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(19) **United States**(12) **Patent Application Publication****Ikawa et al.**(10) **Pub. No.: US 2006/0236521 A1**(43) **Pub. Date: Oct. 26, 2006**(54) **PIPE FIXING STRUCTURE AND PIPE
FIXING METHOD****Publication Classification**(75) Inventors: **Masahiko Ikawa**, Toyohashi-city (JP);
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ALEXANDRIA, VA 22320 (US)(57) **ABSTRACT**(73) Assignee: **Denso Corporation**, Kariya-city (JP)(21) Appl. No.: **11/401,836**(22) Filed: **Apr. 12, 2006**(30) **Foreign Application Priority Data**Apr. 21, 2005 (JP) 2005-124064
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A pipe fixing structure and method are disclosed. In the pipe fixing structure, an ejector 1 on which a pipe 2 is to be fixed is subjected to a pressure which is exerted on the pipe 2 thereby to deform and fix the pipe 2. An enlarged portion 1a larger than the outer diameter of the pipe 2, through which the pipe 2 can be inserted in axial direction, is formed in the ejector 1. A thin portion 2a is formed on the inner peripheral portion of the pipe 2, and a first projection 6 is formed by plastic deformation of the thin portion 2a of pipe 2 under the pressure. The first projection 6 coincides with the enlarged diameter portion 1a so that the pipe is fixed on the ejector 1.

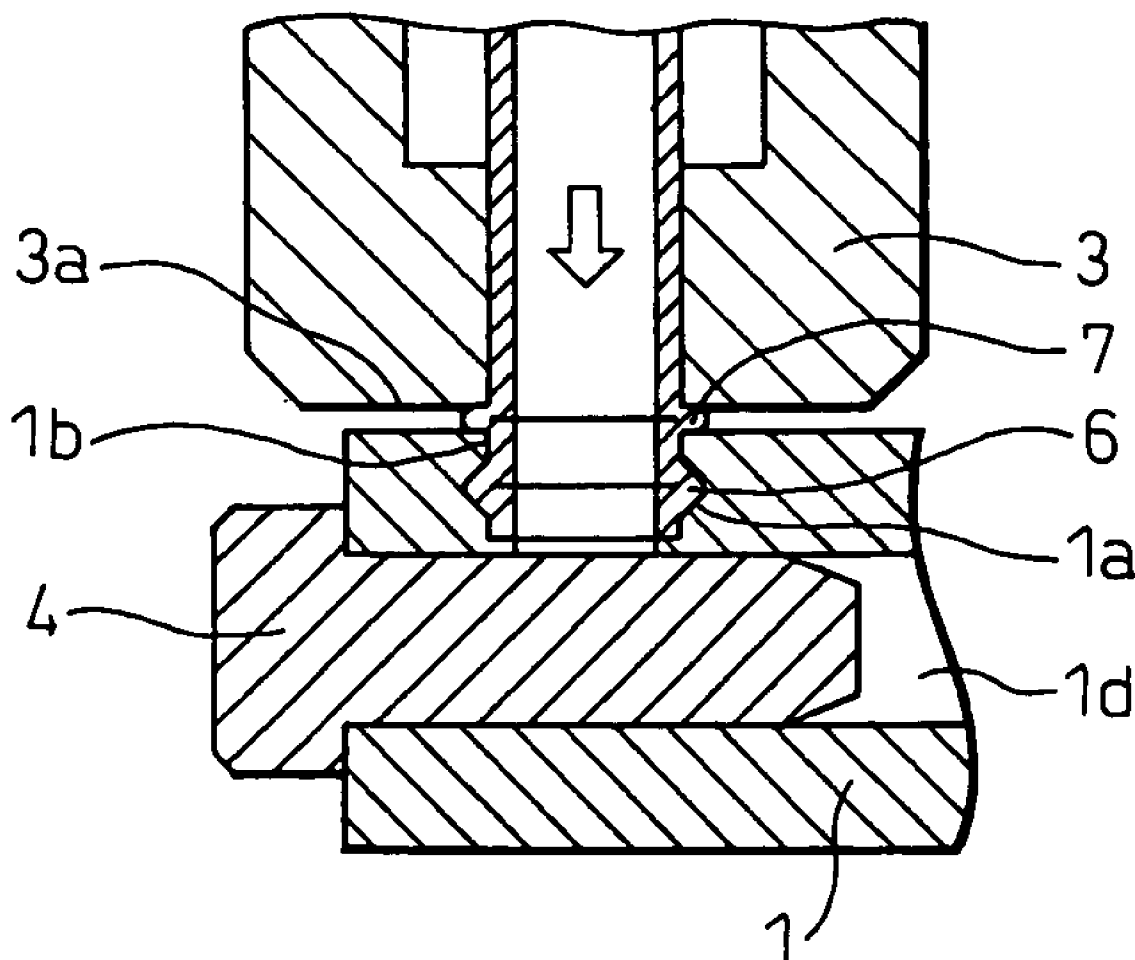


Fig.1

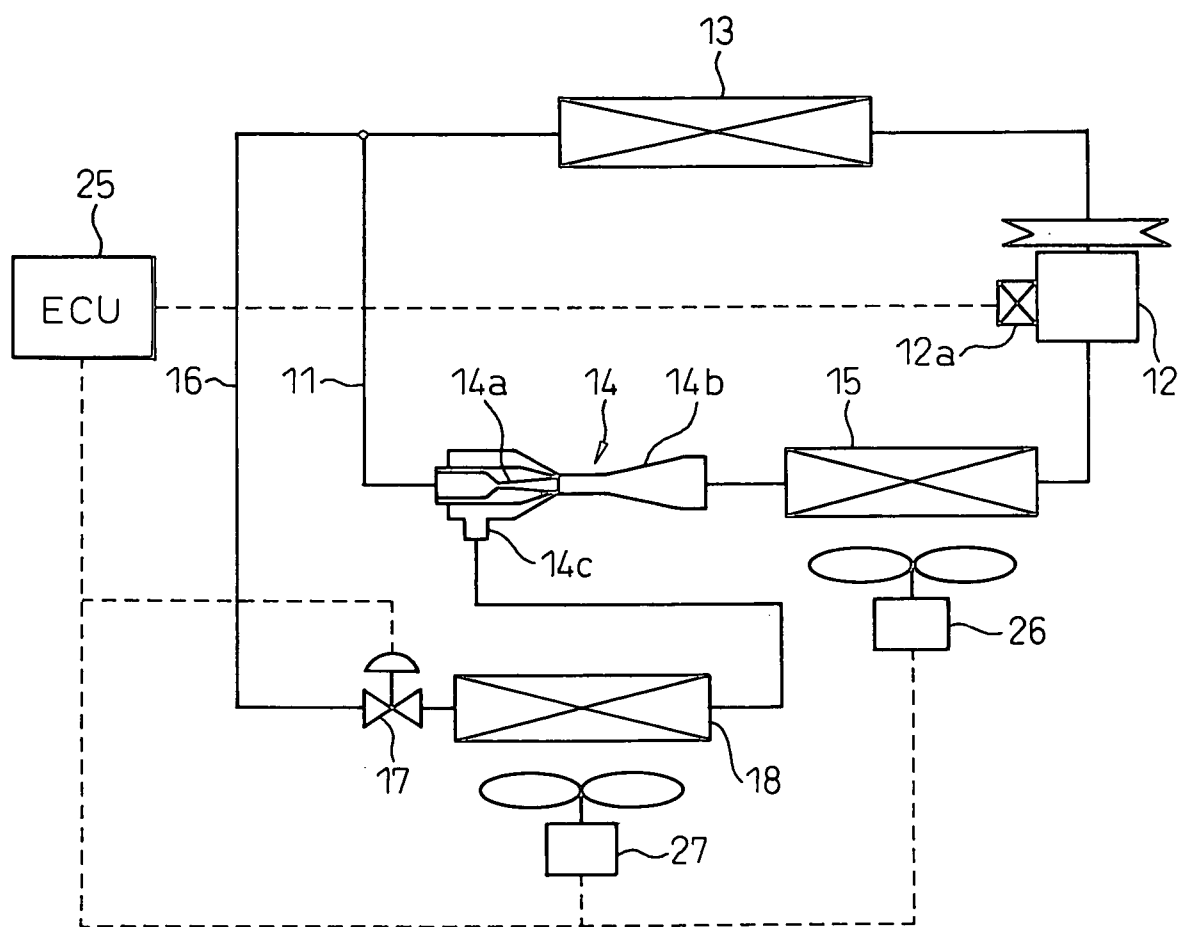


Fig.2

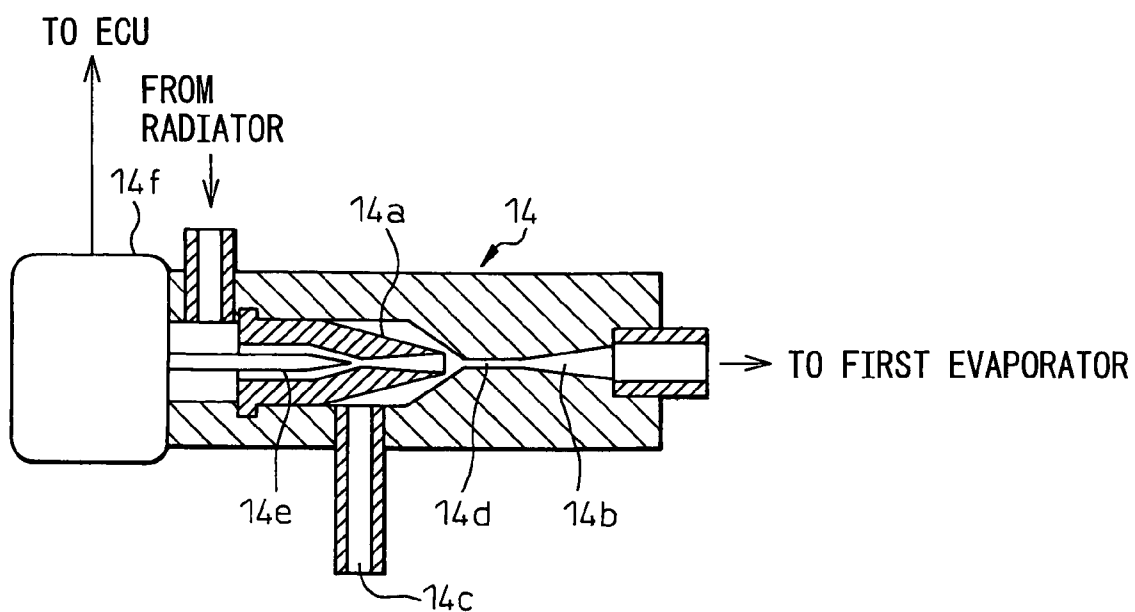


Fig.3

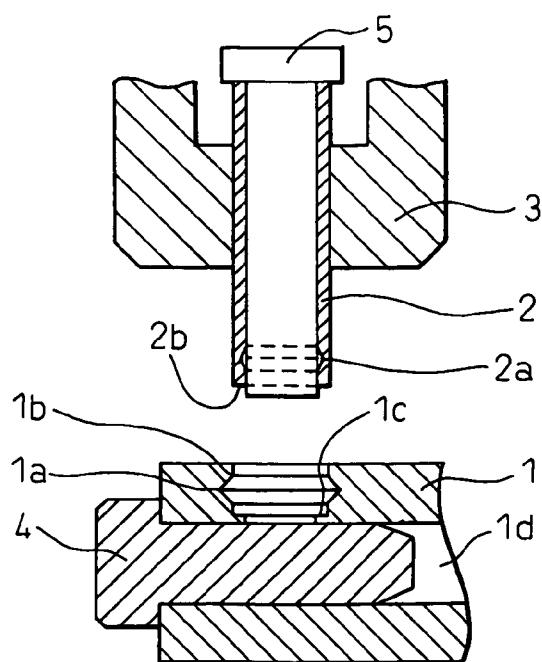


Fig.4

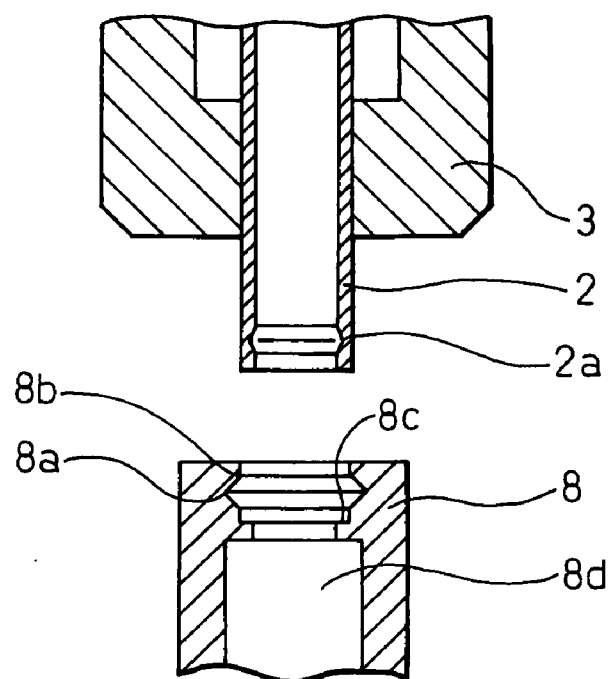


Fig.5

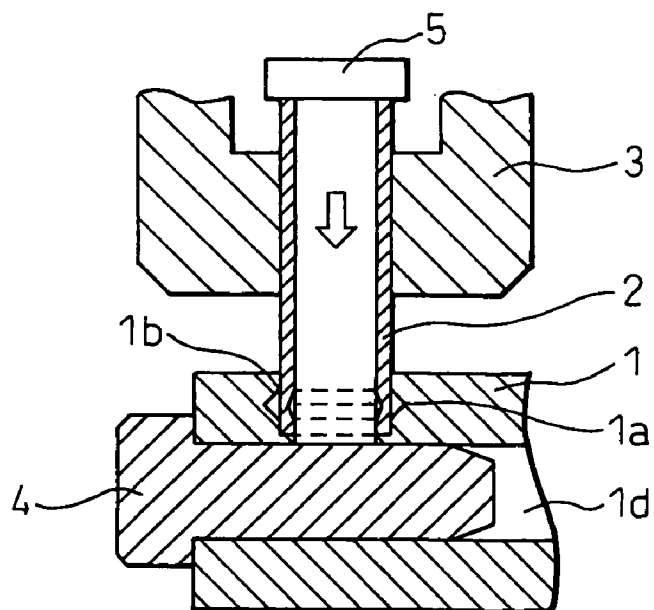


Fig.6

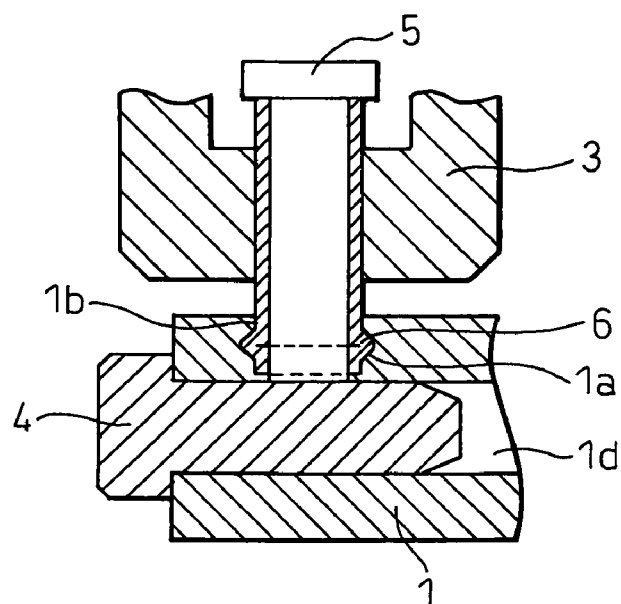


Fig.7

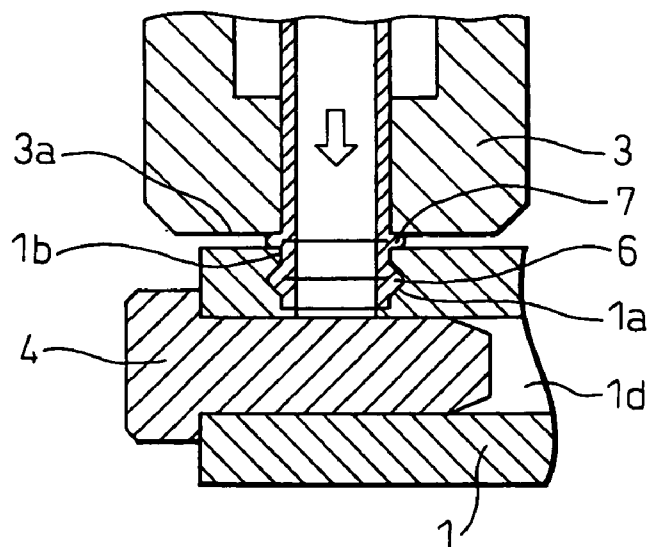


Fig.8

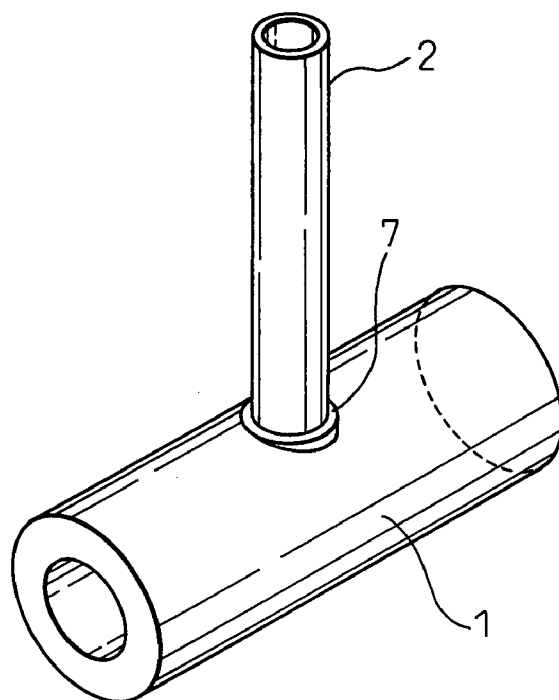


Fig.9

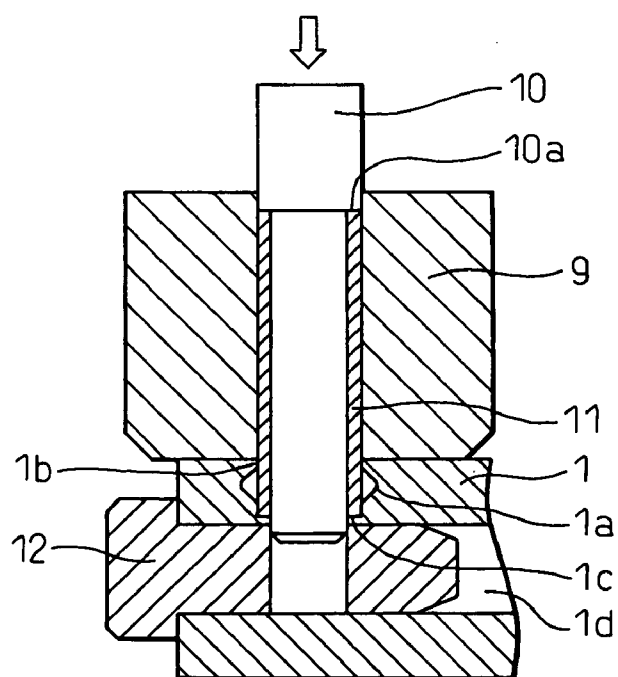


Fig.10

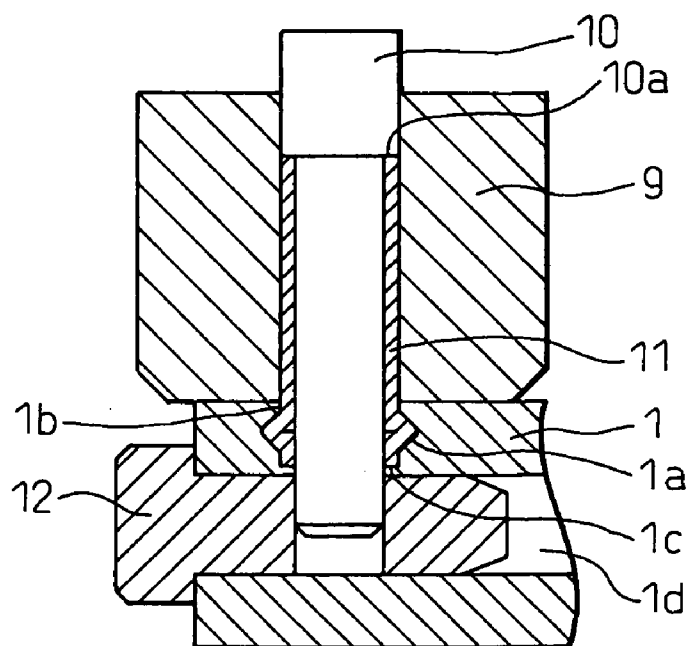


Fig.11

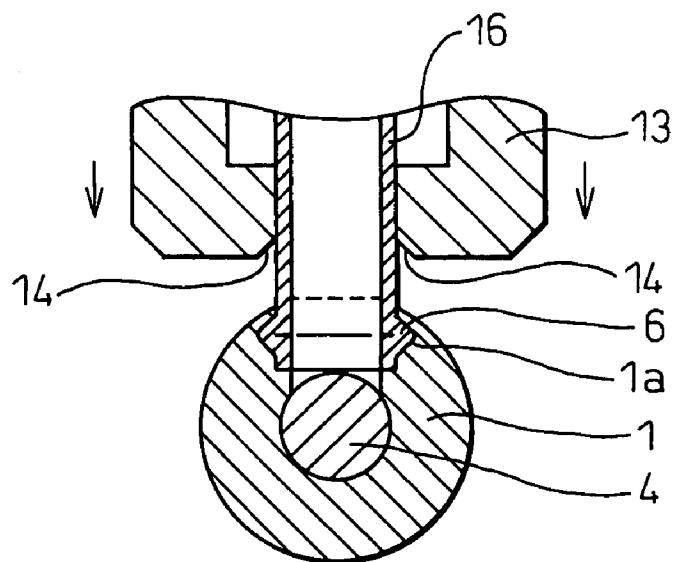


Fig.12

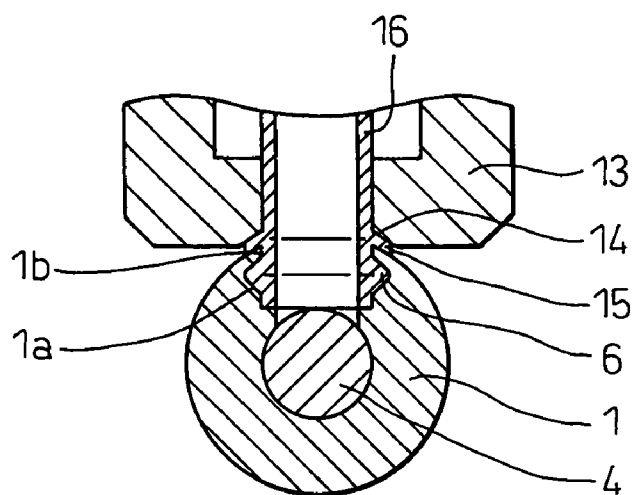


Fig.13

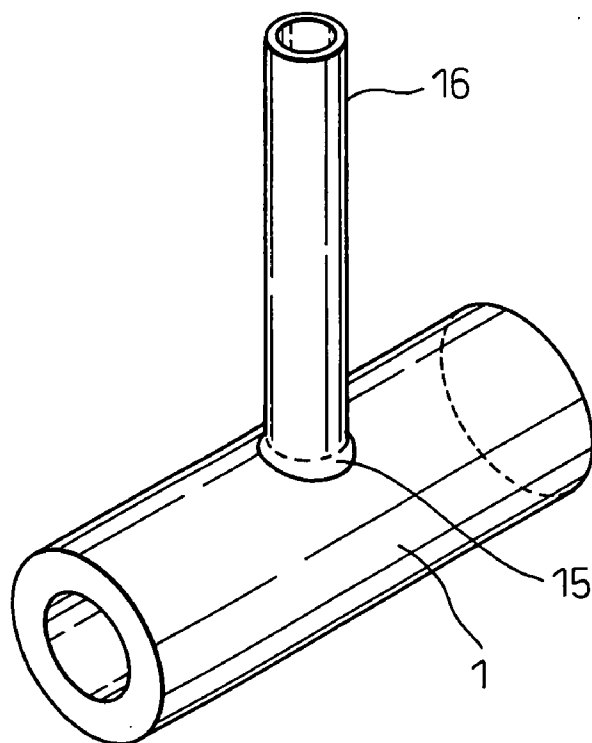
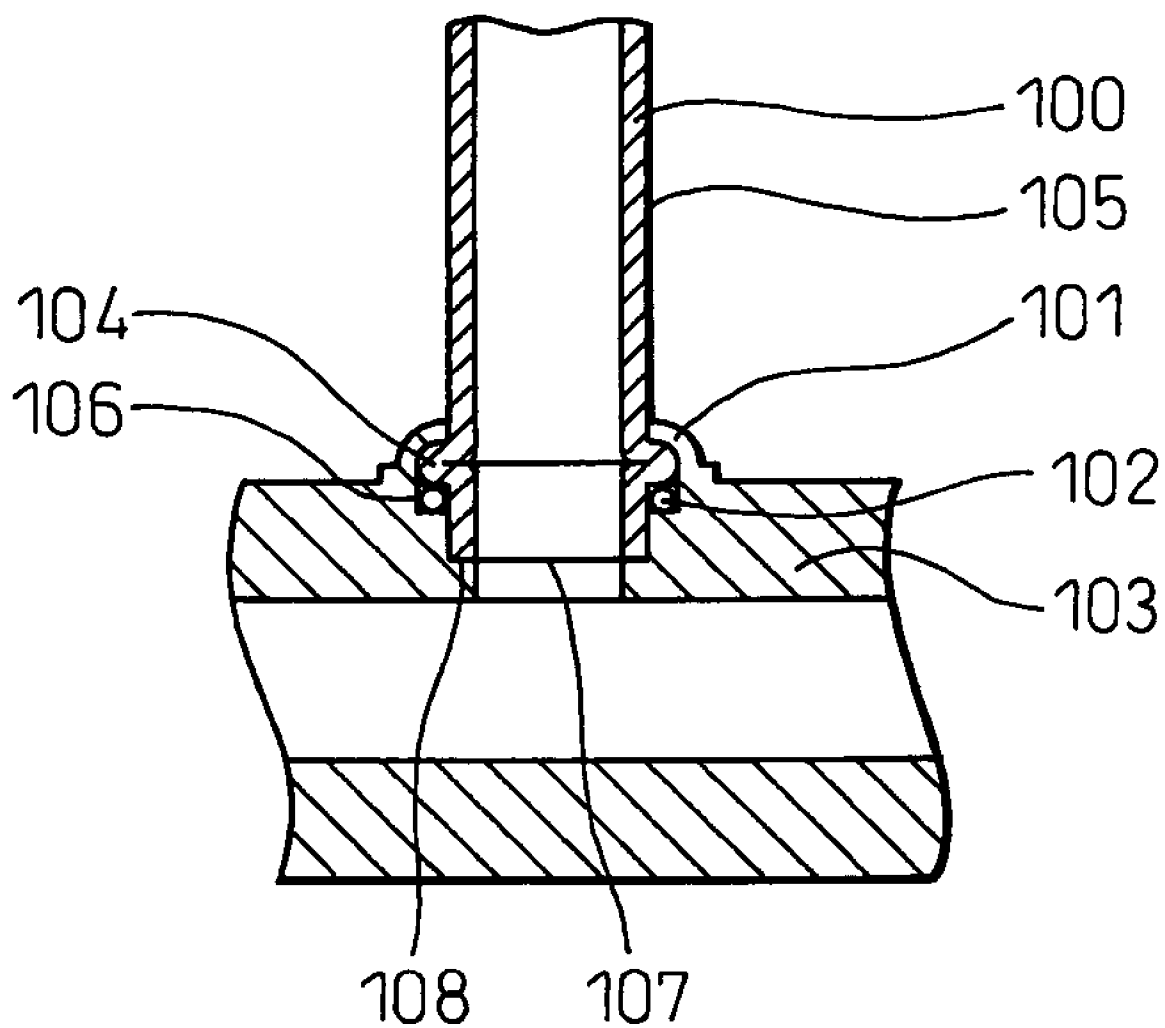


Fig.14



PIPE FIXING STRUCTURE AND PIPE FIXING METHOD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to a pipe fixing structure and a pipe fixing method for fixing a pipe onto an object member by plastically deforming the pipe under an external force.

[0003] 2. Description of the Related Art

[0004] The conventional pipe fixing structure and method in which a pipe is fixed by caulking on an object member to which the pipe is to be fixed (hereinafter referred to simply as "the object member") is known. No reference of the prior art is known to the inventor. This conventional pipe fixing structure and method are described below.

[0005] As shown in **FIG. 14**, a projection **104** is formed at a predetermined position on an outer peripheral portion **105** of a pipe **100**, and an object member **103** is formed with an opening portion **106** into which the pipe **100** with the projection **104** can be inserted, a stopper portion **108** on the opening in contact with the forward end **107** of the pipe **100** and a holder **101** extended from the opening portion **106**.

[0006] As a method of fixing this pipe **100** on the object member **103**, an O-ring **102** is placed on the opening portion **106**, the forward end **107** of the pipe **100** is brought into contact with the stopper portion **108** and the O-ring **102** is held by the lower side surface of the projection **104**. Under this condition, the holder **101** is pushed down by a punch member (not shown). The holder **101** bends down and pushes the upper side surface of the projection **104** thereby to fix the pipe **100** on the object member **103**.

[0007] A method is also available in which the pipe is fixed on an object by plastically deforming the pipe to a predetermined shape. As such a method, the conventional technique described in Japanese Unexamined Patent Publication No. 2003-336560 is known. In this method, the forward end of a pipe held in a chuck is pressed in the axial direction by a punch member having a predetermined shape of a depression. Then, the machining margin at the forward end of the pipe plastically flows so that the forward end of the pipe is deformed into a shape following the predetermined shape of the depression formed on the punch member.

SUMMARY OF THE INVENTION

[0008] In the conventional method of fixing by caulking, however, the holder **101** is projected outward from the object member **103** and, therefore the object member **103** is required to be cut or otherwise machined to form the holder **101**, thereby posing the problem that the object member before machining is bulky. Also, the machining process to form the holder **101** projected outward requires a considerable amount and labor for the cutting work.

[0009] The object of this invention, which has been achieved in view of the problem described above, is to provide a pipe fixing structure and a pipe fixing method whereby at least a predetermined fixing force can be secured with a simple structure without forming the outward projection of the object member.

[0010] In order to achieve the object described above, this invention employs the following technical means.

[0011] According to a first aspect of the invention, there is provided a pipe fixing structure for deforming and fixing a pipe (2) by applying a force to press the pipe (2) in axial direction against an object member (1, 8) to which the pipe (2) is to be fixed, the pipe fixing structure comprises an enlarged diameter portion (1a) formed in the object member (1, 8), which portion (1a) is larger than the outer diameter of the pipe (2) and through which the pipe (2) can be inserted in axial direction, and a first projection (6) into the shape of which a thin portion (2a) of the pipe (2) is deformed under the pressure, wherein the first projection (6) coincides with the enlarged diameter portion (1a).

[0012] In this aspect of the invention, an enlarged diameter portion is formed in the object member, the pipe is formed with a thin portion, and the axial pressure is applied to the pipe thereby to buckle and fix the pipe. Therefore, the fixing process can be simplified with a simple fixing structure and the pipe can be fixed with at least a predetermined fixing force.

[0013] According to a second aspect of the invention, there is provided a pipe fixing structure comprising a second projection (7, 15) projected radially outward from the pipe (2) and integrated with the object (1, 8) in the boundary between the fixed pipe (2) and the outer surface of the object member (1, 8). In this aspect of the invention, the expansion of the second projection further strengthens the fixing force between the pipe and object member.

[0014] According to a third aspect of the invention, there is provided a pipe fixing structure wherein the second projection (15) is formed in a substantially uniform thickness along the shape of the outer surface of the object member (1). In this aspect of the invention, the second projection is formed along the shape of the outer surface of the object member in the boundary between the pipe and the outer surface of the object member. Therefore, the coupling portion is less visible and burrs or the like edge portions of the second projection can be reduced.

[0015] According to a fourth aspect of the invention, there is provided a pipe fixing structure wherein the cross section of the enlarged diameter portion (1a) in axial direction of the pipe (2) is progressively reduced outward. In this aspect of the invention, the cross section of the enlarged diameter portion in axial direction of the pipe is progressively reduced outward. Therefore, the first projection of the pipe plastically flows in close contact with the progressively reduced shape. Thus, the gap between the object member and the pipe is reduced to increase the closeness and the fixing force.

[0016] According to a fifth aspect of the invention, there is provided a pipe fixing structure wherein the object member is an ejector for the refrigeration cycle.

[0017] According to a sixth aspect of the invention, there is provided a pipe fixing method comprising the steps of forming a thin portion (2a) on the inner peripheral portion of the pipe (2), forming the enlarged diameter portion (1a), at a position corresponding to the thin portion (2a), through which the pipe (2) can be axially inserted, in the object member (1, 8) to which the pipe (2) is fixed, and inserting the pipe (2) into the object member (1, 8) and pressing the pipe (2) in axial direction so that the thin portion (2a) is deformed by being projected outward into coincidence with the enlarged diameter portion (1a).

[0018] In this aspect of the invention, after the comparatively simple process of forming a thin portion of the pipe and an enlarged diameter portion in the object member, the pipe is axially pressed and buckled. Thus, a pipe fixing method high in workability, buckling process quality and fixing force is realized.

[0019] According to a seventh aspect of the invention, there is provided a pipe fixing method wherein the pipe (2) inserted into the object member (1, 8) is pressed in axial direction in such a manner that the outer peripheral portion of the pipe (2) is gripped by a chuck (3, 13), and the chuck (3, 13) is moved in axial direction. In this aspect of the invention, the pressure exerted on the pipe can be adjusted easily by moving the chuck mechanically in axial direction. Therefore, a fixing method is obtained in which the deformation amount of the thin portion and the closeness between the thin portion and the enlarged diameter portion can be easily adjusted.

[0020] According to an eighth aspect of the invention, there is provided a pipe fixing method comprising the step of deforming the thin portion (2a) into coincidence with the enlarged diameter portion (1a), followed by applying pressure to the pipe (2) thereby to buckle the pipe (2) in the boundary between the fixed pipe (2) and the outer surface of the object member (1, 8).

[0021] In this aspect of the invention, the second projection expanding outward is formed by buckling the pipe in the boundary between the fixed pipe and the outer surface of the object member, thereby further strengthening the fixing force between the pipe and the object member.

[0022] According to a ninth aspect of the invention, there is provided a pipe fixing method wherein the chuck (3, 13) moved in axial direction while gripping the outer peripheral portion of the pipe (2) has, on the side thereof for gripping the pipe (2), an end surface (14) in opposed relation to the outer surface of the object member (1, 8), which end surface (14) is formed along the shape of the outer surface of the object member (1, 8).

[0023] In this aspect of the invention, burrs or the like edges are prevented from being formed in the boundary between the pipe and the outer surface of the object member in the buckling step, on the one hand, and the buckled portion of the pipe can be formed to the desired thickness, on the other hand.

[0024] According to a tenth aspect of the invention, there is provided a pipe fixing method wherein the outer surface of the object member (1) is curved, and the object member (1, 8) side end surface (14) of the chuck (13) near to the object member (1, 8) for gripping the pipe (2) is curved or inclined along the shape of the curved outer surface of the object member. In this aspect of the invention, a pipe fixing method is obtained in which the boundary between the pipe and the outer surface of the object member can be formed in the shape having a greater similarity to the curved surface of the object member.

[0025] According to a 11th aspect of the invention, there is provided a pipe fixing method comprising the step of inserting the pipe (2) into the object member (1, 8) and thus pressing the pipe (2) in axial direction with a support member (5) inserted in the pipe (2), whereby the thin portion

(2a) is deformed to form an outward projection coincident with the enlarged diameter portion (1a).

[0026] In this aspect of the invention, the pipe is pressed and rendered to flow plastically with the support member inserted in the pipe, and therefore the pipe is urged with a stronger force to expand outward at the time of plastic flow, thereby making it possible to deform the pipe into the more desired shape.

[0027] According to an 12th aspect of the invention, there is provided a pipe fixing method comprising the step of forming, in the object member to which the pipe (11) is to be fixed, an insertion opening into which the pipe (11) can be inserted and forming an enlarged diameter portion (1a) larger than the insertion opening and the outer diameter of the pipe (11) in the object member (1), and the step of applying the axial pressure only to the pipe (11) and deforming by projecting the outer peripheral portion of the pipe (11) outward into coincidence with the enlarged diameter portion (1a) while inserting the pipe into the object member (1) from the insertion opening and holding the outer surface of the pipe (11).

[0028] In this aspect of the invention, a pipe fixing method is obtained in which at least a predetermined fixing force can be secured by a simple process not including the step of forming the object member into the shape projected outward.

[0029] The reference numerals in the parentheses attached to the names of the respective means represent the correspondence with the specific means, respectively, included in the embodiments described later.

[0030] The present invention may be more fully understood from the description of preferred embodiments of the invention, as set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIG. 1 is a schematic diagram showing an automotive refrigeration cycle using an ejector to which the pipe fixing structure and the pipe fixing method according to a first embodiment are applicable.

[0032] FIG. 2 is a schematic diagram showing a configuration of the ejector to which the pipe fixing structure and the pipe fixing method according to the first embodiment are applicable.

[0033] FIG. 3 is a sectional view showing the state before the pipe is pressed in the pipe fixing method according to the first embodiment.

[0034] FIG. 4 is a sectional view showing the state before the pipe is pressed for fixing the pipe in the axial direction of the object member in the pipe fixing method according to the first embodiment.

[0035] FIG. 5 is a sectional view showing the state in which the pipe is inserted into the object member from the state before fixing the pipe in FIG. 3.

[0036] FIG. 6 is a sectional view showing the state after forming the first projection from the state of FIG. 5 in the pipe fixing method according to the first embodiment.

[0037] FIG. 7 is a sectional view showing the state after forming the second projection from the state of FIG. 6.

[0038] FIG. 8 is a perspective view showing the second projection in the pipe fixing structure according to the first embodiment.

[0039] FIG. 9 is a sectional view showing the state before the pipe is pressed in the pipe fixing method according to the second embodiment.

[0040] FIG. 10 is a sectional view showing the state after forming the first projection from the state of FIG. 9.

[0041] FIG. 11 is a sectional view showing the state before forming the second projection in the pipe fixing structure and method according to a third embodiment.

[0042] FIG. 12 is a sectional view showing the state after forming the second projection from the state of FIG. 11.

[0043] FIG. 13 is a perspective view showing the second projection in the pipe fixing structure according to the third embodiment.

[0044] FIG. 14 is a sectional view showing the conventional pipe fixing structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[0045] The pipe fixing structure and the pipe fixing method according to the first embodiment of the invention are used to fix a pipe on a metal device constituting an object member through which a fluid flows. As an example, an explanation is made for a case in which a pipe is fixed on an ejector used for the refrigeration cycle. First, the configuration of the ejector and the configuration of the refrigeration cycle using the ejector are explained.

[0046] FIG. 1 is a schematic diagram showing the automotive refrigeration cycle using the ejector to which the pipe fixing structure and the pipe fixing method according to this embodiment are applicable.

[0047] The refrigeration cycle including the ejector has a refrigerant circulation path 11 in which the refrigerant circulates, and a compressor 12 for sucking in and compressing the refrigerant is arranged in the refrigerant circulation path 11.

[0048] This compressor 12 is adapted to be rotationally driven through a belt or the like by a vehicle driving engine (not shown). The compressor 12 is a variable replacement refrigerant compressor capable of adjusting the refrigerant discharge ability with the change in discharge capacity. The discharge capacity corresponds to the refrigerant amount discharged per rotation and can be changed by changing the refrigerant intake volume.

[0049] The variable displacement refrigerant compressor 12 is typically of swash plate type, in which specifically, the piston stroke is changed by changing the angle of the swash plate and thus the refrigerant intake volume is changed. The angle of the swash plate can be electrically controlled from an external unit by an electromagnetic pressure control unit 12a making up a capacity control mechanism to change the pressure (control pressure) of the swash plate chamber.

[0050] A radiator 13 is arranged downstream of the compressor 12 in the refrigerant flow. The radiator 13 cools the high-pressure refrigerant by exchanging heat between the high-pressure refrigerant discharged from the compressor 12 and the atmospheric air (outdoor air) blown in by a cooling fan (not shown).

[0051] An ejector 14 is arranged further downstream of the radiator 13 in the refrigerant flow. The ejector 14 constitutes a decompression means for reducing the pressure of the fluid on the one hand and a kinetic vacuum pump for transporting the fluid by the suction effect of the working fluid ejected at high speed at the same time.

[0052] FIG. 2 is a schematic diagram showing a configuration of the ejector to which the pipe fixing structure and the pipe fixing method according to this embodiment are applicable.

[0053] The ejector 14 includes a nozzle portion 14a having a small path area for reducing the refrigerant flowing in from the radiator 13 and an intake portion 14c arranged in the same space as the refrigerant ejection port of the nozzle portion 14a for sucking in the gas-phase refrigerant from a second evaporator 18 described later.

[0054] A needle valve 14e for controlling the opening degree of the ejection port is arranged on the same axis as the ejection port in the nozzle portion 14a in a manner movably by an actuator 14f in the axial direction thereof. Further, a mixing portion 14d for mixing the refrigerant flowing in from the intake portion 14c with the refrigerant ejected from the nozzle portion 14a and a diffuser portion 14b for increasing the pressure of the refrigerant by increasing the refrigerant path area gradually are arranged downstream of the nozzle portion 14a.

[0055] The refrigerant that has flowed out of the diffuser portion 14b of the ejector 14 flows into the first evaporator 15 arranged in the air path of the compartment climate control unit to cool the vehicle compartments.

[0056] Specifically, the compartment climate control air is blown into the first evaporator 15 by an electric fan 26 of the compartment climate control unit and the low-pressure refrigerant decompressed by the ejector 14 absorbs heat from the compartment climate control air in the first evaporator 15. In this way, the compartment air climate control air is cooled to exhibit the cooling ability. The gas-phase refrigerant evaporated in the first evaporator 15 is sucked into the compressor 12 and circulates through the refrigerant circulation path 11 again.

[0057] This refrigeration cycle branches from a point between the radiator 13 and the ejector 14 in the refrigerant circulation path 11 and forms a first branch path 16 by merging with the refrigerant circulation path 11 at the intake portion 14c of the ejector 14.

[0058] The first branch path 16 includes a first flow rate regulation valve 17 for adjusting the refrigerant flow rate and decompressing the refrigerant. The valve opening degree of the first flow rate regulation valve 17 can be electrically regulated. The second evaporator 18 is arranged downstream of the first flow rate regulation valve 17 in the refrigerant flow.

[0059] The second evaporator 18 is arranged, for example, in the on-vehicle cool bag to perform a cooling operation of

the cool bag. The air in the cool bag is blown to the second evaporator **18** by the electric fan **27**.

[0060] The electromagnetic pressure control unit **12a** of the variable displacement refrigerant compressor **12**, the first blower **26**, the second blower **27** and the first flow rate regulation valve **17** are electrically controlled by the control signal from the ECU **25**.

[0061] Next, the structure and method for fixing the pipe on the ejector are explained as an example. **FIG. 3** is a sectional view showing the state before pressure application in the pipe fixing method according to this embodiment.

[0062] First, the pipe **2** has a thin portion **2a** on the inner periphery at an end thereof to be connected with the ejector **1** as an example of the object member. The thin portion **2a** is formed over the whole round of the inner surface of the pipe **2** and constitutes the thinnest portion normally about $\frac{2}{3}$ of the pipe thickness. The shape of the thin portion **2a** along the pipe axis is not specifically limited. In the case where the pipe size is reduced progressively radially outward, however, the first projection can be advantageously formed.

[0063] The thin portion **2a** is formed by cutting the inner periphery of the pipe **2**. For example, the pipe **2**, while being kept in the same position, is turned in lathe (not shown) and the cutting tool (not shown) applied to the inner periphery of the rotating pipe **2** is fed centrifugally by the desired amount of cut. In this way, the thin portion **2a** can be formed on the inner periphery of the pipe **2** by a simple machining process.

[0064] A through hole communicating with the path **1d** substantially at right angles to the axial direction of the ejector **1** is formed on the outer surface of the ejector **1** as an example of the object member. This through hole is formed with a stopper wall **1b**, an enlarged diameter portion **1a** and a stopper wall **1c** in that order from the side near the outer surface.

[0065] The bore of the stopper wall **1b** is set to substantially the same size as the outer diameter of the fixed pipe **2** and formed in such a manner that the pipe **2** can be inserted through. The enlarged diameter portion **1a** is formed with the bore thereof continuously increased from the stopper wall **1b**. The bore of the enlarged diameter portion **1a** is formed to such a size that when the thin portion **2a** of the pipe **2** is deformed by plastic flow, as described later, the first projection is in close contact.

[0066] The stopper wall **1c** is a tubular wall parallel with the axial direction of the ejector **1** and formed in such a manner as to connect a bore portion formed in the same size as the outer diameter of the pipe **2** from the enlarged diameter portion **1a** toward the stopper wall **1c** and a bore portion smaller than the outer diameter of the pipe **2**. The pipe **2** inserted into the through hole of the ejector **1**, with the forward end surface **2b** thereof in contact with the stopper wall **1c**, is set in position with the axial motion thereof restricted along the pipe axis. The radial position of the pipe, on the other hand, is limited and set in position by the bore of the stopper-wall **1b** and the bore portion extended toward from the enlarged diameter portion **1a** toward the stopper wall **1c** and formed in the same size as the outer diameter of the pipe **2**.

[0067] This through hole, like the thin portion **2a** of the pipe **2**, is formed by cutting. As an example, the ejector **1** is

turned with the axis of the through hole as a center in the lathe (not shown) while the cutting tool (not shown) applied to the inner periphery of the through hole of the rotating ejector **1** is fed inward along the axis of the ejector by an appropriate amount thereby to form the stopper wall **1b**, the enlarged diameter portion **1a** and the stopper wall **1c**. Thus, the enlarged diameter portion **1a** can be formed on the ejector **1** constituting the object member by a simple machining process. According to this embodiment, the outer diameter of the pipe **2** is 6 to 10 mm and the tube thickness of the ejector **1** is about 5 mm.

[0068] The pipe **2** is formed of a metal such as aluminum, aluminum alloy, copper or copper alloy, which is a material adapted to flow plastically under an external force. The object member, on the other hand, is formed of a metal such as aluminum, aluminum alloy, copper, copper alloy, iron, stainless steel or brass, which may be either the same material as, or a material different from, the pipe **2** with which it is combined.

[0069] The support member **4** is inserted into the path **1d** in the ejector **1** having this configuration thereby to support the inner peripheral portion of the ejector **1** while at the same time fixing the ejector **1**. Also, the support member **5** is inserted into the pipe **2** to support the inner peripheral portion thereof and, with the axis set coincident with the center line of the through hole of the ejector **1**, fixed by the chuck **3**. The chuck **3** and the pipe **2** are arranged movably together downward in axial direction by a press, not shown, for driving the chuck **3**.

[0070] As shown in **FIG. 4**, the pipe can alternatively be fixed in the axial direction of the object member. **FIG. 4** is a sectional view showing the state before pressure is applied to fix the pipe in the axial direction of the object member. In this case, as in the ejector **1** described above, a through hole is formed communicating from an axial end of the object member **8** to the flow path **8d**. Thus, the stopper wall **8b**, the enlarged diameter portion **8a** and the stopper wall **8c** are formed in that order from one end surface of the object member **8**.

[0071] Next, an explanation is given about the process of pressing the pipe **2** against the ejector **1** in the axial direction of the pipe **2**. **FIG. 5** shows a sectional view showing the state in which the pipe is inserted into the object member from the state before being fixed shown in **FIG. 3**. **FIG. 6** is a sectional view showing the state after the first projection is formed from the state of **FIG. 5**.

[0072] As shown in **FIG. 5**, the chuck **3** is moved axially downward of the pipe **2** by a press, and the pipe **2** is advanced into the through hole until the forward end thereof comes into contact with the stopper wall **1c**. In the process, the thin portion **2a** is located at a corresponding position radially inward of the enlarged diameter portion **1a** of the ejector **1**. Also, a distance of about 3 mm is secured between the chuck **3** side outer peripheral surface of the ejector **1** and the lower end surface of the chuck **3**.

[0073] As shown in **FIG. 6**, pressure continues to be applied by the press to move the chuck **3** further axially downward of the pipe **2**. Then, a plastic flow of material occurs in the thin portion **2a** of the pipe **2**, so that thin portion **2a** moves radially outward of the pipe **2** and is deformed until it comes into close contact with the enlarged diameter portion **1a** thereby to form the first projection **6** (first buckling step).

[0074] In the process, the cross section of the enlarged diameter portion 1a is formed in the shape progressively reduced in thickness outward along the axial direction of the pipe 2. Thus, the deformation of the thin portion 2a due to the plastic flow is further promoted, while at the same time improving the closeness between the enlarged diameter portion 1a and the outer surface of the thin portion 2a. Also, the support member 5 inserted in the pipe 2 prevents the deformation of the portion other than the thin portion 2a of the pipe 2, so that the flow path space in the pipe 2 is appropriately maintained, while at the same time promoting the deformation of the thin portion 2a radially outward.

[0075] By forming the first projection 6 in this way, the stopper wall 1b expanded radially inward of the pipe 2 restricts the upward movement of the first projection 6 and the pipe 2 is prevented from coming off and is fixed on the ejector 1.

[0076] Further, in order to improve the fixing force, a second projection 7 shown in FIG. 7 is desirably formed. FIG. 7 is a sectional view showing a state in which the second projection 7 is formed further from the state shown in FIG. 6. FIG. 8 is a perspective view showing the second projection 7. After the first buckling process described above, pressure is exerted from the pipe 2 increasingly against the ejector 1 by the press. Then, the pipe 2 succumbs to the force of the press and begins to buckle, so that the outer peripheral portion of the pipe 2 is projected radially outward in the boundary between the pipe 2 and the chuck 3 side outer surface of the ejector 1 thereby to form the second projection 7 (second buckling process).

[0077] Then, the pressure of the press is released and so is the force of the chuck 3 to grip the pipe 2, while at the same time pulling off the support member 5 from the pipe 2 and the support member 4 from the ejector 1. As shown in FIG. 8, the pipe 2 extending in the direction substantially perpendicular to the axis of the ejector 1 is fixed on the outer peripheral surface of the ejector 1. The second projection 7 is formed in a circle in such a manner as to surround the outer periphery of the pipe 2 in the boundary with the ejector 1 and integrated with the outer surface of the ejector 1.

[0078] In this way, the second projection 7 is integrated with the ejector 1 and formed in such a manner as to expand radially outward of the pipe 2, and therefore the fixing force of the pipe 2 on the ejector 1 is further increased.

[0079] According to this embodiment, the pressure imparted by the press until the first projection 6 is formed is, for example, not more than 9.8×10^3 N and, after the first projection 6 is formed, the pressure of about 1.9 to 4.0×10^4 N is imparted by the press to form the second projection 7. Also, even in the case where a force is applied to press the pipe 2 against the ejector 1, the support member 4 inserted in the ejector 1 prevents the deformation of the ejector 1. In spite of the larger force which may be exerted by the press, therefore, the appropriate path 1d can be secured.

[0080] In the case where a curved pipe is fixed on the object member, pressure is applied through the pipe 2 to the ejector 1 making up the object member with the support member 5 inserted in the pipe 2 as described above. After thus buckling the pipe 2 in the first buckling process or after the second buckling process to improve the strength further, the support member 5 is pulled off from the pipe 2 thereby

to form the pipe 2 into the desired curved shape. By executing these steps, a curved pipe can be fixed on the object member.

[0081] As described above, according to this embodiment, the enlarged diameter portion 1a which is larger than the outer diameter of the pipe 2 and through which the pipe 2 can be inserted along the axial direction is formed in the ejector (object member) 1, the thin portion 2a is formed on the inner periphery of the pipe 2, and the first projection 6 is formed by the plastic deformation of the thin portion 2a by the pressure applied to the pipe 2 in axial direction into coincidence with the large diameter portion 1a thereby to form a pipe fixing structure.

[0082] With this configuration, the enlarged diameter portion 1a is formed in the object member and the thin portion 2a is formed in the pipe 2, after which the pipe 2 is buckled and fixed on the object member. In this way, a simple fixing structure having a positive fixing force is realized.

[0083] Also, a pipe fixing structure is desirable in which the second projection 7 projected from the outer periphery of the pipe 2 and integrated with the ejector (object member) 1 is formed in the boundary between the pipe 2 and the outer surface of the ejector (object member) 1 fixed to each other. In the case where this configuration is employed, the second projection 7 is integrated with the ejector (object member) 1 and expanded radially outward thereby to further increase the fixing force between the pipe 2 and the object member 1.

[0084] Also, the cross section of the enlarged diameter portion 1a in the axial direction of the pipe 2 desirably assumes a tapered shape progressively smaller radially outward of the pipe 2. In the case where this configuration is employed, the first projection 6 of the pipe 2 plastically flows into close contact in the tapered shape of the cross section of the enlarged diameter portion 1a, thereby reducing the gap between the object member and the pipe for an improved closeness and a higher fixing force.

[0085] The pipe fixing method according to this embodiment comprises the steps of forming the thin portion 2a on the inner periphery of the pipe 2, forming the enlarged diameter portion 1a, through which the pipe 2 can be inserted in axial direction, in the ejector (object member) 1 at a position corresponding to the thin portion 2a to which the pipe 2 is fixed, and applying the pressure in axial direction by inserting the pipe 2 into the ejector (object member) 1 thereby to project and deform the thin portion 2a outward into coincidence with the enlarged diameter portion 1a.

[0086] With this fixing method, after the comparatively simple process of forming the thin portion 2a of the pipe 2 and the enlarged diameter portion 1a on the ejector (object member) 1, the pipe 2 is buckled by being pressed in axial direction. Thus, a pipe fixing method is obtained in which the workability, the quality of the buckling process and the fixing force are high.

[0087] Also, in the pipe fixing method according to this embodiment, the process is desirably executed in which the thin portion 2a is deformed by plastic flow into coincidence with the enlarged diameter portion 1a, immediately after which pressure is exerted on the pipe 2 thereby to buckle the

pipe 2 in the boundary between the fixed pipe 2 and the outer surface of the ejector (object member) 1.

[0088] By employing this fixing method, the second projection 7 expanded outward is formed by buckling the pipe 2 in the boundary between the fixed pipe 2 and the outer surface of the object member, with the result the fixing force between the pipe 2 and the ejector (object member) 1 can be further increased.

[0089] Also, the pipe fixing method according to this embodiment desirably includes the step of pressing the pipe 2 against the ejector (object member) 1 thereby to deform the thin portion 2a with the support member 5 inserted in the pipe 2. By employing this fixing method, the tendency of the pipe 2 to expand outward during the plastic flow is strengthened, and therefore the chance of obtaining the desired shape can be further enhanced by the deformation of the pipe 2.

[0090] Also, the pipework 8 side end surface of the chuck 3 shown in FIG. 4 to grip the pipe 2 is formed along the shape of the outer surface of the pipework 8. With this configuration, the second projection can be formed, less visibly, to the desired thickness in the boundary between the pipe 2 and the outer surface of the pipework 8 in the buckling process.

Second Embodiment

[0091] This embodiment, as compared with the method of fixing the pipe on the ejector according to the first embodiment, represents a fixing method in which the pipe 11 having no thin portion is inserted into the ejector 1 and set in position, while pressure is applied only on the pipe 11 to deform the pipe 11. FIG. 9 is a sectional view showing the state before pressing the pipe 11 in the pipe fixing method according to this embodiment. FIG. 10 is a sectional view showing the state after forming the first projection from the state of FIG. 9.

[0092] As shown in FIG. 9, the pipe 11, like the pipe 2 according to the first embodiment, is formed of a material adapted for plastic flow under at least a predetermined external force but has no thin portion 2a unlike the pipe 2. The ejector 1, like in the first embodiment, has a through hole communicating with the path 1d in the direction substantially at right angles to the axial direction. The through hole is formed, sequentially in the order from the outer surface of the pipe 2, with an insertion opening, a stopper wall 1b, an enlarged diameter portion 1a and a stopper wall 1c. The stopper wall 1b, the enlarged diameter portion 1a and the stopper wall 1c have the same shape and function and are processed in the same manner as in the first embodiment.

[0093] The support member 12 is inserted into the path 1d of the ejector 1 configured as described above thereby to support the inner peripheral portion of the ejector 1 while at the same time fixing the ejector 1. The support member 12 has an insertion hole through which the support of a pressure punch member 10 described later can be inserted.

[0094] The pipe 2 is arranged on the ejector 1 by inserting the pipe 2 into the through hole from the insertion opening on the outer surface of the ejector 1 and pushed in until the lower end of the pipe 2 comes into contact with the stopper wall 1c. On the other hand, the support of the pressure punch member 10 is inserted into the pipe 2 to support the inner

peripheral portion of the pipe 2 by the support of the pressure punch member, while at the same time arranging the axis of the pipe 2 in alignment with the center line of the through hole of the ejector 1.

[0095] The pressure punch member 10 has in the upper part thereof a punch portion larger in outer diameter than the support for supporting the inner peripheral portion of the pipe 2. The pressure punch member 10, under its own weight, causes the lower end portion 10a of the punch portion thereof to come into contact with the upper end portion of the pipe 2 and thus is integrated with the pipe 2.

[0096] Also, the outer surface of the pipe 2 is held in such a manner that the radial motion of the pipe 2 is restricted by a guide member 9 while the pipe 2 can be movable in axial direction. Next, the pipe 2 thus set in position is buckled under the pressure applied thereto by the punch portion of the pressure punch member 10. The punch portion of the pressure punch member 10 is pressed downward by the press machine so that the lower end 10a of the punch portion pushes the upper end of the pipe 2 axially downward.

[0097] Upon application of at least a predetermined external force to the pressure punch member 10, the tissue of the pipe 2 begins to flow plastically. As shown in FIG. 10, the plastic flow occurs in the space formed between the inner surface of the enlarged diameter portion 1a and the outer peripheral surface of the pipe 2. The radially inside portion of this space in which the plastic flow occurs is supported by the support of the pressure punch member 10, and therefore the plastic flow occurs radially outward to fill the space. Thus, the pipe 2 is projected outward and deformed into coincidence with the enlarged diameter portion 1a.

[0098] As described above, the pipe fixing method according to this embodiment comprises the step of forming an opening of the ejector (object member) 1 into which the pipe 2 can be inserted and forming the enlarged diameter portion 1a larger than the insertion opening and the outer size of the pipe 2 in the ejector 1, and the step of inserting the pipe 2 into the ejector 1 by way of the insertion opening and pressing only the pipe 2 in axial direction with the outer surface of the pipe 2 supported, thereby projecting the outer peripheral portion of the pipe 2 outward into coincidence with the enlarged diameter portion 1a.

[0099] In the case where this pipe fixing method is employed, a more simple fixing method is realized in which the process of shaping the ejector 1 to conform to the outward projection is eliminated.

Third Embodiment

[0100] In the third embodiment, as compared with the method of fixing a pipe on an ejector according to the first embodiment, a fixing method and a fixing structure capable of forming the second projection into the desired shape are explained. FIG. 11 is a sectional view showing the state before forming the second projection in the pipe fixing structure and method according to this embodiment. FIG. 12 is a sectional view showing the state after the second projection is formed from the state shown in FIG. 11.

[0101] The pipe fixing method according to this embodiment has the same steps as the pipe fixing method according to the first embodiment up to the first buckling step, i.e. the

step of forming the first projection 6 by deforming the thin portion 2a into coincidence with the enlarged diameter portion 1a.

[0102] According to this embodiment, the ejector 1 side end surface 14 of the chuck 13 for gripping and moving the pipe 2 in axial direction is formed in the shape following the outer surface of the ejector 1. Also, the end surface 14 of the chuck 13 is preferably formed as a slope or a curve following the curved shape of the outer surface of the ejector 1.

[0103] The process of pressing the pipe 2 against the ejector 1 in axial direction using this chuck 13 is explained. First, the distance of at least about 3 mm is secured between the chuck 13 side outer peripheral surface of the ejector 1 and the lower end surface of the chuck 13, and the pipe 2 is fixed by the chuck 13. The chuck 13 is moved axially downward of the pipe 2 by a press, and the pipe 2 is advanced into the through hole of the ejector 1 until the forward end of the pipe 2 comes into contact with the stopper wall 1c. In the process, the thin portion 2a of the pipe 2 is located at a position corresponding radially inward to the enlarged diameter portion 1a formed on the ejector 1.

[0104] Further, pressure continues to be applied to the chuck 13 by the press to move the chuck 13 axially downward of the pipe 2. Then, as shown in FIG. 11, the plastic flow of the issue occurs in the thin portion 2a of the pipe 2, and the thin portion 2a is moved radially outward of the pipe 2 and deformed until it comes into close contact with the enlarged diameter portion 1a, thereby forming the first projection 6 (first buckling step).

[0105] Next, the process of forming the second projection 15 shown in FIG. 12 is explained. After the first buckling step described above, the chuck 13 is moved axially further downward by the press to increase the pressure applied to the ejector 1 through the pipe 2. Then, the pipe 2, no longer able to bear the force of the press, begins to buckle and the outer peripheral portion of the pipe 2 begins to be projected radially outward in the boundary between the chuck 13 side outer surface of the ejector 1 and the pipe 2.

[0106] The outer peripheral portion of the pipe 2 that begins to project is crushed by the end surface 14 of the chuck 13, and the pipe portion projected outward by the plastic flow spreads following the curved shape of the outer surface of the ejector 1, thereby forming the second projection 15 of uniform thickness (second buckling step).

[0107] As described above, the second projection 15 in the pipe fixing structure according to this embodiment is formed with a substantially uniform thickness along the shape of the outer surface of the ejector 1. This configuration makes less visible the coupling in the boundary between the pipe 2 and the outer surface of the ejector 2 while at the same time reducing the size of the generated burrs.

[0108] Also, that end surface 14 on the side of the chuck 13 used in the pipe fixing method according to this embodiment which grips the pipe 2 and which is in opposed relation to the outer surface of the ejector 1 is formed along the shape of the outer surface of the ejector 1. This configuration reduces the size of the burrs in the boundary between the pipe 2 and the outer surface of the ejector 1 on the one hand and the second buckling portion 15 can be formed to the desired thickness on the other hand.

[0109] While the invention has been described by reference to specific embodiments chosen for purposes of illustration, it should be apparent that numerous modifications could be made thereto, by those skilled in the art, without departing from the basic concept and scope of the invention.

1. A pipe fixing structure for deforming and fixing a pipe by applying a force to press the pipe in axial direction against an object member to which the pipe is to be fixed, the pipe fixing structure comprising:

an enlarged diameter portion formed in the object member, which portion is larger than the outer diameter of the pipe and through which the pipe can be inserted in axial direction; and

a first projection into the shape of which a thin portion of the pipe is deformed under the pressure;

wherein the first projection coincides with the enlarged diameter portion.

2. A pipe fixing structure according to claim 1, comprising a second projection projected radially outward from the pipe and integrated with the object member in the boundary between the fixed pipe and the outer surface of the object member.

3. A pipe fixing structure according to claim 2,

wherein the second projection is formed in a substantially uniform thickness along the shape of the outer surface of the object member.

4. A pipe fixing structure according to claim 1,

wherein the cross section of the enlarged diameter portion in axial direction of the pipe is progressively reduced outward.

5. A pipe fixing structure according to claim 1,

wherein the object member is an ejector for the refrigeration cycle.

6. A pipe fixing method comprising the steps of:

forming a thin portion on the inner periphery of the pipe;

forming an enlarged diameter portion, in the object member to which the pipe is fixed, which portion is located at a position corresponding to the thin portion and through which the pipe can be axially inserted; and

inserting the pipe into the object member, and pressing the pipe in axial direction so that the thin portion is deformed by being projected outward into coincidence with the enlarged diameter portion.

7. A pipe fixing method according to claim 6,

wherein the pipe inserted into the object member is pressed in axial direction by gripping the outer peripheral portion of the pipe with a chuck and moving the chuck in axial direction.

8. A pipe fixing method according to claim 6,

wherein the thin portion is deformed into coincidence with the enlarged diameter portion, after which pressure is applied to the pipe thereby to buckle the pipe in the boundary between the fixed pipe and the outer surface of the object member.

9. A pipe fixing method according to claim 8,

wherein the chuck moved in axial direction while gripping the outer peripheral portion of the pipe has an end surface in opposed relation to the outer surface of the

object member on the side thereof for gripping the pipe, which end surface is formed along the outer surface of the object member.

10. A pipe fixing method according to claim 9,

wherein the outer surface of the object member is curved, and that end surface of the chuck which grips the pipe and which is nearer to the object member is curved or inclined along the shape of the curved outer surface of the object member.

11. A pipe fixing method according to claim 6, comprising the step of inserting the pipe into the object member and pressing the object member in axial direction with a support member inserted in the pipe, thereby deforming the thin portion into an outward projection coincident with the enlarged diameter portion.

12. A pipe fixing method comprising:

the step of forming an opening into which the pipe can be inserted, in the object member to which the pipe is to be fixed, and forming an enlarged diameter portion larger than the insertion opening and the outer size of the pipe in the object member; and

the step of inserting the pipe into the object member from the insertion opening and holding the outer surface of the pipe while deforming by projecting the outer peripheral portion of the pipe outward into coincidence with the enlarged diameter portion by applying the axial pressure to only the pipe.

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