(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 388 720 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.02.2004 Bulletin 2004/07

(51) Int Cl.⁷: **F28D 7/10**

(21) Application number: **03018139.0**

(22) Date of filing: **08.08.2003**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: **08.08.2002 JP 2002230780**
08.08.2002 JP 2002230779

(71) Applicant: **Mahle Tennex Corporation**
Toshima-ku, Tokyo 171-0014 (JP)

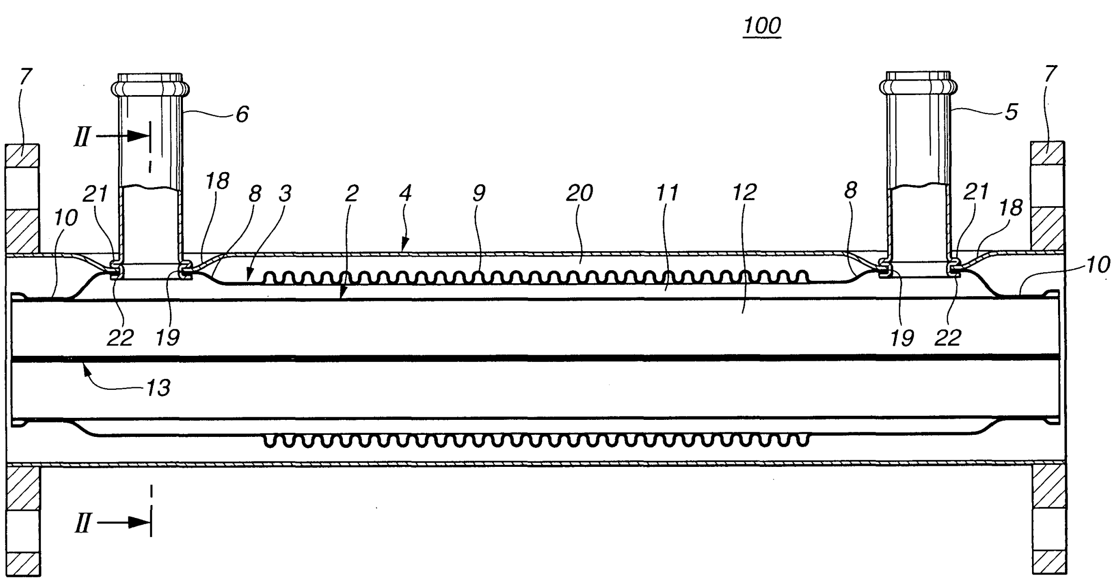
(72) Inventors:
- **Sakurai, Tokuhisa**
  Fujimi-shi, Saitama 354-0032 (JP)
- **Isoda, Katsuhiro**
  Sayama-shi, Saitama 350-1332 (JP)

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser Anwaltssozietät**
Maximilianstrasse 58
80538 München (DE)

(54) **Triple-tube type heat exchanger and method of producing same**

(57) Outer (4), middle (3) and inner (2) tubes are arranged to define between the outer (4) and middle (3) tubes a first cylindrical space (20) and between the middle (3) and inner (2) tubes a second cylindrical space (11). The inner tube (2) has a third cylindrical space (12) defined therein. Radially depressed two portions (18) of the outer tube (4) are respectively mated with radially raised two portions (8) of the middle tube (3) so that openings (19) formed in the radially depressed two portions (8,18) are merged with openings formed in the radially raised two portions respectively. Inlet and outlet pipes (5,6) are inserted at their base ends into the merged openings (19) of the radially depressed and raised portions (8,18) to connect with the second cylindrical space (11), and the base ends (22) are caulked to peripheral edges of the merged openings. Diametrically reduced end portions of the middle tube (3) intimately contact and hold axially spaced end portions of the inner tube (2), so that the second cylindrical space has an isolated part which is defined between the diametrically reduced end portions and communicated with only the input and output pipes (5,6).

FIG.1



EP 1 388 720 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates in general to heat exchangers used in a motor vehicle powered by an internal combustion engine, and more particularly to the heat exchangers or EGR gas coolers that are used for cooling an EGR gas of the internal combustion engine. More specifically, the present invention is concerned with the EGR gas cooler of a triple-tube type and a method of producing the same, the EGR gas cooler including first, second and third tubes which are concentrically arranged to define therebetween a passage for a cooling fluid (viz., engine cooling water) and another passage for a fluid (viz., EGR gas) to be cooled.

2. Description of the Related Art

[0002] In order to clarify the task of the present invention, brief explanation will be directed to a triple-tube type oil cooler that is shown in Laid-open Japanese Patent Application (Tokkaihei) 9-113155.

[0003] Figs. 17 and 18 of the accompanying drawings show two triple-tube type oil coolers described in the published Japanese patent application.

[0004] The oil cooler of Fig. 17 comprises generally an outer tube 101, a double-tube type oil passage unit 102 installed in the outer tube 101, an oil inlet pipe (not shown) connected to one axial end of the oil passage unit 102 and an oil outlet pipe 103 connected to the other axial end of the oil passage unit 102. The double-tube type oil passage unit 102 has a cylindrical space 108 through which a heated oil from the engine flows. The oil passage unit 102 has a cylindrical bore 110 defined therein and a cylindrical space 112 defined between the oil passage unit 102 and the outer tube 101. Under operation, the engine cooling water is forced to flow through both the cylindrical bore 110 and cylindrical space 112 and a heated oil from the engine is forced to flow through the cylindrical space 108 to be cooled by the engine cooling water flowing in the cylindrical bore 110 and cylindrical space 112.

[0005] In order to connect the inlet and outlet pipes 103 to the oil passage unit 102, the following assembling process has been carried out. First, the inlet and output pipes 103 (only one is shown) are prepared, each having a pressed enlarged leading end 104. The pressed enlarged leading end 104 has two opposed flat surfaces 105 and 106 which are shown to be spaced by a distance "H". The enlarged leading end 104 is put into a space defined between a raised flat part 101A of the outer tube 101 and a raised flat part 102A of the oil passage unit 102 in such a manner that the flat surfaces 105 and 106 of the enlarged leading end 104 of the pipe 103 intimately contact the raised flat parts 101A and 102A respectively, as shown. With this intimate contact of the enlarged leading end 104 to the two raised flat parts 101A and 102A, relative positioning between the outer tube 101 and the oil passage unit 102 is assuredly and stably made. Then, brazing is applied to such intimately contacting portions between the enlarged leading end 104 and the raised flat parts 101A and 102A.

[0006] Similar to the oil cooler of Fig. 17, the oil cooler of Fig. 18 comprises an outer tube 101, a double-tube type oil passage unit 102 installed in the outer tube 101, and oil inlet and outlet pipes 113 (only one is shown) respectively connected to axial ends of the oil passage unit 102. The pipe 113 is provided at a leading end 114 thereof with mutually spaced outer and inner annular projections 115 and 116. For connecting the pipe 113 to the oil passage unit 102, the leading end 114 is put into a space defined between a raised aperture part 101A' of the outer tube 101 and a raised aperture part 102A' of the oil passage unit 102 in such a manner that the outer and inner annular projections 115 and 116 of the leading end 114 of the pipe 113 intimately contact the raised aperture parts 101A' and 102A' respectively, as shown. The brazing is applied to such intimately contacting portions between the leading end 114 and the raised aperture parts 101A' and 102A'.

SUMMARY OF THE INVENTION

[0007] Because of the nature of brazing, the intimate contact of the leading end 104 (or 114) to the two raised parts 101A and 102A (or 101A' and 102A') is continuously needed until the time when the brazing is completed. Accordingly, during the brazing operation, certain tools have to be used for retaining the outer tube 101 and the oil passage unit 102. As is known, usage of such tools causes increase in the assembling steps as well as lowering in the assembling facility. Particularly in case of the oil cooler of Fig. 17, the inlet and outlet pipes 103 should be inserted through openings of the raised flat part 101A from inside the same before the oil passage unit 102 is installed into the outer tube 101, and furthermore, the relative positioning between the outer tube 101 and the oil passage unit 102 should be made having the inlet and outlet pipes 103 in contact with the outer tube 101, which however bring about further lowering in the assembling facility.

[0008] Furthermore, in case of the oil coolers of Figs. 17 and 18, there are two mutually independent brazing portions. That is in the oil cooler of Fig. 17, one brazing portion is the portion where the flat surface 105 of the leading end 104 of the pipe 103 and the raised flat part 101A of the outer tube 101 contact, and the other brazing portion is the portion where the flat surface 106 of the leading end 104 of the pipe 103 and the raised flat part 102A of the oil passage unit 102 contact, and in the oil cooler of Fig. 18, one brazing portion is the portion where the outer annular projection 115 of the pipe 113 and the raised aperture part 101A' of the outer tube 101 contact, and the other brazing portion is the portion where the inner annular projection 116 of the pipe 113 and the raised aperture part 102A' contact. As is known, providing the two mutually independent brazing portions causes a difficult or at least troublesome brazing work.

[0009] Accordingly, an object of the present invention is to provide a triple-tube type heat exchanger and a method of producing the same, which are free of the above-mentioned shortcomings.

[0010] According to the present invention, there is provided a triple-tube type heat exchanger in which inlet and outlet pipes are tightly connected to a water passage unit through a minimum amount of brazed part.

[0011] According to the present invention, there is provided a method of producing a triple-tube type heat exchanger, which is simple in the manufacturing steps.

[0012] According to a first aspect of the present invention, there is provided a heat exchanger which comprises an outer tube; a middle tube received in the outer tube in a manner to define therebetween a first cylindrical space; an inner tube received in the middle tube in a manner to define therebetween a second cylindrical space, the inner tube having a third cylindrical space defined therein; first and second diametrically reduced portions possessed by axially spaced end portions of the middle tube, the diametrically reduced portions intimately contacting and holding axially spaced end portions of the inner tube thereby to permit the second cylindrical space to have an isolated part between the first and second diametrically reduced portions; first and second radially depressed end portions possessed by the outer tube, each radially depressed end portion having an outer tube opening formed therethrough; first and second radially raised end portions possessed by the middle tube, each radially raised end portion having a middle tube opening formed therethrough, the first and second radially raised end portions intimately putting thereon the first and second radially depressed end portions respectively in such a manner that the middle tube openings are merged with the outer tube openings respectively; an inlet pipe passing through the merged openings of the first radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the inlet pipe having a portion caulked to peripheral edges of the merged openings of the first radially raised and depressed end portions; and an outlet pipe passing through the merged openings of the second radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the outlet pipe having a portion caulked to peripheral edges of the merged openings of the second radially raised and depressed end portions.

[0013] According to a second aspect of the present invention, there is provided a gas cooler for cooling gas by using water, which comprises an outer tube; a middle tube received in the outer tube in a manner to define therebetween a first cylindrical space; an inner tube received in the middle tube in a manner to define therebetween a second cylindrical space, the inner tube having a third cylindrical space defined therein; first and second diametrically reduced portions possessed by axially spaced end portions of the middle tube, the diametrically reduced portions intimately contacting and holding axially spaced end portions of the inner tube thereby to permit the second cylindrical space to have an isolated part between the first and second diametrically reduced portions; first and second radially depressed end portions possessed by the outer tube, each radially depressed end portion having an outer tube opening formed therethrough; first and second radially raised end portions possessed by the middle tube, each radially raised end portion having a middle tube opening formed therethrough, the first and second radially raised end portions intimately putting thereon the first and second radially depressed end portions respectively in such a manner that the middle tube openings are merged with the outer tube openings respectively; an inlet pipe passing through the merged openings of the first radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the inlet pipe having a portion caulked to peripheral edges of the merged openings of the first radially raised and depressed end portions; and an outlet pipe passing through the merged openings of the second radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the outlet pipe having a portion caulked to peripheral edges of the merged openings of the second radially raised and depressed end portions, wherein the gas to be cooled is forced to flow through the first and third cylindrical spaces, and the water is led into the isolated part of the second cylindrical space through the inlet pipe and discharged from the isolated part through the outlet pipe.

[0014] According to a third aspect of the present invention, there is provided a method of producing heat exchanger, which comprises (a) preparing outer, middle and inner tubes and inlet and outlet pipes, the outer tube having first and second radially depressed end portions each having an outer tube opening, the middle tube having first and second radially raised end portions each having a middle tube opening, the middle tube further having first and second diametrically reduced end portions, and each of the inlet and outlet pipes having a bead portion at a base end thereof; (b) placing the middle tube in the outer tube in such a manner that the first and second radially raised end portions of the middle tube put thereon the first and second radially depressed end portions of the outer tube respectively having the middle tube openings merged with the outer tube openings respectively; (c) inserting the base ends of the inlet and outlet pipes into the merged middle and outer tube openings respectively; (d) caulking the base ends of the inlet and outlet pipes with the aid of the bead portions, so that the caulked parts of the base ends of the inlet and outlet pipes grip peripheral edges of the merged middle and outer tube openings respectively; (e) placing the inner tube in the middle tube in such a manner that the first and second diametrically reduced end portions of the middle tube contact and hold axially spaced end portions of the inner tube, so that the outer, middle and inner tubes and the inlet and outlet pipes constitute a pre-assembled unit; and (f) putting the pre-assembled unit into a furnace to braze mutually contacting portions possessed by the pre-assembled unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Other objects and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a sectional view of a triple-tube type heat exchanger which is a first embodiment of the present invention;
Fig. 2 is a sectional view taken along the line II-II of Fig. 1;
Fig. 3 is an enlarged sectional view of an inner element of the heat exchanger of the first embodiment;
Fig. 4 is a perspective view of a fin plate that is installed in the heat exchanger of the first embodiment;
Fig. 5 is a view showing the step for inserting the fin plates into an inner tube;
Fig. 6 is a view similar to Fig. 1, but showing a flow of engine cooling water and that of EGR gas;
Fig. 7A to 7F are drawings showing steps for assembling the heat exchanger of the first embodiment;
Fig. 8 is a view similar to Fig. 1, but showing a triple-tube type heat exchanger of a second embodiment of the present invention;
Fig. 9 is a sectional view taken along the line IX-IX of Fig. 8;
Fig. 10 is a view similar to Fig. 1, but showing a triple-tube type heat exchanger of a third embodiment of the present invention;
Fig. 11 is a view similar to Fig. 1, but showing a triple-tube type heat exchanger of a fourth embodiment of the present invention;
Fig. 12 is a perspective view of a first modification of the fin plate employable in the present invention;
Fig. 13 is a perspective view of a second modification of the fin plate employable in the present invention;
Fig. 14 is a sectional view of an inner element that employs the fin plates of the first modification or the fin plates of the second modification;
Fig. 15A is a perspective view of an inner element that employs a third modification of the fin plate;
Fig. 15B is a sectional view of the inner element of Fig. 15A;
Fig. 16A is a perspective view of an inner element that is employs a fourth modification of the fin plate;
Fig. 16B is a sectional view of the inner element of Fig. 16A;
Fig. 17 is a sectional view of a conventional triple-tube type oil cooler; and
Fig. 18 is a sectional view of another conventional triple-tube type oil cooler.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0016] In the following, several embodiments of the present invention will be described with reference to the accompanying drawings.

[0017] For ease of understanding, various directional terms, such as, right, left, upper, lower, rightward and the like, are used in the following description. However, such terms are to be understood with respect to only a drawing or drawings on which a corresponding part or portion is shown.

[0018] Referring to Figs. 1 to 7F, particularly Figs. 1 and 2, there is shown a triple-tube type heat exchanger 100 which is a first embodiment of the present invention.

[0019] The heat exchanger 100 described herein is used, for example, as an EGR gas cooler that cools an EGR gas by using an engine cooling water. As is known, the EGR gas is an exhaust gas fed back to an intake system of an internal combustion engine from an exhaust system of the same to reduce the combustion temperature in combustion chambers thereby to reduce emissions of nitrogen oxides (NOx) and pa rticu lates.

[0020] As shown in Figs. 1 and 2, the triple-tube type heat exchanger 100 comprises an inner tube 2, a middle tube 3 and an outer tube 4 which are concentrically arranged. These tubes 2, 3 and 4 are constructed of a metal, such as stainless steel or the like. With the concentric arrangement of the three tubes 2, 3 and 4, there are defined a cylindrical inner passage (or third cylindrical space) 12 within the inner tube 2, a cylindrical middle space (or second cylindrical space) 11 between the inner tube 2 and the middle tube 3 and a cylindrical outer space (or first cylindrical space) 20 between the middle tube 3 and the outer tube 4.

[0021] As will become apparent as the description proceeds, the cylindrical middle space 11 serves as a passage for a cooling water, the cylindrical inner passage 12 serves an inner gas flow passage for an EGR gas and the cylindrical outer space 20 serves an outer gas flow passage for the EGR gas.

[0022] Inlet and outlet pipes 5 and 6 of stainless steel are connected at their based ends to axially opposed end portions of the middle tube 3 respectively, so that an engine cooling water is led into the cylindrical middle space 11 from the inlet pipe 5 and discharged from the outlet pipe 6.

[0023] Mounting flanges 7 are secured through brazing to opposed ends of the outer tube 4 respectively.

[0024] As is seen from the drawings, the inner tube 2 has a simpler cylindrical shape. However, the middle tube 3 has a complicated cylindrical shape. That is, the middle tube 3 comprises a corrugated middle portion 9 that forms a major part of the middle tube 3, radially raised end portions 8 that have openings to which the inlet and outlet pipes 5 and 6 are connected and diametrically reduced ends 10 that are concentrically and intimately put on axially ends of the inner tube 2. Brazing is applied to the reduced ends 10 to tightly couple the inner and middle tubes 2 and 3. With this brazing, the cylindrical middle space 11 forms an isolated part communicated with only the inlet and outlet pipes 5 and 6.

[0025] As is best seen from Fig. 2, within the inner tube 2, there is installed an inner fin unit 13 of generally H-shaped cross section for promoting a heat transferring of the inner tube 2 and promoting a turbulent flow of EGR gas that flows in the cylindrical inner passage 12.

[0026] As is seen from Figs. 3, 4 and 5, the inner fin unit 13 comprises two identical channel-shaped fin plates 14 that are coupled in a back-to-back connection manner. The fin plates 14 are constructed of stainless steel. However, if desired, the fin plates 14 may be constructed of other metals that have a good heat transfer. As is seen from Fig. 4, each fin plate 14 is formed with flanged ends 15 and as is seen from Fig. 2, the flanged ends 15 are brazed to a cylindrical inner surface of the inner tube 2. As will be described in detail hereinafter, the two fin plates 14 are brazed to each other at their mutually contacting back portions.

[0027] Furthermore, as is seen from Fig. 4, each fin plate 14 is formed with a plurality of slits 16 each extending in the direction of the width of the fin plate 14. Each slit 16 is formed at both end portions thereof with small slanted fins 17. More specifically, the small slanted fins 17 possessed by each fin plate 14 comprise a first group of fins 17 that project inward from one side wall of the fin plate 14 and a second group of fins 17 that project outward from the other side wall of the fin plate 14, as will be understood from Fig. 4. With the slits 16, a thermal distortion of the inner fin unit 13 is suppressed or at least minimized. Furthermore, with the small slanted fins 17, the heat transfer area of the inner fin unit 13 is increased.

[0028] Referring back to Fig. 1, the outer tube 4 comprises a cylindrical middle portion and radially depressed end portions 18 that have openings to which the inlet and outlet pipes 5 and 6 are connected. More specifically, the radially raised end portions 8 of the middle tube 3 and the radially depressed end portions 18 of the outer tube 4 are put on one another to mate the openings thereof to constitute pipe fixing openings 19, to which the base ends of the inlet and outlet pipes 5 and 6 are fixed. A hydraulic bulging method may be used for forming the radially raised and depressed portions 8 and 18. For connecting the base ends of the inlet and outlet pipes 5 and 6 to the pipe fixing openings 19, a caulking technique is employed. Then, brazing is applied to such caulked portions to assure a tight connection as well as a hermetic sealing between the base ends of the pipes 5 and 6 and the pipe fixing openings 19.

[0029] That is, as will be described in detail hereinafter, for connecting the inlet and outlet pipes 5 and 6 to the pipe fixing openings 19, the following steps are employed. Previously, the base end of each pipe 5 or 6 has a bead portion 21 with a cylindrical leading end 22. First, the cylindrical leading end 22 of the pipe 5 or 6 is inserted into the pipe fixing opening 19, and then, with the bead portion 21 kept pressed against an upper peripheral edge of the opening 19, the cylindrical leading end 22 is pressed radially outward by using a suitable caulking tool. With this, the base end of each pipe 5 or 6 is caulked to the peripheral edge of the pipe fixing opening 19, as shown.

[0030] As is seen from Fig. 2, due to provision of the radially depressed end portions 18 of the outer tube 4, the caulked base end of each pipe 6 or 5 is neatly received within an imaginary circle that is possessed by the section of the outer tube 4. That is, irrespective of the inlet and outlet pipes 5 and 6, the outer tube 4 is suppressed from having unsightly projected portions. Furthermore, due to the intimate contact between the radially raised end portion 8 of the middle tube 3 and the radially depressed end portion 18 of the outer tube 4, a durable and tight connection between the pipe 5 or 6 and the middle tube 3 is achieved without usage of additional parts between the middle and outer tubes 3 and 4.

[0031] As will be described in detail hereinafter, for production of the triple-tube type heat exchanger 100, the inner tube 2, the middle tube 3, the outer tube 4, the mounting flanges 7, the inlet and outlet pipes 5 and 6 are preliminarily united to constitute a so-called pre-assembled unit in such an arrangement as is shown in Fig. 1, and then this pre-assembled unit is put in a furnace, for example, vacuum furnace or the like, for a given time. In the furnace, brazing is carried out at the mutually contacting portions, viz., the portions between the mounting flanges 7 and the outer tube 4, the portions between the diametrically reduced ends 10 of the middle tube 3 and the inner tube 2, the portions between the caulked base ends of the inlet and outlet pipes 5 and 6 and the peripheral ends of the pipe fixing openings 19 of the outer and middle tubes 4 and 3, the portion between backs of the fin plates 14. For the brazing, Nickel brazing, Cupper brazing and the like are usable. That is, for such brazing, a suitable brazing filler metal plate or paste like filler metal material is previously set at or applied to the portions which are to be brazed. If desired, a clad metal lined with a brazing filler metal or a metal plated with a cupper may be used as a material of the members which are brazed.

[0032] In Fig. 6, there is shown a finished product of the triple-tube type heat exchanger 100 of the first embodiment of the present invention. When it is in use, the inlet pipe 5 is connected to an outlet pipe of a radiator (not shown) and the outlet pipe 6 is connected to an inlet pipe of the radiator, and a left inlet end 100A of the outer tube 4 is connected to an exhaust system of an associated internal combustion engine and the right outlet end 100B of the tube 4 is connected to an intake system of the engine. Under operation of the engine, cooling water (viz., engine cooling water) is led into the engine cooling water passage 11 from the inlet pipe 5 and discharged from the outlet pipe 6 as is indicated by the hatched arrows, and the EGR gas from the exhaust system of the engine is led into both the inner and outer gas flow passages 12 and 20 from the inlet end 100A of the outer tube 4 and discharged from the outlet end 100B of the same and introduced into the intake system of the engine, as is indicated by the blank arrows. Thus, during the flow, the EGR gas is cooled by the cooling water. Because the outer tube 4 is exposed to the open air, the EGR gas flowing in the outer gas flow passage 20 is much effectively cooled as compared with that flowing in the inner gas flow passage 12.

[0033] As has been mentioned hereinabove, due to provision of the radially depressed end portions 18 of the outer tube 4, the caulked base ends of the inlet and outlet pipes 5 and 6 are neatly received in the circle that is possessed by the section of the outer tube 4, as shown in Fig. 2. Thus, the EGR gas flowing in the outer gas flow passage 20 is permitted to have a smoothed flow therein and thus the amount of particles collected around the caulked base ends of the pipes 5 and 6 can be minimized.

[0034] In the following, steps for assembling the triple-tube type heat exchanger 100 of the first embodiment will be described with the aid of Figs. 7A to 7F. It is however to be noted that for clarification of the drawings, the corrugations 9 of the middle tube 3 are omitted from the drawings.

[0035] First, as is seen from Fig. 7A, by using a suitable jig (not shown), the inlet and outlet pipes 5 and 6 are stably positioned with their base ends projected upward. Each pipe 5 or 6 has the bead portion 21 previously.

[0036] Then, as is seen from Fig. 7B, the outer tube 4 with the radially depressed end portions 18 is put on the pipes 5 and 6 having the peripheral edges of the pipe fixing openings 19 respectively seated on the bead portions 21 of the inlet and outlet pipes 5 and 6.

[0037] Then, as is seen from Fig. 7C, the middle tube 3 with the radially raised end portions 8 is inserted into the outer tube 4 and put on the pipes 5 and 6 having the peripheral edges of the pipe fixing openings 19 thereof respectively seated on the peripheral edges of the pipe fixing openings 19 of the outer tube 4. Under this condition, the radially raised end portions 8 of the middle tube 3 intimately contact with the radially depressed end portions 18 of the outer tube 4 due to the positioning effect given by the base ends of the pipes 5 and 6, and at the same time, due to the positioning effect of the pipes 5 and 6, the middle and outer tubes 3 and 4 are concentrically arranged. It is to be noted that the middle tube 3 has the diametrically reduced ends 10 previously formed.

[0038] Then, as is seen from Fig. 7D, a suitable caulking tool (not shown) is inserted into the middle tube 3 to make a caulking to the cylindrical leading ends 22 of the pipes 5 and 6. With this, the peripheral edges of the pipe fixing openings 19 of the middle and outer tubes 3 and 4 are tightly secured to the base ends of the inlet and outlet pipes 5 and 6, as is understood from Fig. 2. With this, the inlet and outlet pipes 5 and 6, the outer tube 4 and the middle tube 3 are united to constitute a first pre-assembled unit which has a so-called "self-holding structure".

[0039] Then, as is seen from Fig. 7E, the inner tube 2 is inserted into the middle tube 3 and as is seen from Fig. 7F, the two fin plates 14 are inserted into the inner tube 2 in such a manner as is seen from Fig. 5. Under this condition, the both ends of the inner tube 2 is intimately held by the diametrically reduced ends 10 of the middle tube 3 and the flanged ends 15 of the two fin plates 14 are intimately held by the inner tube 2 having the backs of the same intimately contacting each other, so that a second pre-assembled unit is constituted. As is mentioned hereinabove, at the mutually contacting portions of the pre-assembled unit, there have been previously set or provided suitable brazing filler metal plates or paste like filler metal material.

[0040] Then, the second pre-assembled unit is put in a furnace (viz., vacuum furnace or the like) for a given time to achieve brazing of the mutually contacting portion of the pre-assembled unit. With these steps, the triple-tube type heat exchanger 100 of the first embodiment is produced.

[0041] It is to be noted that since the second pre-assembled unit has also "self-holding structure" due to the caulked connection of the pipes 5 and 6 to the middle and outer tubes 3 and 4, the intimate thrust connection of the inner tube 2 with the middle tube 3, and the intimate thrust connection of the two fin plates 14 with the inner tube 2. Thus, the brazing of the pre-assembled unit in the furnace can be carried out without usage of any positioning jigs.

[0042] Referring to Figs. 8 and 9, there is shown a triple-tube type heat exchanger 200 which is a second embodiment of the present invention.

[0043] The heat exchanger 200 of this second embodiment is substantially same as the above-mentioned heat exchanger 100 of the first embodiment except that in the second embodiment 200, the inner fin unit 13 is not provided.

[0044] In the above-mentioned heat exchanges 100 and 200, only the middle tube 3 is of a corrugated type. However, if desired, also the inner tube 2 and the outer tube 4 may be of the corrugated type. Furthermore, if desired, the inlet and outlet pipes 5 and 6 may be positioned at diametrically different and axially spaced portions of the outer tube 4. Furthermore, as may be seen from Fig. 11. these pipes 5 and 6 may be positioned at diametrically opposite and axially spaced portions of the outer tube 4.

[0045] Referring to Fig. 10, there is shown a triple-tube type heat exchanger 300 which is a third embodiment of the present invention.

[0046] The heat exchanger 300 of this third embodiment is substantially same as the above-mentioned heat exchanger 200 of the second embodiment except that in the third embodiment 300, the middle tube 3 is free of the corrugations 9.

[0047] Referring to Fig. 11, there is shown a triple-tube type heat exchanger 400 which is a fourth embodiment of the present invention.

[0048] The heat exchanger 400 of this fourth embodiment is substantially same as the heat exchanger 300 of the third embodiment except that in the fourth embodiment 400, the inlet and outlet pipes 5 and 6 are positioned at diametrically opposed and axially spaced portions of the middle and outer tubes 3 and 4, as shown.

[0049] Because the heat exchangers 200, 300 and 400 can also have a so-called "self holding structure", the brazing of their pre-assembled units can be carried out without usage of positioning jigs like in case of the first embodiment 100.

[0050] Referring to 12 to 17B of the drawings, there are shown four types of fin plates which can be used as substitutes for the above-mentioned fin plates 14 in the present invention.

[0051] In Fig. 12, there is shown a first modified fin plate 141. In this modification, there are no construction and means that correspond to the slits 16 and the small slanted fins 17 employed in the fin plate 14 (see Fig. 4). Of course, when received in the inner tube 2, two fin plates 141 are used with their back portions intimately contacting with each other, as is seen from Fig. 14.

[0052] In Fig. 13, there is shown a second modified fin plate 142. In this modification, only slits 16 are provided. Like in the first modified plate 141, two fin plates 142 are used when received in the inner tube 2.

[0053] In Figs. 15A and 15B, there is shown a third modified fin plate 143 that is tightly installed in the inner tube 2. As shown, the third modified fin plate 143 has a generally V-shaped cross section including an apex part 23 and two inwardly bent flanged ends 25. As shown in Fig. 15B, when received in the inner tube 2, the apex part 23 and the two flanged ends 25 are pressed against the cylindrical inner surface of the inner tube 2 because of the resiliency possessed by the fin plate 143. Thus, the fin plate 143 can have a so-called "self holding construction" in the inner tube 2. Of course, the three intimately contacting portions defined between the fin plate 143 and the inner tube 2 have been previously applied with suitable brazing filler metals or paste like filler metal material. Thus, when heated in the furnace, the three intimately contacting portions are brazed to tightly fix the three parts 23 and 25 of the fin plate 143 to the outer tube 2.

[0054] Referring to Figs. 16A and 16B, there is shown a fourth modified fin plate 144 that is tightly installed in the inner tube 2. As shown, the fourth modified fin plate 144 has a generally U-shaped cross section including two apex parts 26 and two inwardly bent flanged ends 35. As shown in Fig. 16B, when received in the inner tube 2, the two apex parts 26 and the two flanged ends 35 are pressed against the cylindrical inner surface of the inner tube 2 because of the resiliency possessed by the fin plate 144. Thus, the fin plate 144 can have the self holding construction in the inner tube 2. Of course, like in the third modified fin plate 143, the four intimately contacting portions defined between the fin plate 144 and the inner tube 2 have been previously applied with suitable brazing filler metals or paste like filler metal material. Thus, upon heated in the furnace, the four intimately contacting portions are brazed to tightly fix the four parts 26 and 35 of the fin plate 144 to the inner tube 2.

[0055] In the following, further modifications of the present invention will be described.

[0056] If desired, the above-mentioned third and fourth modified fin plates 143 and 144 may be provided with slits (16) and small slanted fins (17) like in case of the heat exchange 100 of the first embodiment (see Fig. 4).

[0057] Furthermore, if desired, the inner and outer tubes 2 and 4 may be of a type that has a plurality of corrugations in order to increase the heat transfer area of the tubes.

[0058] The entire contents of Japanese Patent Applications 2002-230780 and 2002-230779 both filed August 8, 2002 are incorporated herein by reference.

[0059] Although the invention has been described above with reference to the embodiments of the invention, the invention is not limited to such embodiments as described above. Various modifications and variations of such embodiments may be carried out by those skilled in the art, in light of the above description.

Claims

1. A heat exchanger comprising:

an outer tube;
a middle tube received in the outer tube in a manner to define therebetween a first cylindrical space;
an inner tube received in the middle tube in a manner to define therebetween a second cylindrical space, the inner tube having a third cylindrical space defined therein;
first and second diametrically reduced portions possessed by axially spaced end portions of the middle tube, the diametrically reduced portions intimately contacting and holding axially spaced end portions of the inner tube thereby to permit the second cylindrical space to have

an isolated part between the first and second diametrically reduced portions;
first and second radially depressed end portions possessed by the outer tube, each radially depressed end portion having an outer tube opening formed therethrough;
first and second radially raised end portions possessed by the middle tube, each radially raised end portion having a middle tube opening formed therethrough, the first and second radially raised end portions intimately putting thereon the first and second radially depressed end portions respectively in such a manner that the middle tube openings are merged with the outer tube openings respectively;
an inlet pipe passing through the merged openings of the first radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the inlet pipe having a portion caulked to peripheral edges of the merged openings of the first radially raised and depressed end portions; and
an outlet pipe passing through the merged openings of the second radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the outlet pipe having a portion caulked to peripheral edges of the merged openings of the second radially raised and depressed end portions.

2. A heat exchanger as claimed in Claim 1, further comprising:

first brazed portions through which the first and second diametrically reduced portions of the middle tube and the axially spaced end portions of the inner tube are secured to each other respectively; and
second brazed portions through which the first and second radially raised end portions and the first and second radially depressed portions are secured to each other respectively.

3. A heat exchanger as claimed in Claim 2, in which the middle tube is formed with a plurality of corrugations which have inner surfaces exposed to the isolated part of the second cylindrical space and outer surfaces exposed to the first cylindrical space.

4. A heat exchanger as claimed in Claim 2, further comprising an inner fin unit installed in and secured to the inner tube for promoting a heat transferring of the inner tube and promoting a turbulence flow of a fluid flowing in the third cylindrical space, the inner fin unit having portions brazed to an inner surface of the inner tube.

5. A heat exchanger as claimed in Claim 4, in which the inner fin unit has a generally H-shaped cross section and has four wall portions whose leading ends are brazed to the inner surface of the inner tube.

6. A heat exchanger as claimed in Claim 5, in which the inner unit comprises two fin plates each having a generally channel shape, the two fin plates being coupled through a brazing in a back-to-back connecting manner.

7. A heat exchanger as claimed in Claim 6, in which each of the fin plates is formed with a plurality of slits.

8. A heat exchanger as claimed in Claim 7, in which each of the fin plates is further formed with a plurality of fins.

9. A heat exchanger as claimed in Claim 2, further comprising a fin plate that is installed in and secured to the inner tube for promoting a heat transferring of the inner tube and promoting a turbulence flow of a fluid flowing in the third cylindrical space, the fin plate having portions brazed to an inner surface of the inner tube.

10. A heat exchanger as claimed in Claim 9, in which the fin plate has a generally V-shaped cross section including an apex part and two inwardly bent flanged ends, the apex part and the two inwardly bent flanged ends being brazed to the inner surface of the inner tube.

11. A heat exchanger as claimed in Claim 9, in which the fin plate has a generally U-shaped cross section including two apex parts and two inwardly bent flanged ends, the two apex parts and the two inwardly bent flanged ends being brazed to the inner surface of the inner tube.

12. A heat exchanger as claimed in Claim 1, the outer tube, the middle tube and the inner tube are concentrically arranged.

13. A heat exchanger as claimed in Claim 1, in which the inlet and outlet pipes are provided on diametrically same and axially spaced portions of the outer and middle tubes.

14. A heat exchanger as claimed in Claim 1, in which the inlet and outlet pipes are provided on diametrically opposed and axially spaced portions of the outer and middle tubes.

15. A heat exchanger as claimed in Claim 1, in which at least one of the outer, middle and inner tubes is constructed to have a plurality of corrugations.

16. A gas cooler for cooling gas by using water, comprising:

an outer tube;
a middle tube received in the outer tube in a manner to define therebetween a first cylindrical space;
an inner tube received in the middle tube in a manner to define therebetween a second cylindrical space, the inner tube having a third cylindrical space defined therein;
first and second diametrically reduced portions possessed by axially spaced end portions of the middle tube, the diametrically reduced portions intimately contacting and holding axially spaced end portions of the inner tube thereby to permit the second cylindrical space to have an isolated part between the first and second diametrically reduced portions;
first and second radially depressed end portions possessed by the outer tube, each radially depressed end portion having an outer tube opening formed therethrough;
first and second radially raised end portions possessed by the middle tube, each radially raised end portion having a middle tube opening formed therethrough, the first and second radially raised end portions intimately putting thereon the first and second radially depressed end portions respectively in such a manner that the middle tube openings are merged with the outer tube openings respectively;
an inlet pipe passing through the merged openings of the first radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the inlet pipe having a portion caulked to peripheral edges of the merged openings of the first radially raised and depressed end portions; and
an outlet pipe passing through the merged openings of the second radially raised and depressed end portions to connect with the isolated part of the second cylindrical space, the outlet pipe having a portion caulked to peripheral edges of the merged openings of the second radially raised and depressed end portions,

wherein the gas to be cooled is forced to flow through the first and third cylindrical spaces, and the water is led into the isolated part of the second cylindrical space through the inlet pipe and discharged from the isolated part through the outlet pipe.

17. A method of producing heat exchanger, comprising:

(a) preparing outer, middle and inner tubes and inlet and outlet pipes, the outer tube having first and second radially depressed end portions each having an outer tube opening, the middle tube having first and second radially raised end portions each having a middle tube opening, the middle tube further having first and second diametrically reduced end portions, and each of the inlet and outlet pipes having a bead portion at a base end thereof;
(b) placing the middle tube in the outer tube in such a manner that the first and second radially raised end portions of the middle tube put thereon the first and second radially depressed end portions of the outer tube respectively having the middle tube openings merged with the outer tube openings respectively;
(c) inserting the base ends of the inlet and outlet pipes into the merged middle and outer tube openings respectively;
(d) caulking the base ends of the inlet and outlet pipes with the aid of the bead portions, so that the caulked parts of the base ends of the inlet and outlet pipes grip peripheral edges of the merged middle and outer tube openings respectively;
(e) placing the inner tube in the middle tube in such a manner that the first and second diametrically reduced end portions of the middle tube contact and hold axially spaced end portions of the inner tube, so that the outer, middle and inner tubes and the inlet and outlet pipes constitute a pre-assembled unit; and
(f) putting the pre-assembled unit into a furnace to braze mutually contacting portions possessed by the pre-assembled unit.

18. A method as claimed in Claim 17, before the step (f), further comprising (g) placing an inner fin unit in the inner tube in such a manner that given portions of the inner fin unit contact with an inner surface of the inner tube.

19. A method as claimed in Claim 17, before the step (f), further comprising (h) disposing two mounting flanges on axially opposed ends of the outer tube.

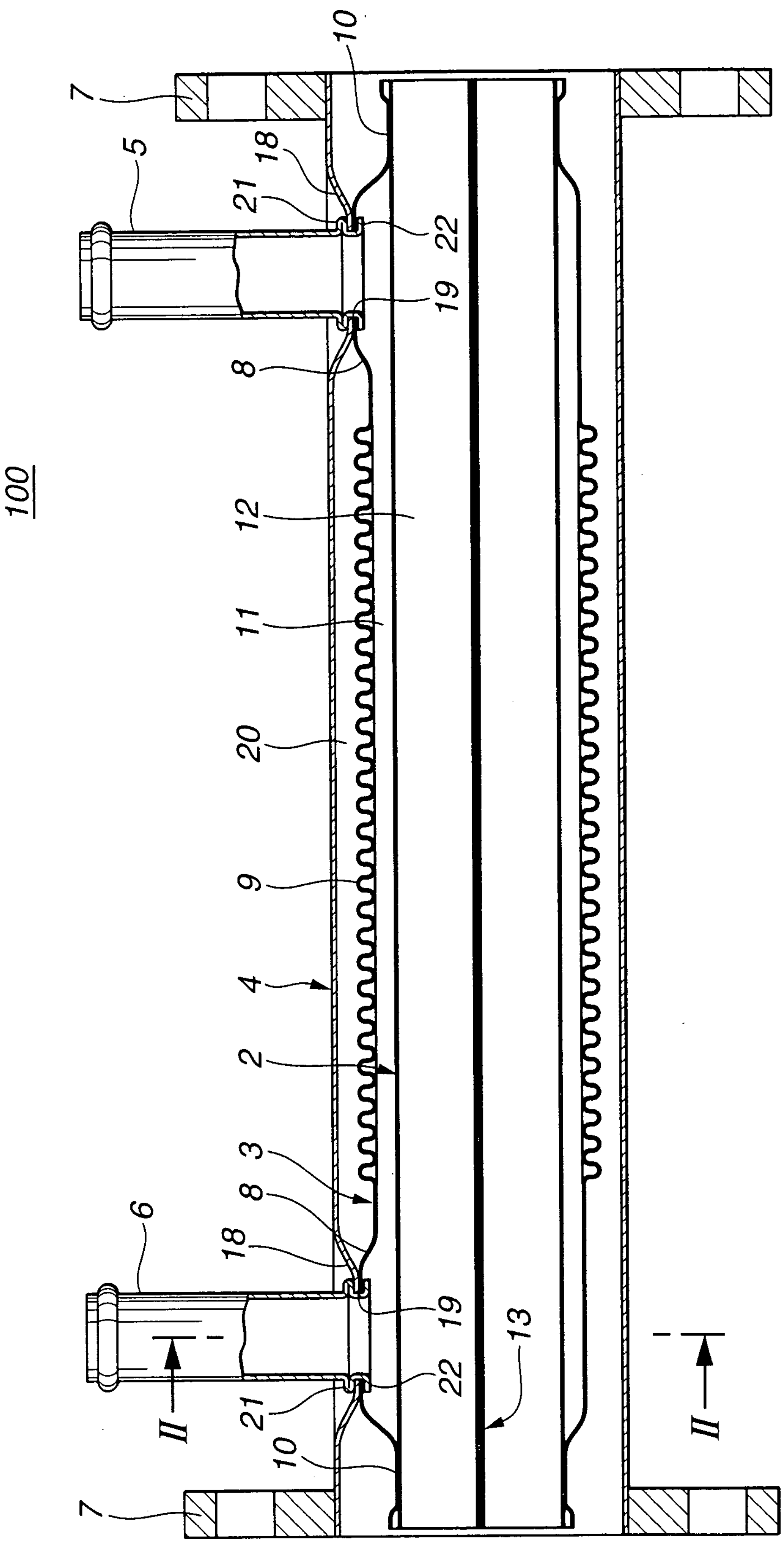


FIG.1

FIG.2

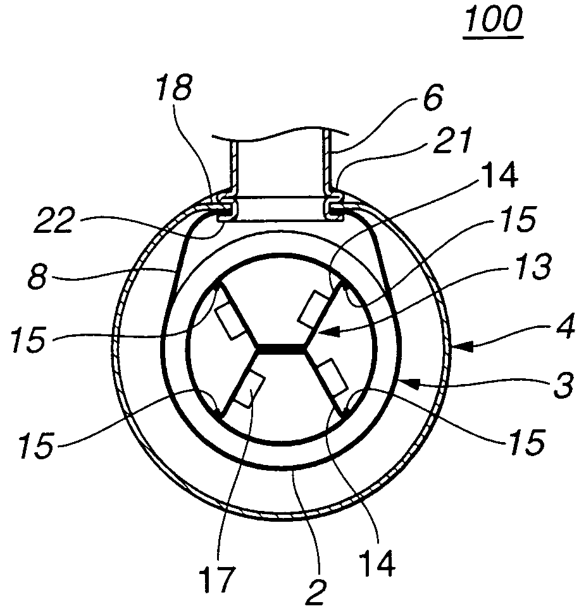


FIG.3

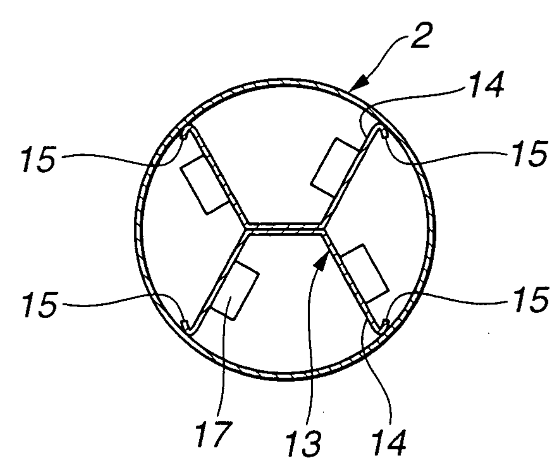


FIG.4

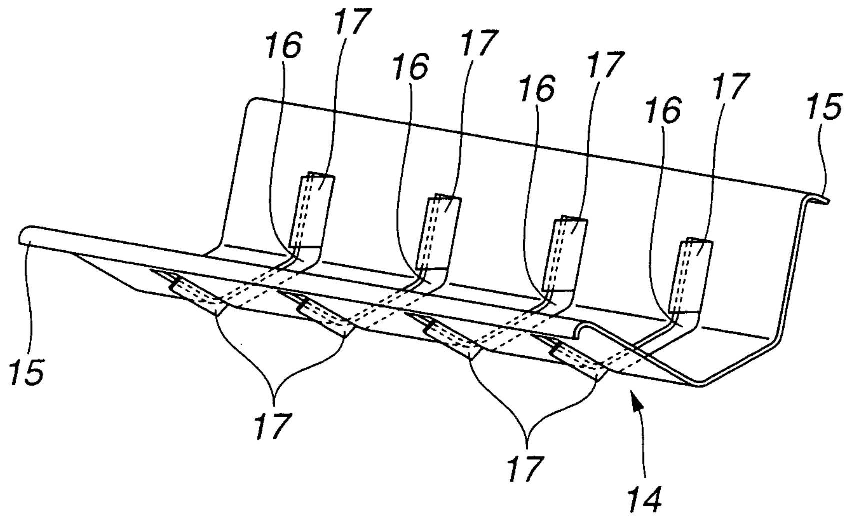


FIG.5

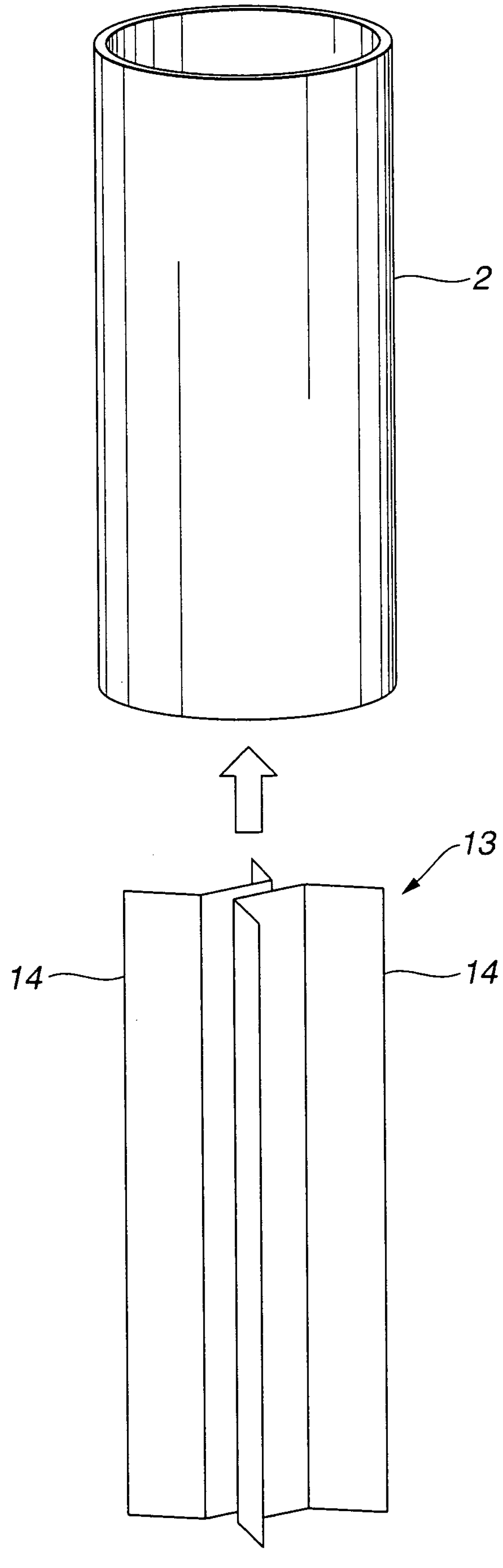


FIG.6

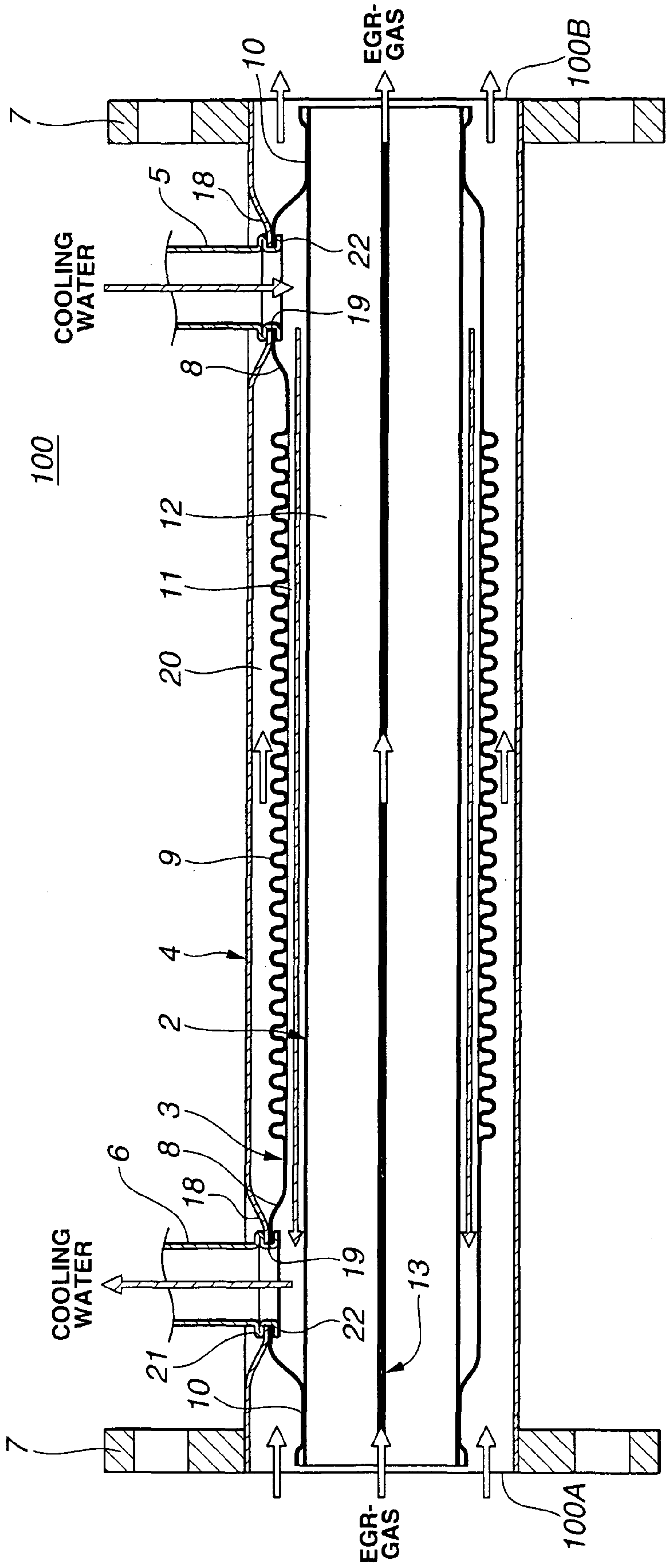

100
COOLING WATER
COOLING WATER
EGR-GAS
EGR-GAS
100A
100B
2
3
4
5
6
7
7
8
8
9
10
10
10
11
12
13
18
18
19
19
20
21
22
22

FIG.7A

FIG.7B

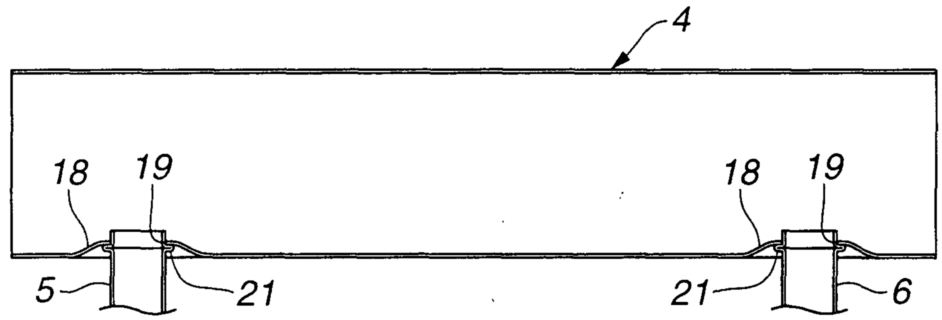


FIG.7C

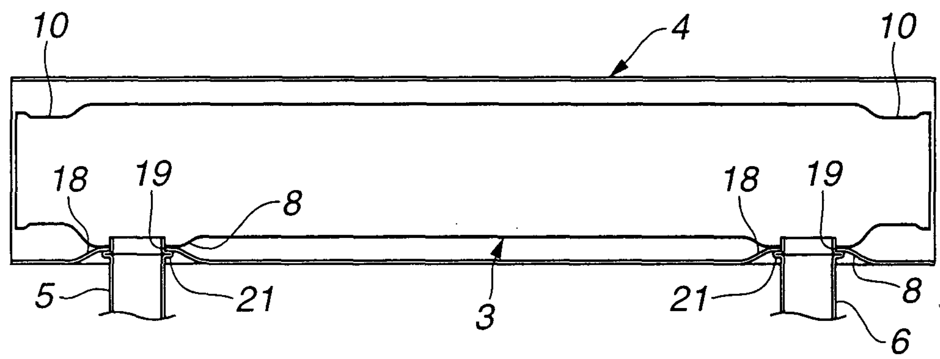


FIG.7D

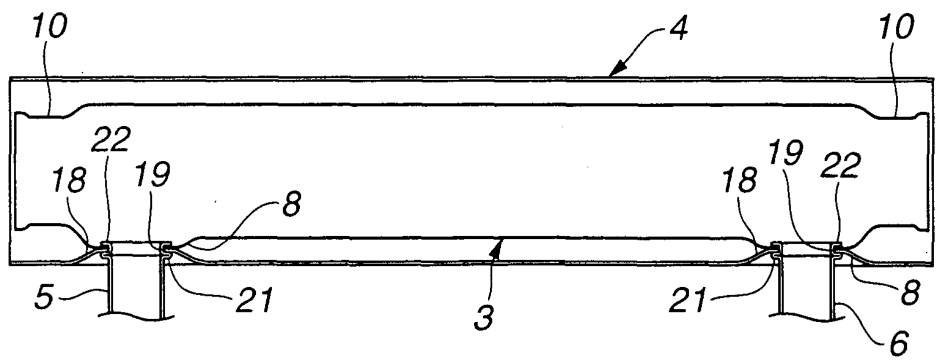


FIG.7E

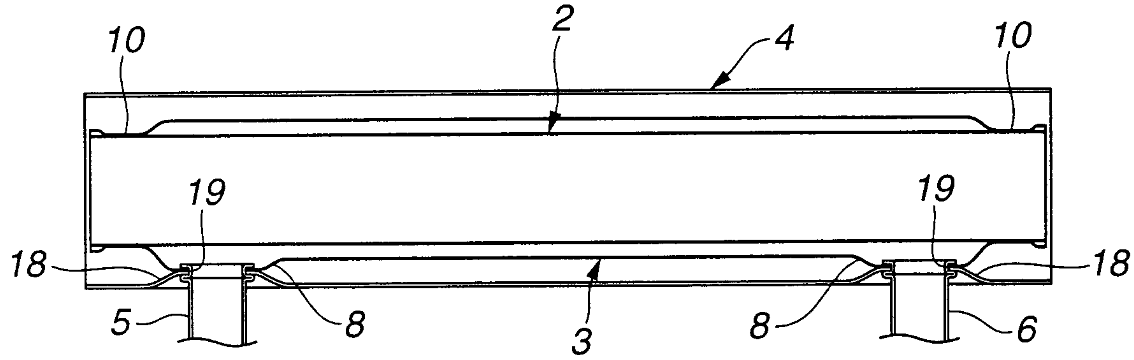


FIG.7F

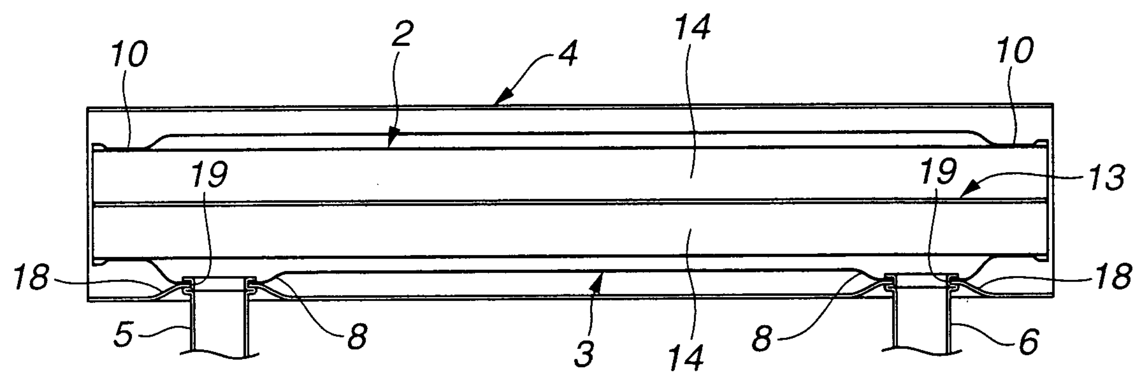


FIG.8

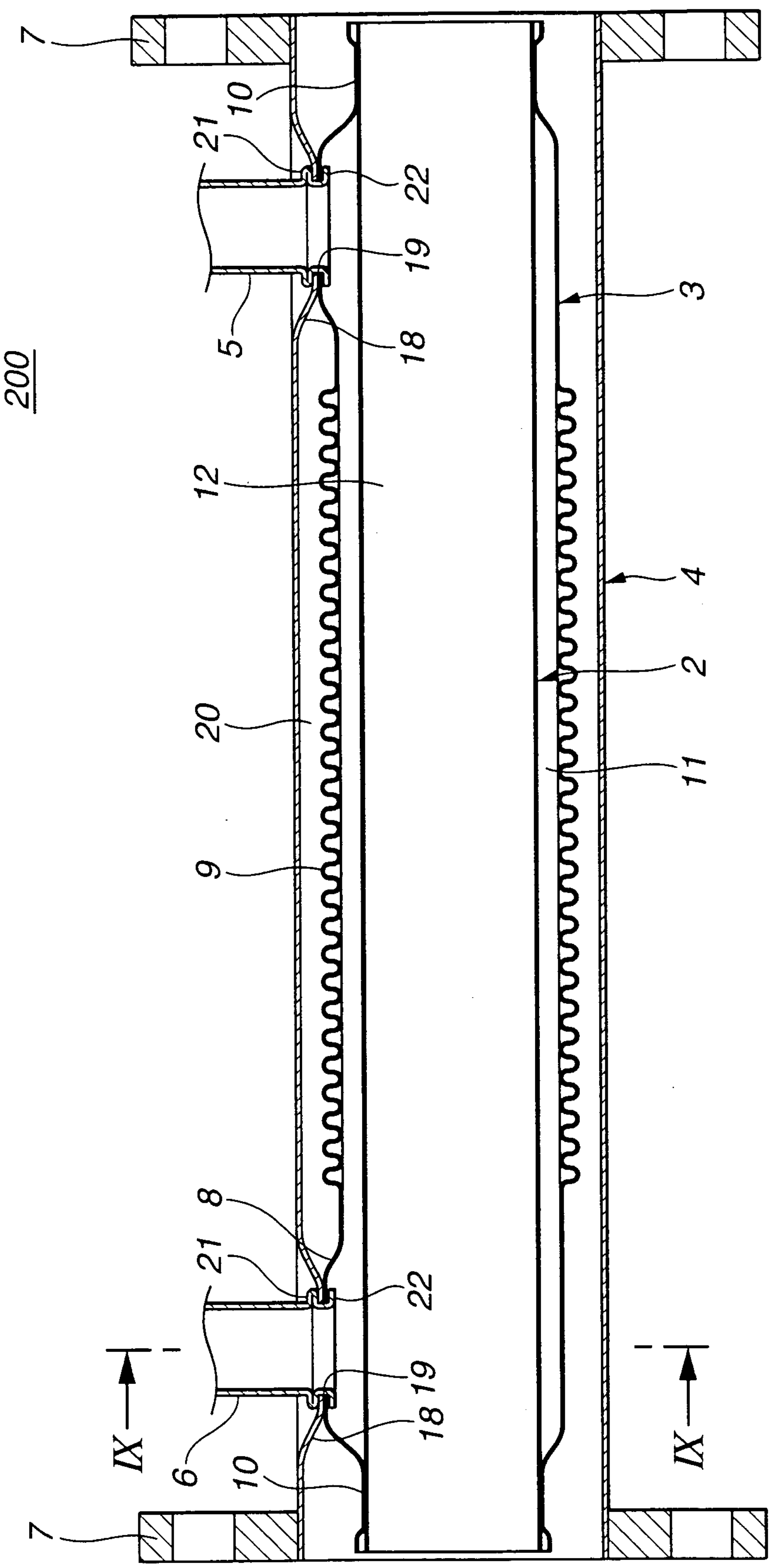


FIG.9

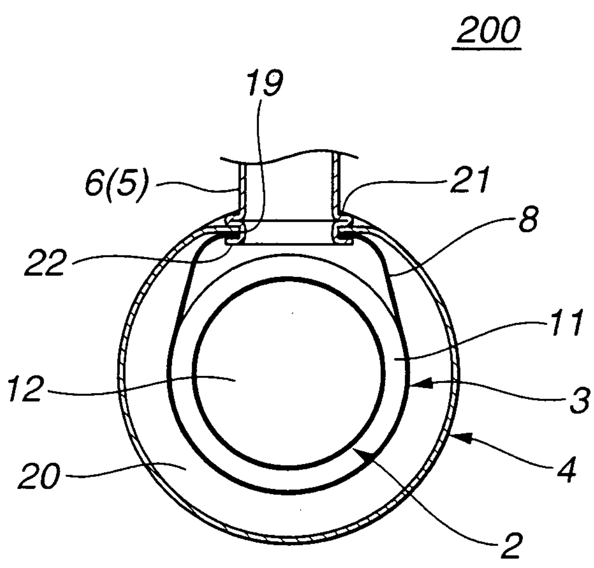


FIG.10

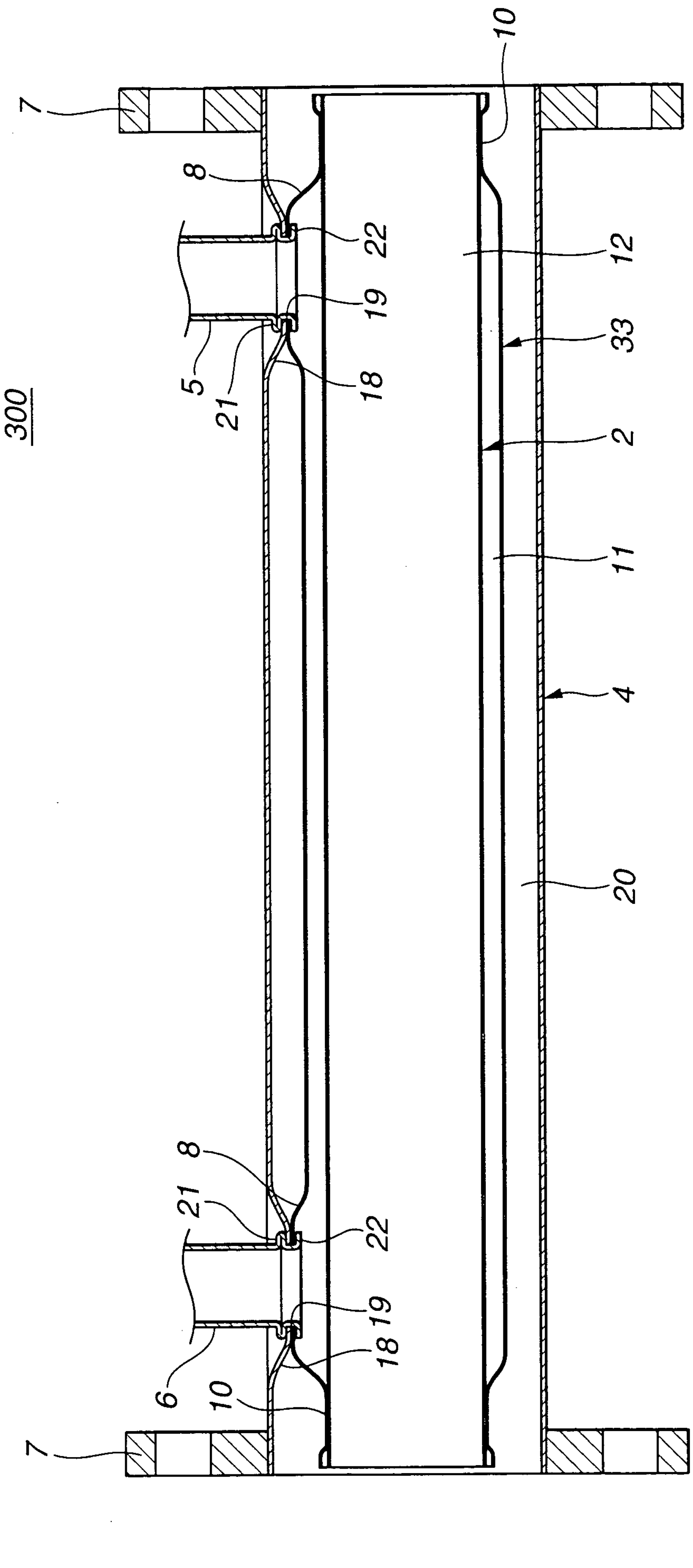


FIG.11

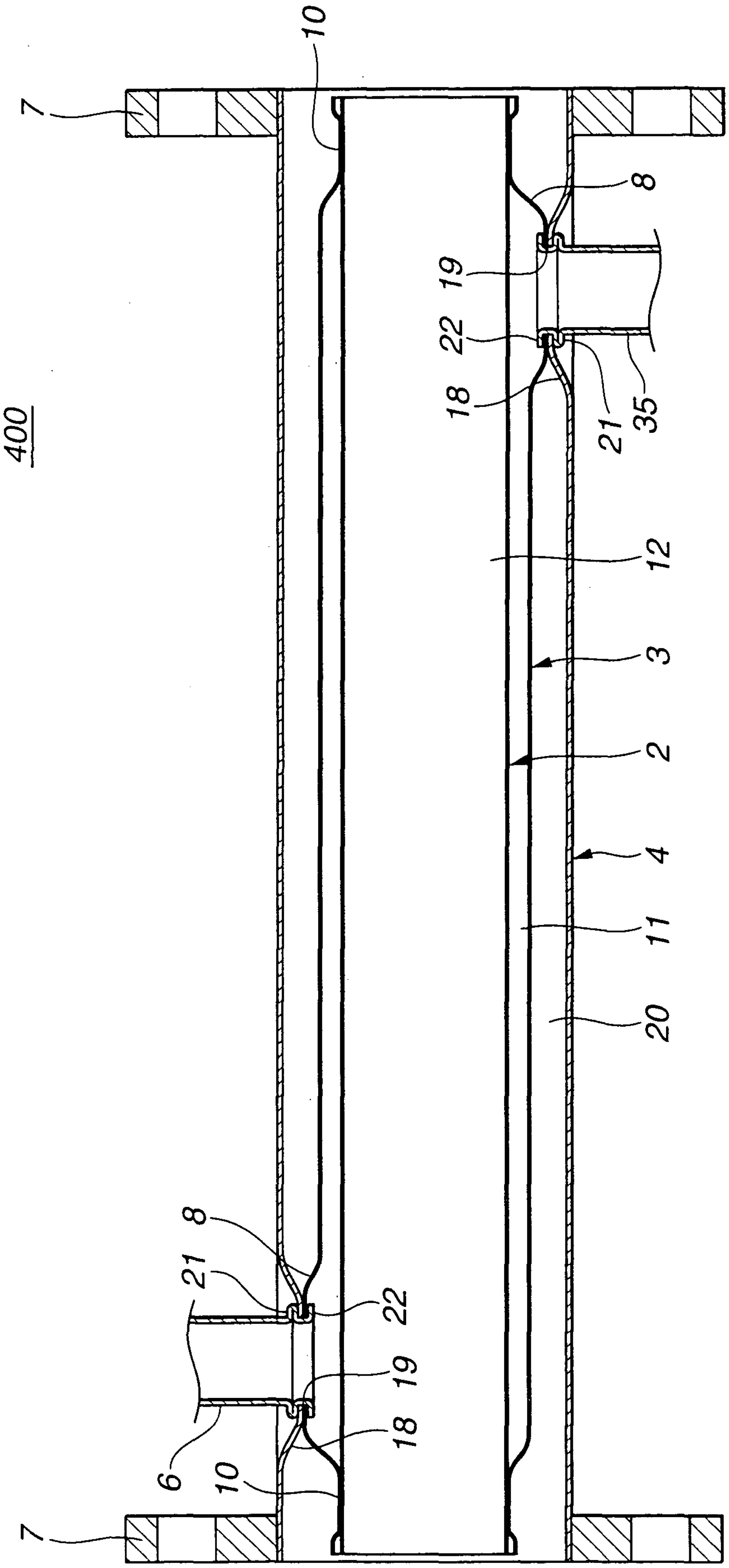


FIG.12

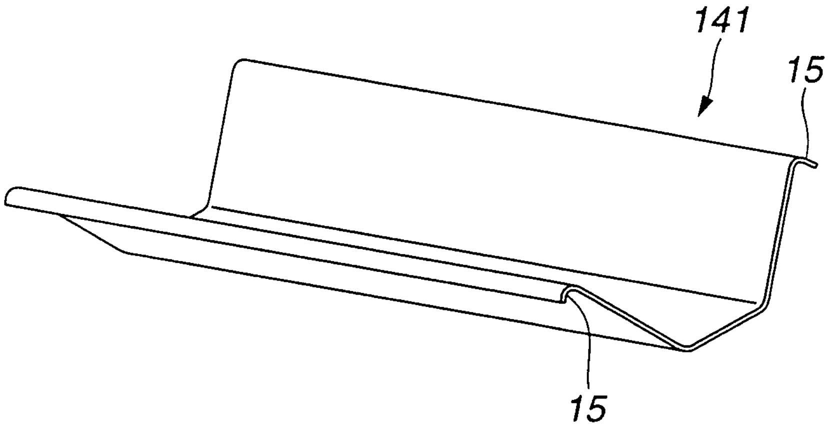


FIG.13

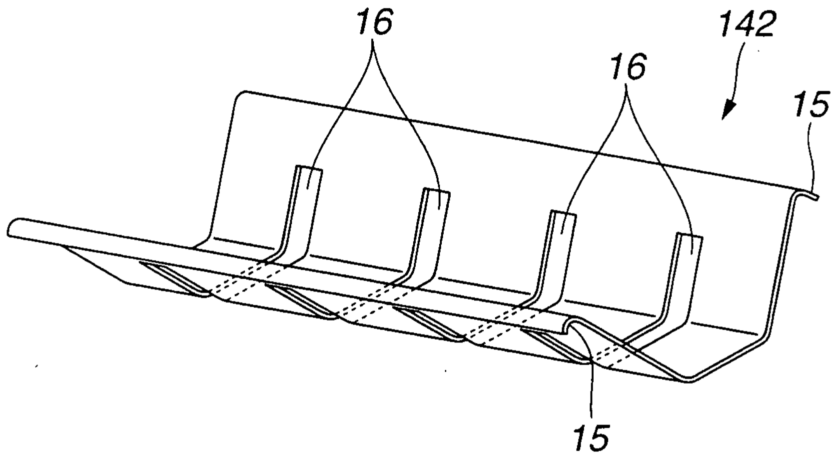


FIG.14

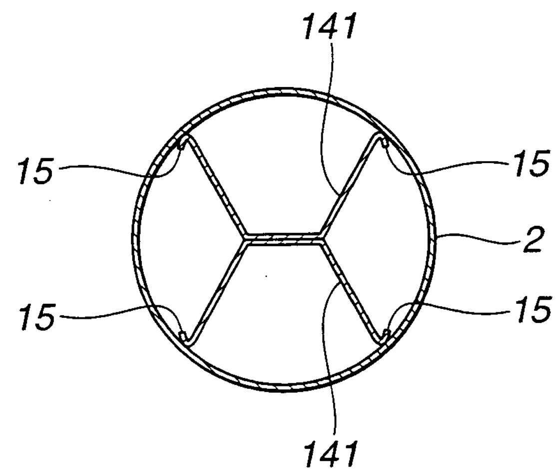


FIG.15A

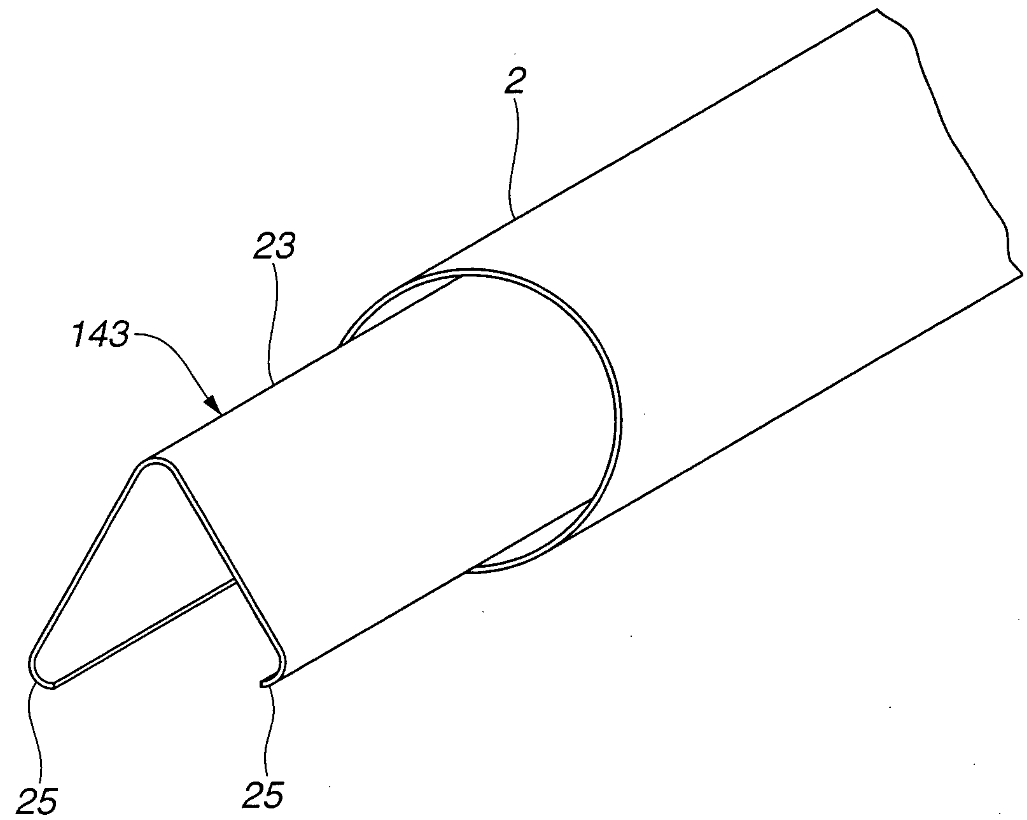


FIG.15B

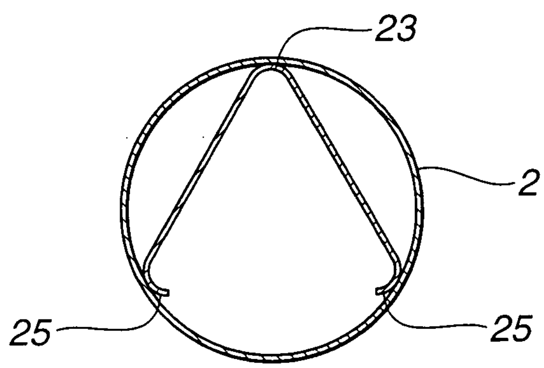


FIG.16A

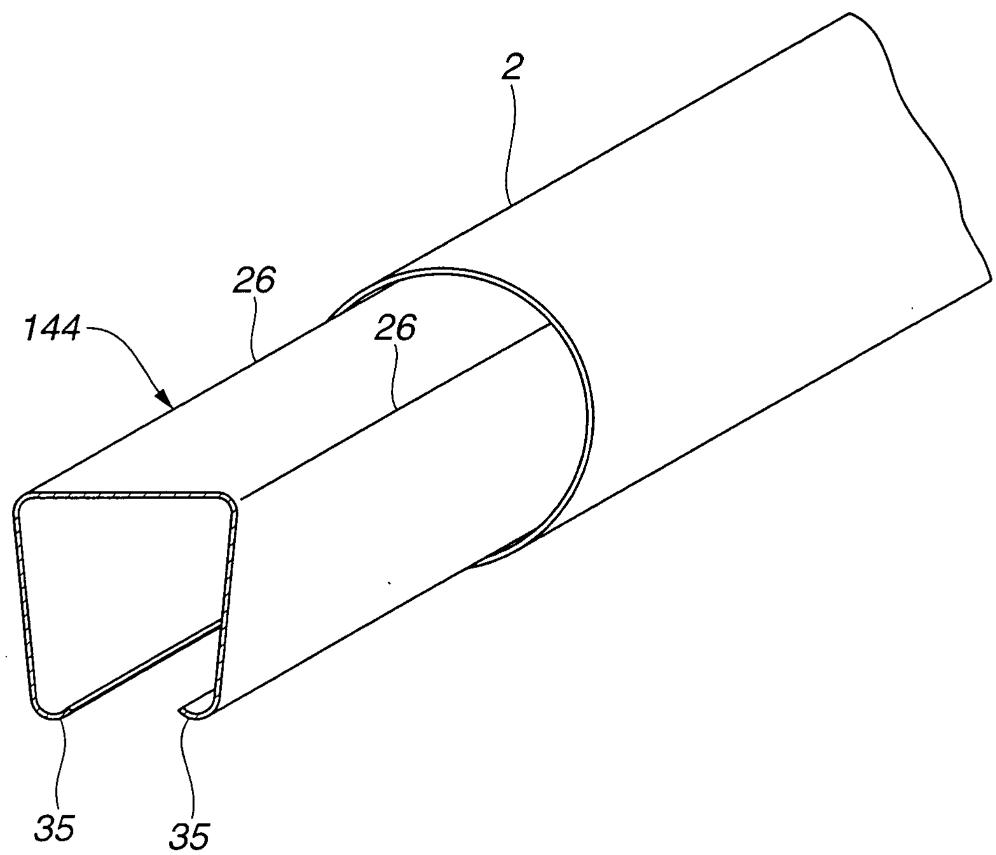


FIG.16B

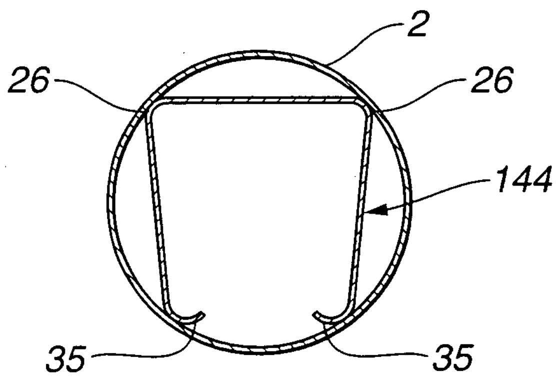


FIG.17
(RELATED ART)

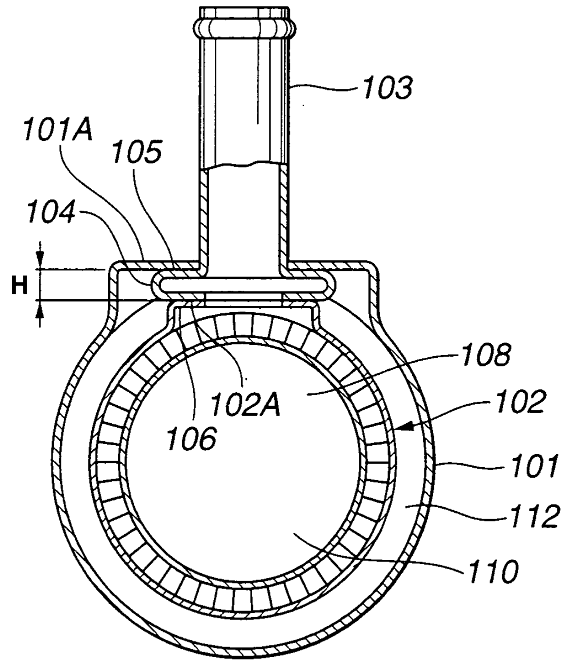


FIG.18
(RELATED ART)