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(54) HEAT EXCHANGE ELEMENT

(57) A heat exchange element (4',4",4‴), suitable for carrying out a heat exchange between a first and a second fluid at different temperatures, comprising a heat exchange apparatus provided with a tube bundle (8) comprising a plurality of tubes (20) traversed internally by said first fluid, containment means (12) of said second fluid, suitable for receiving said heat exchange apparatus so that at least one portion of said tube bundle (8) is externally lapped by said second fluid. The heat exchange apparatus comprises at least one manifold (28) having a side wall (32) delimiting a cavity (36) fluidically connected to said tubes (20) of the tube bundle (8), at the connection ends (40) of said tubes (20). The manifold (28) extends along a main horizontal direction (X-X), wherein said connection ends (40) penetrate at least partially inside said cavity (36) along a cantilevered portion (44). Advantageously, the heat exchange element (4',4'',4‴) comprises at least two manifolds (28',28'') which are contiguous along said main horizontal direction (X-X), connected to each other by means of at least one connecting and centering disc (56) having the shape of a circular crown, wherein the height (H) thereof, defined as the difference between an outer radius (Re) and an inner radius (Ri), is greater than a thickness (S) of the side wall (32) of said manifolds (28), so as to ensure a support between a leading perimeter edge (60) of each manifold (28',28'') and a corresponding front face (64) of the connecting and centering disc (56).

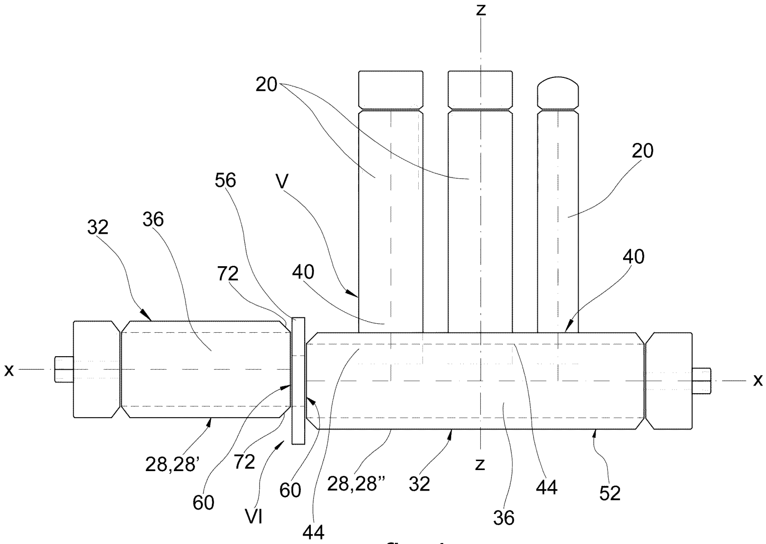

fig.4

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Description

[0001] The present invention relates to a heat exchange element suitable for achieving the exchange of heat between at least two fluids at different temperatures.

[0002] The exchange elements are typically used to transfer the energy inherent to a flow of hot gases, i.e., at a higher temperature, normally originating from an industrial process, to a cold fluid, i.e., at a lower temperature, which circulates within those heat exchange elements that comprise the plants.

[0003] In particular, gases from industrial waste combustion plants are often used as a flow of hot gases.

[0004] Usually, in such plants, the cooling fluid contained inside the elements is a sub-cooled liquid, two-phase saturated liquid-saturated steam mixture, or superheated steam, in a pressure range generally between 10 and 80 bar and in a temperature range between 120°C and 500°C. Such cooling fluid travels through the plant tubes and manifolds at relatively low velocities.

[0005] On the other hand, the hot gases have a temperature that is usually variable between about 100°C and 1300°C and, insofar as they originate from industrial processes for the combustion of municipal and/or industrial waste, they contain ash that is diffused within their mass, typically between 0.5 gr/Nm^3 and 20 g/Nm^3.

[0006] In the heat exchange elements it is known to provide a tube bundle that is simultaneously traversed internally by a first lower-temperature fluid, called the cooling fluid, and lapped externally by a second higher-temperature fluid, typically a gas.

[0007] The tube bundle is usually fluidically connected to at least one manifold, consisting of one or more hollow portions suitably aligned and connected to each other, in order to ensure a fluid connection between the various components. If continuity flaps are arranged between the tubes of the bundle that are connected to the same manifold, said bundle is more properly a membrane wall.

[0008] The connection between the tubes and the manifold portions, as well as between the various manifold portions, is a rather critical point.

[0009] In fact, on the one hand, the ends of the tubes, typically having a circular cross-section, must be connected by means of welding at special holes obtained on the cylindrical side wall of the manifold.

[0010] Such a weld is a critical element for various reasons:

the geometries that are in contact with each other, of the manifold and of the tubes, are complex and nonplanar,
the tubes have a relatively small cross-section,
the welds must be properly executed and must withstand critical working conditions due to the temperatures and pressures of the gases that continuously lap them from the outside. Furthermore, said gases also carry ash which contributes to the mechanical and chemical wear of the metal parts with which they come into contact.

[0011] Furthermore, the liquid flowing in the manifolds and tubes of said heat exchange elements does not have a constant flow but rather a pulsating flow, due to combustion. Such fluid flow pressure oscillations constitute heavy working conditions for the tubes, manifolds, and relevant welds.

[0012] Furthermore, the welds are a slow and delicate step in the construction of the exchange element that considerably slows down the commissioning step and that also requires some precision in the solutions of the prior art involving butt welds.

[0013] Furthermore, the manifolds are formed by welding together several hollow portions, arranged perpendicular to said tubes, which must be aligned beforehand and then welded.

[0014] This alignment step must also be particularly precise insofar as the welds must be properly made, and the tubes and manifolds are very extensive despite having thin walls.

[0015] Such need to achieve a precise prior alignment contributes to an increase in the time and costs for constructing heat exchange elements.

[0016] The object of the present invention is to provide a heat exchange element capable of solving the problems mentioned with reference to the prior art.

[0017] Such object is achieved by a heat exchange element according to claim 1.

[0018] Further features and advantages of the heat exchange element according to the present invention will be apparent from the description provided hereinafter of a non-limiting exemplary embodiment of such element, wherein:

Fig. 1 is a side view of a heat exchange element according to one embodiment of the present invention;

Fig. 2-3 are perspective views of details of the tube bundle and the manifold of the heat exchange element of Fig. 1;

Fig. 4 is a side view of the tube bundle and the manifold of the heat exchange element in Fig. 1;

Fig. 5 is a cross-sectional view of the detail V of Fig. 4;

Fig. 6 is a cross-sectional view of the detail VI of Fig. 4.

[0019] With reference to the accompanying figures, 4', 4'', 4" ' are used to globally denote a heat exchange element, suitable for implementing an exchange of heat between a first and a second fluid at different temperatures.

[0020] In particular, 4' denotes a vaporizer heat exchange bench or membrane wall, 4" denotes a superheater heat exchange bench, and 4‴ denotes an economizer heat exchange bench.

[0021] The definitions of a vaporizer or membrane wall, superheater, and economizer heat exchange bench apply depending upon whether the fluid flowing through the tube bundle is a two-phase saturated liquid-saturated steam mixture, superheated steam, or subcooled liquid, respectively.

[0022] Elements or parts of elements common to the embodiments described hereinafter will be indicated with the same numerical references.

[0023] The heat exchange element 4 may comprise a heat exchange apparatus provided with a tube bundle 8, suitable for being traversed internally by said first fluid, support means 12 of the tube bundle 8 to the heat exchange apparatus, containment means 16 of said second fluid suitable for accommodating said exchange apparatus in such a way that at least one portion of said tube bundle 8 is externally lapped by said second fluid.

[0024] According to a possible embodiment, said tube bundle 8 preferably extends along a main vertical direction Z.

[0025] Preferably, said main direction Z is substantially perpendicular to a support plane P on which said element rests.

[0026] The tube bundle 8 comprises a plurality of tubes 20 parallel with each other, which according to a possible embodiment extend substantially in a vertical direction, i.e., perpendicular to said support plane P of the element and parallel to said main vertical direction Z.

[0027] The tubes of the tube bundle 8 are suitable for being traversed internally by a first fluid such as for example a subcooled liquid (economizer bench) or a two-phase saturated liquid-saturated steam mixture (vaporizer bench) or superheated steam (superheater bench), having a temperature which is indicatively comprised, in the normal fields of use of thermal elements, between 120°C and 500°C and a pressure of between 10 bar and 80 bar.

[0028] Said tubes 20 are preferably made of metal materials, which are able to ensure the mechanical and thermal resistance of the tubes at normal operating conditions, as well as an adequate heat exchange coefficient, without however requiring excessive wall thicknesses of the tubes, in order not to overburden the structure of the bundle.

[0029] Advantageously, at a connection portion 24 of the tube bundle 8, said exchange apparatus comprises at least one manifold 28 fluidically connected to said tube bundle 8.

[0030] The at least one manifold comprises an inlet that is suitable for receiving and conveying the first fluid inside said manifold.

[0031] Each manifold is fluidically connected to a plurality of tubes 20 of the tube bundle 8 so as to be able to distribute a fluid within said tubes 20 through said inlets.

[0032] The fluid circulates within the tubes 20 of the tube bundle 8 so as to enter through at least one inlet and exit through at least one outlet.

[0033] According to a possible embodiment, the tubes 20 of the tube bundle 8 extend according to a coil along said main direction Z.

[0034] For example, said tube bundle 8 extends at least in part according to a broken line which forms a series of angles alternately protruding and re-entering.

[0035] The described thermal exchange elements 4,4',4",4‴ are used in any type of partial or total recovery plants, in other words they are heat exchange devices, or heat exchangers or heat transformers, that are suitable for using the residual thermal content of a fluid discharged from a plant of any type.

[0036] They are advantageously used in waste incineration plants, wherein the fumes produced by the incinerator furnace constitute the 'hot' fluid, in other words the second fluid having a residual thermal content to be recovered, transferring it to the first lower-temperature fluid, called the cooling fluid.

[0037] The combustion gases originating from the thermo-destruction of waste are rich in toxic or polluting dust and must therefore, in order to be released into the atmosphere, be purified.

[0038] Purifying filters may not normally filter such gases at high temperatures, insofar as at such temperatures the toxic substances contained within the gases are extremely corrosive to the point of rapidly deteriorating said filters.

[0039] In such types of plants, the heat exchange elements described above are particularly advantageous.

[0040] In fact, in such incineration plants the fumes produced as a result of the incineration of waste are conveyed according to a predetermined fume path, through the containment means, for example using suitably insulated ducting systems in order to limit heat loss.

[0041] Advantageously, the heat exchange elements disclosed in the present invention are arranged along said path.

[0042] The conveyor systems preferably extend according to a horizontal direction, i.e. parallel to the support plane or base of the plant, while the heat exchange elements 4 extend according to a vertical direction, i.e. perpendicular to the horizontal direction to the support plane P of the plant.

[0043] Such heat exchange elements 4 therefore allow for the exchange of heat between the combustion fumes and a cooling fluid which flows, by means of natural or forced circulation, inside the tube bundle 8.

[0044] Preferably, the tubes 20 of the tube bundle 8 are cylindrical with a circular cross-section; preferably said tubes 20 have an axis of symmetry parallel to said main vertical direction Z-Z. Preferably, the outer radius Re of the connecting and centering disc 56 is greater than an outer radius of said cylindrical tubes 20 with a circular cross-section of the tube bundle 8.

[0045] Advantageously, the first fluid or cooling fluid used consists of water in different physical states, and in particular in the form of a saturated liquid-saturated steam mixture, superheated steam, or subcooled liquid, according to whether these are vaporizer 4', superheater 4'' or economizer 4" ' elements, respectively.

[0046] The first fluid circulating inside the tube bundle, as a result of the heat exchange, increases in temperature and may therefore be conveyed for various uses, for example as a driving fluid in steam turbine plants or to power a thermal utility.

[0047] In particular, the manifold 28 comprises a side wall 32 delimiting a cavity 36 fluidically connected to said tubes 20 of the tube bundle 8, at the connection ends 40 of said tubes 20.

[0048] The manifold extends along a main horizontal direction X-X perpendicular to said main vertical direction Z-Z.

[0049] Preferably, said manifold 28 is cylindrical with a circular cross-section; preferably, the manifold 28 has an axis of symmetry parallel to said main horizontal direction X-X.

[0050] Preferably, said at least two manifolds 28',28" have respective axes of symmetry that are parallel to said main horizontal direction X-X and offset from each other.

[0051] Advantageously, said connection ends 40 of the tubes 20 at least partially penetrate inside said cavity along a cantilevered portion 44.

[0052] For example, said cantilevered portion 44 has an extension, along the main vertical direction Z-Z, less than a thickness S of said side wall 32 of the manifold 28.

[0053] For example, said cantilevered portion 44 has an extension, along the main vertical direction Z-Z, of between 10% and 90% of the thickness S of said side wall 32 of the manifold 28.

[0054] According to one embodiment of the present invention, said connection ends 40 are welded on the side wall 32 of the manifold 28 by means of a partial penetration weld 48, starting from an outer side 52 of said side wall 32 of the manifold 28.

[0055] For example, said partial penetration weld 48 extends, from the outer side 52 of said side wall 32 of the manifold 28, for a portion T of between 10% and 90% of the thickness S of said side wall 32 of the manifold 28.

[0056] Advantageously, said heat exchange element 4 comprises at least two contiguous manifolds 28',28'' along said main horizontal direction X-X, connected to each other by at least one connecting and centering disc 56 having the shape of a circular crown, wherein the height H thereof, defined as the difference between an outer radius Re and an inner radius Ri, is greater than a thickness S of the side wall 32 of said manifolds 28',28'', in such a way as to ensure a support between a leading perimeter edge 60 of each manifold 28 and a corresponding front face 64 of the connecting and centering disc 56.

[0057] According to one embodiment of the present invention, the height of the connecting and centering disc 56 is at least 10% higher than said side wall 32 thickness S of each of the manifolds 28',28''.

[0058] According to one embodiment of the present invention, the connecting and centering disc 56 is fixed to each manifold 28',28'' by a butt weld 68 between the leading perimeter edge 60 and the corresponding front face 64 of the connecting and centering disc 56.

[0059] Preferably, said butt weld forms the hermetic seal of the joint between each manifold 28',28'' and the connecting and centering disc 56. In other words, the butt weld achieves both the mechanical connection and the hermetic seal between the manifolds and the connecting and centering disc 56.

[0060] According to one embodiment of the present invention, the front faces 64 of the connecting and centering disc 56 are flat and the leading perimeter edge 60 of each manifold 28', 28'' has a flaring 72 converging towards the connecting and centering disc 56.

[0061] For example, said flaring 72 extends in such a way as to involve the entire thickness S of the side wall 32 of the manifold 28.

[0062] As may be seen from the above description, the heat exchange elements according to the invention allow the drawbacks presented within heat exchange elements of the prior art to be overcome.

[0063] In particular, the adoption of manifolds having a smaller diameter than normally implemented (due to the constraints required by the EN by formula standard) also allows, in addition to a lower manifold production cost, for a lesser ash accumulation surface area on said manifolds.

[0064] The use of a wall tube-manifold type of joint by means of a partial penetration-type welding method allows for a significant reduction in construction time insofar as the partial penetration allows the same to be adjusted thereby completely eliminating problems associated with cutting the tube in order to make the length uniform.

[0065] Furthermore, by virtue of said partial penetration, a lesser preparation of the surface of the manifold to be welded is required.

[0066] Such partial penetration of the tube inside the manifold also allows the fluid pulsation phenomena, which are normally present in the water-steam circuit of a naturally circulating boiler, to be attenuated, thereby favoring better distribution and homogenization of the flow of the wall tubes constituting the chamber.

[0067] Furthermore, the reduction in pressure oscillations reduces the mechanical stresses on the walls and welds of the tubes and manifold.

[0068] The use of a perforated connecting and centering disc, between one manifold and the next, allows the adjustment thereof in order to compensate for any misalignments without intervening directly upon the manifold, thereby significantly reducing the working time during the placement of the work and without interfering with the normal natural circulation of the fluid inside the same.

[0069] A person skilled in the art, in order to satisfy contingent and specific needs, may make numerous modifications and variations to the heat exchange elements described above.

[0070] The scope of protection of the invention is defined by the following claims.

List of references

[0071]

4: heat exchange elements
8: tube bundle
12: support means
16: containment means
20: tubes
24: connection portion
28: manifold
32: side wall
36: cavities
40: connection end
44: cantilevered portion
48: partial penetration welding
52: outer side
56: connecting and centering disc
60: leading perimeter edge
64: front wall
68: butt weld
72: flaring
Z-Z: main vertical direction
X-X: main horizontal direction
P: support plane
S: thickness
T: portion
H: height
Re: outer radius
Ri: inner radius

Claims

1. Heat exchange element (4',4",4‴), suitable for carrying out a heat exchange between a first and a second fluid at different temperatures, comprising a heat exchange apparatus provided with a tube bundle (8) comprising a plurality of tubes (20) traversed internally by said first fluid and extending along a main vertical direction (Z-Z), containment means (12) for containing said second fluid, suitable for receiving said heat exchange apparatus so that at least one portion of said tube bundle (8) is externally lapped by said second fluid,

   wherein said heat exchange apparatus comprises at least one manifold (28) having a side wall (32) delimiting a cavity (36) fluidically connected to said tubes (20) of the tube bundle (8), at the connection end (40) of said tubes (20), the manifold (28) extending along a main horizontal direction (X-X) perpendicular to said main vertical direction (Z-Z),
   wherein said connection ends (40) penetrate at least partially inside said cavity (36) along a cantilevered portion (44),
   wherein said heat exchange element (4',4'',4‴) comprises at least two manifolds (28',28'') which are contiguous along said main horizontal direction (X-X), connected to each other by means of at least one connecting and centering disc (56) having the shape of a circular crown wherein the height (H) thereof, defined as a difference between an outer radius (Re) and an inner radius (Ri), is greater than a thickness (S) of the side wall (32) of said manifolds (28), so as to ensure a support between a leading perimeter edge (60) of each manifold (28' ,28'') and a corresponding front face (64) of the connecting and centering disc (56).

2. Heat exchange element (4',4",4‴) according to claim 1, wherein the height (H) of the connecting and centering disc (56) is at least 10% higher than said thickness (S) of the side wall (32) of each of the manifolds (28',28'').

3. Heat exchange element (4',4'',4''') according to claim 1 or 2, wherein the connecting and centering disc (56) is fixed to each manifold (28',28'') by means of a butt weld (68) between the leading perimeter edge (60) and the corresponding front face (64) of the connecting and centering disc (56).

4. Heat exchange element (4',4'',4''') according to claim 3, wherein the front faces (64) of the connecting and centering disc (56) are flat and the leading perimeter edge (60) of each manifold (28',28") has a flaring (72) converging towards the connecting and centering disc (56).

5. Heat exchange element (4',4",4‴) according to claim 4, wherein said flaring (72) extends so as to affect the entire thickness (S) of the side wall (32) of the manifold (28).

6. Heat exchange element (4',4",4‴) according to claims 3, 4 or 5, wherein said butt weld achieves the hermetic seal of the joint between each manifold (28',28'') and the connecting and centering disc (56).

7. Heat exchange element (4',4",4‴) according to any one of claims 1 to 6, wherein said at least two manifolds (28' ,28'') have respective axes of symmetry that are parallel to said main horizontal direction (X-X) and offset from each other.

8. Heat exchange element (4',4'', 4''') according to any one of claims 1 to 7, wherein the tubes (20) of the tube bundle (8) are cylindrical with a circular cross-section, and wherein the outer radius (Re) of the connecting and centering disc (56) is greater than the outer radius of said cylindrical tubes (20) with a

circular cross-section of the tube bundle (8).

9. Heat exchange element (4',4",4‴) according to any one of claims 1 to 8, wherein said tubes (20) have an axis of symmetry parallel to said main vertical direction (Z-Z) .

10. Heat exchange element (4',4",4‴) according to any one of claims 1 to 9, wherein said manifold (28) is cylindrical with a circular cross-section.

11. Heat exchange element (4',4",4‴) according to any one of claims 1 to 10, wherein said cantilevered portion (44) has an extension, along the main vertical direction (Z-Z), less than a thickness (S) of said side wall (32) of the manifold (28).

12. Heat exchange element (4',4",4‴) according to any one of claims 1 to 11, wherein said cantilevered portion (44) has an extension, along the main vertical direction (Z-Z), comprised between 10% and 90% of the thickness (S) of said side wall (32) of the manifold (28).

13. Heat exchange element (4',4",4‴) according to any one of claims 1 to 12, wherein said connection ends (40) are welded on the side wall (32) by means of a partial penetration weld (48), starting from an outer side (52) of said side wall (32) of the manifold (28).

14. Heat exchange element (4',4",4‴) according to claim 13, wherein said partial penetration weld (48) extends, from the outer side (52) of said side wall (32) of the manifold (28), for a portion comprised between 10% and 90% of the thickness (S) of said side wall (32) of the manifold (28).

15. Steam production plant comprising a heat exchange element (4',4",4‴) according to any one of claims 1 to 14.

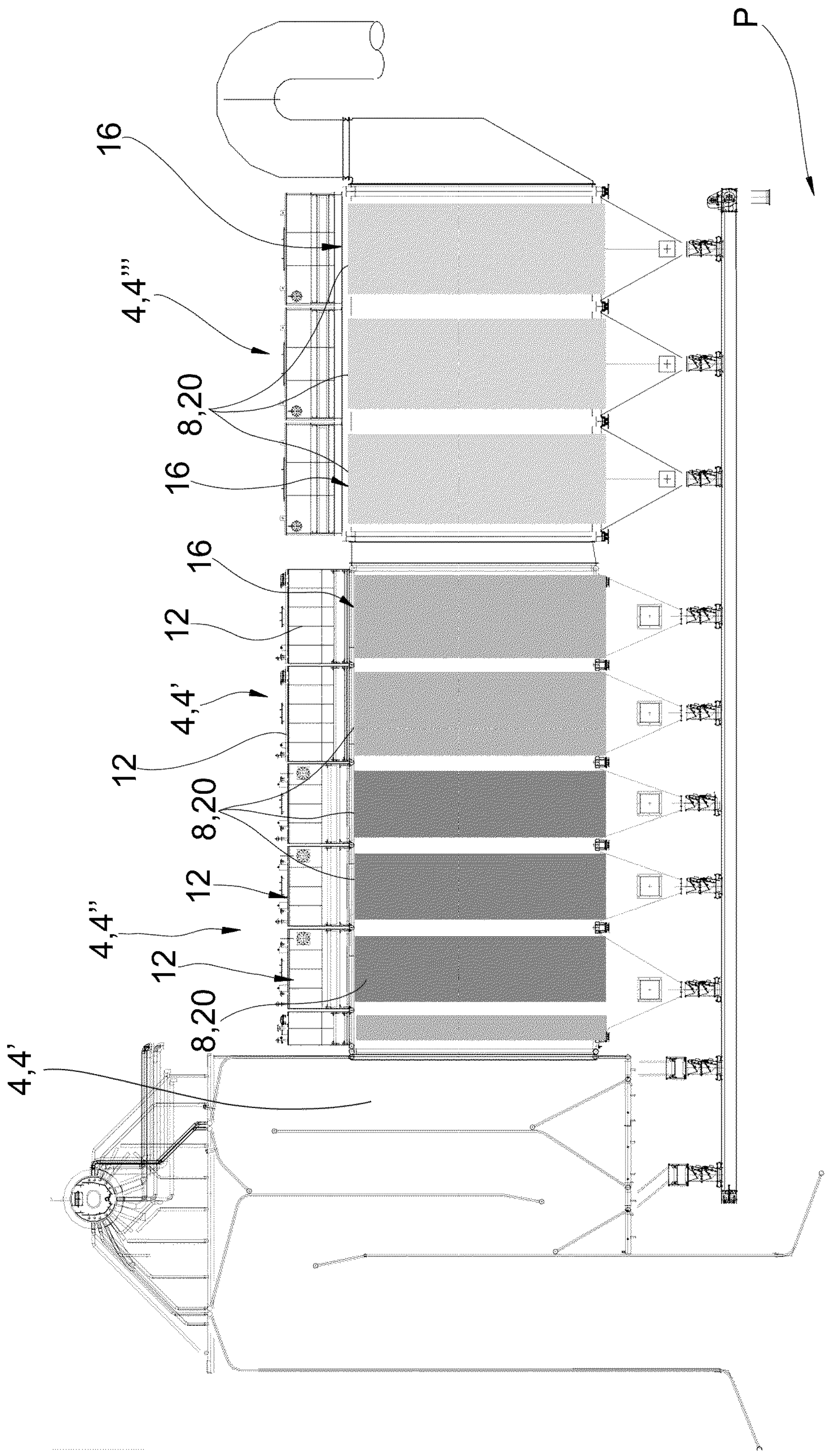

fig.1

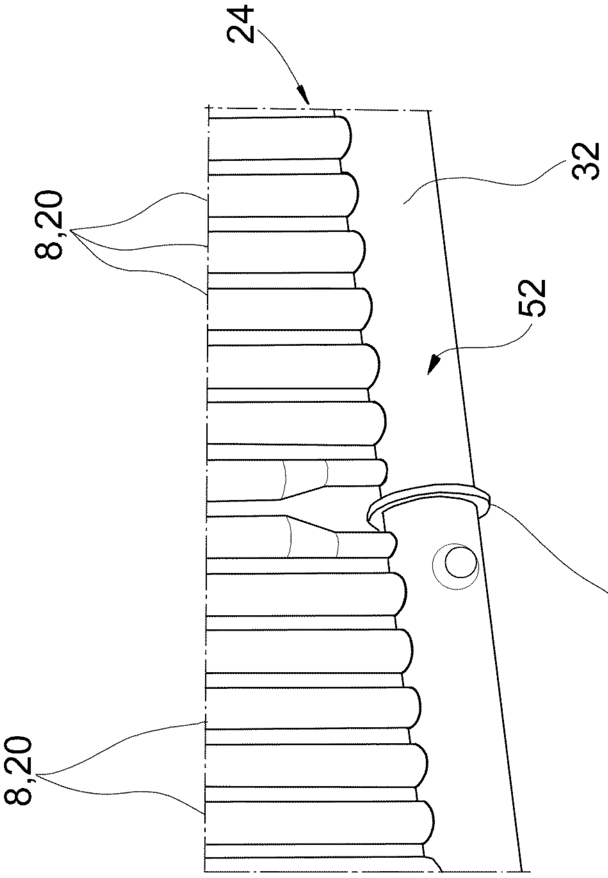

fig.3

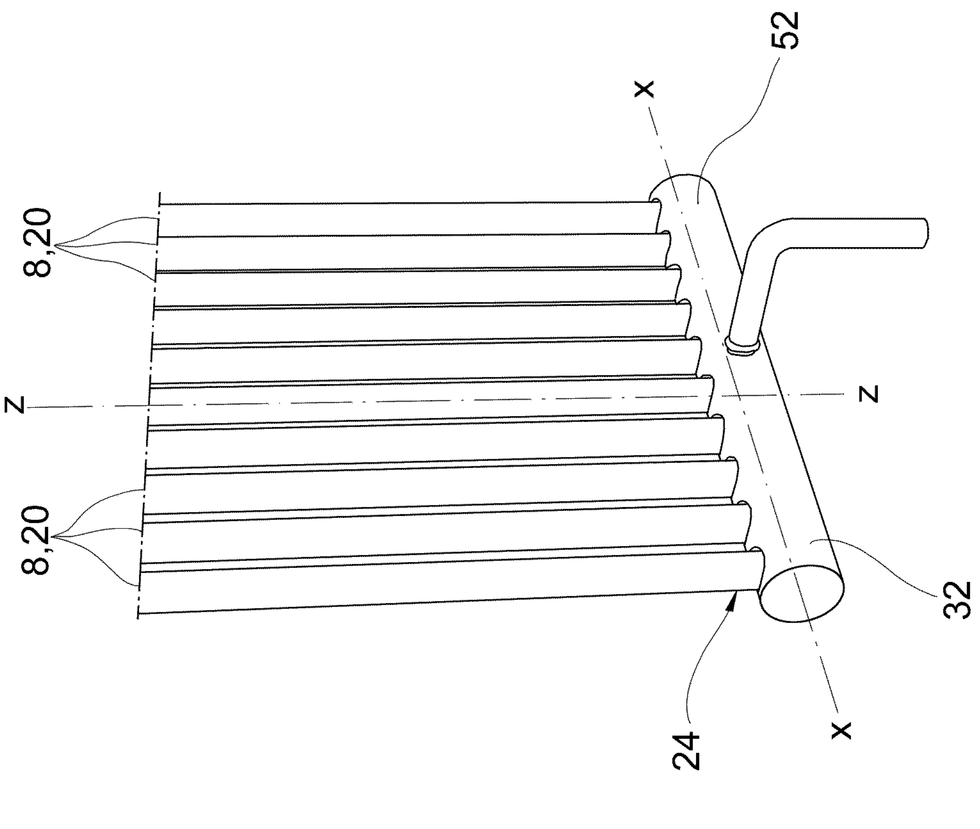

fig.2

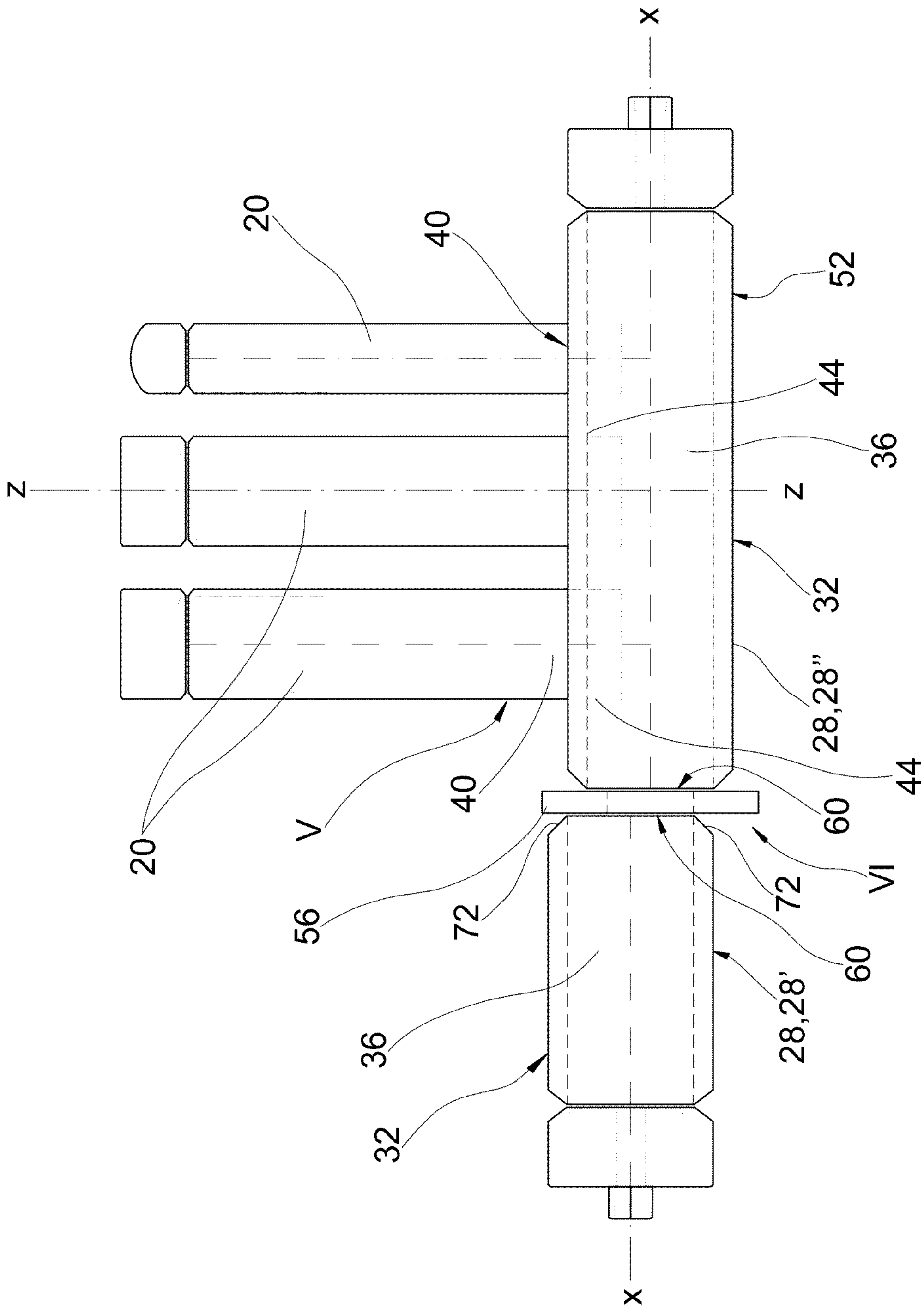

fig.4

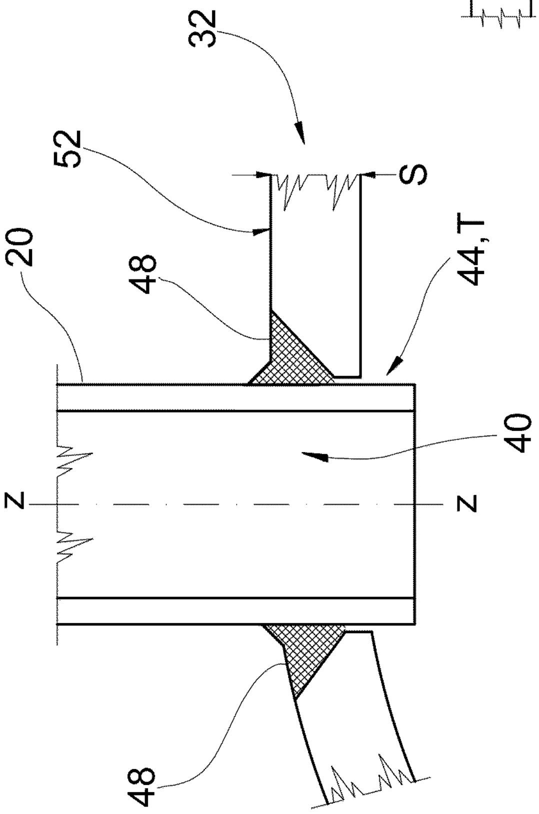

fig.5

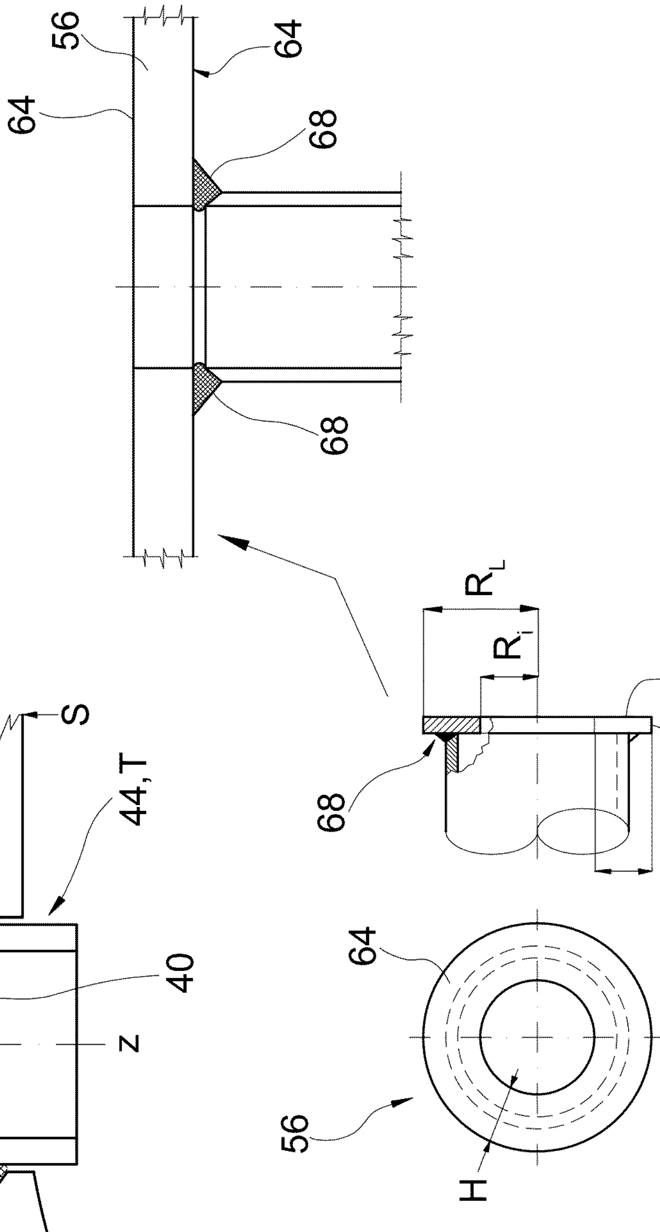

fig.6

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EUROPEAN SEARCH REPORT

Application Number
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TECHNICAL FIELDS SEARCHED (IPC)
F28D
F28F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	13 March 2025	Bloch, Gregor

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