



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 213 557 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.06.2002 Bulletin 2002/24

(51) Int Cl.7: **F28F 9/10, F28F 9/12**

(21) Application number: **01660221.1**

(22) Date of filing: **05.12.2001**

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

(72) Inventor: **Lehtiniemi, Tuomas**
36220 Kangasala (FI)

(74) Representative: **Hakola, Unto Tapani**
Tampereen Patenttitoimisto Oy,
Hermiankatu 6
33720 Tampere (FI)

(30) Priority: **05.12.2000 FI 20002659**

(71) Applicant: **Kvaerner Pulping Oy**
33101 Tampere (FI)

(54) **A tube structure, a flow channel structure, and a heat exchanger**

(57) The invention relates to a tube structure, a flow channel structure and a heat exchanger, as well as their use, particularly in pre-heaters for air in boiler plants. The tube structure (P) is intended to be fixed between opposite walls (1, 2) of a flow channel (VK) or the like for a first heat transfer medium (VK) of a heat exchanger. A second heat transfer medium (TV) is arranged to flow through the tube structure (P). The tube structure (P)

comprises, at its both ends (3, 4), fixing means (5, 6) for fixing the tube structure (P) in a releasable manner to the walls (1, 2) of the flow channel (VK). The first and second walls (1, 2) of the flow channel structure are provided with a compatible pair (17, 18) of holes, through which the tube structures (P) to be inserted in the heat exchanger are installed.

EP 1 213 557 A2

Description

[0001] The invention relates to a tube structure for heat exchangers, wherein the tube structure is intended to be fixed between opposite walls of a flow channel, or the like, for a first heat transfer medium of a heat exchanger, and wherein a second heat transfer medium is arranged to flow through the tube structure.

[0002] The invention also relates to a flow channel structure which is arranged to be used as a part of a heat exchanger, wherein a first heat transfer medium flows in the flow channel, and wherein the flow channel structure, provided by means of a wall structure and having a closed cross-section, has a first wall and a second wall, one or more tube structures being placed in the flow channel between the walls, a second heat transfer medium flowing through the tube structures.

[0003] The invention also relates to a heat exchanger comprising a combination of a flow channel structure and a tube structure placed therein, wherein the tube structure is fixed between opposite walls of the flow channel or the like of the heat exchanger, and wherein a first heat transfer medium flows in the flow channel and a second heat transfer medium flows through the tube structure.

[0004] In addition to those above, the invention also relates to the use of a tube structure, a flow channel structure and a heat exchanger as a pre-heater for air in a boiler plant.

[0005] The tube structure, flow channel structure and heat exchanger according to the invention are intended to be used particularly, but not solely, when heat is to be transferred from flue gases of the boiler plant to the combustion air to be introduced into the furnace of the boiler plant. In normal boiler plant use, the structure is a pre-heater for air, a so-called Luvo heat exchanger structure. In a known manner, these heat exchanger structures comprise horizontal tubes which are connected in a gas-tight manner to vertical tube plates which normally also constitute two of the walls of the flue gas channel forming the flow channel. The combustion air flows inside the tubes, and the flue gases discharged from the furnace of the boiler plant flow outside the tubes, transversely with respect to the tubes. Naturally, the flow can also be arranged *vice versa* according to the practical application.

[0006] According to technology presently in use, the Luvo heat exchanger is formed of one or more tube banks which are assembled in such a way that a group of single tubes are connected at opposite ends to two wall plates which partly form the wall structure of the flow channel and are provided with openings at the locations of the tubes, to form a tube bank by welding either directly or by means of an intermediate sleeve connected to the tube. In such a structure, the problem lies particularly in that strong corrosion is present in the tubes of the tube banks placed in the coldest part of the flue gas channel, when the temperature of the flue gas-

es is close to or within the range of the acid dew point. Manufacturing by welding limits the number of available materials, because the tubes and the wall plates which form at least part of the wall structure of the flue gas channel must be weldable to each other. Also, it is not possible to use coatings on the outer surface of the tubes, because coatings do not stand the heat developed by welding without being damaged, and the coating of the welded location cannot be repaired afterwards. The tube bank assembled by welding has such a structure that the ready welded tube bank cannot be coated afterwards.

[0007] It is an aim of the present invention to substantially eliminate the above-mentioned problems related to prior art and thereby to improve the state of art.

[0008] To achieve these aims, the tube structure according to the invention is primarily characterized in that the tube structure comprises, at its both ends, fixing means for fixing the tube structure to the walls of the flow channel in a releasable manner.

[0009] Furthermore, to achieve these aims, the flow channel structure according to the invention is primarily characterized in that the first and second walls of the flow channel structure are provided with at least one compatible pair of holes for the insertion of at least one tube structure through the second hole of the pair of holes to the flow channel structure in a sealed and releasable manner.

[0010] Furthermore, the heat exchanger according to the invention is primarily characterized in that the tube structure comprises, at its both ends, fixing means for fixing the tube structure in a releasable manner to the walls of the flow channel, and that the first and second walls of the flow channel structure comprise at least one compatible pair of holes through which at least one tube structure is placed in the flow channel structure in a sealed and releasable manner.

[0011] The above-presented solutions yield a tube structure, a flow channel structure and a heat exchanger whose materials and/or coatings can be selected primarily by taking into account their corrosion and erosion resistance as well as their strength against possible vibrations or other mechanical loads. A heat exchanger implemented according to the primary characteristics of the invention is free from deformations which are typical of a welded structure and whose reparation would cause additional costs. Furthermore, the tube structure, the flow channel structure and the heat exchanger according to the invention can be easily maintained fit for duty, because the tube structures of the heat exchanger can even be exchanged one by one, if necessary, in the flow channel structure which may thus be placed in its actual use location, e.g. in a flue gas channel of a boiler plant.

[0012] The locking of the tubes in their places is accomplished by means of tightening members acting in the axial direction. The tube fits freely in the hole, and the locking takes place through shape locking with the aid of tightening means acting at both ends of the tube

and counter surfaces entering against each other in the axial direction of the tube. At both ends, one of the counter surfaces projects radially outwardly from the tube and the other of the counter surfaces is part of the wall. Friction joint requiring clean metal surfaces against each other is not needed, but the tube can be coated.

[0013] Some advantageous embodiments of the invention will be presented in the appended dependent claims related to the tube structure, the flow channel structure and the heat exchanger.

[0014] In the following description, the invention will be illustrated in more detail with reference to an embodiment shown in the appended drawings. In the drawings,

Fig. 1 shows an application of the tube structure according to the invention, seen in a direction perpendicular to the longitudinal direction of the tube structure, in a partial cross-section in the direction of the longitudinal axis of the tube structure,

Fig. 2 shows a part of a heat exchanger application assembled of tube structures according to Fig. 1 in a cross-section perpendicular to the longitudinal direction of the flow channel,

Fig. 3 shows a part of the heat exchanger seen in the direction of arrow III of Fig. 2, from the outside of the flow channel, and

Fig. 4 shows a part of the heat exchanger seen in the direction of arrow IV of Fig. 2, from the outside of the flow channel.

[0015] The tube structure P shown in Fig. 1 is intended to be placed in connection with a heat exchanger, wherein the tube structure P is fixed between opposite walls 1, 2 of the flow channel VK, or the like, for a first heat transfer medium EV in the heat exchanger (Fig. 2). A second heat transfer medium TV is arranged to flow through the tube structure P. The tube structure P comprises, at its both ends 3, 4, fixing means 5, 6 for fixing the tube structure P in a releasable manner to the walls 1, 2 of the flow channel. The first fixing means 5 at the first end 3 is a threading which is arranged to protrude outside the first wall 1 of the flow channel VK when the tube structure P is in installed position. The second fixing means 6 of the tube structure P is, in turn, a collar flange located at the second end 4 of the tube structure P and protruding from its outer surface. The collar flange is arranged to be located outside the second wall 2 of the flow channel VK when the tube structure P is in installed position.

[0016] The first fixing means 5 is, in the embodiment shown in the drawings, provided on the outer surface of a sleeve 8 fixed at the first end 7a of a main tube 7 which forms the actual flow channel for the second heat transfer medium TV in the tube structure P. A part of the

sleeve 8 is placed inside the main tube 7 and the sleeve 8 is fixed, at its outer surface, to the main tube 7. The sleeve 8 is fixed by a welded joint 9 between the outer surface 8a of the sleeve 8 and the front surface 7b at the first end 7a of the main tube. The welded joint 9 forms an annular sealing surface 10, which faces the first end 3 of the tube structure P and whose outer surface is preferably conical. The sealing surface is sealed against a counter surface 11 in the first wall 1 and facing the flow channel VK, when the tube structure P is in installed position as shown in Fig. 2.

[0017] The collar flange 12 forming the second fixing means 6 is placed in connection with a sleeve unit 13 attached to the outer surface of the main tube, wherein the sleeve unit 13 is placed around the main tube 7 in its longitudinal direction, to extend substantially in the flow channel VK, as shown in Fig. 2. The sleeve unit 13 is connected, at its end opposite to the collar flange 12, by a welded joint 14 to the outer surface of the main tube 7. The outer surface of the sleeve unit 13 is cylindrical, and the diameter of its preferably circular inner hole 13a is greater than the diameter of the cross-section of the outer surface of the main tube 7, the sleeve unit 13 being, substantially over its whole length, off the outer surface of the main tube 7.

[0018] The collar flange 12 at the second end 4 of the tube structure P protrudes diagonally from the outer surface of the sleeve unit 13 and forms a sealing surface 12a by its surface facing the flow channel VK. When the tube structure P is in installed position as shown in Fig. 2, the sealing surface 12a is sealed against the counter surface 15 of the second wall 2, directed away from the flow channel VK.

[0019] As can be seen particularly from Fig. 1, the main tube structure 7 and the parts connected to it, particularly the sleeve unit 13, throughout at least those sections which are placed in the flow channel VK when the tube structure P is in installed position as shown in Fig. 2, can be coated with a coating 16 which takes into account the properties of the first heat transfer medium EV, if the materials for the main tube structure 7, the sleeve unit 13 and/or the welded joint 14 therebetween have been selected, for other reasons, in such a way that the material does not stand, or has a limited resistance to, the physical and/or chemical effects of the first heat transfer medium EV. The second heat transfer medium TV flowing in the tube structure P is arranged to flow into the tube structure P through the second end 4 of the tube structure P. Thus, the dimensions and the material and/or the coating of the sleeve construction can be selected so that the whole tubular structure P is resistant at this critical point of the heat exchanger, where the temperature difference between the first EV and second TV heat transfer media is the greatest and which thus has the greatest risk of temperatures below the dew point.

[0020] The flow channel structure according to the invention is arranged to be used as a part of the heat ex-

changer to restrict the cross-sectional area for the flow of the first heat transfer medium EV. The closed flow channel having a closed cross-sectional shape achieved by means of the wall structure forming the flow channel structure has a first wall 1 and a second wall 2, between which one or several tube structures P are placed in the flow channel VK, the second heat transfer medium TV thus flowing through the tube structures P. Naturally, the first 1 and second 2 walls are connected at their edges by end walls (not shown) to achieve said flow channel with a closed cross-section. The first 1 and second 2 walls comprise at least one compatible pair 17, 18 of holes (in practical applications, however, several pairs 17, 18 of holes being placed at regular spacings in the walls 1 and 2), to place at least one tube structure P through the second hole 18 of the pair 17, 18 of holes to the flow channel structure in a sealed and releasable manner. The structure of each pair 17, 18 of holes is formed in such a way that the hole 17 in the first wall 1 of the flow channel structure substantially corresponds, in its diameter, to the inner diameter of the cross-sectional shape of the tube structure P at the location of the flow channel, wherein the edge of the first hole 17 facing the flow channel is provided with a counter surface 11 to be used in the sealing between the tube structure and the first wall 1, the counter surface 11 being placed in abutment with the sealing surface 10 of the tube structure P. The sleeve 8 fixed at the first end 7a of the main tube 7 protrudes through the first hole 17 outside the first wall 1 of the flow channel structure. In the second wall 2 of the flow channel structure, the diameter of the second hole 18, through which the tube structure P is thus installed into the flow channel VK, is equal to or greater than the greatest outer diameter of the cross-section of the tube structure P (in practice, the outer diameter of the sleeve structure 13) at the flow channel VK, wherein the edge of the second hole 18 directed away, i.e. outwards from the flow channel VK is provided with a diagonal annular counter surface 15 which is to be used in the sealing between the tube structure P and the second wall 2 and which is connected to the sealing surface 12a of the collar flange 12 when the tube structure P is in installed position.

[0021] The counter surfaces entering in abutment against each other in axial direction, the counter surface 11 of the hole and the sealing surface 10 of the tube structure at the first hole 17, and the counter surface 15 of the hole and the sealing surface 12a of the tube structure at the second hole 18 of greater diameter, bring about a shape locking on the wall 1, 2 and in the corresponding hole 17, 18 at both ends of the tube structure P in cooperation with tightening members acting on the tube structure P in the axial direction. No friction joint is needed, and when the tightening members have been released, the tube structure P can be freely pulled off on the side of the larger hole 18. When the counter surfaces 11, 10 and 15, 12a lying against each other are sloped with respect to the axial direction, a good sealing

is achieved.

[0022] Consequently, the heat exchanger according to the invention comprises, in the above-described manner, a combination of a flow channel structure (walls 1, 2 and end walls connecting them) and at least one tube structure P placed therein. The tube structures P are thus installed through the second wall 2 in such a way that the first end 3 of the tube structure P is introduced from the outside of the flow channel structure through the second hole 18 into and through the flow channel VK, until the sleeve 8 meets the first hole 17 of said pair of holes, through which the sleeve 8 is led to the position shown in Fig. 2. The layout of the portions sealed against each other in the flow channel structure and in each tube structure P is dimensioned so that a good sealing is achieved after tightening with tightening means in the position shown in Fig. 2. If necessary, it is possible to use separate sealing materials to be placed between the sealing surfaces to secure the sealing effect accomplished with the sealing and counter surfaces (10, 11 and 12a, 15).

[0023] In the embodiment shown in the drawings, the first fixing means 5 of the tube structure P is thus a threading formed on the outer surface of the sleeve 8 at the first end 3 of the tube structure P, arranged to protrude outside the first wall 1 of the flow channel VK when the tube structure P is in installed position. In the fixing of the tube structure P, a nut 19, or the like, is arranged to be installed outwardly of the heat exchanger (Fig. 3), wherein the first wall 1 of the flow channel structure is locked at the first hole 17 between the first end 3 of the tube structure P and the nut 19 or the like. The nut 19 serves thus in the locking of the first end 3 of the tube structure P as a tightening member acting on the tube structure in the axial direction.

[0024] Consequently, the second fixing means 6 of the tube structure P is an annular collar flange 12 located at the second end 4 of the tube structure P and protruding from its outer surface. The collar flange is arranged to be located outside the second wall 2 of the flow channel VK when the tube structure P is in installed position. A press plate 20 or the like, to be installed outwardly from the heat exchanger, is arranged to be used in the fixing, wherein the collar flange 12 is locked between the second wall 2 of the flow channel VK and the press plate 20 or the like, connected to each other with a locking means 21, 22. In the presented embodiment, the press plate 20 or the like is arranged to fix several, preferably four collar flanges 121, 122, 123, 124 belonging to different tube structures P1-P4 (such tube structures P1-P4 are next to each other in the heat exchanger) and located at fixed distance from its centre (Fig. 4). The locking means 21, 22 consists of a stud bolt 21, which is connected (for example by a threaded hole fit) to the second wall 2 of the flow channel VK, protrudes from its outer surface and is arranged to extend through a central hole 20a in the press plate 20 or the like, wherein a tightening nut 22 or the like, belonging to the locking

means, is installed on the stud bolt 21 outside the press plate 20. The tightening nut 22 or the like and the press plate 20, which can be several for one tube structure P in the manner shown by Fig. 3, serve in the locking of the second end 4 of the tube structure P as a tightening member acting on the tube structure in the axial direction and bringing about a force effect in the tube structure in the same direction as does the tightening member (nut 19) of its opposite, first end 3.

Claims

1. A tube structure for heat exchangers, wherein the tube structure (P) is intended to be fixed between opposite walls (1, 2) of a flow channel (VK), or the like, for a first heat transfer medium (EV) of a heat exchanger, and wherein a second heat transfer medium (TV) is arranged to flow through the tube structure (P), **characterized in that** the tube structure (P) comprises, at its both ends (3, 4), fixing means (5, 6) for fixing the tube structure (P) to the walls (1, 2) of the flow channel (VK) in a releasable manner.
2. The tube structure according to claim 1, **characterized in that** the first fixing means (5) of the tube structure (P) is a threading at the first end (3) of the tube structure (P), arranged to protrude outside the first wall (1) of the flow channel (VK) when the tube structure (P) is in installed position.
3. The tube structure according to claim 1 or 2, **characterized in that** the second fixing means (6) of the tube structure (P) is a collar flange (12) located at the second end (4) of the tube structure (P) and protruding from its outer surface, said collar flange being arranged to be positioned outside the second wall (2) of the flow channel (VK) when the tube structure (P) is in installed position.
4. The tube structure according to claim 1, 2 or 3, **characterized in that** the first fixing means (5) is provided on the outer surface of a sleeve (8) fixed at the first end (7a) of a main tube (7) which forms the actual flow channel for the second heat transfer medium (TV), wherein a part of the sleeve (8) is placed inside the main tube (7) and the sleeve (8) is fixed, at its outer surface, to the main tube (7).
5. The tube structure according to claim 4, **characterized in that** the sleeve (8) is fixed by means of a welded joint (9) formed between the outer surface of the sleeve (8) and the front surface (7b) at the first end (7a) of the main tube (7).
6. The tube structure according to claim 5, **characterized in that** said welded joint (9) forms a preferably conical sealing surface (10) in the tube structure

(P), which is sealed against a counter surface (11) located at the first wall (1) and facing the flow channel (VK) when the tube structure (P) is in installed position.

7. The tube structure according to any of the claims 3 to 6, **characterized in that** the collar flange (12) forming the second fixing means (6) is placed in connection with a sleeve unit (13) fixed onto the outer surface of the main tube (P).
8. The tube structure according to claim 7, **characterized in that** the sleeve unit (13) is placed around the main tube (P) to extend substantially into the flow channel (VK).
9. The tube structure according to claim 7 or 8, **characterized in that** the diameter of the inner hole of the cross-section of the sleeve unit (13) is greater than the diameter of the cross-section of the outer surface of the main tube (7), wherein the sleeve unit (13) is, substantially over its whole length, off the outer surface of the main tube (7).
10. The tube structure according to claim 7, 8 or 9, **characterized in that** the sleeve unit (13) is connected, at its end opposite to the collar flange (12), by a welded joint (14) to the outer surface of the main tube (7).
11. The tube structure according to any of the claims 3 to 10, **characterized in that** the collar flange (12) at the second end (4) of the tube structure (P) forms, by its surface facing the flow channel (VK), a sealing surface (12) which is sealed against a counter surface (15) located on the second wall (2) and directed away from the flow channel (VK).
12. The tube structure according to any of the claims 1 to 11, **characterized in that** the main tube structure (7) and the parts connected to it, at least throughout the sections which are placed in the flow channel (VK) when the tube structure (P) is in installed position, are coated with a coating which takes into account the properties of the first heat transfer medium (EV).
13. A flow channel structure which is arranged to be used as a part of a heat exchanger, wherein a first heat transfer medium (EV) flows in the flow channel and wherein the flow channel structure produced by means of a wall structure and having a closed cross-sectional shape has first and second walls (1, 2), between which one or more tube structures (P) are placed in the flow channel (VK), a second heat transfer medium (TV) flowing through the tube structures (P), **characterized in that** the first and second walls (1, 2) are provided with at least one

compatible pair (17, 18) of holes for the insertion of at least one tube structure (P) through the second hole (18) of the pair (17, 18) of holes to the flow channel structure in a sealed and releasable manner.

14. The flow channel structure according to claim 13, **characterized in that** the tube structure (P) is at its both ends (3, 4) locked in the wall (1, 2) through shape locking with the aid of tightening members acting at both ends of the tube and counter surfaces (11, 10 and 15, 12a) entering against each other in the axial direction of the tube structure.

15. The flow channel structure according to claim 13 or 14, **characterized in that** the structure of each pair (17, 18) of holes is formed so that the diameter of the first hole (17) in the first wall (1) of the flow channel structure substantially corresponds to the inner diameter of the cross-section of the tube structure (P) at the location of the flow channel (VK), wherein the edge of the first hole (17) facing the flow channel is provided with a counter surface (11) to be used for the sealing between the tube structure (P) and the first wall (1), and in such a way that the diameter of the hole (18) in the second wall (2) of the flow channel structure is equal to or larger than the outer diameter of the cross-section of the tube structure (P) at the location of the flow channel (VK), wherein the edge of the second hole (18), directed away from the flow channel (VK), is provided with a counter surface (15) to be used in the sealing between the tube structure (P) and the second wall (2).

16. A heat exchanger comprising a combination of a flow channel structure and a tube structure (P) placed therein, wherein the tube structure (P) is fixed between opposite walls (1, 2) of the flow channel (VK) or the like of the heat exchanger, and wherein a first heat transfer medium (EV) flows in the flow channel (VK) and a second heat transfer medium (TV) flows through the tube structure (P), **characterized in that** the tube structure (P) comprises, at its both ends (3, 4), fixing means (5, 6) for fixing the tube structure (P) in a releasable manner to the walls of the flow channel (VK), and that the first and second walls (1, 2) of the flow channel structure are provided with at least one compatible pair (17, 18) of holes, through which at least one tube structure (P) is placed in the flow channel structure in a sealed and releasable manner.

17. The heat exchanger according to claim 16, **characterized in that** the first fixing means (5) of the tube structure (P) is a threading located at the first end (3) of the tube structure (P) and is arranged to protrude outside the first wall (1) of the flow channel (VK) when the tube structure (P) is in installed po-

sition, and that the fixing is arranged to be implemented by means of a nut (19) or the like that can be installed outside the heat exchanger, wherein the first wall (1) of the flow channel (VK) is locked between the first end (3) of the tube structure (P) and the nut (19) or the like.

18. The heat exchanger according to claim 16 or 17, **characterized in that** the second fixing means (6) of the tube structure (P) is a collar flange (12) located at the second end (4) of the tube structure (P) and protruding from its outer surface, the collar flange being arranged to be positioned outside the second wall (2) of the flow channel (VK) when the tube structure (P) is in installed position, and that the fixing is arranged to be implemented by means of a press plate (20) or the like that can be installed outside the heat exchanger, wherein the collar flange (12) is locked between the second wall (2) of flow channel (VK) and the press plate (20) or the like, fixed to each other with a locking means (21, 22).

19. The heat exchanger according to claim 18, **characterized in that** the press plate (20) or the like is arranged to fix several, preferably four collar flanges (121, 122, 123, 124) located at a fixed distance from its centre and belonging to different tube structures (P1-P4).

20. The heat exchanger according to any of the claims 16 to 19, **characterized in that** the locking means (21, 22) of the second end (4) of the tube structure consists of a stud bolt (21) connected to the second wall (2) of the flow channel (VK), protruding from its outer surface, and being arranged to extend through the press plate (20) or the like, wherein a tightening nut (22) or the like is installed on the stud bolt (21) outside the press plate (20).

21. The heat exchanger according to any of the claims 16 to 20, **characterized in that** the second heat transfer medium (TV) flowing in the tube structure (P) is arranged to flow into the tube structure (P) through the second end (4) of the tube structure (P).

22. The use of a tube structure according to any of the claims 1 to 12, a flow channel structure according to any of the claims 13 to 15, or a heat exchanger according to any of the claims 16 to 21 as a pre-heater for air in a boiler plant.

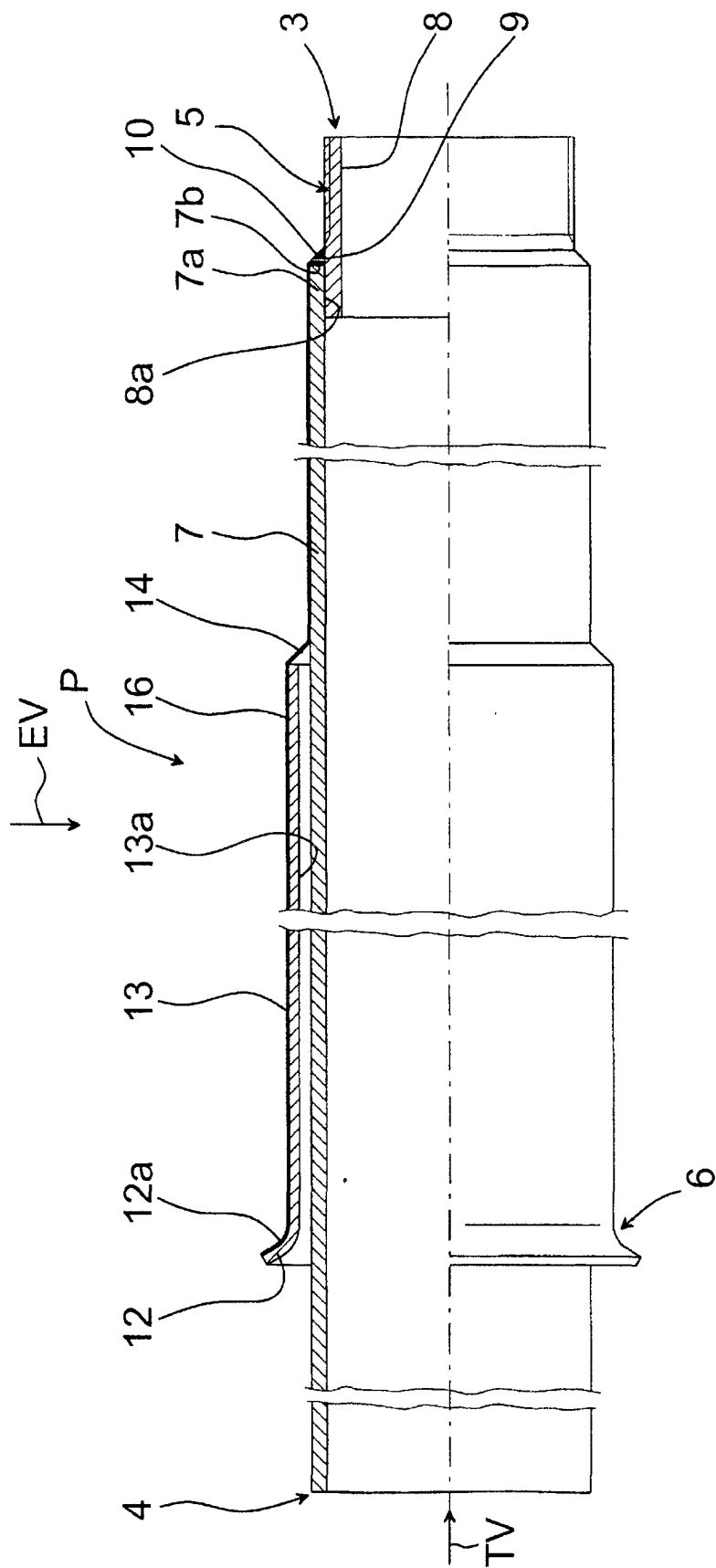


Fig. 1

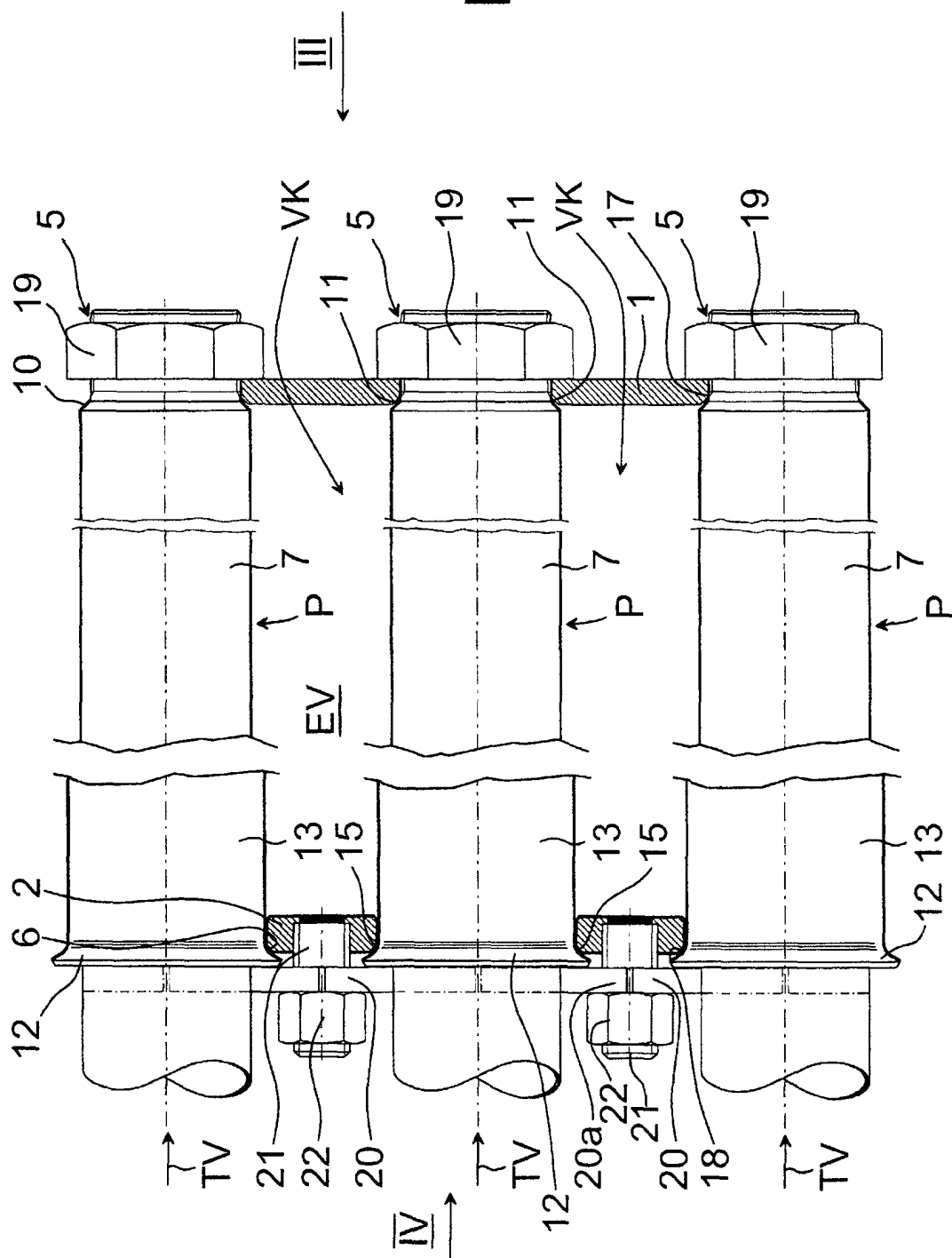


Fig. 2

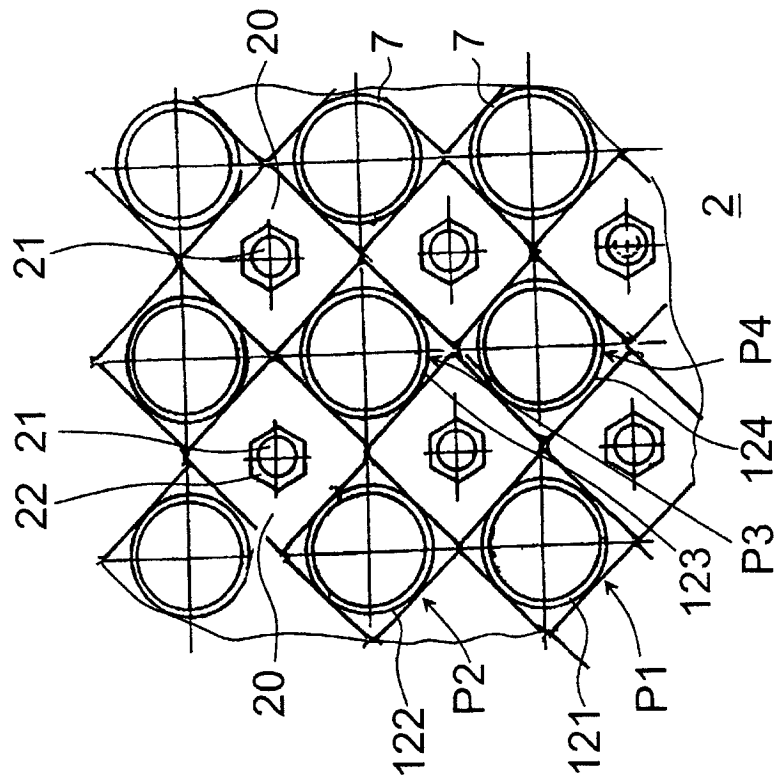


Fig. 4

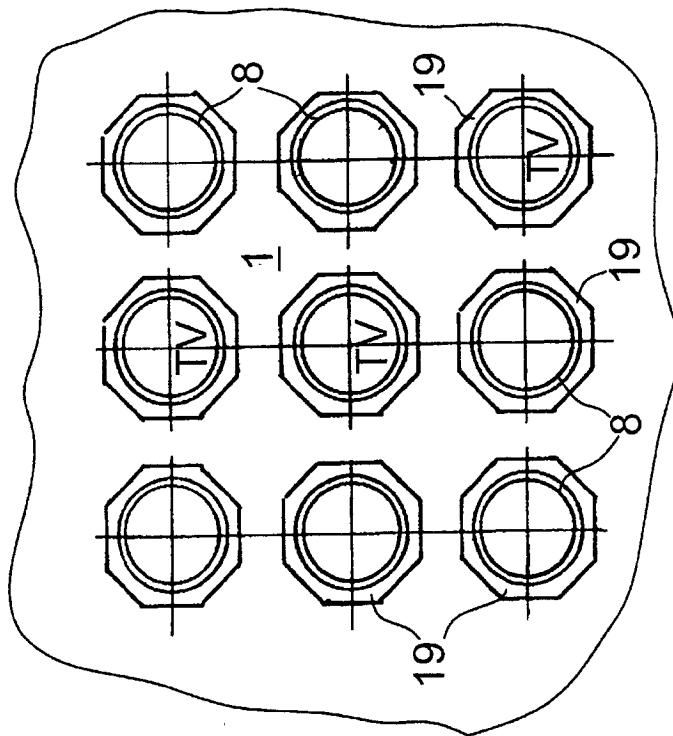


Fig. 3