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

Wärmetauscher mit dreifachen Rohren und Verfahren zu dessen Herstellung

Echangeur de chaleur à triple tubes et sa méthode de fabrication

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- **PATENT ABSTRACTS OF JAPAN vol. 015, no. 081 (M-1086), 25 February 1991 (1991-02-25) -& JP 02 301616 A (CALSONIC CORP), 13 December 1990 (1990-12-13)**
- **PATENT ABSTRACTS OF JAPAN vol. 1996, no. 06, 28 June 1996 (1996-06-28) -& JP 08 049534 A (YANMAR DIESEL ENGINE CO LTD), 20 February 1996 (1996-02-20)**
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Description

[0001] The present invention relates to a heat exchanger according to the preamble of independent claim 1 and to a method of producing a heat exchanger. Such a heat exchanger can be taken from the prior art document DE 35 15 830 A1. Said prior art document relates to a method and a device for suppressing the escape of gas from fuel at higher temperatures in the fuel system of a motor vehicle, heat being extracted from the fuel once a certain temperature is exceeded. In particular an opening is formed at the middle tube. Said opening is inserted into the opening of the outer tube and the inlet or outlet pipe receives an end portion of the opening of the middle tube. The inlet pipe and the outlet pipe are welded or brazed to the outer tube at the opening thereof.

[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. 8 and 9 of the accompanying drawings show two triple-tube type oil coolers described in the published Japanese patent application.

[0004] The oil cooler of Fig. 8 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. 8, the oil cooler of Fig. 9 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'.

[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. 8, 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. 8 and 9, there are two mutually independent brazing portions. That is in the oil cooler of Fig. 8, 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. 9, 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] Prior art document JP 02 301515 A teaches a method for mounting an oil cooler to a radiator tank. With said method a pipe is fixed to an external cylinder of an

oil cooler through expanding or calking of one end of the pipe. Said pipe is inserted into a through hole formed on an external cylinder. The end of the pipe is fixed to the through hole by expanding or calking of the end. Next, an inner fin and an inner cylinder are put in the external cylinder of an oil cooler, and then the inner cylinder of the oil cooler is fixed to the external cylinder of the oil cooler. Furthermore, the oil cooler is mounted by inserting the pipe into a through hole formed on a radiator tank. Said opening of the radiator tank is constituted by a raised part. Between the pipe and the raised part a space is provided. In this way, the radiator tank and the oil cooler are put in inside a brazing furnace, and the pipe is brazed monolithically to the through holes. Consequently, the required portions can be securely brazed.

[0010] Accordingly, an object of the present invention is to provide a heat exchanger as indicated above and a method of producing a heat exchanger which ensures a high operation performance and can be easily produced with low costs.

[0011] According to the present invention said object is solved by a heat exchanger having the features of independent claim 1. Preferred embodiments are laid down in the dependent claims.

[0012] Furthermore, said object is also solved by a method of producing a heat exchanger having the features of independent claim 10. A preferred embodiment is laid down in the dependent claim.

[0013] Accordingly, 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.

[0014] Accordingly, there is provided a method of producing a triple-tube type heat exchanger, which is simple in the manufacturing steps.

[0015] Accordingly, 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.

[0016] Accordingly, 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.

[0017] Accordingly, 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.

[0018] Hereinafter, the present invention is illustrated and explained by means of a preferred embodiment 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 sectional view of a conventional triple-tube type oil cooler; and

Fig. 9 is a sectional view of another conventional triple-tube type oil cooler.

[0019] 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.

[0020] 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.

[0021] 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 particulates.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] Mounting flanges 7 are secured through brazing to opposed ends of the outer tube 4 respectively.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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".

[0041] 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.

[0042] 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.

[0043] 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.

Claims

1. A heat exchanger comprising:

- an outer tube (4);
- a middle tube (3) received in the outer tube (4) in a manner to define therebetween a first cylindrical space (20);
- an inner tube (2) received in the middle tube (3) in a manner to define therebetween a second cylindrical space (11), the inner tube (2) having a third cylindrical space (12) defined therein;
- first and second diametrically reduced end portions (10) possessed by axially spaced end portions of the middle tube (3), the diametrically reduced end portions (10) intimately contacting and holding axially spaced end portions of the inner tube (2) thereby to permit the second cylindrical space (11) to have an isolated part between the first and second diametrically reduced portions (10);
- first and second radially depressed end portions (18) possessed by the outer tube (4), each radially depressed end portion (18) having an outer tube opening formed therethrough;
- first and second radially raised end portions (8) possessed by the middle tube (3), each radially raised end portion (8) having a middle tube opening formed therethrough, the first and second radially raised end portions (8) intimately putting thereon the first and second radially depressed end portions (18) respectively in such a manner that the middle tube openings are merged with the outer tube openings respectively;
- first brazed portions through which the first and second diametrically reduced end portions (10) of the middle tube (3) and the axially spaced end portions of the inner tube (2) are secured to each other respectively; and
- second brazed portions through which the first and second radially raised end portions (8) of the middle tube (3) and the first and second radially depressed end portions of the outer tube (4) (18) are secured to each other respectively;

an inlet pipe (5) connected to the merged openings of the first radially raised and depressed end portions (8,18) to connect with the isolated part of the second cylindrical space (11); and an outlet pipe (6) connected to the merged openings of the second radially raised and depressed end portions (8,18) to connect with the isolated part of the second cylindrical space (11), **characterized in that**

the inlet pipe (5) is passing through the merged openings of the first radially raised and depressed end portions (8,18), and said inlet pipe (5) has a portion caulked to peripheral edges of the merged openings of the first radially raised and depressed end portions (8,18); and the outlet pipe (6) is passing through the merged openings of the second radially raised and depressed end portions (8,18), and said outlet pipe (6) has a portion caulked to peripheral edges of the merged openings of the second radially raised and depressed end portions (8,18), wherein an inner fin unit (13) is installed in and secured to the inner tube (2) for promoting a heat transferring of the inner tube (2) and promoting a turbulence flow of a fluid flowing in the third cylindrical space (12), the inner fin unit (13) has a generally H-shaped cross section and has four wall portions whose leading ends (15) are brazed to the inner surface of the inner tube (2), said inner fin unit (13) comprises two fin plates (14,141,142) each having a generally channel shape, the two fin plates (14,141,142) being coupled through a brazing in a back-to-back connecting manner, each of the fin plates (14) is further formed with a plurality of fins (17), and each of the fin plates (14,142) is formed with a plurality of slits (16).

2. A heat exchanger according to claim 1, **characterized in that** at least one of the outer, middle and inner tubes (4,2) is constructed to have a plurality of corrugations (9).
3. A heat exchanger according to claim 2, **characterized in that** the middle tube (3) is formed with a plurality of corrugations (9) which have inner surfaces exposed to the isolated part of the second cylindrical space (11) and outer surfaces exposed to the first cylindrical space (20).
4. A heat exchanger according to one of the claims 1 to 3, **characterized in that**, the outer tube (4), the middle tube (3) and the inner tube (2) are concentrically arranged.
5. A heat exchanger according to one of the claims 1 to 4, **characterized in that** the inlet and outlet pipes (5,6) are provided on diametrically same and axially

spaced portions of the outer and middle tubes (4,3).

6. A heat exchanger according to one of the claims 1 to 4, **characterized in that** the inlet and outlet pipes (5,6) are provided on diametrically opposed and axially spaced portions of the outer and middle tubes (4,3).
7. A gas cooler for cooling gas by using water, comprising a heat exchanger according to at least one of the claims 1 to 6, **characterized in that** the gas to be cooled is forced to flow through the first and third cylindrical spaces (20,12), and the water is led into the isolated part of the second cylindrical space (11) through the inlet pipe (5) and discharged from the isolated part through the outlet pipe (6).
8. A method of producing a heat exchanger, comprising:
 - (a) preparing outer, middle and inner tubes (4,3,2) and inlet and outlet pipes (5,6), the outer tube (4) having first and second radially depressed end portions (18) each having an outer tube opening, the middle tube (3) having first and second radially raised end portions (8) each having a middle tube opening, the middle tube (3) further having first and second diametrically reduced end portions (10), and each of the inlet and outlet pipes (5,6) having a bead portion (21) at a base end thereof;
 - (b) placing the middle tube (3) in the outer tube (4) in such a manner that the first and second radially raised end portions (8) of the middle tube (3) put thereon the first and second radially depressed end portions (18) of the outer tube (4) respectively having the middle tube openings merged with the outer tube openings respectively;
 - (c) inserting the base ends (22) of the inlet and outlet pipes (5,6) into the merged middle and outer tube openings respectively;
 - (d) caulking the base ends (22) of the inlet and outlet pipes (5,6) with the aid of the bead portions (21), so that the caulked parts of the base ends (22) of the inlet and outlet pipes (5,6) grip peripheral edges of the merged middle and outer tube openings respectively;
 - (e) placing the inner tube (2) in the middle tube (3) in such a manner that the first and second diametrically reduced end portions (10) of the middle tube (3) contact and hold axially spaced end portions of the inner tube (2), so that the outer, middle and inner tubes (4,3,2) and the inlet and outlet pipes (5,6) constitute a pre-assembled unit; and
 - (f) placing an inner fin unit (13) into the inner tube (2) in such a manner that given portions of

the inner fin unit (13) contact with an inner surface of the inner tube (2), the inner fin unit (13) has a generally H-shaped cross section and has four wall portions whose leading ends (15) to be brazed to the inner surface of the inner tube (2), said inner fin unit (13) comprises two fin plates (14,141,142) each having a generally channel shape, the two fin plates (14,141,142) being placed in a back-to-back connecting manner, wherein each of the fin plates (14) is further formed with a plurality of fins (17), and each of the fin plates (14,142) is formed with a plurality of slits (16),
(g) putting the pre-assembled unit into a furnace to braze mutually contacting portions possessed by the pre-assembled unit.

9. A method according to claim 8, **characterized in that** before the step (f), further comprising (h) disposing two mounting flanges (7) on axially opposed ends of the outer tube (4).

Patentansprüche

1. Wärmetauscher, aufweisend:

ein Außenrohr (4);
ein Mittelrohr (3), aufgenommen in dem Außenrohr (4) in einer Weise, um dazwischen einen ersten zylindrischen Raum (20) zu bilden;
ein Innenrohr (2), aufgenommen in dem Mittelrohr (3) in einer Weise, um dazwischen einen zweiten zylindrischen Raum (11) zu bilden, wobei das Innenrohr (2) einen darin gebildeten dritten zylindrischen Raum (12) hat;
erste und zweite diametral reduzierte Endabschnitte (10) an axial beabstandeten Endabschnitten des Mittelrohres (3), wobei die diametral reduzierten Endabschnitte (10) axial beabstandete Endabschnitte des Innenrohres (2) dadurch eng berühren und halten, um dem zweiten zylindrischen Raum (11) zu gestatten, einen isolierten Teil zwischen dem ersten und zweiten diametral reduzierten Endabschnitt (10) zu haben;
erste und zweite radial vertiefte Endabschnitte (18) an dem Außenrohr (4), wobei jeder radial vertiefte Endabschnitt (18) eine dadurch gebildete Außenrohröffnung hat;
erste und zweite radial erhöhte Endabschnitte (8) an dem Mittelrohr (3), wobei jeder radial erhöhte Endabschnitt (8) eine dadurch gebildete Mittelrohröffnung hat, die ersten und zweiten radial erhöhten Endabschnitte (8) jeweils eng darauf die ersten und zweiten radial vertieften Endabschnitte (18) in solch einer Weise aufnehmen, dass jeweils die Mittelrohröffnungen mit den Außenrohröffnungen verschmelzen;

erste hartgelötete Abschnitte, durch die die ersten und zweiten diametral reduzierten Endabschnitte (10) des Mittelrohres (3) und die axial beabstandeten Endabschnitte des Innenrohres (2) jeweils miteinander befestigt sind; und
zweite hartgelötete Abschnitte, durch die die ersten und zweiten radial erhöhte Endabschnitte (8) des Außenrohres (4) und die ersten und zweiten radial vertieften Endabschnitte (18) des Mittelrohres (3) jeweils miteinander befestigt sind;
ein Einlassrohr (5), verbunden mit den zusammengeführten Öffnungen der ersten radial erhöhten und vertieften Endabschnitte (8, 18), um mit dem isolierten Teil des zweiten zylindrischen Raums (11) zu verbinden; und
ein Außenrohr (6), verbunden mit den zusammengeführten Öffnungen der zweiten radial erhöhten und vertieften Endabschnitte (8, 18), um mit dem zweiten isolierten Teil des zweiten zylindrischen Raums (11) zu verbinden, **dadurch gekennzeichnet, dass**
das Einlassrohr (5) durch die zusammengeführten Öffnungen der ersten radial erhöhten und vertieften Endabschnitte (8, 18) geht, und das Einlassrohr (5) einen Abschnitt hat, verstemmt mit den Umfangskanten der zusammengeführten Öffnungen der ersten radial erhöhten und vertieften Endabschnitte (8, 18); und
das Auslassrohr (6) durch die zusammengeführten Öffnungen der zweiten radial erhöhten und vertieften Endabschnitte (8, 18) hindurchgeht und das Auslassrohr (6) einen Abschnitt hat, verstemmt mit den Umfangskanten der zusammengeführten Öffnungen der zweiten radial erhöhten und vertieften Endabschnitte (8, 18), wobei eine innere Rippeneinheit (13) installiert in und befestigt ist an dem Innenrohr (2) zum Unterstützen eines Wärmeübergangs des Innenrohres (2) und zum Unterstützen einer turbulenten Strömung eines Fluids, das in dem dritten zylindrischen Raum (12) strömt, wobei die innere Rippeneinheit (13) einen im Wesentlichen H-förmigen Querschnitt hat und vier Wandabschnitte hat, deren vorauslaufenden Enden (15) an der inneren Oberfläche des Innenrohres (2) hartgelötet sind, wobei die innere Rippeneinheit (13) zwei Rippenplatten (14, 141, 142) aufweist, wobei jede eine im Wesentlichen Kanalförmigkeit hat, die zwei Rippenplatten (14, 141, 142) durch ein Hartlöten in einer Rücken- zu Rücken- Verbindungsweise gekuppelt ist, wobei jede der Rippenplatten (14) außerdem mit einer Mehrzahl von Rippen (17) versehen ist und jede der Rippenplatten (14, 142) mit einer Mehrzahl von Schlitzsen (16) versehen ist.

2. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet, dass** zumindest eines von dem Außen-, Mittel- oder Innenrohr (4, 3, 2) aufgebaut ist, eine Mehrzahl von Wellen (9) zu haben. 5
3. Wärmetauscher nach Anspruch 2, **dadurch gekennzeichnet, dass** das Mittelrohr (3) mit einer Mehrzahl von Wellen (9) gebildet ist, die innere Oberflächen haben, freigelegt zu dem isolierten Teil des zweiten zylindrischen Raums (11), und äußere Oberflächen, freigelegt zu dem ersten zylindrischen Raum (20). 10
4. Wärmetauscher nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** das Außenrohr (4), das Mittelrohr (3) und das Innenrohr (2) konzentrisch angeordnet sind. 15
5. Wärmetauscher nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** das Einlass- und Auslassrohr (5, 6) an diametral gleichen und axial beabstandeten Abschnitten des Außen- und Mittelrohres (4, 3) vorgesehen sind. 20
6. Wärmetauscher nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** das Einlass- und Auslassrohr (5, 8) an diametral entgegengesetzten und axial beabstandeten Abschnitten des Außen- und Mittelrohres (4, 3) vorgesehen sind. 25
7. Gaskühler zum Gaskühlen unter Verwendung von Wasser, aufweisend einen Wärmetauscher nach zumindest einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** das zu kühlende Gas gezwungen wird, um durch den ersten und dritten zylindrischen Raum (20, 12) zu strömen, und das Wasser in den isolierten Teil des zweiten zylindrischen Raums (11) durch das Einlassrohr (5) geführt und aus dem isolierten Teil durch das Auslassrohr (6) abgegeben wird. 30
8. Verfahren zum Herstellen eines Wärmetauschers, aufweisend: 35
 - (a) Vorbereiten des Außen-, Mittel- und Innenrohres (4, 3, 2) und Einlass- und Auslassrohre (5, 6), wobei das Außenrohr (4) erste und zweite vertiefte Endabschnitte (18) hat, jeder mit einer Außenrohröffnung, wobei das Mittelrohr (3) erste und zweite radial erhöhte Endabschnitte (8) hat, jeder eine Mittelrohröffnung hat, das Mittelrohr (3) außerdem erste und zweite diametral reduzierte Endabschnitte (10) hat und jedes der Einlass- und Auslassrohre (5, 6) einen Wulstabschnitt (21) an einem Basisendabschnitt derselben hat, 40
 - (b) Platzieren des Mittelrohres (3) in dem Außenrohr (4) in solch einer Weise, dass die ersten 45

und zweiten radial erhöhten Endabschnitte (8) des Mittelrohres (3) daran angebracht die ersten und zweiten radial vertieften Endabschnitte (18) des Außenrohres (4), die jeweils die Mittelrohröffnungen, zusammengeführt mit den jeweiligen Außenrohröffnungen, haben;

(c) Einsetzen der Basisenden (22) der Einlass- und Auslassrohre (5, 6) in die jeweiligen zusammengeführten Mittel- und Außenrohröffnungen;

(d) Verstemmen der Basisenden (22) der Einlass- und Auslassrohre (5, 6) mit Hilfe der Wulstabschnitte (21), so dass die verstemmten Teile des Basisenden (22) der Einlass- und Auslassrohre (5, 6) jeweils Umfangskanten der zusammengeführten Mittel- Außenrohröffnungen greifen;

(e) Platzieren des Innenrohres (2) in dem Mittelrohr (3) in solch einer Weise, dass die ersten und zweiten diametral reduzierte Endabschnitte (10) des Mittelrohres (3) axial beabstandete Endabschnitte des Innenrohres (2) berühren und halten, so dass die Außen-, Mittel- oder Innenrohre (4, 3, 2) und die Einlass- und Auslassrohre (5, 6) eine vormontierte Einheit bilden; und

(f) Platzieren einer inneren Rippeneinheit (13) in dem Innenrohr (2) in solch einer Weise, dass gegebene Abschnitte der inneren Rippeneinheit (13) sich mit einer inneren Oberfläche des Innenrohres (2) berühren, wobei die innere Rippeneinheit (13) einen im Wesentlichen H-förmigen Querschnitt hat und vier Wandabschnitte hat, deren vorauslaufende Enden (15) an der inneren Oberfläche des Innenrohres (2) hartgelötet werden, wobei die innere Rippeneinheit (13) zwei Rippenplatten (14, 141, 142) aufweist, wobei jede eine im Wesentlichen eine Kanalform hat, die zwei Rippenplatten (14, 141, 142) in einer Rücken- zu- Rücken- Verbindungsweise platziert sind, wobei jede der Rippenplatten (14) außerdem mit einer Mehrzahl von Rippen (17) gebildet ist und jede der Rippenplatten (14, 142) mit einer Mehrzahl von Schlitzten (16) gebildet ist,

(g) Einbringen der vormontierten Einheit in einen Brennofen, um zueinander berührende Abschnitte, die die vormontierte Einheit besitzt, hartzuverlöten.

9. Verfahren nach Anspruch 8, **dadurch gekennzeichnet, dass** vor dem Schritt (f), außerdem (h) das Anordnen zweier Montageflansche (7) an axial gegenüberliegenden Enden des Außenrohres (4) aufweist. 50

Revendications

1. Échangeur de chaleur, comprenant : 55

un tube externe (4) ;
 un tube médian (3) agencé dans le tube externe (4) de manière à définir entre eux un premier espace cylindrique (20) ;
 un tube interne (2) agencé dans le tube médian (3) de manière à définir entre eux un deuxième espace cylindrique (11), un troisième espace cylindrique (12) étant défini dans le tube interne (2) ;
 des première et deuxième extrémités à diamètre réduit (10) étant incluses dans des extrémités espacées axialement du tube médian (3), les extrémités à diamètre réduit (10) saisissant des extrémités espacées axialement du tube interne (2) et établissant avec celles-ci un contact intime, permettant ainsi au deuxième espace cylindrique (11) de comporter une partie isolée entre les première et deuxième parties à diamètre réduit (10) ; des première et deuxième extrémités à dépression radiale (18) faisant partie du tube externe (4), chaque extrémité à dépression radiale (18) comportant une ouverture de tube externe qui la traverse ;
 des première et deuxième extrémités à saillie radiale (8) faisant partie du tube médian (3), chaque extrémité à saillie radiale (8) comportant une ouverture de tube médian qui la traverse, les première et deuxième extrémités à saillie radiale (8) y joignant de manière intime respectivement les première et deuxième extrémités à dépression radiale (18) de telle sorte que les ouvertures du tube médian sont fusionnées respectivement avec les ouvertures du tube externe ;
 des premières parties brasées à travers lesquelles les première et deuxième extrémités à diamètre réduit (10) du tube médian (3) et les extrémités espacées axialement du tube interne (2) sont fixées respectivement entre elles ; et des deuxième parties brasées à travers lesquelles les première et deuxième extrémités à saillie radiale (8) du tube médian (3) et les première et deuxième extrémités à dépression radiale (18) du tube externe (4) sont fixées respectivement entre elles ;
 un tube d'entrée (5) connecté aux ouvertures fusionnées des premières extrémités à saillie radiale et à dépression radiale (8, 18) pour se connecter avec la partie isolée du deuxième espace cylindrique (11) ; et
 un tube de sortie (6) connecté aux ouvertures fusionnées des deuxième extrémités à saillie radiale et à dépression radiale (8, 18) pour se connecter avec la partie isolée du deuxième espace cylindrique (11), **caractérisé en ce que** le tube d'entrée (5) traverse les ouvertures fusionnées des premières extrémités à saillie radiale et à dépression radiale (8, 18), et ledit tube

d'entrée (5) comporte une partie jointe de façon étanche à des bords périphériques des ouvertures fusionnées des premières extrémités à saillie radiale et à dépression radiale (8, 18) ; et le tube de sortie (6) traverse les ouvertures fusionnées des deuxième extrémités à saillie radiale et à dépression radiale (8, 18), et ledit tube de sortie (6) comporte une partie jointe de façon étanche à des bords périphériques des ouvertures fusionnées des deuxième extrémités à saillie radiale et à dépression radiale (8, 18), dans lequel une unité à ailettes interne (13) est installée dans le tube interne (2) et fixée à celui-ci pour promouvoir le transfert de chaleur du tube interne (2) et promouvoir un écoulement turbulent d'un fluide qui s'écoule dans le troisième espace cylindrique (12), l'unité à ailettes interne (13) présente une section transversale généralement en forme de H et comporte quatre parties de paroi dont les extrémités (15) sont brasées à la surface interne du tube interne (2), ladite unité à ailettes interne (13) comprend deux plaques à ailettes (14, 141, 142) conformées chacune généralement sous forme d'un canal, les deux plaques à ailettes (14, 141, 142) étant assemblées par brasage pour réaliser une connexion de type dos à dos, chacune des plaques à ailettes (14) étant en outre formée par une pluralité d'aillettes (17), et chacune des plaques à ailettes (14, 142) étant formée avec une pluralité de fentes (16).

2. Échangeur de chaleur selon la revendication 1, **caractérisé en ce qu'**au moins un des tubes externe, médian et interne (4, 2) est constitué de manière à comporter une pluralité d'ondulations (9).
3. Échangeur de chaleur selon la revendication 2, **caractérisé en ce que** le tube médian (3) est formé avec une pluralité d'ondulations (9) qui ont des surfaces internes exposées à la partie isolée du deuxième espace cylindrique (11) et des surfaces externes exposées au premier espace cylindrique (20).
4. Échangeur de chaleur selon l'une des revendications 1 à 3, **caractérisé en ce que** le tube externe (4), le tube médian (3) et le tube interne (2) sont agencés de manière concentrique.
5. Échangeur de chaleur selon l'une des revendications 1 à 4, **caractérisé en ce que** les tubes d'entrée et de sortie (5, 6) sont agencés sur des parties à même position diamétrale et espacées axialement des tubes externe et médian (4, 3).
6. Échangeur de chaleur selon l'une des revendications 1 à 4, **caractérisé en ce que** les tubes d'entrée et de sortie (5, 6) sont agencés sur des parties à

positions diamétrales opposées et espacées axialement des tubes externe et médian (4, 3).

7. Refroidisseur de gaz pour refroidir un gaz avec de l'eau, comprenant un échangeur de chaleur selon au moins l'une des revendications 1 à 6, **caractérisé en ce que** le gaz à refroidir est forcé à s'écouler à travers les premier et troisième espaces cylindriques (20, 12), et l'eau est conduite dans la partie isolée du deuxième espace cylindrique (11) à travers le tube d'entrée (5) et sort de la partie isolée à travers le tube de sortie (6). 5
8. Procédé de production d'un échangeur de chaleur, comprenant : 15
 - (a) la préparation de tubes externe, médian et interne (4, 3, 2) et de tubes d'entrée et de sortie (5, 6), le tube externe (4) comportant des première et deuxième extrémités à dépression radiale (18) ayant chacune une ouverture de tube externe, le tube médian (3) comportant des première et deuxième extrémités à saillie radiale (8) ayant chacune une ouverture de tube médian, le tube médian (3) comportant de plus des première et deuxième extrémités à diamètre réduit (10), et chacun des tubes d'entrée et de sortie (5, 6) comportant une partie de cordon (21) à sa base ; 20
 - (b) le placement du tube médian (3) dans le tube externe (4) de telle manière que les première et deuxième extrémités à saillie radiale (8) du tube médian (3) y placent les première et deuxième extrémités à dépression radiale (18) du tube externe (4), les ouvertures du tube médian étant ainsi fusionnées respectivement avec les ouvertures du tube externe ; 30
 - (c) l'insertion des extrémités de base (22) des tubes d'entrée et de sortie (5, 6) respectivement dans les ouvertures fusionnées des tubes médian et externe ; 35
 - (d) l'étanchéisation des extrémités de base (22) des tubes d'entrée et de sortie (5, 6) à l'aide des parties de cordon (21), de manière à ce que les parties étanchéisées des extrémités de base (22) des tubes d'entrée et de sortie (5, 6) saisissent respectivement des bords périphériques des ouvertures fusionnées des tubes médian et externe ; 40
 - (e) le placement du tube interne (2) dans le tube médian (3) de telle manière que les première et deuxième extrémités à diamètre réduit (10) du tube médian (3) entrent en contact et saisissent des extrémités espacées axialement du tube interne (2), de façon à ce que les tubes externe, médian et interne (4, 3, 2) et les tubes d'entrée et de sortie (5, 6) constituent une unité préassemblée ; et 45

(f) le placement d'une unité à ailettes interne (13) dans le tube interne (2) de telle manière que des parties données de l'unité à ailettes interne (13) entrent en contact avec une surface interne du tube interne (2), l'unité à ailettes interne (13) présentant une section transversale généralement en forme de H et comportant quatre parties de paroi dont les extrémités (15) doivent être brasées à la surface interne du tube interne (2), ladite unité à ailettes interne (13) comprenant deux plaques à ailettes (14, 141, 142) conformées chacune généralement sous forme d'un canal, les deux plaques à ailettes (14, 141, 142) étant agencées de manière à réaliser une connexion de type dos à dos, dans lequel chacune des plaques à ailettes (14) est en outre formée avec une pluralité d'ailettes (17), et chacune des plaques à ailettes (14, 142) est formée avec une pluralité de fentes (16), 50

(g) la mise de l'unité préassemblée dans un four pour braser les parties en contact mutuel de l'unité préassemblée.

9. Procédé selon la revendication 8, **caractérisé en ce qu'avant l'étape (f)**, il comprend en outre (h) l'agencement de deux brides de montage (7) sur des extrémités axialement opposées du tube externe (4). 55

FIG.1

100

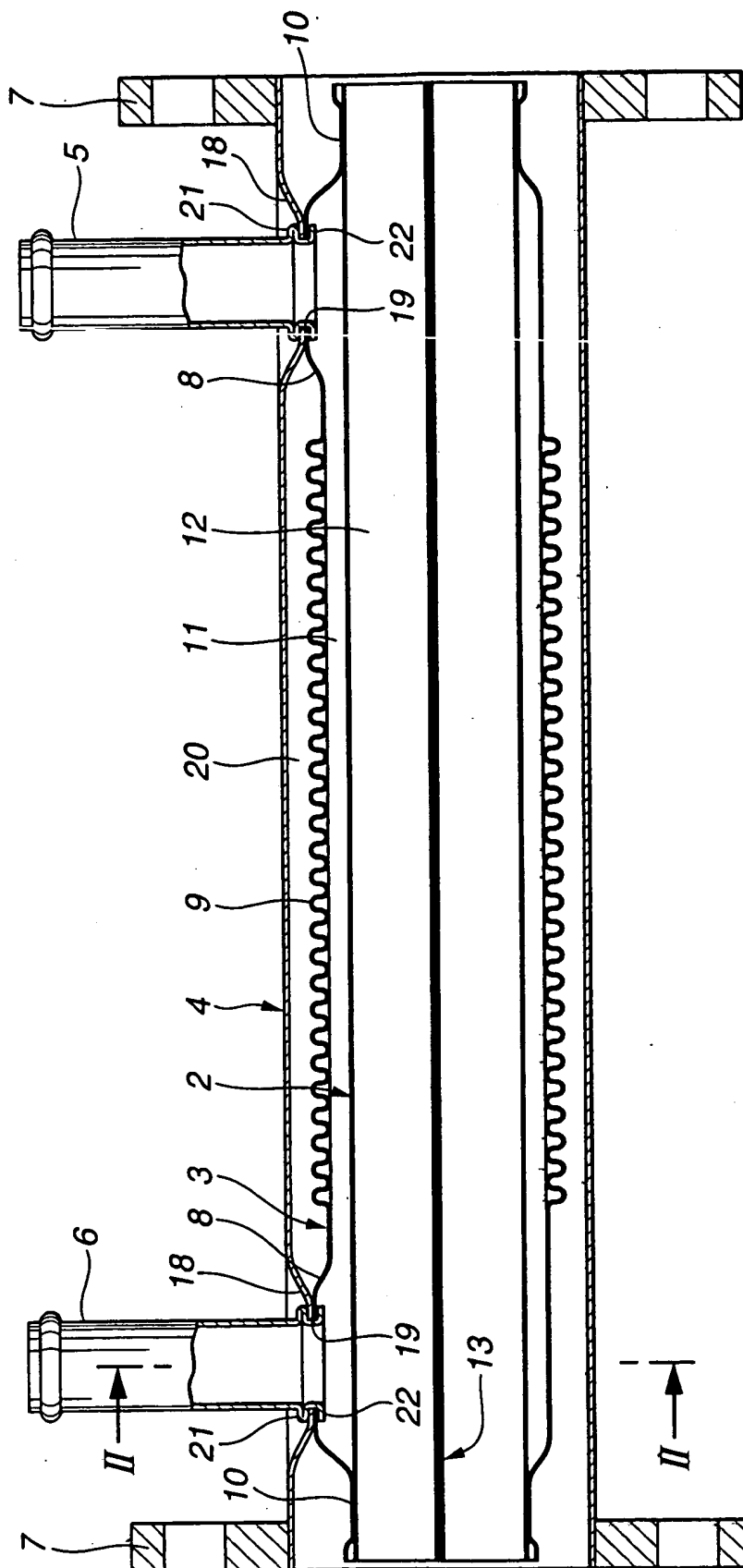


FIG.2

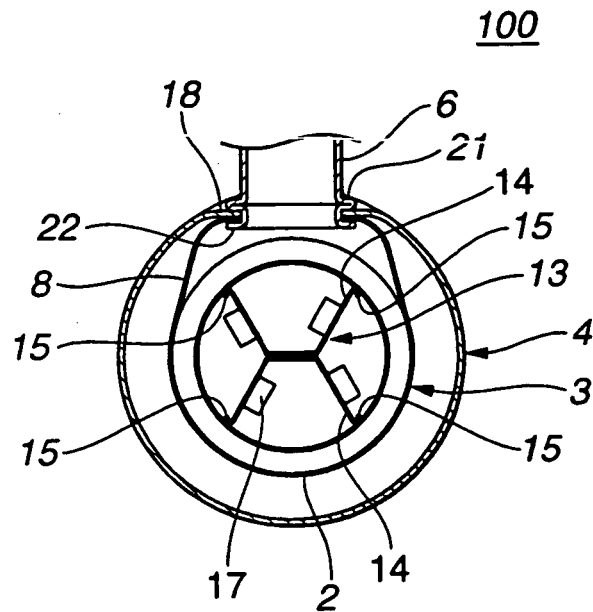


FIG.3

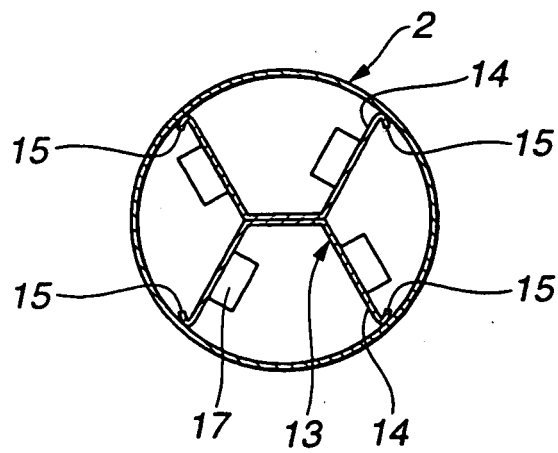


FIG.4

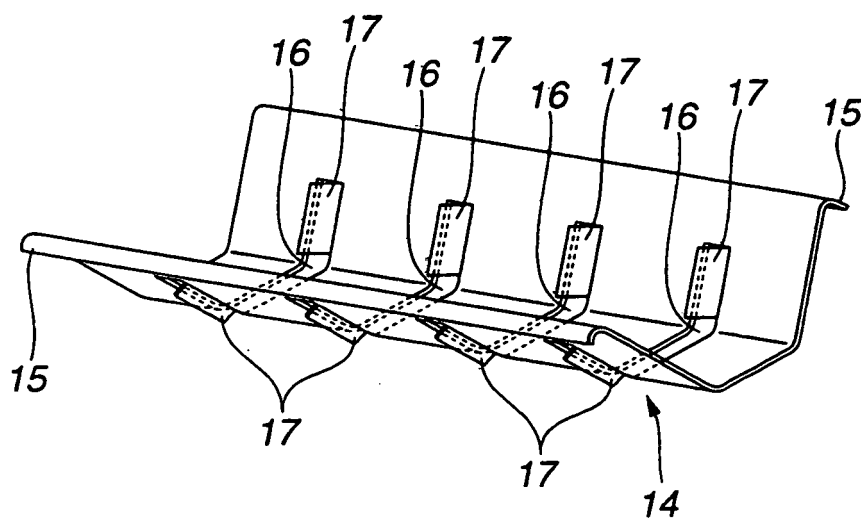


FIG.5

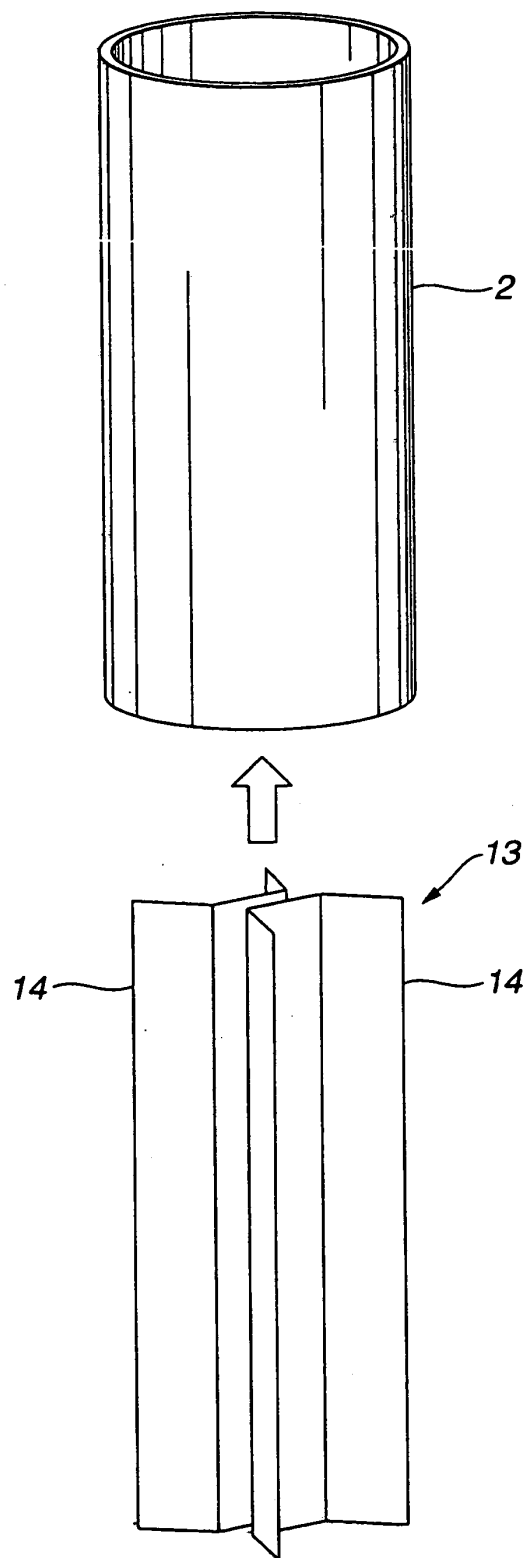


FIG.6

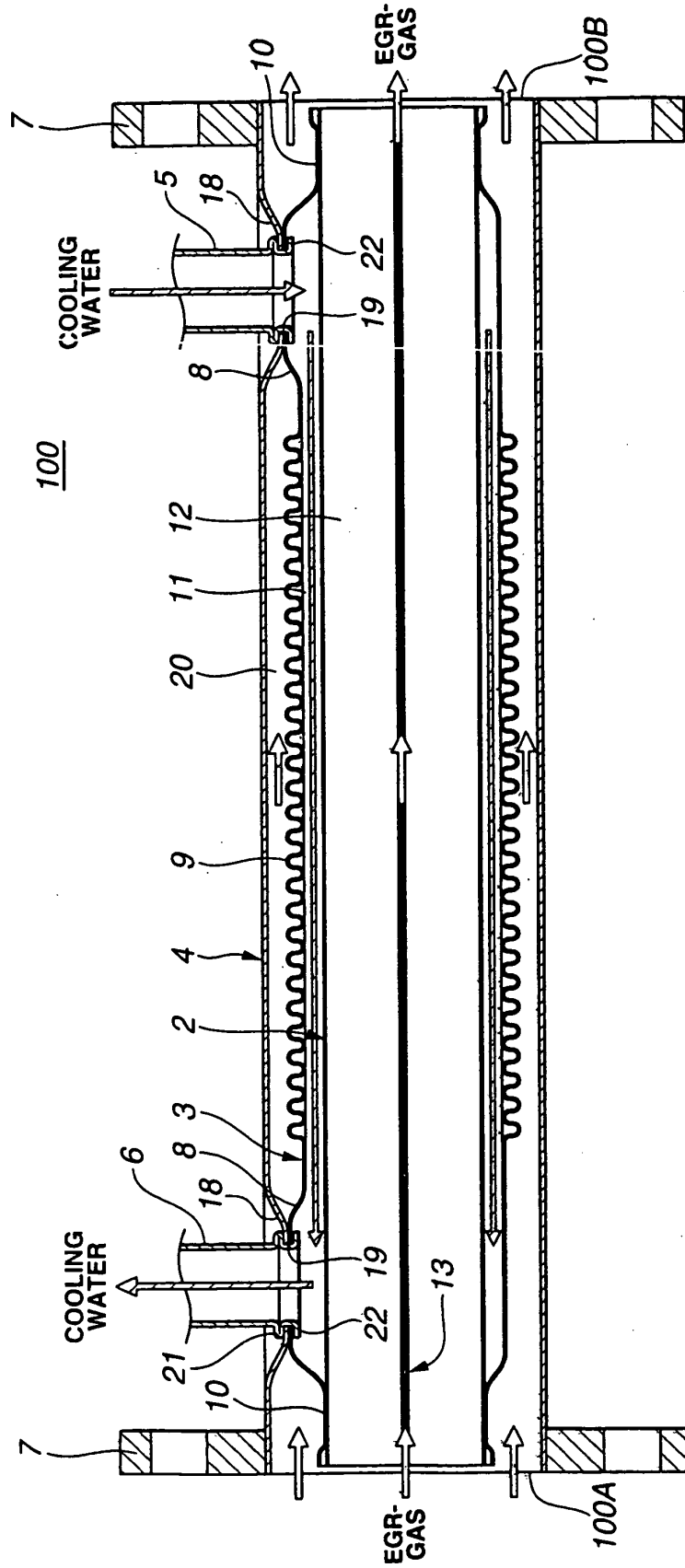


FIG.7A



FIG.7B

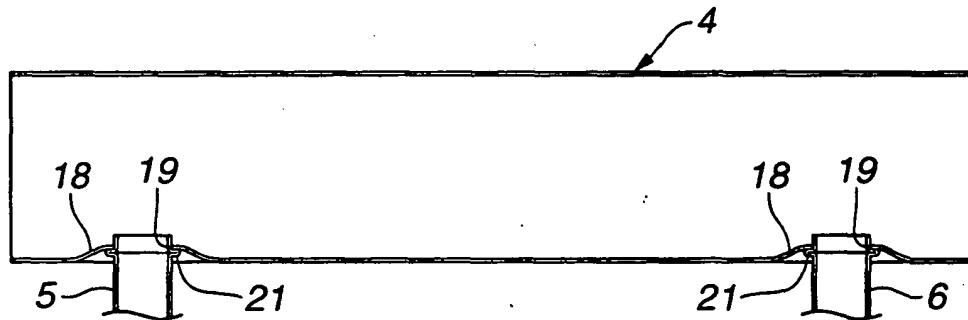


FIG.7C

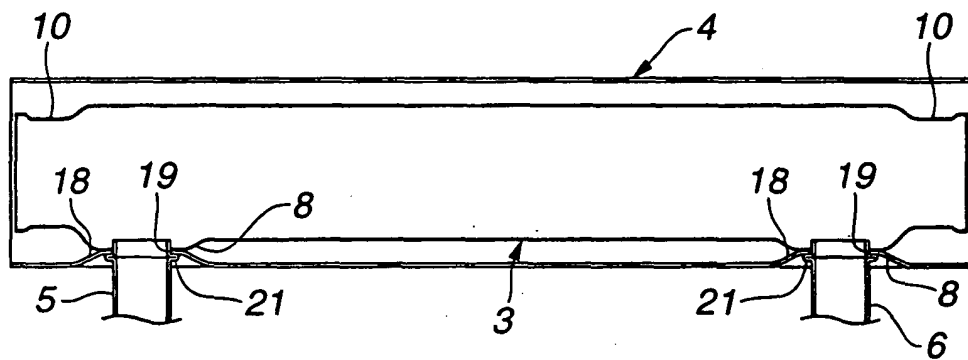


FIG.7D

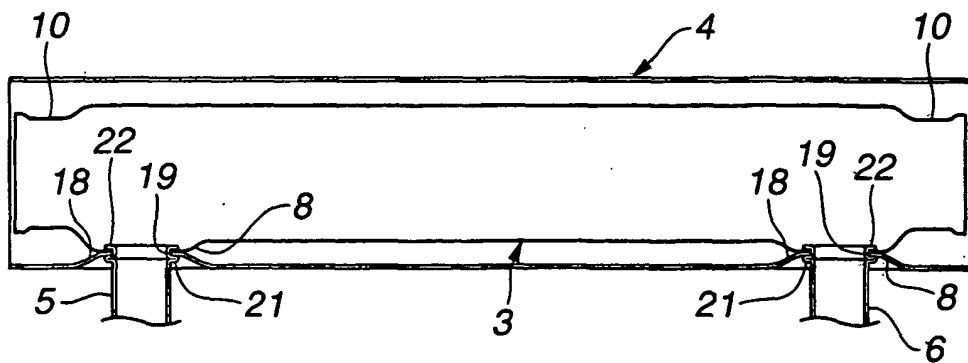


FIG.7E

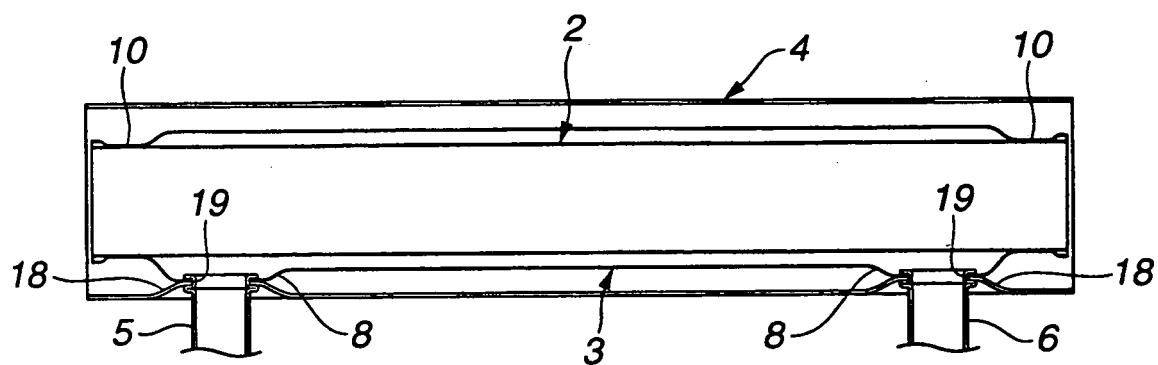


FIG.7F

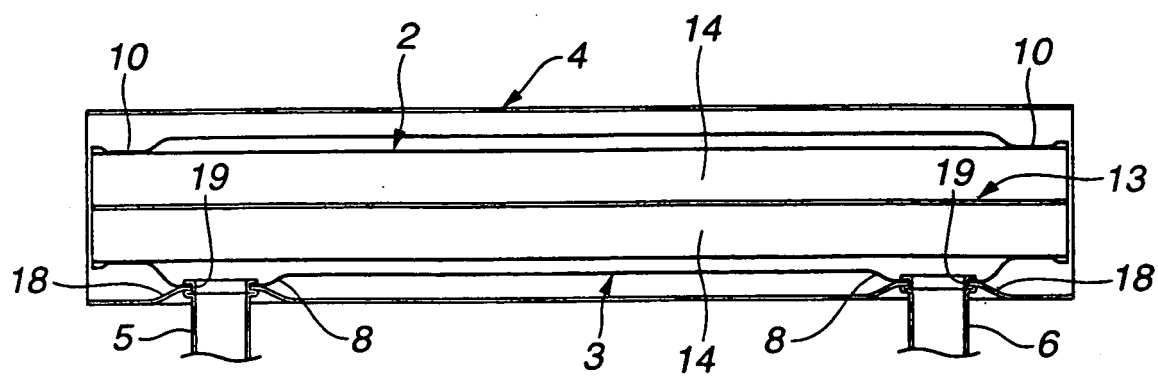


FIG.8
(RELATED ART)

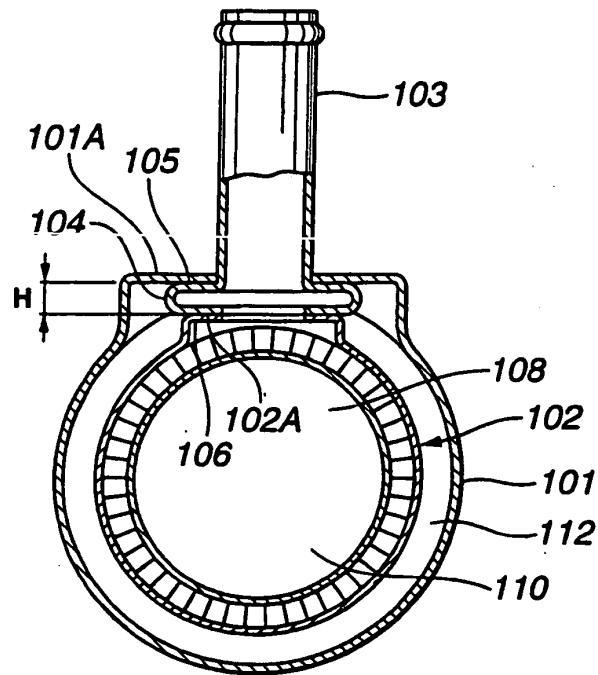
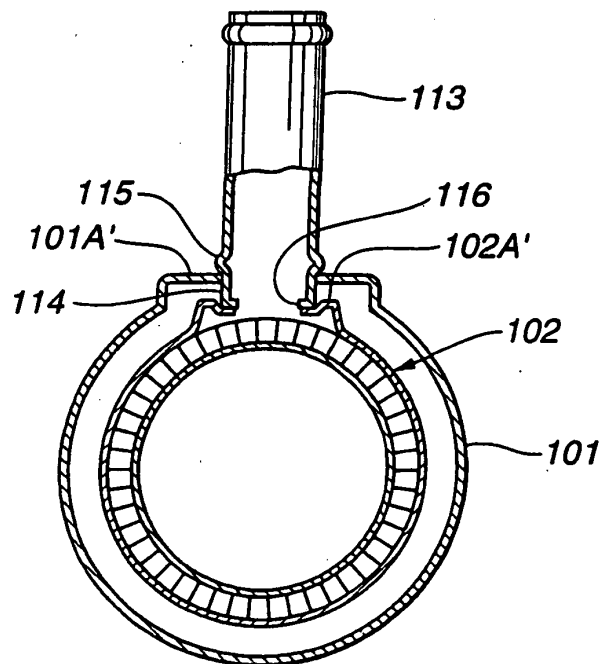


FIG.9
(RELATED ART)



REFERENCES CITED IN THE DESCRIPTION

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