 11b and the fastening protrusion 1613 of the swage ring 16 of the

front part 11c may be fastened to the fastening groove 111.

- [219] Referring to FIG. 17, the fastening groove 111 of the rear part 11b may be connected to the fastening groove 111 of the front part 11c. Therefore, specifications (data) such as a shape, a width, a depth, etc. of the fastening groove 111 may be set in consideration of the specifications (data) of the fastening protrusion of the swage ring 15 and specifications (data) of the fastening protrusion of another swage ring 16, so that the fastening protrusion 1513 of the swage ring 15 and the fastening protrusion 1613 of another swage ring 16 are set to be adjacent to each other in the front-rear direction and fit into the fastening groove 111.
- [220] Further, the forward movement of the swage ring 15 and the backward movement of another swage ring 16 may be made by a fastening tool.
- [221] For example, the fastening tool may move the swage ring 15 and another swage ring 16 such that the swage ring 15 and another swage ring 16 move symmetrically toward each other at the same time. In other words, the fastening tool may move the swage ring 15 and another swage ring 16 such that the forward movement of the swage ring 15 and the backward movement of another swage ring 16 are made at the same time. As described above, in this moving process, the fastening protrusion 1513 of the swage ring 15 comes into contact with the fastening protrusion 1613 of another swage ring 16 before the front end surface 1511 of the swage ring 15 comes into contact with the rear end surface 1611 of another swage ring 16. Until the front end surface 1511 of the swage ring 15 comes into contact with the rear end surface 1611 of another swage ring 16, the fastening protrusion 1513 of the swage ring 15 may be pressed backward and the fastening protrusion 1613 of the other swage ring 16 may be pressed forward. Accordingly, in the restrained state, the front end surface 1511 of the swage ring 15 may

come into contact with the rear end surface 1611 of another swage ring 16, and the fastening protrusion 1513 of the swage ring 15 may come into contact with the fastening protrusion 1613 of another swage ring 16. For example, the fastening tool may include a rear support unit coming into contact with the rear end surface of the swage ring 15, a front support unit coming into contact with the front end surface of another swage ring 16, and a driving unit which provides a driving force for relatively moving the rear support unit to the front support unit side so that the swage ring 15 moves to a position of surrounding the middle portion 11b-1 of the rear part 11b and an axial compressive force according to the driving force, and a driving force for relatively moving the front support unit to the rear support unit side so that another swage ring 16 moves to a position of surrounding the middle portion 11c-1 of the front part 11c and an axial compressive force according to the driving force.

[222] As another example, the fastening tool may first move either the swage ring 15 or another swage ring 16 to a planned position on the outer body 11. Next, the fastening tool may follow a sequential process of moving the other one of the swage ring 15 and another swage ring 16 to the planned position on the outer body 11.

[223] However, the fastening process of the swage ring 15 and another swage ring 16 using the fastening tool is not limited only to the above-described exemplary process, and various fastening tools and processes may be applied as necessary.

[224] FIG. 18 is a schematic cross-sectional view of another embodiment of a third pipe connection device, FIG. 19 is an enlarged view of C of FIG. 18, and FIG. 20 is a schematic cross-sectional view illustrating that a swage ring of another embodiment of the third pipe connection device is introduced into a rear introducing portion for swaging.

- [225] As another embodiment, referring to FIG. 18, the third pipe connection device may include an auxiliary swage ring 17 interposed between the swage ring 15 and another swage ring 16.
- [226] Referring to FIG. 18, in another embodiment, the outer body 11 may be disposed in such a manner that a portion of the middle part 11a and the rear part 11b surround an end portion (front end portion) of the first pipe 210. In addition, the outer body 11 may be disposed in a form in which a portion of the middle part 11a and the front part 11c surround an end portion (rear end portion) of the second pipe 220. For reference, referring to FIG. 18, in another embodiment of the third pipe connection device, the outer body 11 may be divided into the front part 11c, the middle part 11a, and the rear part 11b in a longitudinal direction (3 o'clock to 9 o'clock directions based on FIG. 18).
- [227] Further, referring to FIG. 18, the swage ring 15 may surround, contact and press the outer circumference of the rear part 11b, and the auxiliary swage ring 17 may surround, contact, and press the outer circumference of the middle part 11a. In addition, another swage ring 16 may surround, contact, and press the outer circumference of the front part 11c.
- [228] In addition, referring to FIG. 19, the auxiliary swage ring 17 has a rear contact circumferential surface 171 coming into contact with the front end surface 1511 of the front part 151 of the swage ring 15 in a restrained state and an inclined recess having an inner circumferential surface 172 to guide the deformation so that the fastening protrusion 1513 is fastened to the fastening groove 111 in the restrained state.
- [229] The initial state of the fastening protrusion 1513 may protrude ahead of the front end surface 1511 of the swage ring 15. In addition, if the initial state of the fastening protrusion 1513 is disposed such that the front end surface 1511 of the front part 151 of

the swage ring 15 comes into contact with the rear contact circumferential surface 171 of the auxiliary swage ring 17, the fastening protrusion 1513 may protrude forward ahead of the inner circumferential surface 172 of the inclined recess so as to be partially overlapped with the inner circumferential surface 172. As a result, deformation of the fastening protrusion 1513 may occur by physical pressing of the inner circumferential surface 172 of the inclined recess in the fastening protrusion 1513 before the front end surface 1511 comes into contact with the rear contact circumferential surface 171 by the forward movement of the swage ring 15. In addition, the inner circumferential surface 172 of the inclined recess may be formed in an inclined surface shape of which the inner diameter is decreased forward so as to physically press the fastening protrusion 1513 and gradually induce the fastening protrusion 1513 to be deformed toward the inner fastening groove 111.

[230] In addition, the fastening groove 111 of the rear part 11b may be formed at a position corresponding to the inclined recess so that the fastening with the fastening protrusion 1513 is induced by the pressing of the inner circumferential surface 172. For example, referring to FIG. 19, the fastening groove 111 may be formed in the outer body 11 to be positioned inside the inclined recess. That is, the fastening groove 111 may be formed to be located inward ahead of the inner circumferential surface 172 of the inclined recess corresponding to the position where the inclined recess is formed based on the longitudinal direction (a front and rear direction or a length direction of the pipe).

[231] In addition, referring to FIG. 19, the auxiliary swage ring 17 has a front contact circumferential surface 173 coming into contact with the rear end surface 1611 of the rear part 161 of another swage ring 16 in a restrained state and an inclined recess having an inner circumferential surface 174 to guide the deformation so that the fastening

protrusion 1613 is fastened to the fastening groove 111 of the front part 11c in the restrained state. In addition, the fastening groove 111 of the front part 11c may be formed at a position corresponding to the inclined recess so that the fastening with the fastening protrusion 1613 is induced by the pressing of the inner circumferential surface 174. The front contact circumferential surface 173 of the auxiliary swage ring 17 and the front end portion formed with the inclined recess are configured to be symmetrical with the rear contact circumferential surface 171 of the auxiliary swage ring 17 and the rear end portion formed with the inclined recess. Therefore, detailed descriptions of the front contact circumferential surface 173 and the inclined recess will be omitted.

[232] According to another embodiment of the third pipe connection device, the fastening protrusion 1513 of the swage ring 15 and the fastening protrusion 1613 of another swage ring 16 are pressed by the inner circumferential surfaces 172 and 174 of inclined recesses formed at both vertical sides of the auxiliary swage ring 17, respectively, to be induced to be fastened to the fastening groove 111, so that rigid mechanical coupling may be achieved.

[233] Further, while the auxiliary swage ring 17 is first disposed on the middle part 11a of the outer body, both the swage ring 15 and another swage ring 16 are symmetrically moved toward the auxiliary swage ring 17 to perform the swage ring fastening process. In other words, the fastening tool may move the swage ring 15 and another swage ring 16 such that the forward movement of the swage ring 15 and the backward movement of another swage ring 16 are made at the same time. In this case, the fastening tool includes a rear support unit coming into contact with the rear end surface of the swage ring 15, a front support unit coming into contact with the front end surface of another swage ring 16, and a driving force providing unit for providing a driving force of

moving the rear support unit and the front support unit to face each other and an axial compressive force according to the driving force.

[234] In addition, as another example, the auxiliary swage ring 17 may be a configuration used as one configuration of the fastening tool in the fastening process through the swaging of the third pipe connecting device. For example, when the swage ring 15 is to be installed on the rear part 11b of the outer body 11, the fastening tool may include a rear support unit coming into contact with the rear end surface of the swage ring 15, a front support unit coming into contact with the front end surface of the swage ring 15, and a driving unit which provides a driving force of relatively moving the rear support unit to the front support unit side and an axial compressive force according to the driving force so that the swage ring 15 is moved from the rear side of the rear part 11b of the outer body 11 to a position which surrounds the middle portion 11b-1 of the rear part 11b. At this time, the auxiliary swage ring 17 may be used as a front support unit of the fastening tool. On the other hand, when another swage ring 16 is to be installed on the front part 11c of the outer body 11, the rear support unit may be used as the front support unit that contacts the front end surface of another swage ring 16 and the auxiliary swage ring 17, which is the front support unit, may be used as a rear support unit that contacts the rear end surface of another swage ring 16.

[235] However, by using the fastening tool utilizing the auxiliary swage ring 17, in the swage ring 15 and another swage ring 16, when the swage ring 15 is first installed on the rear part 11b of the outer body 11 and then another swage ring 16 is to be installed on the front part 11c of the outer body 11, the rear support unit comes into contact with the rear end surface of the preinstalled swage ring 15, the front support unit comes into contact with the front end surface of another swage ring 16 to be installed, and then the front

support unit may be relatively moved to the rear support unit side using the driving unit so that another swage ring 16 moves from the rear side of the front part 11c of the outer body 11 to a position of surrounding the middle portion 11c-1 of the front part 11c. On the contrary, by using the fastening tool utilizing the auxiliary swage ring 17, in the swage ring 15 and another swage ring 16, when another swage ring 16 is first installed on the front part 11c of the outer body 11, the fastening tool may be symmetrically applied as described above.

- [236] Referring to FIGS. 15 and 18, in the third pipe connection device, an inner protrusion 116 may be formed on an inner circumferential surface of the outer body 11. A part of the inner protrusion 116 may come into contact with the first pipe 210 during swaging. In addition, the other portion of the inner protrusion 116 may come into contact with the second pipe 220 during swaging of another swage ring 16. In the swaging process, the outer body 11 may be plastically deformed in a direction in which the inner diameter and the outer diameter are reduced. Accordingly, the portion of the inner protrusion 116 formed on the inner circumferential surface of the outer body 11 corresponding to the outer circumferential surface of the first pipe 210 comes into contact with the outer circumferential surface of the first pipe 210, press the outer circumferential surface of the first pipe 210, and may be at least partially deformed. A portion of the inner protrusion 116 corresponding to the outer circumferential surface of the second pipe 220 may contact the outer circumferential surface of the second pipe 220, press the outer circumferential surface of the second pipe 220, and may be at least partially deformed. Also, each of the first pipe 210 and the second pipe 220 may be deformed by the pressing of the inner protrusion 116. Accordingly, a portion of the inner protrusion 116 may be coupled to the first pipe 210 in the form of penetrating the outer

circumferential surface of the first pipe 210. In addition, the other portion of the inner protrusion 116 may be coupled to the second pipe 220 in the form of penetrating the outer circumferential surface of the second pipe 220.

[237] In addition, a minimum inner diameter of the inner protrusion 116 may preferably have a larger value than the maximum outer diameter considering the tolerances of the first pipe 210 and the second pipe 220 in consideration of the manufacturing tolerance of the first pipe 210 and the second pipe 220.

[238] Also, referring to FIGS. 15 and 16, the inner protrusion 116 is preferably formed in a symmetrical shape with respect to the center point between the first pipe 210 and the second pipe 220 in the longitudinal direction such that the same or similar physical deformation or fastening may be made to each of the first pipe 210 and the second pipe 220.

[239] Further, the inner protrusion 116 may include a sealing-type protrusion which seals between the middle portion 11b-1 of the rear part 11b and the first pipe 210 or between the middle portion 11c-1 of the front part 11c and the second pipe 220 and resists an axial force applied to the first pipe 210 or the second pipe. A plurality of inner protrusions 116 is provided, and some of the plurality of inner protrusions 116 press the first pipe 210 during swaging of the swage ring 15 and some of the inner protrusions 116 press the second pipe 220 during swaging of another swage ring 16 to seal between the outer body 11 and the first pipe 210 and between the outer body 11 and the second pipe 220. For example, the sealing-type protrusion may be provided in an annular structure that extends continuously in a circumferential direction. In addition, a plurality of sealing-type protrusions may be provided at intervals in the longitudinal direction.

- [240] The sealing-type protrusion may be a lattice-type protrusion in which if there is a defect on the outer circumferential surface of the first pipe 210 or the second pipe 220, lattices adjacent to the defect form a closed space of the local area and are repeatedly arranged in the circumferential direction on the inner circumferential surfaces of the middle portion 11b-1 of the front part 11b and the middle portion 11c-1 of the rear part 11c so as to resist torsion together. In other words, the sealing-type protrusion may be provided to protrude in the form of a lattice. For example, the lattice shape may be provided as an axial symmetric structure, but is not limited thereto. Accordingly, the sealing-type protrusion, such a lattice-type protrusion, may protrude in a lattice form in the circumferential direction on the inner circumferential surface so that if there is a defect on the surfaces of the first pipe 210 and the second pipe 220, lattices adjacent to the defect form a closed space of the local area and prevent torsion of the first pipe 210 and the second pipe 220. As such, when the sealing-type protrusion is provided in the form of a lattice, each lattice acts as a kind of partition wall that partitions an area inside the lattice with an area outside the lattice, thereby more enhancing a higher anti-leakage capability. That is, when the sealing is made in the form of a lattice, leakage from the defect may be limited to only a predetermined lattice area and additional leakage to the outside of the lattice area may be blocked. In addition, the lattice shape may serve to resist the torsion applied to the pipe as well as to resist the axial force applied to the pipe due to the structure.
- [241] In addition, the inner protrusion 116 may include a torsion resistant protrusion that resists the torsion acting on the first pipe 210 or the second pipe 220.
- [242] For example, the torsion resistant protrusion may have a knurling shape (spline). In other words, the torsion resistant protrusion has a tooth form elongated in the

longitudinal direction (continuously extending in the longitudinal direction) which is repeatedly disposed along the circumferential direction on the inner circumference of the outer body 11 (internal gear shape). In other words, the inner protrusion 116 may be provided to have a tooth form when viewing the inner circumference of a longitudinal cross-section of the outer body 11. This torsion resistant protrusion may be provided in the form of extending from the middle portions 11b-1 and 11c-1 of the rear part 11b and the front part 11c of the outer body 11 to the rear introducing portions 11b-2 and 11c-2 or the front end portions 11b-3 and 11c-3. By arranging such a torsion resistant protrusion, a structure in which the torsion resistant protrusion is more effectively resistant also to a bending deformation moment applied to the pipe may be provided. Further, the torsion resistant protrusion may be applied in combination with the above-mentioned sealing-type protrusion. In another example, the inner protrusion 116 may be formed in an annular shape having an oblique inclination (an acute angle inclination of less than 90 degrees with respect to the axial direction of the pipe), or formed as a lattice protrusion as described above to serve as both the sealing-type protrusion and the torsion resistant protrusion. As such, the inner protrusion 116 may be provided in various forms in consideration of sealing, axial force resistance, torsion resistance, and the like.

- [243] In addition, the inner protrusion 116 may be configured to be integrally formed on the inner surface of the outer body 11. Alternatively, as another example, the inner protrusion 116 may be implemented by inserting a ring-shaped part processed separately from the outer body 11. When the inner protrusion 116 is formed through the ring-shaped part processed separately, since the airtightness needs to be satisfied with respect to both the inner surface of the outer body 11 and the outer surface of the pipe (first pipe

210 or second pipe 220), it is preferable that the projections are formed on a portion contacting each surface (both an outer end and an inner end in a radial direction in the form of separately processed rings). In addition, when the inner protrusion 116 is a ring-shaped part separately processed, the strength and hardness of the ring-shaped part may be set to be higher than the strength and hardness of the outer body 11 and higher than the strength and hardness of the first and second pipes 210 and 220. According to such strength and hardness setting, the inner protrusion 116 may be formed to penetrate deeper into the inner surface of the outer body and the outer surface of the pipe, thereby improving the airtightness and mechanical strength of the third pipe connection device.

[244] In addition, the length of the outer body 11 may be set to a length that satisfies the minimum number of inner protrusions 116 capable of withstanding an axial external force on the pipe that is expected or actually acted upon in the pipe connection design. Since the length of the outer body 11 is related to the structural strength of the inner protrusion 116 and the strength of the first pipe 210 and the second pipe 220, the length of the outer body 11 is preferably set differently according to each case and conditions based on the material and shape of the inner protrusion 116, the material and thickness of the first pipe 210 and the second pipe 220, etc.

[245] In addition, referring to FIG. 15, the inner circumferential surface corresponding to the center of the outer body 11 may have a stopper (not illustrated) which limits forward movement of the first pipe 210 and limits backward movement of the second pipe 220. For example, referring to FIG. 15, when the outer body 11 is divided into the front part 11c and the rear part 11b in the longitudinal direction, the stopper may be formed on one inner circumference of a portion facing the front part 11c of the rear part 11b and a portion facing the rear part 11b of the front part 11c. Referring to FIG. 18, when the

outer body 11 is divided into the front part 11c, the middle part 11a, and the rear part 11b in the longitudinal direction, the stopper may be formed on the inner circumference of the middle part 11a.

[246] The stopper may limit the forward movement of the first pipe 210 and the backward movement of the second pipe 220. In other words, each of the first pipe 210 and the second pipe 220 may be inserted into the outer body 11 to a position in contact with the stopper. By disposing the stopper at the center of the outer body 11, the symmetrical arrangement of the first pipe 210 and the second pipe 220 with respect to the outer body 11 may be facilitated. The inner protrusion 116 described above may be symmetrically formed with respect to the stopper.

[247] In addition, the stopper may be provided in the same as or similar to the inner protrusion 116. For example, the stopper may be configured to be integrally formed on the inner surface of the outer body 11. Alternatively, as another example, the stopper may be implemented in a form in which a ring-shaped part (for example, a C-shaped ring) processed separately from the outer body 11 is inserted into the outer body 11.

[248] Meanwhile, in order to adjust and align a gap between the first pipe 210 and the second pipe 220 before the fastening operation (swaging), it may be easier for the stopper not to be provided. In addition, in the case of an operation for repairing the pipe (the first pipe 210 or the second pipe 220), it may be more preferable that there is no stopper, and thus the stopper may be selectively provided in some cases.

[249] Further, the fastening groove 111 may be a groove formed by pressing the outer circumferential surface of the front end portion of the outer body 11 while the fastening protrusion 1513 is deformed from an initial state to a restrained state. As described above, the fastening protrusion 1513 may be deformed in the form of being pressed

back and plastically deformed to penetrate (press) the outer circumferential surface of the outer body 11. The fastening groove 111 may be formed on the outer circumferential surface of the outer body 11 by pressing according to the deformation of the fastening protrusion 1513. Accordingly, the fastening protrusion 1513 may be naturally engaged with and fastened to the fastening groove 111 formed by pressing of the fastening protrusion.

[250] Alternatively, as another example, the fastening groove 111 may be a groove pre-formed on the outer circumferential surface of the front end portion of the outer body 11 before swaging the swage ring 15. In this case, less external force may be required to fasten the fastening protrusion 1513 and the fastening groove 111. The pre-formed groove may be previously formed on the outer circumferential surface of the outer body 11 before fastening the fastening groove 111 and the fastening protrusion 1513 in consideration of a position, a depth, and a width of the fastening groove 111 in the restrained state. Alternatively, the pre-formed groove may be previously formed only to guide the deformation of the fastening protrusion 1513 to be induced to the inside thereof, and may be extended to have a greater depth, width, and the like in the restrained state. As such, it may be understood in a wide concept that the pre-formed groove is formed only to guide, and then when the fastening protrusion 1513 is inserted, a groove formed wider or deeper is included.

[251] Further, the fastening groove 111 may be formed on the outer circumferential surface of the outer body 11 to be positioned between the front end surface 1511 and the recessed surface 1512 of the front part 151 of the swage ring 15 in a restrained state. Accordingly, when the object presses the fastening protrusion 1513 backward while contacting the front end surface 1511 of the swage ring 15, the fastening protrusion

1513 formed to obliquely protrude to the front inside is naturally deformed inward, and a part of the fastening protrusion 1513 may be inserted to the fastening groove 111 to engage with the fastening groove 111.

[252] For reference, since the fastening groove 111 of the rear part 11b and the fastening groove 111 of the front part 11c may be the same as or similar to each other except that the fastening grooves are symmetrical with each other, the description of the fastening groove 111 of the rear part 11b described above may also be applied to the fastening groove 111 of the front part 11c.

[253] In the third pipe connection device, referring to FIGS. 15 and 18, the inner circumferential surface of the front end portion 11b-3 of the rear part 11b of the outer body 11 may have a front end support member 1191 which protrudes inward to maintain an outer diameter relatively larger than the middle portion 11b-1 of the rear part 11b. According to the front end support member 1191, the influence of deformation in which the outer diameter of the outer body 11 is reduced by swaging by the swage ring 15 may be more minimized with respect to the front end portion 11b-3 of the outer body 11. Referring to FIGS. 15 and 18, the inner circumferential surface of the rear end portion 11c-3 of the front part 11c may have a rear end support member 1192 which protrudes inward to maintain an outer diameter relatively larger than the middle portion 11c-1 of the front part 11c. According to the rear end support member 1192, the influence of deformation in which the outer diameter of the outer body 11 is reduced by swaging by the swage ring 15 may be more minimized with respect to the rear end portion 11c-3 of the outer body 11. Referring to FIGS. 15 and 18, at least a portion of the front end support member 1191 and at least a portion of the rear end support member 1192 may be provided between the front tapered portion 152 and the rear tapered portion 162 to be

described later.

[254] In addition, in the third pipe connecting device, referring to FIGS. 15 and 18, by the swaging of the swage ring 15 which deforms the middle portion 11b-1 of the rear part 11b in a direction in which the outer diameter is decreased and the swaging of another swage ring 16 which deforms the middle portion 11c-1 of the front part 11c in a direction in which the outer diameter is decreased, at least a part of the inner circumferential surface of the middle portion 11b-1 of the rear part 11b may press the outer circumferential surface of the first pipe 210, and at least a portion of the inner circumferential surface of the middle portion 11c-1 of the front part 11c may press the outer circumferential surface of the second pipe 220. Referring to FIGS. 15 and 18, by the swaging of the swage ring 15 and another swage ring 16 which deforms the middle portion 11b-1 of the rear part 11b and the middle portion 11c-1 of the front part 11c in the direction in which the outer diameter is decreased, the middle portion 11b-1 of the rear part 11b may have an outer diameter smaller than that of the front end portion 11b-3 of the rear part 11b, and the middle portion 11c-1 of the front part 11c may have an outer diameter smaller than that of the rear end 11c-3 of the part 11c.

[255] In other words, by the swaging of the swage ring 15 which deforms the middle portion 11b-1 of the rear part 11b in the direction of decreasing outer diameter, the front end portion 11b-3 may have an outer diameter relatively larger than that of the middle portion 11b-1. As described above, since the swage ring 15 is provided with a shorter length than the rear part 11b, the swage ring 15 may press the middle portion 11b-1 without reaching the front end portion 11b-3 on the rear part 11b. Accordingly, the front end portion 11b-3 of the rear part 11b of the outer body 11 may have an outer diameter relatively larger than that of the middle portion 11b-1 of the rear part 11b of

the outer body 11 having the decreased outer diameter.

[256] Further, by the swaging of another swage ring 16 which deforms the middle portion 11c-1 of the front part 11c in the direction of decreasing outer diameter, the rear end portion 11c-3 may have an outer diameter relatively larger than that of the middle portion 11c-1. Since another swage ring 16 is provided with a shorter length than the front part 11c, another swage ring 16 may press the middle portion 11c-1 without reaching the rear end portion 11c-3 on the front part 11c. Accordingly, the rear end portion 11c-3 of the front part 11c may have an outer diameter relatively larger than that of the middle portion 11c-1 of the front part 11c having the decreased outer diameter.

[257] Referring to FIGS. 15 and 18, in the rear part 11b of the outer body 11, the front end portion 11b-3 may prevent the swage ring 15 from being separated forward by the outer diameter relatively larger than the middle portion 11b-1. In other words, the front end portion 11b-3 naturally having a relatively larger outer diameter than the middle portion 11b-1 by the swaging method of pressing only the middle portion 11b-1 of the third pipe connection device may serve as a limiting jaw (limiter) that restricts further advancement in the direction in which the swage ring 15 has advanced after the swaging is completed.

[258] Referring to FIGS. 15 and 18, at the front end portion of the inner circumferential surface of the swage ring 15, the front tapered portion 152 may be formed to come into contact with a part of the outer circumferential surface of the front end portion 11b-3 which has an outer diameter relatively larger than that of the middle portion 11b-1 by swaging of the swage ring 15 in which the middle portion 11b-1 is deformed in a direction where the outer diameter is reduced. The inner diameter of the front tapered portion 152 may increase toward the front side. The introduction of the swage ring 15

into the rear introducing portion 11b-2 may be smoothly and easily made by the front tapered portion 152. In addition, a part of the outer circumferential surface of the front end portion 11b-3 of the rear part 11b of the outer body 11 may be provided in the form of gradually enlarging (extending) an outer diameter while coming into contact with the front tapered portion 152 by the front tapered portion 152. Thus, the frictional resistance due to the contact may be organically combined in the role of the limiting jaw of the front end portion 11b-3. That is, the front end portion 11b-3 may serve as a limiting jaw that limits the forward detachment of the swage ring 15 by the outer diameter relatively larger than the middle portion 11b-1 and the frictional resistance with the front tapered portion 152. As such, when the front tapered portion 152 is formed in the swage ring 15, a portion (the front tapered portion) of the swage ring 15 may also come into contact with the front end portion 11b-3 of the rear part 11b of the outer body 11 as described above. That is, the swage ring 15 swages by pressing the middle portion 11b-1 of the rear part 11b of the outer body 11 to the inner circumferential surface having the largest inner diameter, whereas may be subjected to swaging which is gradually relaxed forward by pressing a portion of the front end portion 11b-3 of the rear part 11b of the outer body 11 by the front tapered portion 152 of which the inner diameter is gradually extended.

[259] Referring to FIGS. 15 and 18, the front tapered portion 152 may be formed to connect the front part 151 and the middle portion formed to have a constant inner diameter in the swage ring 15. In addition, the fastening protrusion 1513 may be provided to be fastened with the fastening groove 111 formed on the outer circumferential surface of the front end portion 11b-3 of which an outer diameter is relatively larger than that of the middle part 11a by swaging of the swage ring 15 in the restrained state. In addition,

the swage ring 15 may include a middle portion formed to have a constant inner diameter, thereby acting and pressing a constant external force against the middle portion 11b-1 of the rear part 11b in the front-rear direction.

[260] The inner diameter of the front part of the swage ring 15 (the front part of the front tapered portion 152) may have an inner diameter capable of being fitted to the outer body 11 (particularly, the rear introducing portion 11b-2) so that the swage ring 15 is introduced (assembled) into the outer body 11 so as not to be easily detached from the outer body 11 before movement to the front side of the swage ring 15 is made (before fastening starts by the fastening tool). The front tapered portion 152 connected to the front part of the swage ring 15 may be formed to be inclined to have an inner diameter that gradually decreases backward from the inner diameter corresponding to the outer diameter of the outer body 11 to be fitted. As such, the inner diameter of the rear end of the front tapered portion 152 (the portion connected to the middle portion of the swage ring as the most end portion) is set to be smaller than the outer diameter of the rear part 11b of the outer body 11, so that a part of the front end portion 11b-3 of the rear part 11b of the outer body 11 may serve as a limiting jaw that causes frictional resistance and shear resistance with respect to the front tapered portion 152. At this time, in the case of the inner diameter of the rear end of the front tapered portion 152, within the range set smaller than the outer diameter of the outer body 11, the inner diameter may be preferably determined to a proper numerical value considering a mechanical coupling requirement value of the pipe connection device and a manufacturing tolerance of the pipe (tube).

[261] In addition, although not illustrated in the drawings, a rear tapered portion may be formed at the rear end of the inner circumferential surface of the swage ring 15 provided

for the rear part 11b. The rear tapered portion may have a shape in which the inner diameter increases toward the rear side. As described above, the rear introducing portion 11b-2 of the rear part 11b of the outer body 11 is deformed in a direction in which the outer diameter is reduced by swaging of the swage ring 15, and then at least a portion of the outer body 11 is elastically restored after the swage ring 15 passes, or the outer circumferential surface side thereof may be pulled forward at least a portion according to the movement of the swage ring 15 to be deformed in a direction in which the outer diameter becomes relatively larger than that of the middle portion 11b-1 of the rear part 11b. At this time, the rear tapered portion comes into contact with a part of the rear introducing portion 11b-2 having an outer diameter relatively larger than the middle portion 11b-1 of the rear part 11b of the outer body 11, so that the rear introducing portion 11b-2 serves as a limiting jaw for preventing backward movement of the swage ring 15, thereby exhibiting friction resistance due to a contact. That is, the rear introducing portion 11b-2 of the rear part 11b of the outer body 11 may serve as a limiting jaw that limits the backward movement of the swage ring 15 as the outer diameter is relatively larger than that of the middle portion 11b-1. In the case where the rear tapered portion is formed at the swage ring 15, a resistant force by friction with the rear tapered portion may be organically combined to act more strongly as a limiting jaw.

[262] On the other hand, in the front part 11c of the outer body 11, the rear end portion 11c-3 may prevent the rearward detachment of another swage ring 16 by the outer diameter relatively larger than the middle portion 11c-1. In other words, the rear end portion 11c-3 naturally having a relatively larger outer diameter than the middle portion 11c-1 may serve as a limiting jaw (limiter) that limits further advancement in the direction in

which another swage ring 16 has advanced after the swaging is completed.

[263] Referring to FIGS. 15 and 18, at the rear end portion of the inner circumferential surface of another swage ring 16, the rear tapered portion 162 may be formed to come into contact with a part of the outer circumferential surface of the rear end portion 11c-3 which has an outer diameter relatively larger than that of the middle portion 11c-1 by swaging of another swage ring 16 in which the middle portion 11c-1 is deformed in a direction where the outer diameter is reduced. The inner diameter of the rear tapered portion 162 may increase toward the rear side. The introduction of another swage ring 16 into the front introducing portion 11c-2 may be smoothly and easily made by the rear tapered portion 162. In addition, a part of the outer circumferential surface of the rear part 11c-3 of the front part 11c of the outer body 11 may be provided in the form of gradually enlarging (extending) an outer diameter while coming into contact with the rear tapered portion 162 by the rear tapered portion 162. Thus, the frictional resistance due to the contact may be organically combined in the role of the limiting jaw of the rear end portion 11c-3. That is, the rear end portion 11c-3 may serve as a limiting jaw that limits the forward detachment of another swage ring 16 by the outer diameter relatively larger than the middle portion 11c-1 and the frictional resistance with the rear tapered portion 162. As such, when the rear tapered portion 162 is formed in another swage ring 16, a portion (the rear tapered portion) of another swage ring 16 may also come into contact with the rear end portion 11c-3 of the front part 11c of the outer body 11 as described above. That is, another swage ring 16 swages by pressing the middle portion 11c-1 of the front part 11c of the outer body 11 to the inner circumferential surface having the largest inner diameter, whereas may be subjected to swaging which is gradually relaxed backward by pressing a portion of the rear end portion 11c-3 of the

front part 11c of the outer body 11 by the rear tapered portion 162 of which the inner diameter is gradually extended.

[264] Referring to FIGS. 15 and 18, the rear tapered portion 162 may be formed to connect the front part and the middle portion formed to have a constant inner diameter in another swage ring 16. In addition, the fastening protrusion 1613 may be provided to be fastened with the fastening groove 111 formed on the outer circumferential surface of the rear end portion 11c-3 of which an outer diameter is relatively larger than that of the middle portion 11c-1 by swaging of another swage ring 16 in the restrained state. As described above, the front part 11c of the outer body 11 and another swage ring 16 provided for the front part 11c are configurations disposed symmetrically with the rear part 11b and the swage ring 15 provided for the rear part 11b, and the configurations, operations, effects and the like are the same as or similar to each other, and thus a detailed description thereof will be omitted.

[265] In addition, the third pipe connection device may include the above-mentioned fastening tool. The fastening tool may be a temporary configuration in which the swage ring 15 is fastened to surround the rear part 11b and then removed. However, in another embodiment, the auxiliary swage ring 17, which may be utilized as a configuration of the fastening tool, may not be removed.

[266] In addition, the outer body 11, the swage ring 15, and another swage ring 16 may be preferably made of the same materials as the first pipe 210 and the second pipe 220. This is to minimize a change in the physical bonding force between the first pipe 210 and the outer body 11 and between the second pipe 220 and the outer body 11 due to an influence of a surrounding environment of the first pipe 210 and the second pipe 220, such as a temperature change. In addition, when metals having the same material as

the first pipe 210 and the second pipe 220 are used in the outer body 11, the swage ring 15, and another swage ring 16, there is also an advantage that potential corrosion due to a potential difference between metals in contact with each other may be minimized.

[267] In addition, each of the outer circumferential surface of the outer body 11, the inner circumferential surface of the swage ring 15, and the inner circumferential surface of another swage ring 16 may be preferably lubricated and coated with a lubricant or a material having good lubricity. This is to lower the need to use unnecessarily strong fastening tools. However, a material that is coated on the outer circumferential surface of the outer body 11, the each of the inner circumferential surfaces of the swage ring 15 and another swage ring 16 for lubricating coating has corrosion resistance of corrosion resistance surface treatment or less applied to the first pipe 210 and the second pipe 220, it is preferred that corrosion resistant surface treatment is first performed on the outer body 11, the swage ring 15, and another swage ring 16 before lubrication coating to ensure corrosion resistance equal to or greater than that of the material of the pipe (first pipe 210 and second pipe 220).

[268] In addition, as described above, the fastening tool may include a rear support unit, a front support unit and a driving unit. For example, the driving unit may relatively pull the rear support unit with respect to the front support unit and move the rear support unit and the front support unit to be close to each other. Since various driving devices such as a driving unit (actuator) using hydraulic pressure may be applied to the driving unit, a more detailed description thereof will be omitted.

[269] Further, the rear support unit has a second ring contact circumferential surface coming into contact with the rear end surface of the swage ring 15, and a second body contact recessed surface formed to be recessed backward from ahead of the second ring contact

circumferential surface with a step and coming into contact with the rear end surface of the rear introducing portion 11b-2 of the rear part 11b of the outer body 11. Here, the recession amount (step amount) of the second body contact recessed surface may be set to correspond to the length of the rear introducing portion 11b-2 of the rear part 11b, that is, equally. Alternatively, as another example, the recession amount (step amount) of the second body contact recessed surface is set to be shorter than the length of the rear introducing portion 11b-2 of the rear part 11b, so that while the rear introducing portion 11b-2 is compressed by a difference between the recession amount (step amount) and the length of the rear introducing portion 11b-2, deformation in which a part thereof protrudes outward may occur and a bead for limiting the backward movement of the swage ring 15 may be formed by the protruding deformation. In addition, in order to induce such bead formation, a groove for inducing beads to be recessed outward may be formed in the inner circumferential surface of the rear introducing portion 11b-2. That is, according to the groove for inducing beads formed on the inner circumferential surface of the rear introducing portion 11b-2, when the rear introducing portion 11b-2 is compressed, deformation in a direction in which a part thereof protrudes outward may be induced more naturally. This bead and the groove for inducing the bead may be applied to the front part 11c as well as the rear part 11b. That is, the bead and the groove for inducing the bead may be applied to both the swage ring 15 corresponding to the rear part 11b and the swage ring 16 corresponding to the front part 11c.

[270] In the third pipe connection device, the outer body 11 is provided without a structure protruding to the outer surface and an outer protrusion, so that the outer body 11 may be manufactured with as little processing and material as possible from raw materials in the

form of pipes, thereby greatly reducing manufacturing cost. In addition, since the mechanical coupling of the swage ring 15 and the outer body 11 may be made by plastic deformation of the fastening protrusion 1513, by using a friction coupling configuration between the swage ring and the outer body 11 in the related art or an elastic deformation configuration of a member, a high detachment stopping force may be secured compared to a method for preventing the detachment from the outer body of the swage ring. Accordingly, in the pipe connection device, greater mechanical coupling performance against vibration and shock may be ensured.

[271] In addition, since a direct mechanical coupling is made between the swage ring 15 and the outer body 11, a function of the protrusion of the outer body in the related art (mounting of the fastening tool and fixing the swage ring) is unnecessary. As a result, since the length of the outer body 11 may be reduced compared to the conventional outer body, it is possible to greatly reduce the weight and perform construction in a narrower space.

[272] The aforementioned description of the present invention is to be exemplified, and it can be understood by those skilled in the art that the technical spirit or required features of the present invention can be easily modified in other detailed forms without changing. Therefore, it should be appreciated that the aforementioned exemplary embodiments described above are all illustrative in all aspects and are not restricted. For example, respective constituent elements described as single types can be distributed and implemented, and similarly, constituent elements described to be distributed can also be implemented in a coupled form.

[273] The scope of the present disclosure is represented by claims to be described below rather than the detailed description, and it is to be interpreted that the meaning and

scope of the claims and all the changes or modified forms derived from the equivalents thereof come within the scope of the present disclosure.

[CLAIMS]

[Claim 1]

A pipe connection device for connecting facing end portions of two pipes to each other, the device comprising:

an outer body into which an end portion of a first pipe is inserted from a rear side and an end portion of a second pipe is inserted from a front side; and

a swage ring which surrounds, contacts, and presses an outer circumference of the outer body,

wherein an initial inner diameter of the swage ring before swaging is smaller than an initial outer diameter of the outer body before the swaging,

the contact and pressing of the swage ring are performed with respect to a middle portion except for a rear introducing portion which contacts the swage ring only upon introduction of the swage ring and a front end portion which does not contact the swage ring in the outer body, and an outer circumferential surface of the front end portion of the outer body has a fastening groove,

the swage ring includes a front part provided with a fastening protrusion that protrudes obliquely toward a front inner side and is fastened to the fastening groove,

the fastening protrusion is deformed into a restrained state to be fastened to the fastening groove from an initial state of protruding so as not to interfere with the outer circumferential surface of the outer body by an axial compressive force thereto,

an inner portion of a front end surface of the front part has a recessed surface recessed backward with a step, and

the fastening protrusion is provided to protrude forward ahead of the front end surface of the front part from the recessed surface in the initial state and deformed to be fastened to the fastening groove while non-protruding forward ahead of the front end surface of the front part in the restrained state.

[Claim 2]

The pipe connection device of claim 1, wherein the restrained state is a state in which a backward movement of the swage ring is prevented by the fastening of the fastening protrusion and the fastening groove.

[Claim 3]

The pipe connection device of claim 1, wherein the fastening groove is a groove pre-formed on the outer circumferential surface of the front end portion of the outer body before the swaging the swage ring or a groove formed by pressing the outer circumferential surface of the front end portion of the outer body while the fastening protrusion is deformed from the initial state to the restrained state.

[Claim 4]

The pipe connection device of claim 1, wherein when in the initial state a portion protruding forward ahead of the front end surface of the front part is pressed backward to a position corresponding to the front end surface of the front part by the axial compressive force, the fastening protrusion is provided in a shape that is induced to be protruding-deformed inward ahead of the outer circumferential surface of the outer body.

[Claim 5]

The pipe connection device of claim 1, further comprising:

a fastening tool which is removed after fastening the swage ring to the intermediate portion such that the swage ring surrounds and swages the middle portion,

wherein the fastening tool includes a rear support unit coming into contact with a rear end surface of the swage ring, a front support unit coming into contact with the front end surface of the front end portion of the outer body, and a driving unit which provides the axial compressive force by a driving force and the driving force by which the rear support unit relatively moves to the front support unit side so that the swage ring moves from the rear side of the outer body to a position surrounding the middle portion, and

the front support unit has a first ring contact circumferential surface coming into contact with a portion corresponding to the front end surface of the front part of the swage ring and the front part of the fastening protrusion in the restrained state, and a first body contact recessed surface formed to be recessed forward ahead of the first ring contact circumferential surface to come into contact with the front end surface of the front end portion of the outer body in the restrained state.

[Claim 6]

The pipe connection device of claim 1, wherein by the swaging of the swage ring which deforms the middle portion in a direction of decreasing the outer diameter, the outer diameter of the front end portion of the outer body is relatively larger than that of the middle portion to prevent a forward detachment of the swage ring.

[Claim 7]

The pipe connection device of claim 6, wherein at the front end portion of an inner circumferential surface of the swage ring, a front tapered portion is formed to come into contact with a part of the outer circumferential surface of the front end portion which has an outer diameter relatively larger than that of the middle portion by the swaging of the swage ring which deforms the middle portion in a direction of decreasing the outer diameter, and

the front end portion serves as a limiting jaw that prevents the forward detachment of the swage ring by the outer diameter relatively larger than the middle portion and a frictional resistance with the front tapered portion.

[Claim 8]

The pipe connection device of claim 7, wherein the front tapered portion is formed to connect the front part and the middle portion formed to have a constant inner diameter in the swage ring, and

the fastening protrusion is provided to be fastened with the fastening groove formed on the outer circumferential surface of the front end portion of which an outer diameter is relatively larger than that of the middle portion by the swaging of the swage ring in the restrained state.