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Inventor(s)	Tanaka; Ryunosuke et al.

Pipe joint and pipe joining method

Abstract

In a pipe joint, a spigot of a first pipe is inserted into a socket of a second pipe, a lock-ring storage groove is formed in the socket, a lock ring is stored in the lock-ring storage groove, a spigot protrusion is formed on an outer circumference of the spigot, and the spigot protrusion is engaged with the lock ring from a deeper portion of the socket in a separation direction of the spigot so as to prevent the spigot from separating from the socket. The lock ring has a first surface for preventing separation facing an opening end of the socket and a second surface for preventing separation facing the deeper portion of the socket.

Inventors: **Tanaka; Ryunosuke (Amagasaki, JP), Komaru; Yuito (Amagasaki, JP), Oda; Keita (Amagasaki, JP)**

Applicant: **KUBOTA CORPORATION** (Osaka, JP)

Family ID: **1000008766924**

Assignee: **KUBOTA CORPORATION (Osaka, JP)**

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Primary Examiner: Dunwoody; Aaron M

Attorney, Agent or Firm: Renner, Otto, Boisselle & Sklar, LLP

Background/Summary

FIELD OF THE INVENTION

(1) The present invention relates to a pipe joint having a separation preventive function and a pipe joining method.

BACKGROUND OF THE INVENTION

(2) A pipe joint is described in Japanese Patent Laid-Open No. 2005-140138. As illustrated in FIG. **26**, the pipe joint has a first pipe **201** with a spigot **202** inserted into a socket **204** of a second pipe **203**. A lock-ring storage groove **205** is formed on the inner circumference face of the socket **204**. In the lock-ring storage groove **205**, a lock ring **206** is stored as a single-split ring in the circumferential direction. A spigot protrusion **207** is formed on the outer circumference face of the spigot **202**. The lock ring **206** has a tapered face **209** facing the opening end of the socket **204** and a backside **212** facing the deeper portion of the socket **204**.

(3) When a large tensile force is applied to the pipes **201** and **203** due to earthquakes or the like, the spigot **202** and the socket **204** are likely to separate from each other in the pipe axial direction and the spigot protrusion **207** is engaged with the lock ring **206** from the deeper portion of the socket **204** in a separation direction **211** of the spigot **202** as illustrated.

(4) At this point, a drawing force, a force that separates the spigot **202** and the socket **204** in the pipe axial direction, is applied to the lock ring **206**. This force brings the tapered face **209** of the lock ring **206** into contact with an opening edge **208** of the lock-ring storage groove **205** and brings the spigot protrusion **207** into contact with the backside **212** of the lock ring **206** in the pipe axial direction. These contacts prevent separation of the spigot **202** from the socket **204**.

(5) At a position where the opening edge **208** of the lock-ring storage groove **205** and the tapered face **209** of the lock ring **206** come into contact with each other, a force applied to the pipes **201** and **203** with the contact portion serving as an application position acts as a force F that presses the tapered face **209** in the pipe axial direction. The force F is divided into a component force F**1** in a direction perpendicular to a tangential plane at the contact point on the tapered face **209** and a component force F**2** in a direction parallel to the tangential plane. A line of application **210** of the component force F**1** in the direction perpendicular to the tangential plane extends in a direction of the surface normal of the tangential plane. The gradient of the tapered face **209** is set such that the surface normal passes through the inner circumference face of the lock ring **206** and extends to the spigot **202**.

(6) In the configuration illustrated in FIG. **26**, on the backside **212** of the lock ring **206** in contact with the spigot protrusion **207**, a moment M in a counterclockwise direction in FIG. **26** is applied to the lock ring **206** by the component force F**1** with respect to a center A at an inner edge of the lock ring **206**. The moment M presses the lock ring **206** to the outer circumference of the spigot **202**. This prevents the lock ring **206** from being separated from the outer circumference of the spigot **202**.

(7) However, when a large force exceeding an assumed value of the design is applied to the pipes **201** and **203** in the event of a large-scale earthquake, the moment M increases and the lock ring **206** is pressed to the outer circumference of the spigot **202** by an excessive force. Thus, the strength of the spigot **202** needs to be increased to prevent damage to the spigot **202**. In order to increase the strength of the spigot **202**, the spigot **202** needs to have a larger thickness.

(8) When the lock ring **206** is set in a normal orientation in the lock-ring storage groove **205**, as illustrated in FIG. **26**, the tapered face **209** faces the opening end of the socket **204** and the backside **212** faces the deeper portion of the socket **204** on the lock ring **206**.

(9) However, the lock ring **206** in an inverted orientation may be set in the lock-ring storage groove **205** by mistake. In this case, the tapered face **209** of the lock ring **206** faces the deeper portion of

the socket **204** and the backside **212** faces the opening end of the socket **204**.
(10) When the lock ring **206** in an inverted orientation is set in the lock-ring storage groove **205** by mistake, an operator cannot find the inverted orientation of the lock ring **206** until a pipe inserting operation is performed to insert the spigot **202** into the socket **204**. Thus, a rejoining operation of the pipes **201** and **203** requires extra time.
(11) An object of the present invention is to provide a pipe joint and a pipe joining method, which can suppress a force pressing a lock ring to the outer circumference of a spigot.

SUMMARY OF THE INVENTION

(12) A pipe joint according to the present invention is presented, in which a spigot of a first pipe is inserted into a socket of a second pipe, a lock-ring storage groove is formed on an inner circumference of the socket, a lock ring stored in the lock-ring storage groove is attached to an outer circumference of the spigot, a spigot protrusion is formed on the outer circumference of the spigot, and the spigot protrusion is engaged with the lock ring from a deeper portion of the socket in a separation direction of the spigot so as to prevent the spigot from separating from the socket. The lock ring has a first surface for preventing separation facing an opening end of the socket and a second surface for preventing separation facing the deeper portion of the socket. In a state in which the spigot protrusion is engaged with the lock ring and the first surface for preventing separation of the lock ring is in contact with an opening edge of the lock-ring storage groove around a pipe axial direction, a surface normal of a tangential plane at a contact point between the opening edge of the lock-ring storage groove and the first surface for preventing separation of the lock ring passes through the second surface for preventing separation of the lock ring.
(13) When a drawing force is applied to the pipes in the pipe joint, the spigot protrusion is engaged with the lock ring and the first surface for preventing separation of the lock ring is brought into contact with the opening edge of the lock-ring storage groove. At this point, a force in the pipe axial direction is applied to the contact point between the first surface for preventing separation of the lock ring and the opening edge of the lock-ring storage groove. The force applied to the contact point in the pipe axial direction is applied to the lock ring as a component force along the surface normal of the tangential plane at the contact point and a component force along the tangential plane.
(14) The surface normal of the tangential plane passes through the second surface for preventing separation, so that a line of application of the component force along the surface normal of the tangential plane passes through the second retaining surface.
(15) The component force applied along the surface normal of the tangential plane has a component of force applied in the axial direction of the lock ring and a component of force applied in a radial direction of the lock ring. The component in the axial direction of the lock ring increases and the component in the radial direction of the lock ring decreases as an angle of the surface normal decreases with respect to the axis of the lock ring. Thus, the surface normal of the tangential plane passes through the second surface for preventing separation of the lock ring, so that the component in the radial direction of the lock ring is small in the component force along the surface normal of the tangent surface as compared with a case where the surface normal of the tangential plane passes through an inner circumference face of the lock ring. This can suppress an applied force that presses the lock ring onto the outer circumference of the spigot based on the drawing force.
(16) According to the pipe joint of the present invention, the inner edge of the lock ring is preferably included in the second surface for preventing separation. The surface normal of the tangential plane preferably passes through the inner edge of the lock ring while passing through the second surface for preventing separation.
(17) According to the pipe joint of the present invention, the inner edge of the lock ring is preferably included in the second surface for preventing separation. The surface normal of the tangential plane preferably passes through the second surface for preventing separation between the

inner edge of the lock ring and a position where the outer edge of the spigot protrusion is in contact with the second surface for preventing separation.
(18) According to the pipe joint of the present invention, the first surface for preventing separation of the lock ring is preferably shaped like a circular conical surface.
(19) According to the pipe joint of the present invention, the first surface for preventing separation of the lock ring is preferably curved along an arc having the center on the surface normal of the tangential plane.
(20) According to the pipe joint of the present invention, the center of the arc of the first surface for preventing separation is preferably located at an intersection point of the surface normal of the tangential plane and the second surface for preventing separation.
(21) According to the pipe joint of the present invention, the lock ring is preferably a ring having a single-cut structure with a dividing portion at a point along a circumferential direction. End faces at the dividing portion of the lock ring in the circumferential direction preferably have engaging portions that allow engagement of a spacing keeping tool, the spacing keeping tool keeping a spacing between the end faces of the lock ring increased in diameter. At least one of the end faces of the lock ring preferably has a release portion for releasing the spacing keeping tool in a separation direction that separates the spacing keeping tool inward from the end face of the lock ring in the radial direction of the lock ring. If the lock ring is stored in a normal orientation in the lock ring storage groove, the engaging portion is preferably placed near the opening end of the socket and the release portion is preferably placed near a deep end of the socket. The engaging portions and the release portion are preferably exposed inward from the lock-ring storage groove in the radial direction in a state in which the lock ring is increased in diameter.
(22) With this configuration, when the first pipe and the second pipe are joined, the lock ring is first set in the lock-ring storage groove. At this point, if the lock ring is stored in a normal orientation in the lock-ring storage groove in the pipe axial direction, the engaging portion is placed near the opening end of the socket and the release portion is placed near the deep end of the socket.
(23) Thereafter, in a state in which the lock ring is increased in diameter by an expander tool, the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is engaged with the engaging portions. At this point, the engaging portions are placed closer to the opening end of the socket than the release portion, so that the spacing keeping tool is engaged with the engaging portion. Thus, the spacing keeping tool can keep the spacing between the end faces of the lock ring increased in diameter.
(24) In this state, the spigot is inserted into the socket. At this point, the spigot protrusion passes through the inner circumference of the lock ring from the opening end to the deep end of the socket, and then the spacing keeping tool is removed from the lock ring. The removal reduces the diameter of the lock ring.
(25) When the first pipe and the second pipe are joined, the lock ring in an inverted orientation may be set by mistake in the lock-ring storage groove in the pipe axial direction. At this point, the release portion is placed near the opening end of the socket, and the engaging portion is placed near the deep end of the socket.
(26) In such positioning with the lock ring increased in diameter by the expander tool, the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is engaged with the engaging portions. At this point, the release portion is placed closer to the opening end of the socket than the engaging portions, so that the spacing keeping tool is guided to the release portion and is separated inward from the end face of the lock ring in the radial direction of the lock ring without being engaged with the engaging portions.
(27) As described above, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove, the spacing keeping tool to be engaged with the engaging portions of the lock ring is guided to the release portion and is separated from the end face of the lock ring without being engaged with the engaging portions. Thus, the spacing keeping tool cannot keep the spacing

between the end faces of the lock ring increased in diameter.
(28) With this configuration, an operator can find an error in the attachment of the lock ring before a pipe inserting operation is performed to insert the spigot into the socket. This can shorten a time for a rejoining operation of the pipes.
(29) According to the pipe joint of the present invention, the release portion is preferably an inclined face extending from the end face of the lock ring to the inner circumference face of the lock ring, and the inclined face preferably tilts in a direction that increases the spacing between the end faces of the lock ring toward the inside in the radial direction.
(30) In the pipe joint, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove, the spacing keeping tool is guided inward in the radial direction of the lock ring by the inclined face of the release portion and is separated from the end face of the lock ring while the lock ring is increased in diameter by using the expander tool.
(31) According to the pipe joint of the present invention, the release portion is preferably a curved surface extending like an arc from the end face of the lock ring to the inner circumference face of the lock ring, and the curved surface is preferably curved in a direction that increases the spacing between the end faces of the lock ring toward the inside in a radial direction.
(32) In the pipe joint, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove, the spacing keeping tool is guided inward in the radial direction of the lock ring by the curved surface of the release portion and is separated from the end face of the lock ring while the lock ring is increased in diameter by using the expander tool.
(33) A pipe joining method for assembling the pipe joint of the present invention is presented. The method includes setting the lock ring into the lock-ring storage groove in the socket, inserting the spacing keeping tool from the opening end of the socket into the dividing portion of the lock ring and engaging the spacing keeping tool with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool, removing the expander tool from the lock ring and keeping, by using the spacing keeping tool, the spacing between the end faces of the lock ring increased in diameter, and removing the spacing keeping tool from the lock ring and reducing the diameter of the lock ring when the spigot protrusion is caused to pass through the inner circumference of the lock ring from the opening end to the deeper portion of the socket by inserting the spigot into the socket.
(34) According to the joining method, if the lock ring is set in a normal orientation in the lock-ring storage groove in the pipe axial direction, the engaging portion is placed near the opening end of the socket and the release portion is placed near the deep end of the socket. Thus, the spacing keeping tool can be engaged with the engaging portions of the lock ring, so that the spacing keeping tool can keep the spacing between the end faces of the lock ring increased in diameter.
(35) A pipe joining method for assembling the pipe joint of the present invention is presented. The method includes setting the lock ring into the lock-ring storage groove in the socket, determining that the lock ring is attached in an inverted orientation in the pipe axial direction if the spacing keeping tool is guided to the release portion and is separated from the end face of the lock ring without being engaged with the engaging portions when the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is to be engaged with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool, removing the expander tool from the lock ring to reduce the diameter of the lock ring, removing the lock ring from the lock-ring storage groove, correcting the lock ring to a normal orientation and setting the lock ring into the lock-ring storage groove again, inserting the spacing keeping tool from the opening end of the socket into the dividing portion of the lock ring and engaging the spacing keeping tool with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool, removing the expander tool from the lock ring and keeping, by using the spacing keeping tool, the spacing between the end faces of the lock ring increased in diameter, and removing the spacing keeping tool from the lock ring and reducing the

diameter of the lock ring when the spigot protrusion is caused to pass through the inner circumference of the lock ring from the opening end to the deeper portion of the socket by inserting the spigot into the socket.
(36) According to the joining method, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove in the pipe axial direction, the release portion is placed near the opening end of the socket and the engaging portion is placed near the deep end of the socket. Thus, the spacing keeping tool is guided to the release portion and is separated inward from the end face of the lock ring in the radial direction of the lock ring without being engaged with the engaging portions.
(37) The separation does not allow the spacing keeping tool to keep the spacing between the end faces of the lock ring increased in diameter. Therefore, an operator can find an error in the attachment of the lock ring before a pipe inserting operation is performed to insert the spigot into the socket. This can shorten a time for a rejoining operation of the pipes.
(38) According to the present invention, in a state in which the opening edge of the lock-ring storage groove is in contact with the first surface for preventing separation of the lock ring, a force applied from the opening edge at the contact point between the opening edge and the first surface for preventing separation in the pipe axial direction is applied to the lock ring as a component force along the surface normal of the tangential plane and a component force along the tangential plane.
(39) The surface normal of the tangential plane passes through the second surface for preventing separation, so that a line of application of the component force along the surface normal of the tangential plane passes through the second retaining surface.
(40) The component force applied along the surface normal of the tangential plane has a component of force applied in the axial direction of the lock ring and a component of force applied in a radial direction of the lock ring. The component in the axial direction of the lock ring increases and the component in the radial direction of the lock ring decreases as the angle of the surface normal decreases with respect to the axis of the lock ring. Thus, the surface normal of the tangential plane passes through the second surface for preventing separation, so that the component of force in the radial direction of the lock ring is small in the component force along the surface normal of the tangent surface as compared with the case where the surface normal of the tangential plane passes through the inner circumference face of the lock ring. This can suppress an applied force that presses the lock ring onto the outer circumference of the spigot based on a drawing force when the spigot is removed from the socket.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a cross-sectional view illustrating a pipe joint along a pipe axial direction according to a first embodiment of the present invention.
(2) FIG. **2** is a front view illustrating a divided portion of a lock ring provided in the pipe joint.
(3) FIG. **3** illustrates a principal part of the pipe joint.
(4) FIG. **4** illustrates the principal part of the pipe joint and a relationship between a component force F**1** along a surface normal direction of a tangential plane on the lock ring and a component F**11** oriented in the pipe axial direction of the component force F**1** and a component F**12** oriented in a pipe radial direction.
(5) FIG. **5** is a schematic diagram showing a relationship between a tangential plane and a surface normal and a center position of an arc in a principal part of a pipe joint according to a second embodiment of the present invention.
(6) FIG. **6** illustrates a principal part of a pipe joint according to a third embodiment of the present invention.

(7) FIG. **7** illustrates a principal part of a pipe joint according to a fourth embodiment of the present invention.
(8) FIG. **8** is a front view illustrating a dividing portion of a lock ring provided in a pipe joint according to a fifth embodiment of the present invention.
(9) FIG. **9** is a view along X in FIG. **8**.
(10) FIG. **10** is a view along Y in FIG. **8**.
(11) FIG. **11** is a view along Z in FIG. **8**.
(12) FIG. **12** is a rear view illustrating a dividing portion of the lock ring.
(13) FIG. **13** is an enlarged perspective view illustrating one end face of the lock ring.
(14) FIG. **14** illustrates an expander tool used when pipes of the pipe joint are joined to each other.
(15) FIG. **15** illustrates a spacing keeping tool used when the pipes of the pipe joint are joined to each other.
(16) FIG. **16** is a cross-sectional view of the spacing keeping tool.
(17) FIG. **17** is an explanatory drawing of a joining method of the pipe constituting the pipe joint, in which the lock ring in a normal orientation is set in a lock-ring storage groove.
(18) FIG. **18** is an explanatory drawing of a subsequent step of FIG. **17**, illustrating a state in which the lock ring is increased in diameter by using the expander tool.
(19) FIG. **19** is an explanatory drawing of a subsequent step of FIG. **18**, illustrating a state in which the spacing keeping tool is inserted into the dividing portion of the lock ring while the lock ring is increased in diameter by using the expander tool.
(20) FIG. **20** is an explanatory drawing of a subsequent step of FIG. **19**, illustrating a state in which the expander tool is removed from the lock ring and the spacing between the end faces of the lock ring increased in diameter is kept by the spacing keeping tool.
(21) FIG. **21** is an explanatory drawing of a subsequent step of FIG. **20**, illustrating a state in which the spacing keeping tool is removed from the lock ring and the lock ring is reduced in diameter.
(22) FIG. **22** is another explanatory drawing of a pipe joining method, illustrating a state in which the lock ring in an inverted orientation is set in the lock-ring storage groove.
(23) FIG. **23** is an explanatory drawing of a subsequent step of FIG. **22**, illustrating a state in which the lock ring is increased in diameter by using the expander tool.
(24) FIG. **24** is an explanatory drawing of a subsequent step of FIG. **23**, illustrating a state in which the spacing keeping tool is guided to a release portion and is separated from the end face of the lock ring when the spacing keeping tool is inserted into the dividing portion of the lock ring while the lock ring is increased in diameter by using the expander tool.
(25) FIG. **25** is a rear view illustrating a dividing portion of a lock ring provided in a pipe joint according to a sixth embodiment of the present invention.
(26) FIG. **26** illustrates a principal part of a conventional pipe joint.

DETAILED DESCRIPTION OF THE INVENTION

(27) Embodiments of the present invention will be described below in accordance with the accompanying drawings.

First Embodiment

(28) In a first embodiment, as illustrated in FIG. **1**, a spigot **3** of a first pipe **2** is inserted into a socket **5** of a second pipe **4** in a pipe joint **1**, so that the pipes **2** and **4** are joined.
(29) A lock-ring storage groove **7** is circumferentially formed on the inner circumference of the socket **5**. A lock ring **8** is stored in the lock-ring storage groove **7**. The lock ring **8** is attached to be wrapped around the outer circumference of the spigot **3** while being stored in the lock-ring storage groove **7**.
(30) A spigot protrusion **10** is formed around the outer circumference of the distal end portion of the spigot **3**.
(31) The pipe joint **1** has a separation preventive function. The separation preventive function engages the spigot protrusion **10** onto the lock ring **8** from the deeper portion of the socket **5** in a

separation direction **12** of the spigot **3**, thereby preventing separation of the spigot **3** from the socket **5**.
(32) A socket protrusion **16** protruding inward from the inner circumference of the socket **5** in a radial direction **15** faces the lock-ring storage groove **7** from a point near the opening end of the socket **5**. A deep end face **26** opposed to the distal end face of the spigot **3** along the pipe axial direction is formed in the deeper portion of the socket **5**.
(33) A clearance between the outer circumference of the spigot **3** and the inner circumference of the socket **5** is sealed with an annular seal member **17** made of an elastic material such as rubber.
(34) A gland **18** that presses the seal member **17** toward the deeper portion of the socket **5** is in contact with an opening end face **14** of the socket **5**. The gland **18** is coupled to a flange **21** at the opening end of the socket **5** with a plurality of T bolts **19** and nuts **20** in the circumferential direction.
(35) A backup ring **23** made of resin is provided between the inner circumference of the socket protrusion **16** and the outer circumference of the spigot **3**. The backup ring **23** is a ring having a single-cut structure that is divided at a point in the circumferential direction. The backup ring **23** is adjacent to the lock ring **8**.
(36) The spigot **3** passes through the inner circumferences of the gland **18**, the seal member **17**, the backup ring **23**, and the lock ring **8**.
(37) As illustrated in FIG. **2**, the lock ring **8** is a ring having a single-cut structure with a dividing portion **24** at a point in a circumferential direction **31**. As illustrated in FIGS. **2** and **3**, the lock ring **8** has an inner circumference face **27**, an outer circumference face **28**, a first surface for preventing separation **29** that faces the opening end of the socket **5** when being set in a normal orientation, a second surface for preventing separation **30** that faces the deeper portion of the socket **5** when being set in a normal orientation, and a pair of end faces **32** and **33** opposed to each other at the dividing portion **24**.
(38) As illustrated in FIGS. **1** and **3**, the first surface for preventing separation **29** can make contact with one opening edge **7***a* of the lock-ring storage groove **7** around the pipe axis. The second surface for preventing separation **30** is a flat face extending along a radial direction of the lock ring **8** and faces the spigot protrusion **10** in the pipe axial direction.
(39) The spigot protrusion **10** circumferentially has a face **10***a* facing the second surface for preventing separation **30** of the lock ring **8**. The face **10***a* of the spigot protrusion **10** is a flat face extending along a radial direction. The face **10***a* can entirely make contact with the second surface for preventing separation **30** of the lock ring **8** from the innermost position to the outermost position in the radial direction.
(40) Specifically, in a cross section illustrated in FIG. **3**, the face **10***a* of the spigot protrusion **10** is in contact with the second surface for preventing separation **30** between an A point at the innermost position and a B point at the outermost position in the radial direction of the lock ring **8**. The A point at the innermost position is the position of an inner edge **43** of the lock ring **8**.
(41) The B point at the outermost position is a position where the outer edge of the face **10***a* of the spigot protrusion **10** is in contact with the second surface for preventing separation **30** of the lock ring **8**. The A point at the innermost position of the spigot protrusion **10**, that is, a point corresponding to the inner edge **43** of the lock ring **8** and the B point at the outermost position are also included in the second surface for preventing separation **30** of the lock ring **8**.
(42) As illustrated in FIG. **3**, the spigot protrusion **10** is engaged with the lock ring **8**, and the first surface for preventing separation **29** of the lock ring **8** is in contact with the one opening edge **7***a* of the lock-ring storage groove **7** around the pipe axis. In this contact state, a surface normal **42** of a tangential plane **41** at a contact point **40** between the opening edge **7***a* of the lock-ring storage groove **7** and the first surface for preventing separation **29** of the lock ring **8** passes through the second surface for preventing separation **30** of the lock ring **8**.
(43) In the cross section illustrated in FIG. **3**, the first surface for preventing separation **29** has a

curved shape along an arc having a center S**1** on the surface normal **42** of the tangential plane **41**. The center S**1** is located at the intersection point of the surface normal **42** of the tangential plane **41** and the second surface for preventing separation **30**.

(44) While passing through the second surface for preventing separation **30**, the surface normal **42** of the tangential plane **41** passes through the inner edge **43** of the lock ring **8**, that is, the A point. The A point is the innermost position of the second surface for preventing separation **30** in the radial direction, that is being placed in contact with the spigot protrusion **10**.

(45) With this configuration, when a large drawing force is applied to the pipes **2** and **4** due to an earthquake or the like, the spigot **3** and the socket **12** are likely to separate from each other in the pipe axial direction. Thus, a state illustrated in FIG. **1** changes to a state illustrated in FIG. **3**. Hence, the spigot protrusion **10** is engaged with the lock ring **8** from the deeper portion of the socket **5** in the separation direction **12** of the spigot **3**.

(46) At this point, a force for separating the spigot **3** and the socket **5** in the pipe axial direction is applied to the lock ring **8**. This force brings the first surface for preventing separation **29** of the lock ring **8** into contact with the opening edge **7***a* of the lock-ring storage groove **7** in the pipe axial direction and brings the spigot protrusion **10** into contact with the second surface for preventing separation **30** of the lock ring **8**. Thus, the spigot **3** can be prevented from separating from the socket **12**.

(47) At the contact point **40** between the opening edge **7***a* of the lock-ring storage groove **7** and the first surface for preventing separation **29** of the lock ring **8**, a force F that presses the first surface for preventing separation **29** in the pipe axial direction is applied by the drawing force applied between the pipes **2** and **4** while the contact point **40** serves as a point of application. The force F is applied to the lock ring **8** as a component force F**1** perpendicular to the tangential plane **41** at the contact point **40** of the first surface for preventing separation **29** and a component force F**2** parallel to the tangential plane **41**. A line of application of the component force F**1** perpendicular to the tangential plane **41** extends in the direction of the surface normal **42** of the tangential plane **41**.

(48) In the cross section illustrated in FIG. **3**, the surface normal **42** of the tangential plane **41** passes through the A point at the innermost position in the radial direction of the second surface for preventing separation **30**. Thus, around the A point at the innermost position, a moment generated by the component force F**1** along the surface normal **42** is not applied to the lock ring **8**.

(49) The first surface for preventing separation **29** is curved along the arc having the center S**1** on the surface normal **42** of the tangential plane **41**. The center S**1** of the arc of the first surface for preventing separation **29** is present at the intersection point of the surface normal **42** of the tangential plane **41** and the second surface for preventing separation **30**. Thus, even if the position of the contact point **40** between the one opening edge **7***a* of the lock-ring storage groove **7** and the first surface for preventing separation **29** of the lock ring **8** is displaced by an assembling error or the like, the surface normal **42** of the tangential plane **41** passes through the center S**1** of the arc, the center S**1** being located on the second surface for preventing separation **30**.

(50) The center S**1** of the arc of the first surface for preventing separation **29** is located at the intersection point of the surface normal **42** of the tangential plane **41** and the second surface for preventing separation **30**, thereby securely setting the position of the passage of the surface normal **42** of the tangential plane **41** through the second surface for preventing separation **30**.

(51) As illustrated in FIG. **4**, the component force F**1** applied along the surface normal **42** of the tangential plane **41** has a component F**11** of force applied along the axis of the lock ring **8** and a component F**12** of force applied in a radial direction of the lock ring **8**. The component F**11** along the axis of the lock ring **8** increases and the component F**12** in the radial direction of the lock ring **8** decreases as the angle of the surface normal **42** decreases with respect to the axis of the lock ring **8**.

(52) As illustrated in FIG. **3**, if the surface normal **42** passes through the A point at the innermost position of the second surface for preventing separation **30** of the lock ring **8**, the angle of the surface normal **42** with respect to the axis of the lock ring **8** is smaller than that in the case where

the surface normal passes through the inner circumference face of the lock ring **206** as illustrated in FIG. **26**. Thus, as illustrated in FIG. **4**, the component F**12** of the component force F**1** applied along the surface normal **42** decreases, the component F**12** being applied in the radial direction of the lock ring **8**. This can suppress a pressing force that presses the lock ring **8** to the spigot **3** based on a force from the contact point **40**.

Second Embodiment

(53) In a second embodiment, as illustrated in FIG. **5**, an opening edge **7***a* (see FIG. **3**) of a lock-ring storage groove **7** and a first surface for preventing separation **29** of a lock ring **8** are in contact with each other at a contact point **40**. When a center S**2** of an arc of the first surface for preventing separation **29** is displaced on a second surface for preventing separation **30** in a radial direction of the lock ring **8**, the cross-sectional shape of the first surface for preventing separation **29** changes according to a change of a distance between the contact point **40** and the center S**2** of the arc.

(54) Furthermore, a position where a surface normal **42** of a tangential plane **41** at the contact point **40** passes through the second surface for preventing separation **30** also moves in a radial direction of the lock ring **8** according to a movement of the center S**2** of the arc.

(55) If the surface normal **42** of the tangential plane **41** at the contact point **40** passes through the second surface for preventing separation **30** between an A point at the innermost position and a B point at the outermost position, a moment M**1** in a clockwise direction in FIG. **5** is applied to the lock ring **8** by a component force F**1** applied along the surface normal **42**, with respect to the A point at the innermost position where the spigot protrusion **10** is in contact with the second surface for preventing separation **30** of the lock ring **8**.

(56) At this point, the surface normal **42** passes through the second surface for preventing separation **30** of the lock ring **8**, so that the angle of the surface normal **42** with respect to the axis of the lock ring **8** is smaller than that in the case where the surface normal passes through the inner circumference face of the lock ring **206** as illustrated in FIG. **26**. Thus, a component F**12** (see FIG. **4**) in a radial direction of the lock ring **8** decreases in the component force F**1** along the surface normal **42**. This can suppress a pressing force that presses the lock ring **8** to the outer circumference of a spigot **3** based on a force from the contact point **40**.

(57) The lock ring **8** has stiffness against a twist. If a force exceeding the stiffness is applied to the lock ring **8**, the center of a moment applied to the lock ring **8** moves from the A point at the innermost position to the B point at the outermost position in the radial direction of the spigot protrusion **10**.

(58) Thus, a moment M**2** in a counterclockwise direction in FIG. **5** is applied to the lock ring **8** centered on the B point at the outermost position, the moment M**2** being generated by the component force F**1** applied along the surface normal **42**. The lock ring **8** is pressed to the outer circumference of the spigot **3** by the moment M**2**. Thus, the lock ring **8** can be prevented from separating from the outer circumference of the spigot **3**.

Third Embodiment

(59) In a third embodiment, as illustrated in FIG. **6**, a first surface for preventing separation **29** of a lock ring **8** is formed as a tapered face.

(60) In this case, the gradient of the taper of the first surface for preventing separation **29** is adjusted, so that a configuration can be obtained such that a surface normal **42** of a tangential plane **41** at a contact point **40** passes through an A point at the innermost position. Furthermore, the gradient of the tapered face of the first surface for preventing separation **29** is regulated, so that a configuration also can be obtained such that the surface normal **42** of the tangential plane **41** at the contact point **40** passes through a second surface for preventing separation **30** at a position between the A point at the innermost position and a B point at the outermost position.

Fourth Embodiment

(61) In a fourth embodiment, as illustrated in FIG. **7**, a spigot protrusion **10** is formed on the outer circumference of a spigot **3** by overlaying. Only at an A point at the innermost position, the spigot

protrusion **10** is in contact with a second surface for preventing separation **30** of a lock ring **8**. A first surface for preventing separation **29** is curved along an arc having a center S**1** on a surface normal **42** of a tangential plane **41**. The center S**1** of the arc of the first surface for preventing separation **29** is located at the intersection point of the surface normal **42** of the tangential plane **41** at a contact point **40** and the second surface for preventing separation **30**.

(62) In this case, while passing through the second surface for preventing separation **30**, the surface normal **42** of the tangential plane **41** passes through an A point at the innermost position in a radial direction of the second surface for preventing separation **30**. Around the A point at the innermost position, a moment generated by a component force F**1** along the surface normal **42** is not applied to the lock ring **8**.

(63) The surface normal **42** passes through the A point at the innermost position of the second surface for preventing separation **30** of the lock ring **8**, so that the angle of the surface normal **42** with respect to the axis of the lock ring **8** is smaller than that in the case where the surface normal passes through the inner circumference face of the lock ring **206** as illustrated in FIG. **26**. Thus, a component F**12** in a radial direction of the component force F**1** applied along the surface normal **42** decreases. This can suppress a pressing force that presses the lock ring **8** to the outer circumference of a spigot **3** based on a force from the contact point **40**.

(64) In the descriptions of the first to fourth embodiments, the pipe joint **1** is not bent. However, even if the pipe joint **1** is bent, the position of the contact point **40** is not changed and the line of application of the component force F**1** along the surface normal **42** always passes through the second surface for preventing separation **30**. Thus, even if the pipe joint **1** is bent, the same effect can be obtained as in the case where the pipe joint **1** is not bent.

(65) Regarding the second to fourth embodiments, matters not described in the foregoing description are identical to or shared with the first embodiment.

Fifth Embodiment

(66) In a fifth embodiment, the lock ring **8** according to the first to fourth embodiments further includes the following structure. In the following description, the same members as those of the pipe joints **1** described in the first to fourth embodiments are denoted by the same reference numerals and a detailed description thereof is omitted.

(67) The lock ring **8** is a metallic ring having elasticity and can elastically expand and contract in a radial direction. Thus, the lock ring **8** can be increased in diameter by using an expander tool **101** illustrated in FIG. **14**. Moreover, the lock ring **8** can keep a spacing **34** between end faces **32** and **33** at a dividing portion **24** by using a spacing keeping tool **123** illustrated in FIGS. **15** and **16**.

(68) As illustrated in FIGS. **8** to **10**, the end faces **32** and **33** at the dividing portion **24** of the lock ring **8** have engaging portions **32***a* and **33***a* where contact members **121** and **122** (see FIGS. **15** and **16**) of the spacing keeping tool **123** can be engaged.

(69) The end face **32** at the dividing portion **24** of the lock ring **8** has a release portion **45** that releases the contact members **121** and **122** of the spacing keeping tool **123** in a separation direction **44** (see FIG. **24**). The separation direction **44** is a direction that separates the contact members **121** and **122** inward from the end face **32** of the lock ring **8** in a radial direction of the lock ring **8**.

(70) As illustrated in FIG. **12**, the release portion **45** is an inclined face extending from the end face **32** to the inner circumference face **27** of the lock ring **8**. When the lock ring **8** is viewed from the side where the second surface for preventing separation **30** is formed, the release portion **45** tilts in a direction that increases the spacing **34** between the end faces **32** and **33** toward the inside in the radial direction and tilts in a direction that increases the spacing **34** between the end faces **32** and **33** as the first surface for preventing separation **29** approaches the second surface for preventing separation **30**.

(71) As illustrated in FIG. **9**, the release portion **45** decreases in size in the radial direction **15** as the second surface for preventing separation **30** approaches the first surface for preventing separation **29** and is shaped like a right triangle when viewed in the circumferential direction **31** of the lock

ring **8**.
(72) As illustrated in FIG. **17**, if the lock ring **8** is stored in a normal orientation in the lock-ring storage groove **7**, the engaging portion **32***a* of the end face **32** is placed near the opening end face **14** of the socket **5** and the release portion **45** of the one end face **32** is placed near the deep end face **26** (see FIG. **1**) of the socket **5**.
(73) As illustrated in FIG. **22**, if the lock ring **8** is stored in an inverted orientation in the lock-ring storage groove **7**, the release portion **45** of the one end face **32** is placed near the opening end face **14** of the socket **5** and the engaging portion **32***a* of the end face **32** is placed near the deep end face **26** of the socket **5**.
(74) As illustrated in FIGS. **18** and **23**, the engaging portions **32***a* and **33***a* and the release portion **45** are exposed inward from the lock-ring storage groove **7** in the radial direction **15** in a state in which the lock ring **8** is increased in diameter by using the expander tool **101**. At this point, an outer end portion **45***a* (see FIGS. **9** and **13**) of the release portion **45** in the radial direction **15** is placed into the lock-ring storage groove **7**.
(75) The structure of the expander tool **101** will be described below.
(76) As illustrated in FIG. **14**, the expander tool **101** is a forficate tool including a pair of leg portions **102** that can be opened and closed, screw rods **103** screwed into the leg portions **102**, and handles **104**. When the handles **104** are rotated, the leg portions **102** are opened or closed by a screw feed mechanisms of the screw rods **103** to increase or reduce a spacing between the distal end portions of the leg portions **102**.
(77) The structure of the spacing keeping tool **123** will be described below.
(78) As illustrated in FIGS. **15** and **16**, the spacing keeping tool **123** includes the pair of contact members **121** and **122** that can be inserted into the dividing portion **24** of the lock ring **8** and make contact with the engaging portions **32***a* and **33***a* of the end faces **32** and **33** of the lock ring **8**, and a spacing regulating member **125** that connects the contact members **121** and **122** and can regulate a spacing **124** between the contact members **121** and **122** along the circumferential direction **31** of the lock ring **8**.
(79) The spacing regulating member **125** includes a screw portion **126** provided from the first contact member **121** and the second contact member **122**, a wing bolt **127** that is attached to one end of the screw portion **126** to rotate the screw portion **126**, and a shaft portion **128** attached to the other end of the screw portion **126**.
(80) The shaft portion **128** is a member like a straight round bar that has a smaller diameter than a recessed portion of the screw portion **126** and has no external threads on the outer circumference.
(81) The first contact member **121** has a plate-like insertion portion **121***a* formed with a length to the outside of the socket **5**, a handgrip portion **121***b*, and a supporter **121***c* in which the shaft portion **128** of the screw portion **126** is inserted.
(82) The screw portion **126** idles with respect to the supporter **121***c*, and the supporter **121***c* is prevented from moving relative to the axial direction of the screw portion **126**.
(83) The second contact member **122** has a plate-like insertion portion **122***a* formed with a length to the outside of the socket **5**, a handgrip portion **122***b*, and a feed nut **122***c* that has an internal thread **122***d* on the inner surface so as to be engaged with the screw portion **126**. The screw portion **126** is screwed into the feed nut **122***c*.
(84) On the outer surface of the supporter **121***c* of the first contact member **121**, a rod-like rotation preventing member **129** is attached to prevent relative rotations of the first contact member **121** and the second contact member **122**. The rotation preventing member **129** extends from the supporter **121***c* of the first contact member **121** to the feed nut portion **122***c* of the second contact member **122**.
(85) When the screw portion **126** is rotated, the second contact member **122** is brought close to or separated from the first contact member **121** in the axial direction of the screw portion **126** by the screw feed mechanism. Through the operations of approach and separation, the spacing **124**

between the first contact member **121** and the second contact member **122** can be regulated.
(86) A method for joining the pipes **2** and **4** in the pipe joint **1** will be described below.
(87) The backup ring **23**, the seal member **17**, and the gland **18** are fit onto the spigot **3** in advance. In the fit state, the lock ring **8** is set into the lock-ring storage groove **7** as illustrated in FIG. **17**. At this point, if the lock ring **8** is set in a normal orientation in the lock-ring storage groove **7** in the pipe axial direction, the engaging portion **32***a* of the one end face **32** is placed near the opening end face **14** of the socket **5** and the release portion **45** is placed near the deep end face **26** (see FIG. **1**) of the socket **5**.
(88) In the positioned state, the diameter of the lock ring **8** is increased by the expander tool **101** as illustrated in FIG. **18**. At this point, as illustrated in FIG. **14**, the distal ends of the leg portions **102** of the expander tool **101** are inserted into the dividing portion **24** of the lock ring **8**. Through the insertion, the distal end of one of the leg portions **102** is inserted into the lock-ring storage groove **7** and is engaged with the end face **32** of the lock ring **8** and the distal end of the other leg portion **102** is inserted into the lock-ring storage groove **7** and is engaged with the other end face **33** of the lock ring **8**.
(89) At this point, as illustrated in FIG. **18**, the distal ends of the leg portions **102** of the expander tool **101** are shifted close to the deep end face **26** of the socket **5** in the lock-ring storage groove **7**.
(90) Thereafter, the handles **104** are rotated to open the leg portions **102**. Thus, the spacing **34** between the end faces **32** and **33** of the lock ring **8** is extended to increase the diameter of the lock ring **8**.
(91) In this state, as illustrated in FIG. **15**, the insertion portions **121***a* and **122***a* of the spacing keeping tool **123** are inserted into the dividing portion **24** of the lock ring **8** from the opening end of the socket **5**. Furthermore, the wing bolt **127** is rotated to extend the spacing **124** between the first contact member **121** and the second contact member **122**.
(92) Thus, as illustrated in FIG. **19**, the insertion portion **121***a* of the first contact member **121** of the spacing keeping tool **123** is engaged with the engaging portion **32***a* of the end face **32** of the lock ring **8**. At this point, the insertion portion **122***a* of the second contact member **122** is engaged with the engaging portion **33***a* of the other one end face **33** of the lock ring **8**.
(93) Thereafter, as illustrated in FIG. **20**, the expander tool **101** is removed from the lock ring **8**. As a result, the spacing **34** between the end faces **32** and **33** of the lock ring **8** increased in diameter is kept by the spacing keeping tool **123**. Thus, even if the expander tool **101** is removed from the lock ring **8**, the lock ring **8** is continuously kept with an increased diameter.
(94) In this state, the spigot **3** is inserted into the socket **5**. When the spigot protrusion **10** of the spigot **3** passes through the inner circumference of the lock ring **8** from the opening end to the deeper portion of the socket **5**, the spacing keeping tool **123** is removed from the lock ring **8**.
(95) Thus, as illustrated in FIG. **21**, the insertion portions **121***a* and **122***a* of the spacing keeping tool **123** are separated from the engaging portions **32***a* and **33***a* of the lock ring **8**. Through the separation, the spacing **34** between the end faces **32** and **33** of the lock ring **8** is reduced, so that the lock ring **8** is reduced in diameter to be wrapped around the outer circumference of the spigot **3**.
(96) Thereafter, as illustrated in FIG. **1**, the backup ring **23** is moved in the pipe axial direction and is inserted between the inner circumference of the socket protrusion **16** and the outer circumference of the spigot **3**.
(97) In this state, the seal member **17** is moved in the pipe axial direction and is inserted between the inner circumference of the socket **5** and the outer circumference of the spigot **3**. Thus, the gland **18** is coupled to the flange portion **21** of socket **5** with the plurality of sets of T bolts **19** and nuts **20** and is brought into contact with the opening end face **14**. Hence, the pipes **2** and **4** are joined to each other.
(98) In the following description, when the lock ring **8** is set in the lock-ring storage groove **7**, the lock ring **8** in an inverted orientation is set by mistake in the lock-ring storage groove **7** in the pipe axial direction as illustrated in FIG. **22**. In this case, the engaging portion **32***a* of the end face **32** is

placed near the deep end face **26** of the socket **5**, and the release portion **45** of the one end face **32** is placed near the opening end face **14** of the socket **5**.

(99) Also in this case, as illustrated in FIG. **23**, the distal ends of the leg portions **102** of the expander tool **101** are inserted into the dividing portion **24** of the lock ring **8**. Through the insertion, the distal end of one of the leg portions **102** is inserted into the lock-ring storage groove **7** and is engaged with the end face **32** of the lock ring **8** and the distal end of the other leg portion **102** is inserted into the lock-ring storage groove **7** and is engaged with the other end face **33** of the lock ring **8**.

(100) At this point, the distal ends of the leg portions **102** are shifted close to the deep end face **26** of the socket **5** in advance in the lock-ring storage groove **7**.

(101) Thereafter, the leg portions **102** are opened by rotating the handles **104**. Thus, the spacing **34** between the end faces **32** and **33** of the lock ring **8** is extended to increase the diameter of the lock ring **8**.

(102) In this state, as illustrated in FIG. **24**, the insertion portions **121***a* and **122***a* of the spacing keeping tool **123** are inserted into the dividing portion **24** of the lock ring **8** from the opening end of the socket **5**. In this state, the wing bolt **127** is rotated to extend the spacing **124** between the first contact member **121** and the second contact member **122**.

(103) Thus, the insertion portions **121***a* and **122***a* of the spacing keeping tool **123** are engaged with the engaging portions **32***a* and **33***a* of the lock ring **8** as follows: the release portion **45** of the end face **32** is placed near the opening end face **14** of the socket **5**, so that the insertion portion **122***a* of the second contact member **122** is guided to the tilted release portion **45** and slides along the release portion **45** in the separation direction **44** without being engaged with the engaging portion **32***a* of the one end face **32**. Through the sliding, as indicated by virtual lines in FIG. **24**, the insertion portion **122***a* is separated inward from the one end face **32** in the radial direction **15** of the lock ring **8**.

(104) Thus, the spacing keeping tool **123** cannot keep the spacing **34** between the end faces **32** and **33** of the lock ring **8**, which has been increased in diameter by the expander tool **101**. Therefore, an operator can notice an inverted orientation of the mounted lock ring **8** in the pipe axial direction before inserting the spigot **3** into the socket **5** to insert the pipe. This can shorten a time for a rejoining operation of the first pipe **2** and the second pipe **4**.

(105) The rejoining operation of the first pipe **2** and the second pipe **4** will be described below. In this case, first, the diameter of the lock ring **8** is reduced by removing the expander tool **101** from the lock ring **8**. The lock ring **8** reduced in diameter is removed from the lock-ring storage groove **7**. As illustrated in FIG. **17**, the removed lock ring is corrected to a normal orientation and then is set into the lock-ring storage groove **7** again.

(106) Thereafter, as illustrated in FIGS. **18** to **21**, the lock ring **8** is similarly increased in diameter by the expander tool **101**, and the lock ring **8** is kept with the extended diameter by the spacing keeping tool **123**.

(107) As illustrated in FIGS. **1** to **7**, in the first to fourth embodiments, the lock ring **8** does not include the release portion **45** (see FIG. **9**) in the fifth embodiment. However, in the first to fourth embodiments, the lock ring **8** including the release portion **45** may be used as in the fifth embodiment. In this case, the pipes **2** and **4** are joined in the same steps as in the fifth embodiment.

Sixth Embodiment

(108) In the fifth embodiment, the release portion **45** is an inclined face as illustrated in FIG. **12**. However, the release portion **45** is not limited to an inclined face. For example, as a sixth embodiment, a release portion **45** may be a curved surface extending like an arc from an end face **32** to an inner circumference face **27** of a lock ring **8** as illustrated in FIG. **25**. The curved surface is formed in a direction along which a spacing **34** between the end face **32** and an end face **33** increases toward the inside in a radial direction.

(109) If the lock ring **8** in FIG. **25** is set in an inverted orientation by mistake in a lock-ring storage

groove **7**, the method for joining the pipes **2** and **4** is configured as follows: while the diameter of the lock ring **8** is increased by an expander tool **101**, an insertion portion **121***a* of a first contact member **121** of a spacing keeping tool **123** is not engaged with one engaging portion **32***a*. The insertion portion **121***a* is then guided to the curved release portion **45**, slides along the release portion **45** in a separation direction **44** indicated in FIG. **24**, and is separated inward from the one end face **32** of the lock ring **8** in a radial direction **15** of the lock ring **8**.

(110) In the fifth and sixth embodiments, as illustrated in FIGS. **12** and **25**, the release portion **45** is formed on the either one end face **32** of the lock ring **8**. However, the release portion **45** may be formed on each of the end faces **32** and **33**.

(111) As illustrated in FIGS. **1** to **7**, the lock ring **8** according to the first to fourth embodiments does not include the release portion **45** (see FIG. **25**) described in the sixth embodiment. However, in the first to fourth embodiments, the lock ring **8** including the release portion **45** may be used as in the sixth embodiment.

(112) According to the descriptions of the embodiments, techniques are disclosed as follows:

(113) (Technique 1)

(114) A pipe joint in which a spigot of a first pipe is inserted into a socket of a second pipe, a lock-ring storage groove is formed on an inner circumference of the socket, a lock ring stored in the lock-ring storage groove is attached to an outer circumference of the spigot, a spigot protrusion is formed on the outer circumference of the spigot, and the spigot protrusion is engaged with the lock ring from a deeper portion of the socket in a separation direction of the spigot so as to prevent the spigot from separating from the socket, wherein the lock ring has a first surface for preventing separation facing an opening end of the socket and a second surface for preventing separation facing the deeper portion of the socket, and in a state in which the spigot protrusion is engaged with the lock ring and the first surface for preventing separation of the lock ring is in contact with an opening edge of the lock-ring storage groove around a pipe axial direction, a surface normal of a tangential plane at a contact point between the opening edge of the lock-ring storage groove and the first surface for preventing separation of the lock ring passes through the second surface for preventing separation of the lock ring.

(115) When a drawing force is applied to the pipes in the pipe joint, the spigot protrusion is engaged with the lock ring and the first surface for preventing separation of the lock ring is brought into contact with the opening edge of the lock-ring storage groove. At this point, a force in the pipe axial direction is applied to a contact point between the first surface for preventing separation of the lock ring and the opening edge of the lock-ring storage groove. The force applied to the contact point in the pipe axial direction is applied to the lock ring as a component force along the surface normal of the tangential plane at the contact point and a component force along the tangential plane.

(116) The surface normal of the tangential plane passes through the second surface for preventing separation, so that a line of application of the component force along the surface normal of the tangential plane passes through the second retaining surface.

(117) The component force applied along the surface normal of the tangential plane has a component of force applied in the axial direction of the lock ring and a component of force applied in a radial direction of the lock ring. The component in the axial direction of the lock ring increases and the component in the radial direction of the lock ring decreases as an angle of the surface normal decreases with respect to the axis of the lock ring. Thus, the surface normal of the tangential plane passes through the second surface for preventing separation of the lock ring, so that the component in the radial direction of the lock ring is small in the component force along the surface normal of the tangent surface as compared with a case where the surface normal of the tangential plane passes through the inner circumference face of the lock ring. This can suppress an applied force that presses the lock ring onto the outer circumference of the spigot based on a drawing force.

(118) (Technique 2)
(119) The pipe joint according to technique 1, wherein the inner edge of the lock ring is included in the second surface for preventing separation, and the surface normal of the tangential plane passes through the inner edge of the lock ring while passing through the second surface for preventing separation.
(Technique 3)
(120) The pipe joint according to technique 1, wherein the inner edge of the lock ring is included in the second surface for preventing separation, and the surface normal of the tangential plane passes through the second surface for preventing separation between the inner edge of the lock ring and a position where the outer edge of the spigot protrusion is in contact with the second surface for preventing separation.
(Technique 4)
(121) The pipe joint according to any one of techniques 1 to 3, wherein the first surface for preventing separation of the lock ring is shaped like a circular conical surface.
(122) (Technique 5)
(123) The pipe joint according to any one of techniques 1 to 3, wherein the first surface for preventing separation of the lock ring is curved along an arc having a center on the surface normal of the tangential plane.
(124) (Technique 6)
(125) The pipe joint according to technique 5, wherein the center of the arc of the first surface for preventing separation is located at an intersection point of the surface normal of the tangential plane and the second surface for preventing separation.
(126) (Technique 7)
(127) The pipe joint according to any one of techniques 1 to 6, wherein the lock ring is a ring having a single-cut structure with a dividing portion at a point along the circumferential direction, end faces at the dividing portion of the lock ring in the circumferential direction have engaging portions that allow engagement of a spacing keeping tool, the spacing keeping tool keeping a spacing between the end faces of the lock ring increased in diameter, at least one of the end faces of the lock ring has a release portion for releasing the spacing keeping tool in a separation direction that separates the spacing keeping tool inward from the end face of the lock ring in a radial direction of the lock ring, if the lock ring is stored in a normal orientation in the lock ring storage groove, the engaging portion is placed near the opening end of the socket and the release portion is placed near the deep end of the socket, and the engaging portions and the release portion are exposed inward from the lock-ring storage groove in the radial direction in a state in which the lock ring is increased in diameter.
(128) With this configuration, when the first pipe and the second pipe are joined, the lock ring is first set in the lock-ring storage groove. At this point, if the lock ring is stored in a normal orientation in the lock-ring storage groove in the pipe axial direction, the engaging portion is placed near the opening end of the socket and the release portion is placed near the deep end of the socket.
(129) Thereafter, in a state in which the lock ring is increased in diameter by an expander tool, the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is engaged with the engaging portions. At this point, the engaging portions are placed closer to the opening end of the socket than the release portion, so that the spacing keeping tool is engaged with the engaging portion. Thus, the spacing keeping tool can keep the spacing between the end faces of the lock ring increased in diameter.
(130) In this state, the spigot is inserted into the socket. At this point, the spigot protrusion passes through the inner circumference of the lock ring from the opening end to the deep end of the socket, and then the spacing keeping tool is removed from the lock ring. The removal reduces the diameter of the lock ring.
(131) When the first pipe and the second pipe are joined, the lock ring in an inverted orientation

may be set by mistake in the lock-ring storage groove in the pipe axial direction. At this point, the release portion is placed near the opening end of the socket, and the engaging portion is placed near the deep end of the socket.
(132) In such positioning with the lock ring increased in diameter by the expander tool, the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is engaged with the engaging portions. At this point, the release portion is placed closer to the opening end of the socket than the engaging portions, so that the spacing keeping tool is guided to the release portion and is separated inward from the end face of the lock ring in the radial direction of the lock ring without being engaged with the engaging portions.
(133) As described above, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove, the spacing keeping tool to be engaged with the engaging portions of the lock ring is guided to the release portion and is separated from the end face of the lock ring without being engaged with the engaging portions. Thus, the spacing keeping tool cannot keep the spacing between the end faces of the lock ring increased in diameter.
(134) With this configuration, an operator can find an error in the attachment of the lock ring before a pipe inserting operation is performed to insert the spigot into the socket. This can shorten a time for a rejoining operation of the pipes.
(135) (Technique 8)
(136) The pipe joint according to technique 7, wherein the release portion is an inclined face extending from the end face of the lock ring to the inner circumference face of the lock ring, and the inclined face tilts in a direction that increases the spacing between the end faces of the lock ring toward the inside in a radial direction.
(137) In the pipe joint, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove, the spacing keeping tool is guided inward in the radial direction of the lock ring by the inclined face of the release portion and is separated from the end face of the lock ring while the lock ring is increased in diameter by using the expander tool.
(138) (Technique 9)
(139) The pipe joint according to technique 7, wherein the release portion is a curved surface extending like an arc from the end face of the lock ring to the inner circumference face of the lock ring, and the curved surface is curved in a direction that increases the spacing between the end faces of the lock ring toward the inside in a radial direction.
(140) In the pipe joint, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove, the spacing keeping tool is guided inward in the radial direction of the lock ring by the curved surface of the release portion and is separated from the end face of the lock ring while the lock ring is increased in diameter by using the expander tool.
(141) (Technique 10)
(142) A pipe joining method for assembling the pipe joint according to any one of techniques 7 to 9, the method including: setting the lock ring into the lock-ring storage groove in the socket; inserting the spacing keeping tool from the opening end of the socket into the dividing portion of the lock ring and engaging the spacing keeping tool with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool; removing the expander tool from the lock ring and keeping, by using the spacing keeping tool, the spacing between the end faces of the lock ring increased in diameter; and removing the spacing keeping tool from the lock ring and reducing the diameter of the lock ring when the spigot protrusion is caused to pass through the inner circumference of the lock ring from the opening end to the deeper portion of the socket by inserting the spigot into the socket.
(143) According to the joining method, if the lock ring is set in a normal orientation in the lock-ring storage groove in the pipe axial direction, the engaging portion is placed near the opening end of the socket and the release portion is placed near the deep end of the socket. Thus, the spacing keeping tool can be engaged with the engaging portions of the lock ring, so that the spacing

keeping tool can keep the spacing between the end faces of the lock ring increased in diameter.
(144) (Technique 11)
(145) A pipe joining method for assembling the pipe joint according to any one of techniques 7 to 9, the method including: setting the lock ring into the lock-ring storage groove in the socket; determining that the lock ring is attached in an inverted orientation in the pipe axial direction if the spacing keeping tool is guided to the release portion and is separated from the end face of the lock ring without being engaged with the engaging portions when the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is to be engaged with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool; removing the expander tool from the lock ring to reduce the diameter of the lock ring; removing the lock ring from the lock-ring storage groove; correcting the lock ring to a normal orientation and setting the lock ring into the lock-ring storage groove again; inserting the spacing keeping tool from the opening end of the socket into the dividing portion of the lock ring and engaging the spacing keeping tool with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool; removing the expander tool from the lock ring and keeping, by using the spacing keeping tool, the spacing between the end faces of the lock ring increased in diameter; and removing the spacing keeping tool from the lock ring and reducing the diameter of the lock ring when the spigot protrusion is caused to pass through the inner circumference of the lock ring from the opening end to the deeper portion of the socket by inserting the spigot into the socket.
(146) According to the joining method, if the lock ring is set in an inverted orientation by mistake in the lock-ring storage groove in the pipe axial direction, the release portion is placed near the opening end of the socket and the engaging portion is placed near the deep end of the socket. Thus, the spacing keeping tool is guided to the release portion and is separated inward from the end face of the lock ring in the radial direction of the lock ring without being engaged with the engaging portions.
(147) The separation does not allow the spacing keeping tool to keep the spacing between the end faces of the lock ring increased in diameter. Therefore, an operator can find an error in the attachment of the lock ring before a pipe inserting operation is performed to insert the spigot into the socket. This can shorten a time for a rejoining operation of the pipes.

Claims

1. A pipe joint, comprising: a spigot of a first pipe; a socket of a second pipe into which the spigot of the first pipe is inserted; a lock-ring storage groove formed on an inner circumference of the socket; a lock ring stored in the lock-ring storage groove, the lock ring being attached to an outer circumference of the spigot; and a spigot protrusion formed on the outer circumference of the spigot, and, wherein the spigot protrusion is engaged with the lock ring from a deeper portion of the socket in a separation direction of the spigot so as to prevent the spigot from separating from the socket, wherein the lock ring has a first surface for preventing separation facing an opening end of the socket and a second surface for preventing separation facing the deeper portion of the socket, and wherein, in a state in which the spigot protrusion is engaged with the lock ring and the first surface for preventing separation of the lock ring is in contact with an opening edge of the lock-ring storage groove around a pipe axial direction, a surface normal of a tangential plane at a contact point between the opening edge of the lock-ring storage groove and the first surface for preventing separation of the lock ring passes through the second surface for preventing separation of the lock ring.
2. The pipe joint according to claim 1, wherein an inner edge of the lock ring is included in the second surface for preventing separation, and wherein the surface normal of the tangential plane passes through the inner edge of the lock ring while passing through the second surface for

preventing separation.
3. The pipe joint according to claim 1, wherein an inner edge of the lock ring is included in the second surface for preventing separation, and wherein the surface normal of the tangential plane passes through the second surface for preventing separation between the inner edge of the lock ring and a position where an outer edge of the spigot protrusion is in contact with the second surface for preventing separation.
4. The pipe joint according to claim 1, wherein the first surface for preventing separation of the lock ring is shaped like a circular conical surface.
5. The pipe joint according to claim 1, wherein the first surface for preventing separation of the lock ring is curved along an arc having a center on the surface normal of the tangential plane.
6. The pipe joint according to claim 5, wherein the center of the arc of the first surface for preventing separation is located at an intersection point of the surface normal of the tangential plane and the second surface for preventing separation.
7. The pipe joint according to claim 1, wherein the lock ring is a ring having a single-cut structure with a dividing portion at a point along a circumferential direction, wherein end faces at the dividing portion of the lock ring in the circumferential direction have engaging portions that allow engagement of a spacing keeping tool, the spacing keeping tool keeping a spacing between the end faces of the lock ring increased in diameter, wherein at least one of the end faces of the lock ring has a release portion for releasing the spacing keeping tool in a separation direction that separates the spacing keeping tool inward from the end face of the lock ring in a radial direction of the lock ring, wherein, if the lock ring is stored in a normal orientation in the lock ring storage groove, the engaging portion is placed near the opening end of the socket and the release portion is placed near a deep end of the socket, and wherein the engaging portions and the release portion are exposed inward from the lock-ring storage groove in the radial direction in a state in which the lock ring is increased in diameter.
8. The pipe joint according to claim 7, wherein the release portion is an inclined face extending from the end face of the lock ring to an inner circumference face of the lock ring, and the inclined face tilts in a direction that increases the spacing between the end faces of the lock ring toward inside in the radial direction.
9. The pipe joint according to claim 7, wherein the release portion is a curved surface extending like an arc from the end face of the lock ring to an inner circumference face of the lock ring, and the curved surface is curved in a direction that increases the spacing between the end faces of the lock ring toward inside in the radial direction.
10. A pipe joining method for assembling the pipe joint according to claim 7, the method comprising: setting the lock ring into the lock-ring storage groove in the socket; inserting the spacing keeping tool from the opening end of the socket into the dividing portion of the lock ring and engaging the spacing keeping tool with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool; removing the expander tool from the lock ring and keeping, by using the spacing keeping tool, the spacing between the end faces of the lock ring increased in diameter; and removing the spacing keeping tool from the lock ring and reducing the diameter of the lock ring when the spigot protrusion is caused to pass through an inner circumference of the lock ring from the opening end to the deeper portion of the socket by inserting the spigot into the socket.
11. A pipe joining method for assembling the pipe joint according to claim 7, the method comprising: setting the lock ring into the lock-ring storage groove in the socket; determining that the lock ring is attached in an inverted orientation in the pipe axial direction if the spacing keeping tool is guided to the release portion and is separated from the end face of the lock ring without being engaged with the engaging portions when the spacing keeping tool is inserted from the opening end of the socket into the dividing portion of the lock ring and is to be engaged with the engaging portions of the end faces while the lock ring is increased in diameter by using the

expander tool; removing the expander tool from the lock ring to reduce a diameter of the lock ring; removing the lock ring from the lock-ring storage groove; correcting the lock ring to a normal orientation and setting the lock ring into the lock-ring storage groove again; inserting the spacing keeping tool from the opening end of the socket into the dividing portion of the lock ring and engaging the spacing keeping tool with the engaging portions of the end faces while the lock ring is increased in diameter by using the expander tool; removing the expander tool from the lock ring and keeping, by using the spacing keeping tool, the spacing between the end faces of the lock ring increased in diameter; and removing the spacing keeping tool from the lock ring and reducing the diameter of the lock ring when the spigot protrusion is caused to pass through an inner circumference of the lock ring from the opening end to the deeper portion of the socket by inserting the spigot into the socket.