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

(11) **EP 1 559 983 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
22.08.2007 Bulletin 2007/34

(51) Int Cl.:
F28F 9/18 *(2006.01)*

(21) Application number: **04075261.0**

(22) Date of filing: **28.01.2004**

(54) **Method for forming a welded connection between a tubesheet and a number of tubes and a device produced by such method**

Verfahren zum Verschweissen von Rohren mit einem Rohrboden und eine durch ein solches Verfahren hergestellte Vorrichtung

Procédé pour souder un nombre de tubes à une plaque tubulaire et dispositif issu d'un tel procédé

(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

(43) Date of publication of application:
03.08.2005 Bulletin 2005/31

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EP 1 559 983 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention according to a first aspect relates to a method for performing a welded connection between a tubesheet and at least one tube.

[0002] According to a second aspect the present invention relates to a device produced by the method according to the invention. Such a device finds application in e.g. a heat exchanger. However, a useful application in other technical fields is not excluded.

[0003] In related heat exchangers there is an exchange in heat between the medium that runs through the tubes and the medium flowing at the outer side of the tubes. To ensure that these two media are separated and remain to be so seperated from each other, adequate tube to tubesheet connections have to be executed.

[0004] In those cases in which the usage of the heat exchanger requires extra certainty that the tube-tubesheet connections will be leak tight, tubes are welded to the tubesheet.

[0005] An important property of the welded connection is that the welds must provide a sufficiently long leak path. The person skilled in the art will be familiar with the term leak path, being the shortest way of the end of the crevice between tube and bore to the medium inside the tube seen through the weld.

[0006] The weld-connections provided previously exhibited the property that a weld-connection was made by melting the edge of the tubesheet-borezone together with the relatively thin tube-ends, which operation is very critical in terms of amongst others a) fulfilment of specified minimum leak path at all weldpositions, b) avoiding damage or penetration of the tube end by e.g. a welding-arc, c) avoiding the blocking of a centering-device, used for automated welding, at removal due to a narrowing of the tube diameter caused by the weld, etcetera.

[0007] A specific method and device according to prior art are known from US-A-3.841.938, which disclosure is reflected in the preambles of independent claims 1 and 12, which are directed at a method and a device respectively.

[0008] In the method according to the invention a groove is provided in the corresponding bore, which groove extends from the first surface in the axial direction of the bore over at least a portion of the axial length thereof. In such an embodiment the tube has a tight fit in the bore, in the part where the groove is located, over a distance shorter then the axial length of the groove. The groove can be made in any form. A suitable form for making the groove is by making a screw thread. This because making a screw thread is a technique which is well known and for which many suitable devices are available. The inventive function of the groove is to provide an open channel for a fluid between the second surface and the first surface despite the tight fit of the pipe in at least a part of the bore over a distance shorter then the axial length of the groove. Further it is note here that an internal screw thread shaped groove in the bore can be employed in combination with an external screw thread on the outer surface of the tube to provide a mechanical interconnection between the tube sheet in the bore and the tube. The tube can then be screwed into the bore, and in such an embodiment the open channel can still be realised, provided the screwed interconnection is sufficiently loose to allow passage of expanding gasses and sufficiently fixed at the same time to allow for subsequent flaring and/or welding without the risk of misalignment of the tubes and the tube sheet during flaring and/or welding.

[0009] The presence of a groove in or on the internal surface of the bore prevents blowing up of the weld material during welding, especially when closing the weld around the flare, as there remains an open channel between the bore and the tube leading to the second surface, along which channel any gas near the area subjected to welding, that expands as a result of the heat generated by the welding operation, can escape. In an embodiment, wherein the tube is expanded, the groove can also perform the function of providing a suitable grip for the expanded tube, without closing the open channel. Even if the groove does not extend through the bore, all the way to the second surface, the channel is not closed in an embodiment, wherein the tube is expanded only over a distance from the first surface, which distance is shorter than the length of the groove.

[0010] The groove or at least the open channel also makes it possible to conduct pressure using Non-Destructive Testing (NDT) to test if the welded connection of the tube to the sheet is sufficient leak tight. Examples of such pressure using NDT methods are the so called "soap test", a Helium leak test, and a pressure test. As these NDT methods are known to the skilled person they will be discussed below only briefly.

[0011] A suitable NDT method is the soap test in which a light air-over pressure is made around the tubes on the side of the second surface. The welds are than provided with a soap solution. On leaking, soap bubbles will develop which show the leak position.

[0012] Another suitable NDT is the He-leak test. In this test a light over-pressure of Helium gas is applied around the tubes on the side of the second surface. Subsequently the welded connections are sniffed with special equipment, which is able to detect break trough of the very penetrable helium.

[0013] A third suitable NDT is the pressure test. With this test water pressure is applied around the tubes on the side of the second surface. The level of the water pressure is related to the design pressure of the tube-tubesheet assembly. During the test the pressure is monitored and leakage is detected by any observed pressure drop event or any visual leakage.

[0014] In the method according to the invention the weld arc is aimed on the circumference of the flare and tubesheet itself, at a distance, e.g. several millimeters away, from the edge of the tubesheet-bore zone. This makes the welding operation far less critical.

[0015] In the method according to the invention the

leak path is freely and better controllable opposed to the traditional welding details. This because the size of the welded connection is freely controllable as the weld arc is aimed at the circumference of the flare and the tubesheet itself.

[0016] Due to the fact that the weld-arc is now aimed at the circumference of the flare and the tubesheet, damage or penetration of the tube-end is less likely to occur. Also the possibility of a centering device getting blocked in the tube is avoided, as the welded connection does not influence the tube diameter.

[0017] Furthermore, the new method according to the invention provides benefits for execution of re-tubing. Re-tubing is some times executed to replace leaking tubes of a heat exchanger. Such leakage may occur after prolonged operation of the heat exchanger. Especially when operated under harsh conditions (e.g. very corrosive media).

[0018] In the re-tubing execution of the tubes connected to the tubesheet with the traditional weld details it is often necessary to clean up the bores due to local contamination that easily may influence the welding process in a negative way. Such clean up is normally executed by grinding the inner surface of the bores. Thus the diameter of the bores may run out of tolerance which influences the fit of the new tubing.

[0019] With the method according to the present invention retubing of a heat exchanger does not require cleaning of the bores in order to remove contaminations. It is sufficient to grind the first surface of the tubesheet to remove any contamination which might be present.

[0020] In the method according to the invention a tubesheet with a first surface and a second surface is provided. The tubesheet can be formed by any material which can be subjected to a welding operation and which has suitable properties for the intended use. A selection of a suitable material is within the knowledge of the skilled person. Examples of suitable materials can be selected from metals and metal alloys, such as (stainless) steel, nickel (alloys), copper (alloys), titanium (alloys), zirconium. The material of the tubesheet may be cladded or coated with a material which is more corrosion resistant then the base material wherein cladding or coating may be executed prior or subsequent to assembly with the tube(s). Suitable cladding materials may me selected from the group consisting of stainless steel, nickel (alloys), copper (alloys), titanium (alloys).

[0021] The tubesheet is provided with a number of bores extending from the first surface to the second surface. These bores can be circular, in correspondence with the tubes, but these tubes may have any other desired shape or form in transverse section, e.g. rectangular, along with the bores. Within this specification and the claims it is to be understood that the wording "a number of" refers to at least one, viz. one or more, in all instances that it is used. The bores can be provided by any suitable technique known to the skilled person such as drilling. Preferably the bore has a diameter, shape, form or other dimensions, which enables standard tubes to be placed in the bore. The selection of suitable diameters, shapes, forms or dimensions of the bore in connection with the tubing used is within the knowledge of the skilled person. Suitable guides are given in tables RCB-7.41 and RCB-7.41 M of the eight edition of the standards of the Tubular Exchanger Manufacturers Association.

[0022] The number of tubes provided in the method according to the invention have an exterior diameter, shape, form or other dimension, which enables the tube to be placed in a bore. This can be either with a tight fit, a loose fit, or a temperature dependent fit. A temperature dependant fit can be reached by cooling the pipe prior to fitting it into the bore, or heating the tubesheet prior to fitting the tube into the bore. Preferably the tube is of a type which is commercially readily available. It is to be understood that the invention is not limited to the use of a specific type of tube.

[0023] The provided tubes are made from a pliable material, which enables them to be flared at their ends. Any pliable material can be used, as long as it can be subjected to a welding operation as well as deformation or other operation to provide a flare. The selection of suitable materials is within the knowledge of the skilled person. Examples of suitable materials can be selected from the group comprising metals, metal alloys, such as (stainless) steel, nickel (alloys), copper (alloys), titanium (alloys), zirconium.

[0024] Flaring of the end of the protruded portion of the tube can be done by any suitable methods known to the skilled person, e.g. by using a flaring tool. Preferably the flares are made by hydraulic pressing or forming.

[0025] It must be understood that if the other end of a tube is freely movable through the bore, flaring can be done before a tube is placed in the bore. If the other end of a tube does not permit passage through the bore, flaring will be done after the tube is placed in a bore.

[0026] The welded connection between the tubesheet and each tube, is made at the circumference of each flare. The welded connection can be made by using known welding techniques and equipment. It is possible to make the welded connection in a single passage of the weld arc around the circumference of the flare. During such a single welding passage the material of the tube and the tubesheet is melted together. During such a single welding passage preferably welding material is deposited to strengthen the welded connection. In addition to this in the method according to the present invention deposition of weld material will increase the leak path. However, such deposition of weld material is not strictly obligatory since for some applications the melting operation will provide a welded connection with sufficient strength and leak path.

[0027] It is also possible to use multiple welding passages, such as two or three or more welding passages. Such additional welding passages can be used to further strengthen the welded connection. When multiple welding passages are used, all welding passages can be sim-

ilar or different welding modes can be used. For instance, when two welding passages are used, the first welding passage can be used to prepare the path for the second welding passage by e.g. evening it to provide a smooth surface. In such a case the first welding passage only melts the material of the tubesheet and the tube together, and none or little filler material is deposited. During the second subsequent welding passage, welding material is deposited.

[0028] After the second welding passage it is possible to use a third welding passage in order to melt the deposited welding material in order to improve the weld shape. The use of such a third weld passage may provide a welded connection with a flattened surface. If electric welding is used preferably the third welding passage is then performed with a higher voltage than the previous welding passages.

[0029] According to a preferred embodiment of the method according to the invention, the flares are provided with a trumpet shape or a cone shape. It is also possible that the form of the flare is a combination of a cone shape and a trumpet shape. In such a case the trumpet shape is located closer to the circumference of the flare, then the cone shape. The trumpet shape or cone shape or the combined trumpet-cone shape of the flare provides a smooth flow of a fluid medium when accessing or leaving the pipe.

[0030] According to a different preferred embodiment of the method according to the invention the end of the bore at the first surface is rounded and/or has the shape of a cone. Such a shape of the bore end facilitated flaring the tube in a trumpet shape, a cone shape or a combined trumpet-cone shape.

[0031] A preferred embodiment of the method according to the invention comprises: mechanically interconnecting the tube and the tube sheet at the latest prior to welding the flared protruding end portion of the tube, thus providing a preliminary positional fixation of the tube and the tube plate relative to one another to be maintained during at least one of the operations of flaring the protruding end portion of the tube and welding the flare to the tube sheet. As a consequence the mutual positioning of the tubes and the tube sheet is ensured, even when during subsequent operations like flaring and welding the relative mutual positioning may be endangered without the said mechanical fixation. In such an embodiment, especially when the provided tube has a loose fit in the bore, it is preferred to expand the tube to fit tightly in at least a part of the bore. This operations is performed preferably prior to performing the flaring operation on the end of the tube or at least (at the latest) prior to welding. The expanded tight fit of the tube in at least a part of the bore fixates the tube in the bore which is beneficial for the flaring operation and/or the welding operation.

[0032] After performing the pressure-using NDT method or at least establishing the interconnection, the remaining part of the tube not having a tight fit in the bore may be fitted tightly in the bore. This can be done by e.g. expanding the part of the tube not having a tight fit to fit tightly in the bore. During the expanding operation care is taken to avoid expanding of any part of the tube located outside the bore. In practice this can be achieved by not expanding the remaining 2-7 mm e.g. 5 mm of the tube located in the bore near the second surface. Hereby the channel formed by the groove is closed off. This provides additional sealing of the tube to tubesheet connection.

[0033] When more than one pipe and more than one bore are provided, it is beneficial if the bores are provided at such a distance of each other, that when the ends of the pipes are flared, the circumferences of the flares come in such proximity of each other that the welded connection at adjacent flares overlap. In this way a continuous surface is formed by the flares and the welded connections. Such a continuous surface forms a coverage over the tubesheet and can have the function of a cladding layer. Thus in applications in which the use of a cladded material for the tubesheet is suitable, the cladding layer may be formed by the continuous surface formed by the flares of the tubes and the welded connections. Any part of the tubesheet not covered by the continuous surface may be cladded in the usual way, or otherwise covered with a protective layer.

[0034] In order to form a smooth surface, the continuous surface formed by the flares and the welded connections is ground to a smooth surface and preferably subsequently polished. The presence of such a smooth continuous surface is beneficial in special applications wherein it is undesired if surface imperfections e.g. crevices etc. are present on the surface of the tubesheet. This e.g. provides a better septic quality of the tubesheet and in particular the tubesheet-bore-zone.

[0035] The present invention relates also to a device produced in accordance with the method of the invention. The device according to the invention finds application in heat exchangers, although other applications are not excluded.

[0036] In a preferred embodiment of the device according to the invention a groove is located in the surface of the bore, which groove extends from the first surface in the axial direction of the bore for at least a portion of the axial length of the bore. In this case the tube can have a tight fit in the bore, in the part where the groove is located, over a distance shorter then the axial length of the groove. The function of the groove is providing an open channel for a fluid between the second and first surfaces, despite the tight fit of the pipe in at least a part of the bore over a shorter distance than the axial length of the groove.

[0037] The presence of such a groove in the surface of the bore makes it possible to conduct pressure using Non-Destructive Testing (NDT) to test if the welded connection of the tube to the tubesheet is sufficient leak tight. Examples of such pressure using NDT methods have been discussed above.

[0038] It will be evident to the skilled person that the embodiment of the device according to the invention wherein there remains an open channel between the first

surface and the second surface is not (optimally) suited for use in a heat exchanger. However, this embodiment is possibly or optionally an important intermediate state in the production of a heat exchanger on which pressure using NDT methods can be performed. In order to make this embodiment of the device suitable for the application in a heat exchanger it is of importance to ensure that the tube has a tight fit over substantially the full axial length of the bore. If the tight fit of the tube in the bore is obtained by expanding the tube in the bore, in practice the remaining 2-7 mm e.g. 5 mm of the tube located in the bore near the second surface will remain unexpanded to prevent that any part of the tube located outside the bore is expanded.

[0039] The groove can have any form. A suitable form of the groove is a screw thread. This because making a screw thread is a technique which is well known and for which many suitable devices are available.

[0040] According to a preferred embodiment of the device according to the invention, the flares are provided with a trumpet shape or a cone shape. It is also possible that the form of the flare is a combination of a cone shape and a trumpet shape. In such a case the trumpet shape is located closer to the circumference of the flare, than the cone shape. The trumpet shape or cone shape or the combined trumpet-cone shape of the flare provides a smooth flow of a fluid medium when accessing or leaving the tube.

[0041] According to a different preferred embodiment of the device according to the invention the end of the bore at the first surface is rounded and/or has the shape of a cone. Such a shape of the bore end facilitates flaring the tube in a trumpet shape, a cone shape or a combined trumpet-cone shape.

[0042] It is preferred that the tube has a tight fit in at least a part of the bore. The tight fit of the tube in at least a part of the bore fixates the tube in the bore which is beneficial for the flaring operation and/or the welding operation. Furthermore, the tight fit provides additional sealing of the tube to tubesheet connection.

[0043] In a preferred embodiment of the device according to the invention more then one bore and more then one tube are provided and the welded connections between adjacent flares overlap. This embodiment of the device according to the invention comprises a continuous surface formed by the flares and the welded connections. Such a continuous surface forms a coverage over the tubesheet and can have the function of a cladding layer. Thus in application in which the use of a cladded material for the tubesheet is suitable, the cladding layer may be formed by the continuous surface formed by the flares of the tubes and the welded connections. Any part of the tubesheet not covered by the continuous surface may be cladded in the usual way, or otherwise covered with a protective layer.

[0044] Preferably the continuous surface is an even and smooth surface. Such an even and smooth surface is beneficial in special applications wherein it is undesired if surface imperfections such as crevices etc. are present on the surface of the tubesheet. This e.g. provides a better septic quality of the tubesheet, in particular the tubesheet-borezone.

[0045] The invention will be further explained with reference to the figures showing non-limiting embodiments of the invention.

[0046] Figures 1A-1D show cross sectional overviews of welded tubesheet to tube connections according to the prior art.

[0047] Figures 2A-2C show cross sectional overviews of different stages of the method according to the invention.

[0048] Figure 3 shows a cross sectional overview along the line III-III in fig. 4 of a preferred embodiment of the device according the invention.

[0049] Figure 4 shows a plan overview of a preferred embodiment of the device according to the invention.

[0050] Figure 1A shows a cross sectional overview of a so called "seal weld" known from the art. This figure shows a tube 1 located in a bore of a tubesheet 2. The end 3 of the tube 1 is melted together with the tubesheet 2 by the weld arc 4. In this weld detail the weld 5 is formed by a single passage of the weld arc, whereby mostly just a little amount of weld-filler material is added or none at all. Although this weld detail is popular because of the relatively low costs for machining, it has the disadvantage that the weld penetration is relatively small, which makes that the leak path is in principle also relatively small.

[0051] Figure 1B shows an alternative "seal weld". In this alternative the tubesheet 2 is provided with a circular incision 6 around the bore. The incision 6 ensures a larger weld penetration. Moreover it effects that the tubesheet gets less change on distortion by weld-shrinkage-forces, due to the fact that these forces more easily can be reduced by relaxation. The appliance of a stringent set of weld parameters such as velocity, current, voltage stays very important to ensure that a sufficient leak path is obtained.

[0052] Figure 1C shows a so called "strength weld". The tube 1 is located in the bore of a tubesheet 2. The end of the bore is enlarged relative to the rest of the bore. The tube 1 is fitted into the bore up to the enlarged section of the bore. The tube end 3 is melted together with the tubesheet by the weld arc 4 under suppliance of weld-filler-material by supply means 7. Usually the welding is performed by two weld passages, of which formation of the root layer 8 is the most critical part of the welding process. The benefit of this weld detail opposed to those shown in figures 1A and 1B, is that the leak path can be better controlled.

[0053] Figure 1D shows a so called "fillet weld" which is only applicable for relatively thick tubes, to avoid that the weld arc punctures the wall of the tube. The tube 1 is located in the bore of the tubesheet 2, such that it protrudes with its end 3 above the second surface 11 of the tubesheet 2. Again the end of the bore of the tubesheet 2 is enlarged and the weld connections 8,9 are made in

two welding passages in the enlarged part of the bore. Here too formation of the root layer 8 is the most critical part of the welding process.

[0054] Now turning to a preferred embodiments of the present invention, figure 2A shows a tubesheet 2 with a first surface 10 and a second surface 11. The tubesheet 2 is provided with a bore 12, in which a screw thread 13, serving as a groove, is formed. The screw thread 13 starts from the first surface 10 and extends in the axial direction of the bore 12 towards the second surface 11. The axial length of the screw thread is shorter than the axial length of the bore. A tube 1 with an external diameter, that enables it to be placed in the bore 12 with a loose fit, is provided and placed in the bore by moving it in the direction of the arrow.

[0055] Figure 2B shows the position of the tube 1 in the bore 12 of the tubesheet 2, after it has been expanded to fit tightly in a portion of the bore, which portion is shorter then the axial length of the groove 13. As shown, the end 3 of the tube 1 protrudes above the first surface 10 of the tubesheet 2. The end of the bore in this situation is relatively unworked. However, it may be rounded of or have a trumpet, cone or a combined trumpet-cone shape. As the tube 1 remains to have a loose fitting in the bore on the side nearer to the second surface 11, there remains a connection 14 with the groove 13. Thus there is a free channel for passage of a fluid going from the second surface to the first surface 10.

[0056] Figure 2C shows the next step in the method according to the invention. As is shown, the protruding end 3 of the tube 1 is flared, whereby a flare 20 is formed. At the circumference 21 of the flare, the welded connection is made with the weld arc 4 under suppliance of filler material by supply means 7.

[0057] Figure 3 shows a cross sectional overview along the lines III-III as shown in figure 4 of a preferred embodiment of the device according to the invention. As is shown the remaining unexpanded part of the tube is expanded to provide a tight fit of the tube 1 in the bore 12. Thereby the connection 14 is closed off. As is also shown, the bores 12 in the tubesheet 2 are provided at a distance such that the flares 20 come in such proximity of each other that adjacent welds 22 overlap. Thus, a continuous surface is formed by the flares 20 and the overlapping welds 22. This surface may be ground to an even surface and further polished to a smooth surface (not shown in figure 3) .

[0058] Figure 4 shows a plan overview of a preferred embodiment of the device according to the invention. The device contains multiple tubes 1 connected to a tubesheet 2. At the first surface 10 of the tubesheet 2, a continuous surface 25, which is slightly elevated, is formed by the flares and the welded connections. The continuous surface 25 is ground and polished to an even and smooth surface. The continuous surface 25 may serve as a cladding layer, as it fully covers the first surface 10 of the tube plate 2 located directly underneath it. The remaining uncovered part of the first surface may be covered by a different material to protect it from corrosion. The device shown in figure 4 maybe applied in a heat exchanger.

Claims

1. Method for forming a connection between a tube sheet and at least one tube comprising:

- providing a tube sheet (2) with a first surface (10) and a second surface (11) and a number of bores (12) extending from the first surface to the second surface,
- providing the tube (1) of a pliable material with an exterior shape and dimensions, which enable the tube to be accommodated in a corresponding bore;
- placing the tube in the corresponding bore, such that an end portion of the tube protrudes from the side of the first surface of the tube sheet;
- flaring the protruding end portion of the tube, to form a flare (20); and
- making a welded connection between the tube sheet and the tube at the circumference (21) of the flare,

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- providing a groove (13) in the corresponding bore from the first surface in the axial direction of the bore over at least a portion of the axial length thereof.

2. Method according to claim 1, wherein interconnecting comprises: expanding the tube to fit tightly in at least a part of the corresponding bore accommodating the tube.

3. Method according to claim 2, comprising: expanding the tube prior to flaring thereof.

4. Method according to any one of claims 1-3, wherein the tube accommodated in the bore is expanded over a distance shorter than the axial length of the groove (13) located in the bore accommodating the tube.

5. Method according to any one of claims 1-4, further comprising testing a welded connection by means of a pressure using non-destructive testing method, that is selected from the group comprising a soap test, a He-leak test, a water pressure test.

6. Method according to any one of claims 1-5, further comprising expanding any remaining, previously unexpanded part in the bore (14) of the tube over substantially the full axial length of the bore wherein the tube is accommodated.

7. Method according to claim 6, comprising expanding the any remaining, previously unexpanded part of the tube after testing of the welded connection.

8. Method according to any one of claims 1-7, wherein the groove is provided in the form of a screw thread (13).

9. Method according to any one of claims 1-8, wherein more than one pipe and more than one bore in the tube sheet are provided, which bores are provided at a distance from each other, further comprising: dimensioning the protruding end portions of the tubes and thus the flares, to approximate the circumferences of the flares to one another, whereby the welded connections at adjacent flares overlap.

10. Method according to any one of claims 1-9, further comprising grinding the surface formed by the flare and the welded connection to a smooth surface and preferably polishing the smooth surface.

11. Device comprising:

- a tubesheet (2) with a first surface (10) and a second surface (11) and a number of bores (12) extending from the first surface to the second surface,
- at least one tube (1) of a pliable material placed in a corresponding bore, wherein the tube has a flared portion (20) on the side of the first surface, which flared portion is weld-connected at its circumference (21) to the first surface of the tube sheet,

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a groove (13) is provided in the corresponding bore, which groove extends from the first surface in the axial direction of the bore over at least a portion of the axial length thereof.

12. Device according to claim 11, wherein the tube is expanded to fit tightly in at least a part of the corresponding bore accommodating the tube.

13. Device according to claim 12, wherein the tube is expanded prior to flaring thereof.

14. Device according to any one of claims 11-13, wherein the tube accommodated in the bore is expanded over a distance shorter than the axial length of the groove (13) located in the bore accommodating the tube.

15. Device according to claim 14, wherein any remaining unexpanded part in the bore (14) of the tube is expanded over substantially the full axial length of the bore wherein the tube is accommodated, after realising the welded connection.

16. Device according to any one of claims 11-15, wherein the groove is provided in the form of a screw thread (13).

17. Device according to any one of claims 11-16, wherein more than one pipe and more than one bore in the tube sheet are provided, which bores are provided at a distance from each other, wherein the protruding end portions of the tubes and thus the flares are dimensioned to approximate the circumferences of the flares to one another, whereby the welded connections at adjacent flares overlap.

18. Device according to any one of claims 11-17, further comprising grinding the surface formed by the flare and the welded connection to a smooth surface and preferably polishing the smooth surface.

Patentansprüche

1. Verfahren zur Bildung einer Verbindung zwischen einem Rohrboden und mindestens einem Rohr, mit den Schritten

- Versehen eines Rohrbodens (2) mit einer ersten Oberfläche (10) und einer zweiten Oberfläche (11) sowie mehreren Bohrungen (12), die von der ersten Oberfläche zur zweiten Oberfläche verlaufen,
- Versehen des Rohrs (1) aus biegsamem Material mit einer äußeren Form und Abmessungen, die es ermöglichen, das Rohr in einer entsprechenden Bohrung anzubringen,
- Einführen des Rohrs in der entsprechenden Bohrung, so dass ein Endabschnitt des Rohrs über die erste Oberfläche des Rohrbodens übersteht,
- Ausbauchen des überstehenden Endabschnitts des Rohrs, um eine trompetenförmige Ausbauchung (20) zu bilden, sowie
- Herstellen einer Schweißverbindung zwischen dem Rohrboden und dem Rohr am äußeren Rand (21) der Ausbauchung,

gekennzeichnet durch

- Bilden eines Kanals (13) in der entsprechenden Bohrung, der an der ersten Oberfläche beginnt und sich in Axialrichtung der Bohrung mindestens über einen Teil der Axiallänge der Bohrung hinweg erstreckt.

2. Verfahren nach Anspruch 1, bei dem das Verbinden das Aufweiten des Rohrs umfasst, um dieses in mindestens einem Teil der entsprechenden Bohrung, in

der das Rohr angebracht ist, fest einzupassen.

3. Verfahren nach Anspruch 2, bei dem das Rohr vor dem Ausbauchen aufgeweitet wird.

4. Verfahren nach einem der Ansprüche 1 bis 3, bei dem ein Teil des in der Bohrung angebrachten Rohrs aufgeweitet wird, wobei dieser Teil kürzer ist als die Axiallänge des Kanals (13), der in der Bohrung, in der das Rohr angebracht ist, gebildet ist.

5. Verfahren nach einem der Ansprüche 1 bis 4, das weiterhin das Prüfen der Schweißverbindung mit einer mit Druck arbeitenden zerstörungsfreien Prüfung, die aus der einen Seifenblasentest, einen He-Lecktest und einen Wasserdrucktest umfassenden Gruppe ausgewählt wird, umfasst.

6. Verfahren nach einem der Ansprüche 1 bis 5, das weiterhin das Aufweiten des übrigen, noch nicht aufgeweiteten Teils des Rohrs in der Bohrung (14) über im Wesentlichen die gesamte Axiallänge der Bohrung, in der das Rohr angebracht ist, hinweg umfasst.

7. Verfahren nach Anspruch 6, bei dem der übrige, noch nicht aufgeweitete Teil des Rohrs nach dem Prüfen der Schweißverbindung aufgeweitet wird.

8. Verfahren nach einem der Ansprüche 1 bis 7, bei dem der Kanal in Form eines Schraubengewindes (13) gebildet wird.

9. Verfahren nach einem der Ansprüche 1 bis 8, bei dem mehr als ein Rohr und mehr als eine Bohrung im Rohrboden vorgesehen sind, wobei die Bohrungen voneinander beabstandet sind, weiterhin umfassend das Dimensionieren der überstehenden Endabschnitte des Rohrs und somit der Ausbauchungen auf eine Weise, dass die äußeren Ränder der Ausbauchungen einander angenähert werden, wodurch sich die Schweißverbindungen an benachbarten Ausbauchungen überlappen.

10. Verfahren nach einem der Ansprüche 1 bis 9, das weiterhin das Schleifen der durch die Ausbauchung und die Schweißverbindung gebildeten Fläche zu einer glatten Oberfläche und vorzugsweise das Polieren der glatten Oberfläche umfasst.

11. Vorrichtung mit

- einem Rohrboden (2) mit einer ersten Oberfläche (10) und einer zweiten Oberfläche (11) sowie mehreren Bohrungen (12), die von der ersten Oberfläche zur zweiten Oberfläche verlaufen,
- mindestens einem Rohr (1) aus biegsamem Material, das in einer entsprechenden Bohrung angebracht ist, wobei das Rohr auf der Seite der ersten Oberfläche einen ausgebauchten Abschnitt (20) aufweist, der an seinem äußeren Rand (21) mit der ersten Oberfläche des Rohrbodens verschweißt ist,

dadurch gekennzeichnet,
dass in der entsprechenden Bohrung ein Kanal (13) gebildet ist, der sich ausgehend von der ersten Oberfläche in Axialrichtung der Bohrung mindestens über einen Teil der Axiallänge der Bohrung hinweg erstreckt.

12. Vorrichtung nach Anspruch 11, bei der das Rohr aufgeweitet wird, um dieses in mindestens einem Teil der entsprechenden Bohrung, in der das Rohr angebracht ist, fest einzupassen.

13. Vorrichtung nach Anspruch 12, bei der das Rohr vor dem Ausbauchen aufgeweitet wird.

14. Vorrichtung nach einem der Ansprüche 11 bis 13, bei dem ein Teil des in der Bohrung angebrachten Rohrs aufgeweitet ist, wobei dieser Teil kürzer ist als die Axiallänge des Kanals (13), der in der Bohrung, in der das Rohr angebracht ist, gebildet ist.

15. Vorrichtung nach Anspruch 14, bei der nach Herstellung der Schweißverbindung der übrige, noch nicht aufgeweitete Teil des Rohrs in der Bohrung (14) über im Wesentlichen die gesamte Axiallänge der Bohrung, in der das Rohr angebracht ist, hinweg aufgeweitet wird.

16. Vorrichtung nach einem der Ansprüche 11 bis 15, bei dem der Kanal in Form eines Schraubengewindes (13) gebildet ist.

17. Vorrichtung nach einem der Ansprüche 11 bis 16, bei der mehr als ein Rohr und mehr als eine Bohrung im Rohrboden vorgesehen sind, wobei die Bohrungen voneinander beabstandet sind und die überstehenden Endabschnitte der Rohre und somit die Ausbauchungen so dimensioniert sind, dass die äußeren Ränder der Ausbauchungen einander angenähert sind, wodurch sich die Schweißverbindungen an benachbarten Ausbauchungen überlappen.

18. Vorrichtung nach einem der Ansprüche 11 bis 17, bei der weiterhin die durch die Ausbauchung und die Schweißverbindung gebildete Fläche zu einer glatten Oberfläche geschliffen wird und vorzugsweise die glatte Oberfläche poliert wird.

Revendications

1. Procédé pour former un raccord entre une plaque tubulaire et au moins un tube comprenant les étapes consistant à :

- munir une plaque tubulaire (2) d'une première surface (10) et une seconde surface (11) et d'un nombre d'alésages (12) s'étendant de la première surface à la seconde surface ;
- munir le tube (1) d'un matériau pliable avec une forme extérieure et des dimensions permettant au tube d'être logé dans un alésage correspondant ;
- placer le tube dans l'alésage correspondant, de sorte qu'une partie d'extrémité du tube fasse saillie depuis le côté de la première surface de la plaque tubulaire ;
- évaser la partie d'extrémité saillante du tube de manière à former un évasement (20) ; et
- réaliser un raccord soudé entre la plaque tubulaire et le tube au niveau de la circonférence (21) de l'évasement, **caractérisé par**
- l'agencement d'une rainure (13) dans l'alésage correspondant depuis la première surface dans la direction axiale de l'alésage sur au moins une partie de la longueur axiale de celui-ci.

2. Procédé selon la revendication 1, dans lequel l'interconnexion consiste à : étendre le tube pour l'ajuster de manière étroite dans au moins une partie de l'alésage correspondant logeant le tube.

3. Procédé selon la revendication 2, consistant à : étendre le tube avant d'évaser ce dernier.

4. Procédé selon l'une quelconque des revendications 1 à 3, dan lequel le tube logé dans l'alésage est étendu sur une distance plus courte que la longueur axiale de la rainure (13) située dans l'alésage logeant le tube.

5. Procédé selon l'une quelconque des revendications 1 à 4, consistant en outre à tester un raccord soudé au moyen d'une pression en utilisant un procédé de test non destructif, qui est choisi dans le groupe comprenant un test au savon, un test de fuite à l'hélium, un test de pression d'eau.

6. Procédé selon l'une quelconque des revendications 1 à 5, consistant en outre à étendre toute partie restante non étendue précédemment dans l'alésage (14) du tube sensiblement sur toute la longueur axiale de l'alésage dans lequel le tube est logé.

7. Procédé selon la revendication 6, consistant à étendre la partie restante non étendue précédemment du tube après avoir testé le raccord soudé.

8. Procédé selon l'une quelconque des revendications 1 à 7, dans lequel la rainure est agencée sous la forme d'un filetage de vis (13).

9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel sont agencés plus d'un tuyau et plus d'un alésage dans la plaque tubulaire, ces alésages étant prévus à une certaine distance les uns des autres, comprenant en outre les étapes consistant à : dimensionner les parties d'extrémité saillantes des tubes et ainsi les évasements, de manière à approcher les circonférences des évasements les unes des autres, moyennant quoi les raccords soudés se chevauchent au niveau d'évasements adjacents.

10. Procédé selon l'une quelconque des revendications 1 à 9, consistant en outre à meuler la surface formée par l'évasement et le raccord soudé afin d'obtenir une surface lisse et de préférence polir la surface lisse.

11. Dispositif comprenant

- une plaque tubulaire (2) avec une première surface (10) et une seconde surface (11) et un nombre d'alésages (12) s'étendant depuis la première surface vers la seconde surface,
- au moins un tube (1) composé d'un matériau pliable placé dans un alésage correspondant, le tube ayant une partie évasée (20) sur le côté de la première surface, dont la partie évasée est raccordée par soudage au niveau de sa circonférence (21) à la première surface de la plaque tubulaire,

caractérisé en ce qu'une rainure (13) est agencée dans l'alésage correspondant, cette rainure s'étendant de la première surface dans la direction axiale de l'alésage sur au moins une partie de la longueur axiale de ce dernier.

12. Dispositif selon la revendication 11, dans lequel le tube est étendu de manière à s'ajuster de façon étroite dans au moins une partie de l'alésage correspondant logeant le tube.

13. Dispositif selon la revendication 12, dans lequel le tube est étendu avant son évasement.

14. Dispositif selon l'une quelconque des revendications 11 à 13, dans lequel le tube logé dans l'alésage est étendu sur une distance plus courte que la longueur axiale de la rainure (13) située dans l'alésage logeant le tube.

15. Dispositif selon la revendication 14, dans lequel toute partie restante non étendue dans l'alésage (14)

du tube est étendue sensiblement sur toute la longueur axiale de l'alésage dans lequel le tube est logé, après la réalisation du raccord soudé.

16. Dispositif selon l'une quelconque des revendications 11 à 15, dans lequel la rainure est agencée sous la forme d'un filetage de vis (13).

17. Dispositif selon l'une quelconque des revendications 11 à 16, dans lequel sont agencés plus d'un tuyau et plus d'un alésage dans la plaque tubulaire, ces alésages étant prévus à une certaine distance les uns des autres, dans lequel les parties d'extrémité saillantes des tubes et ainsi les évasements sont dimensionnés de manière à approcher les circonférences des évasements les unes des autres, moyennant quoi les raccords soudés se chevauchent au niveau d'évasements adjacents.

18. Dispositif selon l'une quelconque des revendications 11 à 17, comprenant en outre l'étape consistant à meuler la surface formée par l'évasement et le raccord soudé afin d'obtenir une surface lisse et de préférence polir la surface lisse.

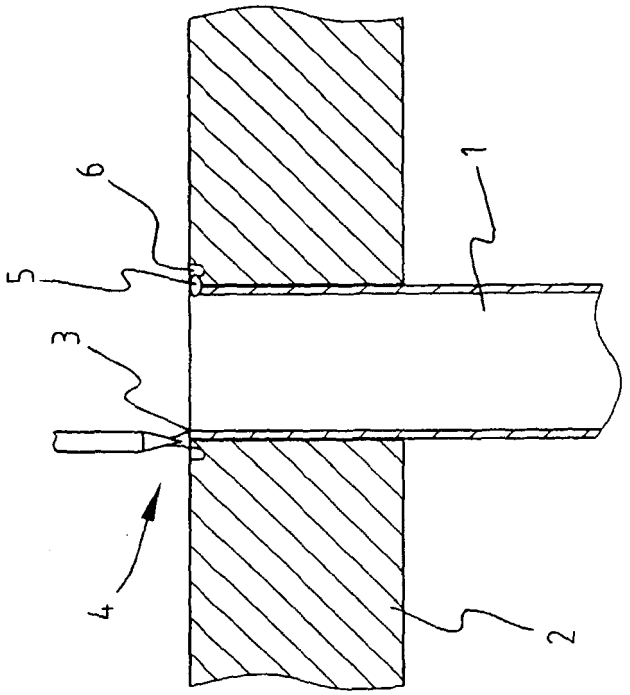

FIG. 1B

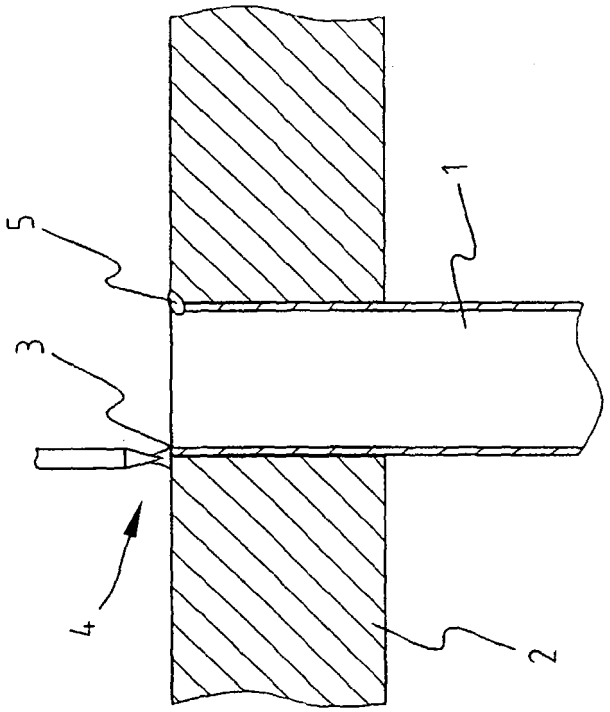

FIG. 1A

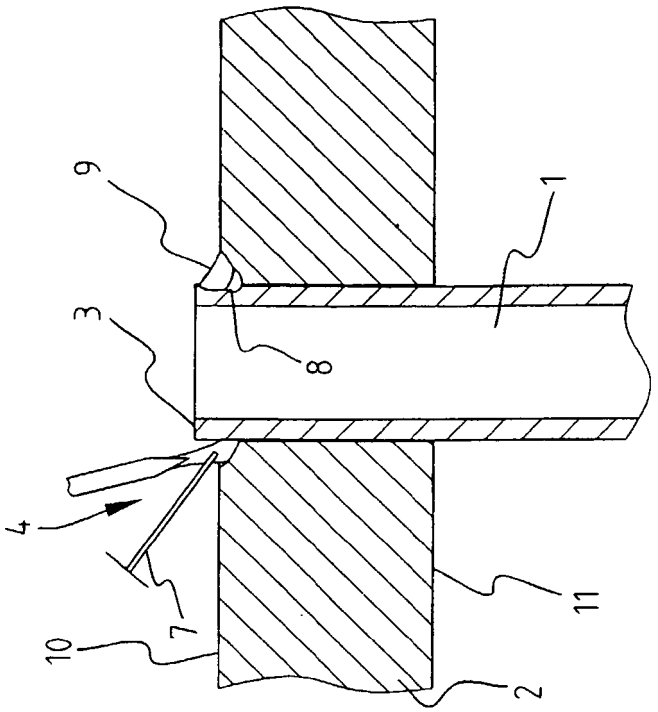

FIG. 1D

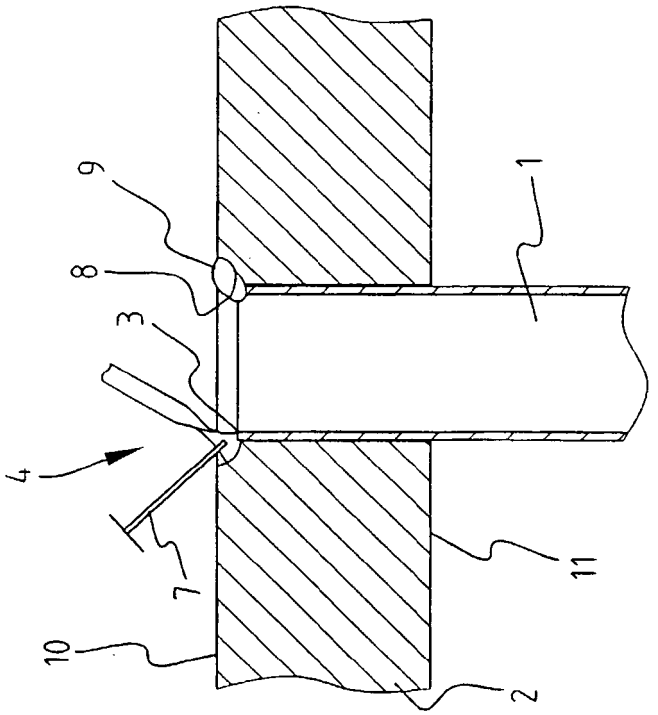

FIG. 1C

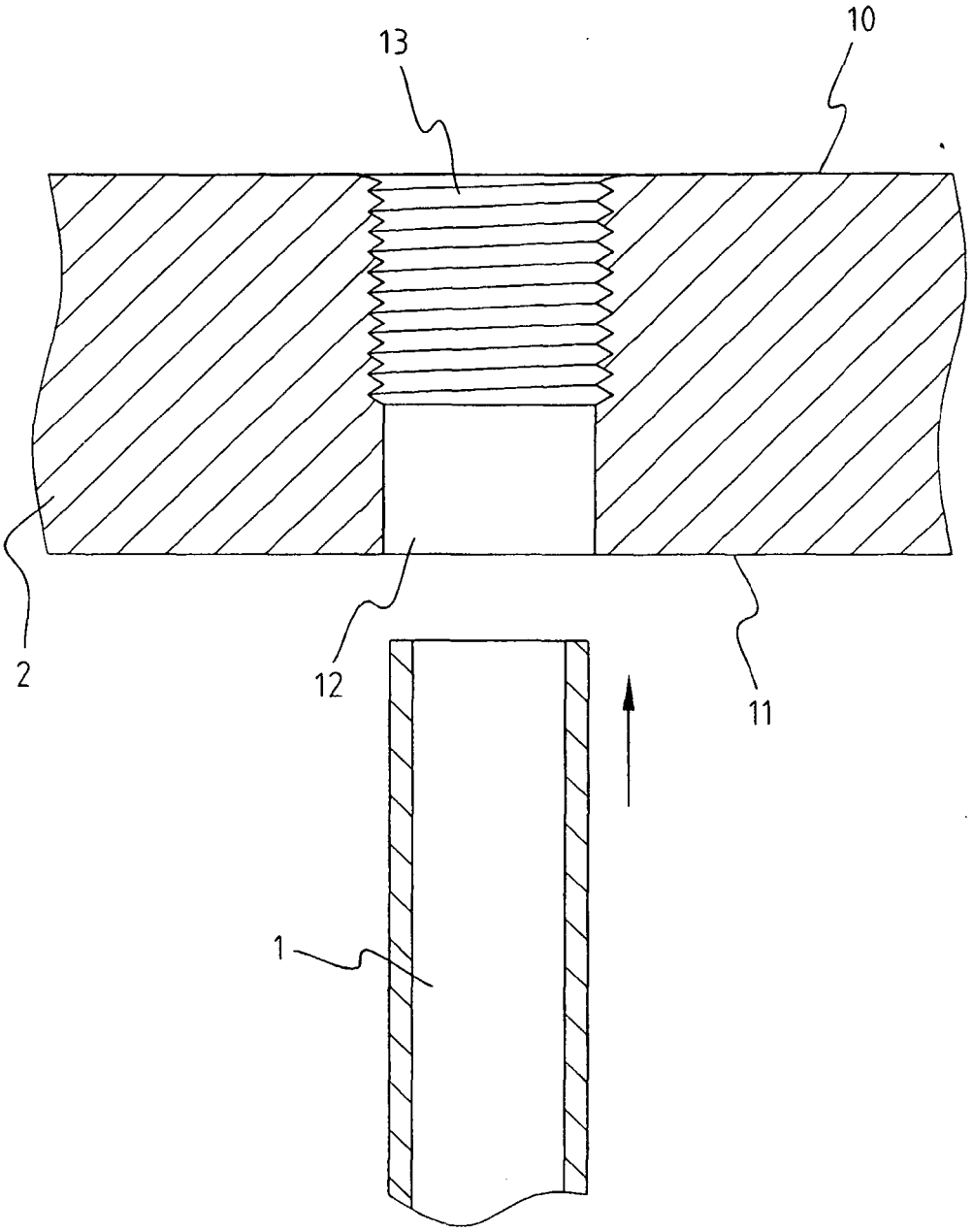

FIG. 2A

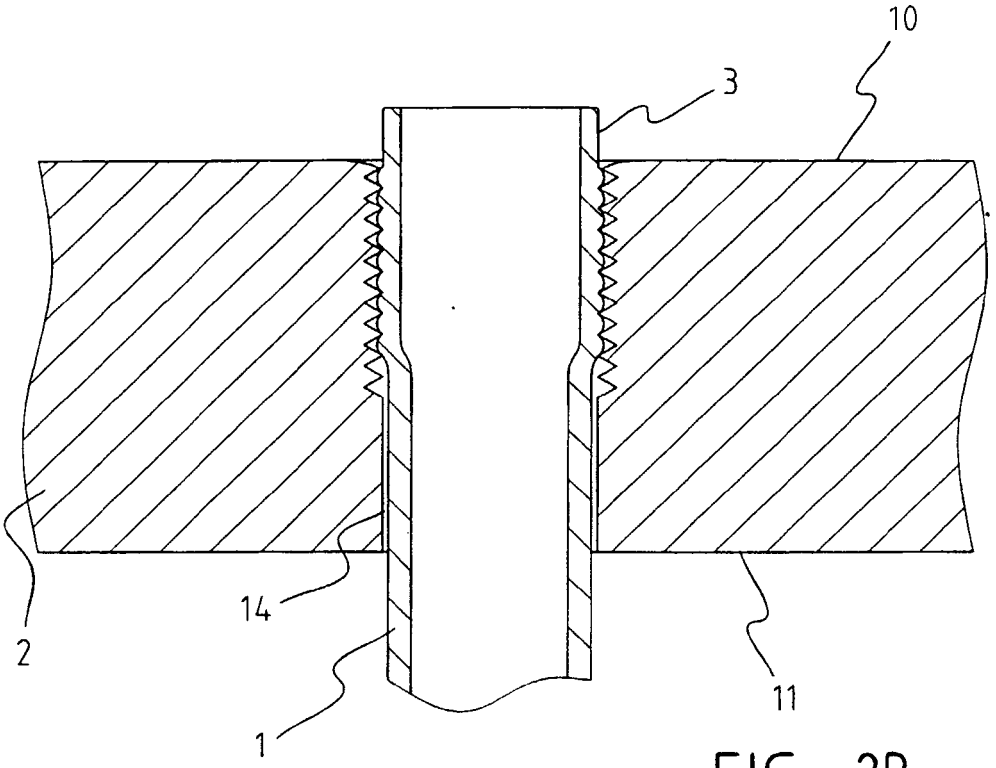

FIG. 2B

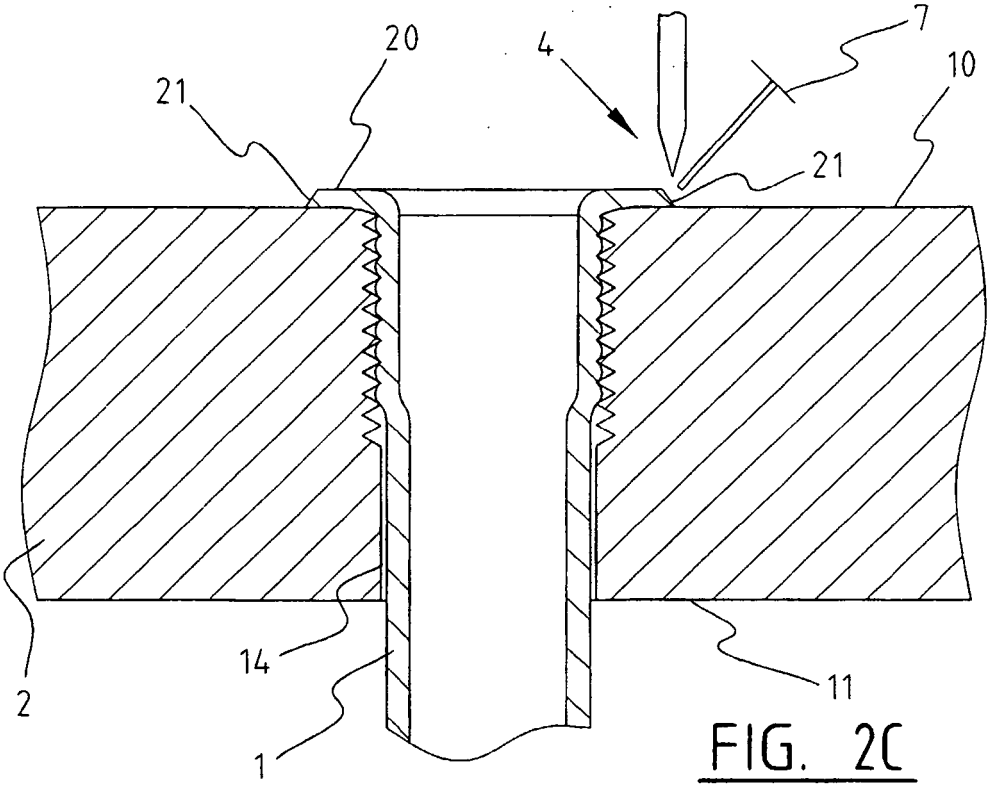

FIG. 2C

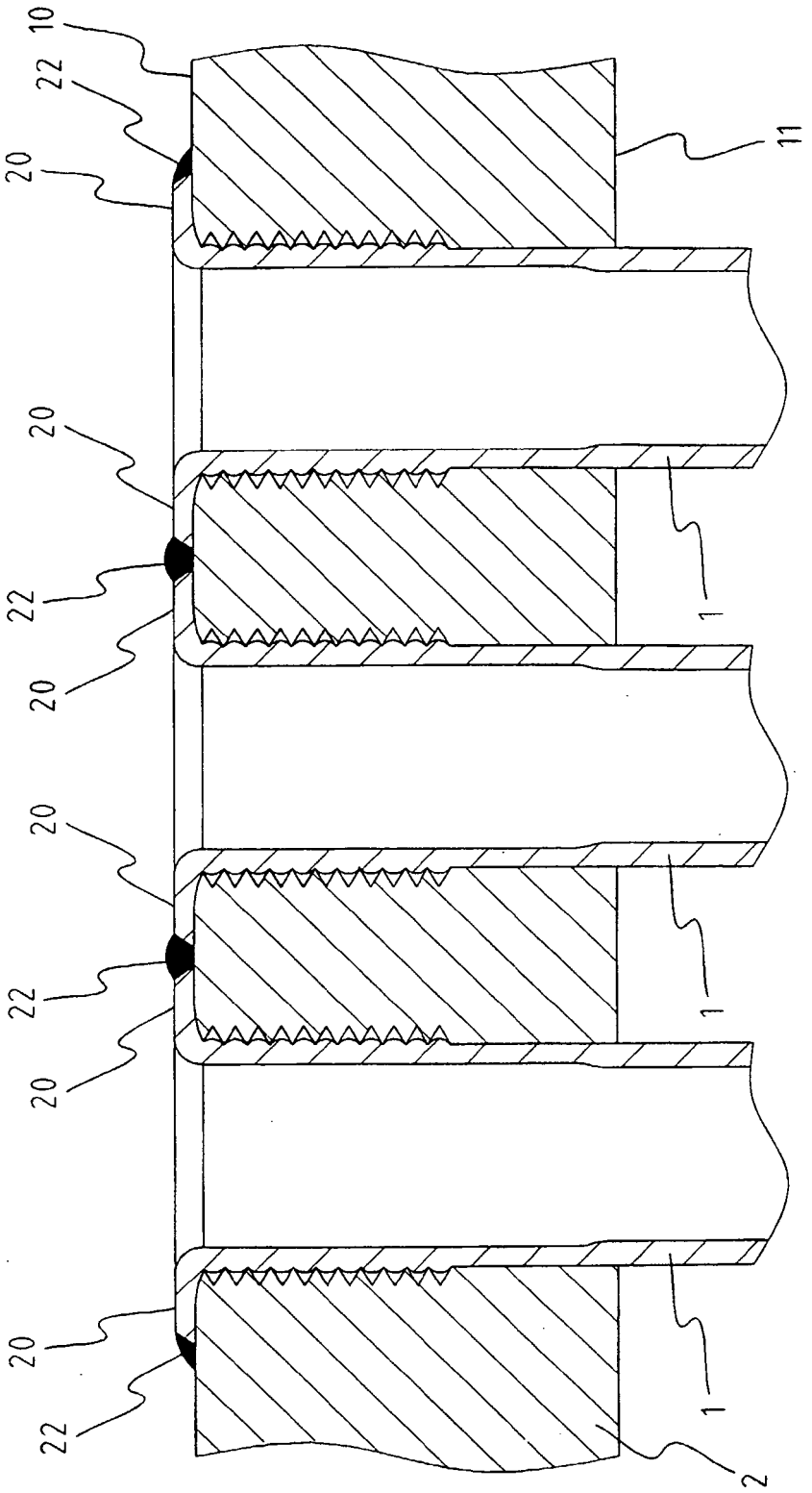

FIG. 3

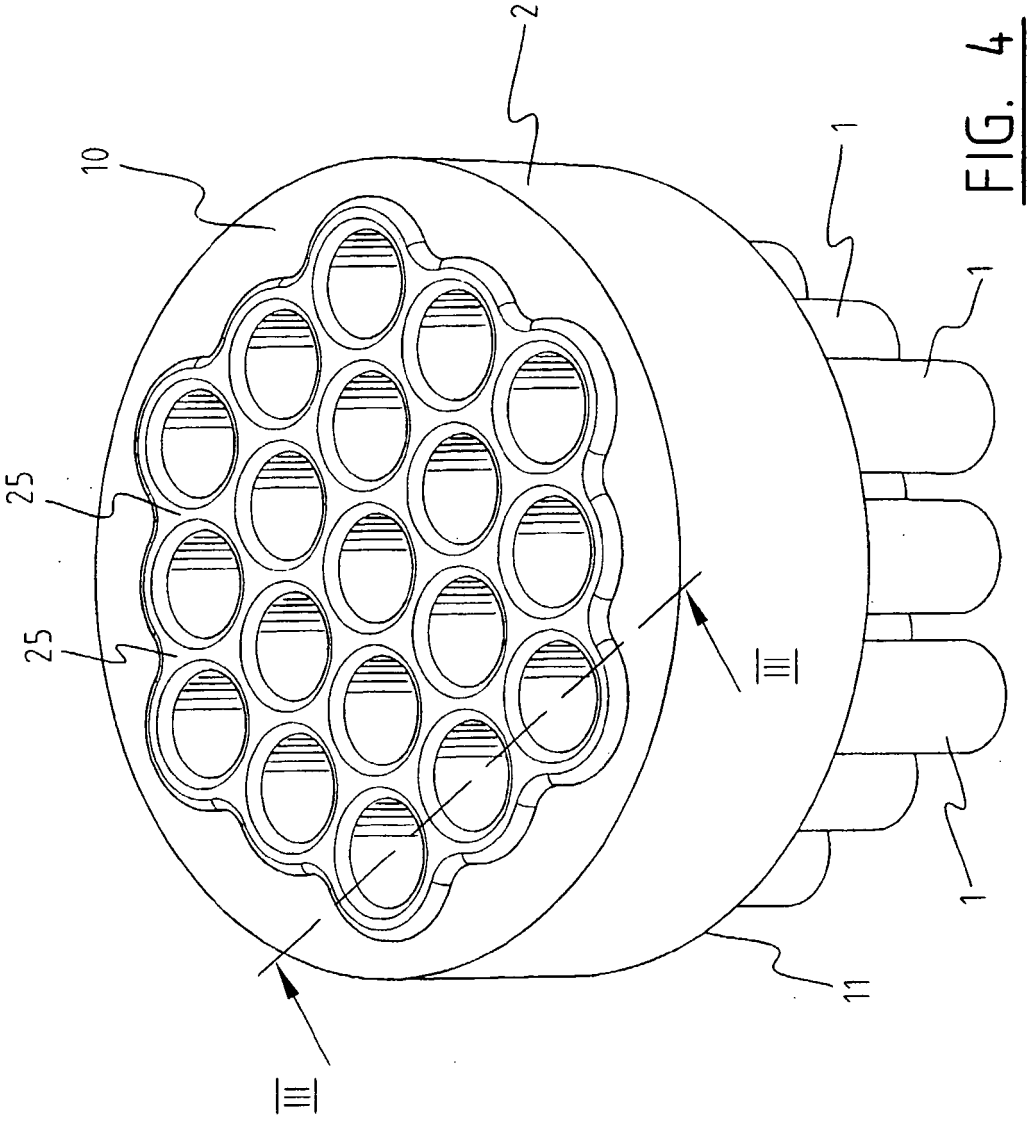

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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