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(72) Inventor: **Nielsen, Anders Busk**
9000 Aalborg (DK)

(74) Representative: **von Friesendorff, Filip et al**
Alfa Laval Corporate AB
P.O. Box 73
221 00 Lund (SE)

(71) Applicant: **Aalborg Industries A/S**
9100 Aalborg (DK)

(54) **Boiler or heater elements and configurations for pressurized gasses, such as flue gasses**

(57) The present invention relates to a boiler element for pressurized gasses comprising an outer casing (2) surrounding one or more inner tubular elements (3), said casing (2) being provided with an inlet (6) and an outlet (7), such that a medium can flow from said inlet (6) to said outlet (7) substantially along the one or more inner tubular elements (3), and where said one or more inner tubular elements (3) are provided with an inlet (8) and an outlet (9), such that a medium can flow through the one

or more inner tubular elements (3) from the inlet (8) to the outlet (9) of the one or more inner tubular elements, wherein one or more of the surfaces of the casing (2) and/or the inner tubular elements (3) that transfer heat to or from surrounding media are provided with surface extending means. The invention relates furthermore to a composite boiler comprising at least two of the boiler elements according to the invention and to systems, in which such boiler elements and/or composite boilers are used.

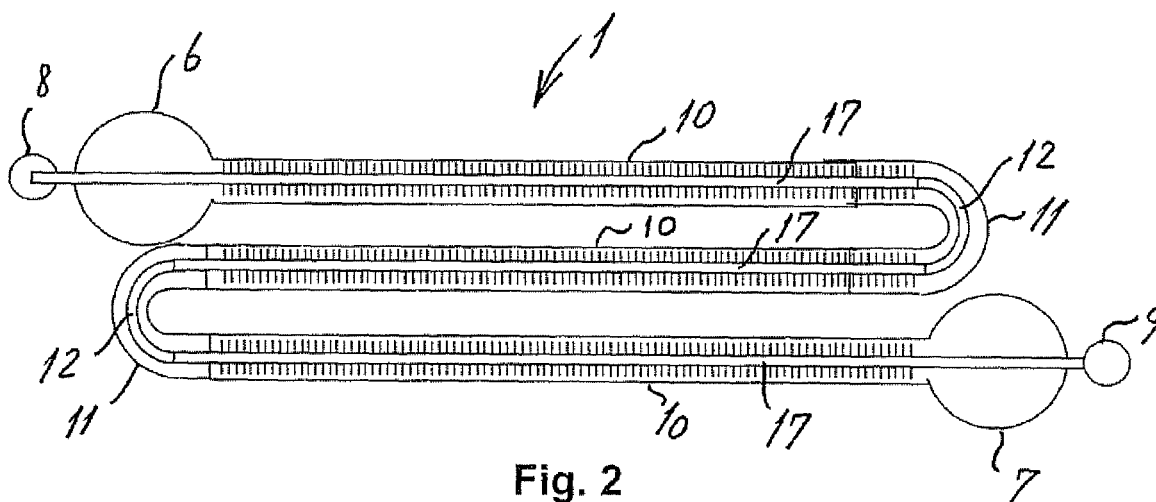


Fig. 2

Description

TECHNICAL FIELD

[0001] The present invention relates generally to boilers or heaters and specifically to waste heat recovery in energy plants and after engines or turbines and still more specifically to improved boilers or heaters that are capable to withstand the excess pressure exerted by pressurized gasses provided to such boilers or heaters.

BACKGROUND OF THE INVENTION

[0002] In order to improve waste heat recovery in energy plants, devices such as boilers or heaters comprising heating surfaces for pressurized waste heat media, such as flue gas from an engine or hot air, have gained increased importance. One of the challenges caused by pressurized hot gasses is that the boiler or heater elements require a particularly strong design of the casing of the boiler or heater element in order to withstand the internal excess pressure exerted on the relatively large surfaces of traditional boiler or heater casings.

[0003] Typically, in traditional boilers or heaters, the casing comprises a large number of internal steam/water tubes leading to large dimensions and a corresponding large surface area of the surrounding casing. It would hence be advantageous in order to reduce the required strength and hence the weight of the casing to optimise the casing with respect to the internal steam/water tubes housed within the casing.

SUMMARY OF THE INVENTION

[0004] On the above background it is an object of the present invention to provide new and improved boiler or heater elements and boiler or heater configurations for pressurized exhaust gasses, such as flue gasses. The boiler or heater elements according to the invention will in the following description and claims collectively be termed "boiler elements". It is specifically an object of the present invention to provide boiler elements for pressurized gas that reduce the requirements of said particularly strong design of the casing. A fundamental idea behind the invention is to provide each or a very limited number of individual inner tubular elements with its/their own casing instead of, as is customary in the prior art, to provide one casing for a large number of inner tubular elements, whereby the surface area of the casing becomes very large. Providing each or a few individual inner tubular element with its/their own casing, where the cross sectional shape corresponds to that of the inner tubular element(s), the smallest possible surface area of the casing can be obtained. If, according a specific embodiment of the invention, a few, for instance two, inner tubular elements are provided with a common casing, the cross sectional shape of the casing is adapted to the inner tubular elements, i.e. envelops the outer surface of the in-

ner tubular elements as closely as possible. Both this specific embodiment and embodiments of the invention, wherein each individual inner tubular element is provided with its own casing are described in the detailed description of the invention.

[0005] According to preferred embodiments of the invention there is provided more than one casing for a number of inner tubular elements and according to specific embodiments of the invention there is provided a casing for each individual inner tubular element.

[0006] The above and other objects and advantages are according to the present invention provided by a boiler or heater element for pressurized gasses comprising an outer casing surrounding one or more inner tubular elements, the casing being provided with an inlet and an outlet, such that a medium can flow from said inlet to said outlet in thermal contact with the one or more inner tubular elements, and where the one or more inner tubular elements are provided with an inlet and an outlet, such that a medium can flow through the one or more inner tubular elements from the inlet to the outlet of the one or more inner tubular elements, and wherein the surface area of the casing is minimised by adapting the cross sectional shape of the casing to the one or more inner tubular elements, such that there is provided a fluid passage between the inner surface of the casing and the outer surface(s) of the one or more inner tubular elements, where the cross sectional area of the passage is chosen such that a required maximum pressure drop ΔP over the boiler or heater element and/or a required flow speed of fluid through the passage is obtained.

[0007] The above and other objects are according to preferred embodiments of the present invention obtained by the provision of a boiler element, wherein one or more of those surfaces that transfer heat to or from surrounding media are provided with surface extending means. By the provision of such means, the volume of the casing surrounding the hot gas, and hence the surface area of the casing, is reduced as much as possible without thereby negatively affecting the pressure drop across a boiler element and/or the flow speed through the boiler element and thereby the heat transfer between the media flowing in the boiler element. Embodiments of the invention that obtain this objective are described in the detailed description of the invention.

[0008] According to the invention there is provided a boiler element (that could be tubular, although other cross-sectional shapes would also be possible, and hence such terms as "tube" and "tubular" as used in the following are not restricted to a passageway of circular cross-sectional shape) comprising at least one inner tube provided in an outer casing. The one or more inner tubes are according to embodiments of the invention provided with extended surface, thereby extending the heating surface of the one or more inner tubes, i.e. the outer surface of the one or more inner tubes. This extended surface may change form and/size from the inlet to the outlet of the casing of the boiler element. Specific, non-

limiting, embodiments of tubes with extended surface are shown in the detailed description of the invention.

[0009] According to the invention the boiler element may comprise means for providing an extended outer surface of the casing. Generally all heat transfer surfaces on the boiler elements according to the invention can be provided with surface extending means and these means may differ for different surfaces for instance determined by specific heat transfer requirements or by the specific geometrical configuration of the parts constituting the boiler element.

[0010] According to a first aspect of the present invention there is provided a boiler on heater element for pressurized gasses, such as, but not limited to, flue gasses, comprising an outer casing surrounding one or more inner tubular elements, the casing being provided with an inlet and an outlet, such that a medium can flow from the inlet to the outlet in thermal contact with the one or more inner tubular elements, and where said one or more inner tubular elements are provided with an inlet and an outlet, such that a medium can flow through the one or more inner tubular elements from the inlet to the outlet of the one or more inner tubular elements, and wherein one or more of the surfaces of the casing and/or the inner tubular elements that transfer heat to or from a medium in thermal contact with said one or more surfaces are provided with surface extending means.

[0011] According to an embodiment of the invention the medium flowing from the inlet to the outlet of the casing flows substantially along (in parallel with) the one or more inner tubular elements.

[0012] According to an alternative embodiment of the invention the medium flowing from the inlet to the outlet of the casing flows substantially perpendicular to the one or more inner tubular elements.

[0013] According to a preferred embodiment of the invention the boiler element comprises a casing accommodating only a single inner tubular member, whereby the boiler element of the invention can be made very compact with minimum surface area of the casing.

[0014] According to the preferred embodiment of the invention the casing and the inner tubular element are both circular cylindrical in cross section and form a coaxial structure of the boiler element, but it is understood that also other cross sectional shapes of the casing or the one or more inner tubular elements will fall within the scope of the present invention.

[0015] According to an embodiment of the invention said one or more inner tubular elements on their inner circumferential surface are provided with means for extending the area of said inner circumferential surface of the one or more inner tubular elements.

[0016] According to an embodiment of the invention, the means for extending the outer circumferential surface are a plurality of pins or fins or other radially extending elements provided on the outer circumferential surface of the one or more inner tubular elements.

[0017] According to an alternative embodiment of the

invention, the means for extending the outer circumferential surface are provided by a corrugation that may for instance be circular or helically wound of the outer circumferential surface of the one or more inner tubular elements.

[0018] According to a further embodiment of the invention the means for extending the inner circumferential surface are provided by a corrugation that may for instance be circular or helically wound of the inner circumferential surface of the one or more inner tubular elements.

[0019] According to an embodiment of the invention a combination of means for extending both the inner and outer circumferential surface of the inner tubular means is provided.

[0020] According to an embodiment of the invention the boiler element may comprise a casing comprising a plurality of sections, where adjacent sections are connected via end elements, such that the boiler element attains for instance a S-shape or meander shape between respective inlet and outlet portions of the casing, and where each of said sections respectively surrounds one or more inner tubular elements, where the one or more inner tubular elements in a given section of the casing is connected to the one or more tubular elements in the adjacent section of the casing via end elements accommodated within corresponding end element of the casing.

[0021] According to a second aspect of the invention there is furthermore provided a composite boiler element comprising at least two boiler elements as described above, said at least two boiler elements being coupled in parallel between common inlet portions of the respective casings of the composite boiler element and common outlet portions of the respective casings of the composite boiler element. Similarly, the one or more inner tubular elements are coupled in parallel between common inlet portions and common outlet portions. In this manner, for instance a 3-dimensional structure of a composite boiler element can be constructed, comprising a plurality of boiler elements according to the invention, each located within a respective plane, such that the composite boiler element comprises a plurality of for instance substantially parallel planes of boiler elements. A non-limiting example of such a 3-dimensional structure will be given in the detailed description of the invention.

[0022] According to a third aspect the present invention relates to a system, in which one or more boiler elements and/or composite boiler elements are used.

[0023] An example of a system according to the invention for pressurized flue gasses with a larger pressure drop available than in traditional exhaust gas boilers will be exemplified by the system shown and described in the detailed description of the invention. It is however understood that the boiler elements according to the invention can find application in many other systems and devices, such as fuelled boilers and other units used for heat transmission.

[0024] According to a fourth aspect of the present invention there is provided a steam drum comprising boiler or heater elements according to the invention. A specific embodiment of such a steam drum will be described in the detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The present invention will be better understood by reading the following detailed description of embodiments of the invention in conjunction with the figures of the drawing, wherein:

Figure 1(a) shows a schematic longitudinal cross-sectional view of a boiler element according to an embodiment of the invention;

Figure 1(b) shows a cross-sectional view of a boiler element according to an embodiment of the invention;

Figure 2 shows a schematic longitudinal cross-sectional view of a boiler element according to an embodiment of the invention, wherein the boiler element is formed in an s-shape between inlet and outlet portions;

Figure 3 shows a schematic perspective view of an embodiment of a composite boiler element according to the invention comprising two parallel coupled boiler elements of the kind shown in figure 2 and comprising common inlet and outlet portions for the two boiler elements;

Figure 4 shows a partly transparent representation of the embodiment shown in figure 3, where the surface extending pins provided on the outer circumferential surface of the inner tubular elements can be seen;

Figure 5 shows a schematic perspective partly cut-away view of an inner tubular element with corrugated inner and outer surfaces for use in the boiler element of the invention;

Figure 6 shows a schematic cross-sectional view of a steam drum comprising a number of boiler elements according to the invention, wherein the outer surfaces of the boiler elements function as evaporator tubes producing saturated steam in the steam drum, which steam can subsequently as an option be directed to and flow through the inner tubular element of the boiler element for superheating the steam;

Figure 7 shows a cross-sectional view of a boiler element according to another embodiment comprising extensions of all surfaces contributing to heat

transfer with the object of increasing heat transfer to the medium that is in contact with the respective surface;

Figure 8 shows a schematic system, wherein the boiler element or composite boiler element functions under different operational conditions; and

Figure 9(a), (b) and (c) shows a non-limiting example of alternative embodiments boiler or heater elements according to the present invention

DETAILED DESCRIPTION OF THE INVENTION

[0026] The various aspects of the present invention will be illustrated below with reference to different non-limiting embodiments of the invention.

[0027] With reference to figure 1(a) there is shown a schematic longitudinal cross-sectional view of a boiler element according to an embodiment of the invention. The boiler element, which is generally designated by reference numeral 1, comprises an outer casing 2 surrounding an inner tubular element 3 that is provided with an extended outer surface in the form of a plurality of radially extending pins or fins 4, 5. A first medium M1 (for instance pressurized flue gas) flows longitudinally through the outer casing 2 as indicated by the arrow, and a second medium M2 (for instance water) flows longitudinally through the inner tubular element 3 as indicated by the arrow. It should be noted, as will also be apparent from the following description of specific embodiments of the invention, that the media M1 and M2 may in fact be the same type of medium 3 or even the same medium ($M1 = M2$), for instance the same pressurized flue gas in both cases

[0028] As shown in figure 1(b) the radial extension of the surface extension means 4, 5 may change in the longitudinal direction of the boiler element 1, for instance due to high temperature of the first medium M1 at the entrance of the boiler element, which may cause damage to long pins provided close to the entrance of the boiler element.

[0029] In figure 1(b) the same embodiment as in figure 1(a) is shown in cross sectional view. From figure 1(b) it appears that this specific embodiment of the boiler element according to the invention comprises a circular cylindrical outer casing 2, coaxially with which there is provided one inner circular cylindrical tubular element 3. Although this circular coaxial boiler element structure is used in the following to illustrate various embodiments of the invention it should be noted that both the outer casing 2 and the inner tubular element 3 can have other shapes without thereby departing from the present invention. Furthermore, although all of the shown embodiments of the invention are provided with only one inner tubular element 3 it falls within the scope of the invention to provide more than one inner tubular element within a single outer casing.

[0030] With reference to figure 2 there is shown a sche-

matic longitudinal cross-sectional view of a boiler element according to an embodiment of the invention, wherein the boiler element is formed in an S-shape between inlet and outlet portions. This embodiment of the boiler element comprises three substantively parallel sections 10 placed above each other, where adjacent sections are in fluid connection through bended end elements 11. According to an alternative embodiment the sections 10 may form an angle α between each other (this angle is in the embodiment shown in figure 2 equal to zero), such that the individual sections are not extending in parallel with each other but rather form a zigzag structure. The outer casing is provided with an inlet 6 and an outlet 7. Through the outer casing there extend longitudinally inner tubular elements 17 that follow the bended S-shape of the outer casing via end elements 12. The inner tubular element 17 is provided with an inlet 8 and an outlet 9. Although the respective inlets and outlets of the outer casing and of the inner tubular element in the shown embodiment are located at the same longitudinal end of the boiler element it is understood that alternatively an inlet of the outer casing and an outlet of the inner tubular element could be located at the same longitudinal end of the boiler element.

[0031] In figure 2 the inner tubular element is only provided with an extended outer surface at the portions of the inner tubular element that passes through the sections 10 of the outer casing. It would however also be possible to provide the bended end elements 12 of the inner tubular element 17 with an extended surface.

[0032] It is noted that the tension that results from a temperature difference between the outer casing and the inner tubular element is according to the invention reduced to a minimum as the outer casing can expand freely relative to the inner tubular element.

[0033] The embodiment of a boiler element according to the invention will typically be used as pre-heaters, evaporators and super-heaters, but the use of the boiler elements according to the invention — and specifically according to the above described embodiment — is in no way limited to such devices.

[0034] With reference to figure 3 there is shown a schematic perspective view of an embodiment of a composite boiler element according to the invention comprising two parallel coupled boiler elements 10, 13 of the kind shown in figure 2 and comprising common inlet or outlet portions 18, 20 and outlet or inlet portions 19, 21 for the two boiler elements 10, 13. Thus, the media flowing in the casing and in the one or more inner tubular elements may either flow in the same direction through the boiler element (termed "current flow") or in opposite directions (termed "counter flow").

[0035] The at least two boiler elements are coupled in parallel between common inlet portions 18 of the respective casings of the composite boiler element and common outlet portions 19 of the respective casings of the composite boiler element, and said one or more inner tubular elements 3 are coupled in parallel between common inlet

or outlet portions 20 and common outlet or inlet portions 21, whereby the composite boiler element can be constructed as a 3-dimensional structure comprising at least two boiler elements according to the invention, each located within a respective plane, such that the composite boiler element comprises a plurality of planes of boiler elements. The two boiler elements 10, 13 shown in the embodiment of a composite boiler element according to the invention that is illustrated in figure 3 are located in planes that extend substantially parallel to each other, but it would fall within the scope of the invention to incline the planes containing each respective boiler element relative to one another or to shift the respective boiler elements relative to one another within planes that are either extending substantially in parallel (as in figure 3) or are inclined relative to one another. Furthermore, although only two boiler elements according to the invention are shown in figure 3, the composite boiler element of the invention could comprise more than two such elements.

[0036] With reference to figure 4 there is shown a partly transparent representation of the embodiment shown in figure 3, where the surface extending pins 4 provided on the outer circumferential surface of the inner tubular elements 3 can be seen.

[0037] In the embodiments described above, the surface extending means have been pin or fin elements provided on the outer circumferential surface of the inner tubular element 3, 17. Other surface extending means could however also be applied without departing from the scope of the present invention.

[0038] With reference to figure 5 there is thus shown a schematic perspective partly cut-away view of an inner tubular element with corrugated outer surface 15 as the surface extending means for use in the boiler element of the invention. It furthermore appears from figure 5 that surface extending means 15 may also be provided on the inner surface of the inner tubular element. In the shown embodiment the outer and inner surfaces are extended by means of a helical corrugation of the tubular element, but other corrugation patterns could also be provided.

[0039] As the circumferential wall of the outer casing 2 of the boiler element according to the invention can be made of a material of high thermal conductivity it is possible to use the boiler element according to the present invention in the manner illustrated in figure 6. Figure 6 shows a schematic cross-sectional view of a steam drum 22 internally comprising a number of boiler elements 2 according to the invention, wherein the outer surfaces of the boiler elements function as evaporator tubes producing saturated steam in the steam drum, which steam can subsequently as an option be directed to and flow through the inner tubular elements 3 of the boiler element 2 for superheating the steam. The steam drum 22 is partly filled with water 23 and above the water surface, saturated steam 24 is present.

[0040] With reference to figure 7 there is shown a cross-sectional view of a boiler element according to an-

other embodiment of the invention, wherein all heat transferring surfaces both of the outer casing 2 and on the inner tubular member 3 are provided with surface extending means 4, 5, 25, 26 in order to increase heat transfer to respective media that are in contact with the respective surfaces.

[0041] Figure 8 illustrates in principle a possible use of the boiler element or composite boiler element according to the present invention in a waste heat recovery system

[0042] The system is generally subdivided in three zones: A high-pressure zone, receiving for instance pressurized flue gas 27, in which zone the pressure drop and the flow speed on the gas side of the boiler or heater elements 28, 29, 30 are limited to a level substantially corresponding to conventional values, in order to ensure a high gas pressure at the outlet 34 from the high-pressure zone. The second zone is the gas-pressure reducing zone that comprises devices 39, 40, 41 that extract energy among others by a reduction of gas-pressure and temperature from a high to a low gas-pressure. Across the second zone there is both a large pressure drop and the possibility of generating a very high flow speed on the gas side of the heater elements 35, 36, 37. Finally, there follows the low-pressure zone, located after the pressure-reducing devices in the second zone. In the low-pressure zone, conventional heaters 43, 44, 45, such as conventional waste heat recovery (WHR) boilers, can be applied. Typically, the highest pressure level (at the inlet 27 in figure 8) will be on the order 15 Bar absolute pressure and the pressure level at the outlet 47 of the low gas-pressure zone will be approximately 1 Bar absolute pressure. It is noted that the "inlets" and "outlets" 27, 34, 42 and 47 shown in figure 8 are to be understood symbolically and the configurations of connections between different pressure zones in actual implementations of such systems may be of a different and possibly more complex nature.

[0043] One or more of the high gas-pressure zone, the gas-pressure reducing zone and the low gas-pressure zone may comprise additional energy-converting means, in figure 8 symbolically indicated by reference numerals 32 and 33.

[0044] As it appears from the schematic representation in figure 8, each of the above mentioned zones comprises groups containing three boiler/heater elements (28, 29, 30 in the high-pressure zone; 35, 36, 37 in the pressure reducing zone; and 43, 44, 45 in the low pressure zone) that are coupled in series such that pressurized gas passes from the first group of the boiler/heater elements 28, 29, 30 via the second boiler/heater elements 35, 36, 37 to the third boiler/heater elements 43, 44, 45. The steam conduits of the respective boiler/heater elements are also coupled from one boiler/heater element to the next element of the respective group, such that water initially flows through a pre-heater (economizer) 30, 37, 45 to an evaporator/boiler 29, 36, 44 and finally to a super-heater 28, 35, 43 that delivers super-heated

high pressure steam at respective outlets 48, 49, 50 of the super-heaters 28, 35, 43. In figure 8, reference numerals 31, 38 and 46 indicates steam drums comprised in the above mentioned three groups of boiler/heater elements.

[0045] The system, illustrated schematically in figure 8, comprise in the pressure reducing zone a turbo charger 39, 40, and a power turbine 41. This system illustrates which new possibilities are provided when exhaust gas pressurised boilers are introduced in addition to a traditional waste heat recovery (WHR) system in which all heating surfaces are located on the non-pressurised side of the turbo charger 39, 40 and power turbine 41.

[0046] With reference to figures 9(a), (b) and (c) there are illustrated three non-limiting examples of alternative embodiments boiler or heater elements according to the present invention.

[0047] With reference to figure 9(a) there is shown boiler or heater element according to an embodiment of the invention comprising a casing 2 provided with an inlet 6 and an outlet 9, where the casing 2 surrounds an inner tubular element 3 comprised of one or more first sections 3' extending substantially parallel to a longitudinal axis X of the casing 2 and one or more second sections 3'' extending at an angle different from zero to the longitudinal axis X of the casing. In the specific embodiment shown in figure 9(a) said angle is substantially 90 degrees.

[0048] With reference to figure 9(b) there is shown boiler or heater element according to an embodiment of the invention, wherein the casing 2 comprises a number of surface sections 2', 2'', 2''' corresponding to the number of inner tubular elements 3, such that each individual of said subsections envelops a substantial portion of the outer circumferential surface of one of said inner tubular elements (3).

Claims

1. A boiler or heater element for pressurized gasses comprising an outer casing (2) surrounding one or more inner tubular elements (3), said casing (2) being provided with an inlet (6) and an outlet (7), such that a medium can flow from said inlet (6) to said outlet (7) in thermal contact with the one or more inner tubular elements (3), and where said one or more inner tubular elements (3) are provided with an inlet (8) and an outlet (9), such that a medium can flow through the one or more inner tubular elements (3) from the inlet (8) to the outlet (9) of the one or more inner tubular elements, wherein the surface area of the casing (2) is minimised by adapting the cross sectional shape of the casing (2) to the one or more inner tubular elements (3), such that there is provided a fluid passage (p) between the inner surface of the casing (2) and the outer surface(s) of the one or more inner tubular elements (3), where the

cross sectional area (S_p) of the passage (p) is chosen such that a desired maximum pressure drop (ΔP) over the boiler or heater element and/or a desired flow speed of fluid through the passage (p) is obtained.

2. A boiler or heater element according to claim 1, wherein one or more of the surfaces of the casing (2) and/or the inner tubular elements (3) that transfer heat to or from a medium in thermal contact with said one or more surfaces are provided with surface extending means (4, 5; 15, 16; 25, 26)
3. A boiler or heater element according to claim 2, wherein the medium flowing from the inlet (6) to the outlet (7) of the casing (2) flows substantially along (in parallel with) said one or more inner tubular elements (3).
4. A boiler or heater element according to claim 2, wherein the medium flowing from the inlet (6) to the outlet (7) of the casing (2) flows substantially perpendicular to the one or more inner tubular elements (3)
5. A boiler or heater element according to claim 2, wherein said casing (2) accommodates only a single inner tubular member (3), whereby the boiler element of the invention can be made compact and with minimum surface area of the casing (2).
6. A boiler or heater element according to claim 2, wherein the casing (2) and the inner tubular element (3) are both circular cylindrical in cross section and form a coaxial structure of the boiler element.
7. A boiler or heater element according to claim 2, wherein said one or more inner tubular elements (3) on their outer circumferential surface are provided with means (4, 5) for extending the area of said outer circumferential surface of the one or more inner tubular elements (3).
8. A boiler or heater element according to claim 2, wherein said one or more inner tubular elements (3) on their inner circumferential surface are provided with means (15) for extending the area of said inner circumferential surface of the one or more inner tubular elements (3).
9. A boiler or heater element according to claim 2, wherein said casing (2) on its inner circumferential surface is provided with means (25) for extending the area of said inner circumferential surface of the casing (2)
10. A boiler or heater element according to claim 2, wherein said casing (2) on its outer circumferential

surface is provided with means (26) for extending the area of said inner circumferential surface of the casing (2).

11. A boiler or heater element according to any of the preceding claims 2 to 10, wherein said means for extending the surface are a plurality of pins or fins (4, 5, 25, 26).
12. A boiler or heater element according to any of the preceding claims 2 to 10, wherein said means for extending the surface are provided by a corrugation (15, 16) of the surface.
13. A boiler or heater element according to any of the preceding claims, wherein said casing comprises a plurality of sections (10, 13), where adjacent sections are connected via end elements (11, 14), and where each of said sections (10, 13) respectively surrounds one or more inner tubular elements (17), where the one or more inner tubular elements (17) in a given section (10) of the casing is connected to the one or more tubular elements (17) in the adjacent section (10) of the casing via end elements (12) accommodated within the corresponding end element (11, 14) of the casing.
14. A boiler or heater element according to claim 13, wherein said sections (10, 13) are provided in a common plane and form an angle α between adjacent sections.
15. A boiler or heater element according to claim 14, wherein said angle is substantially equal to zero degrees, whereby the individual sections (10, 13) extend substantially in parallel to each other.
16. A composite boiler or heater element comprising at least two boiler elements (1) according to any of the preceding claims, said at least two boiler elements (1) being coupled in parallel between common inlet portions (18) of the respective casings of the composite boiler element and common outlet portions (19) of the respective casings of the composite boiler element, and said one or more inner tubular elements (3) are coupled in parallel between common inlet portions (20) and common outlet portions (21), whereby the composite boiler element can be constructed as a 3-dimensional structure comprising at least two of said boiler elements (1), each located within a respective plane, such that the composite boiler element comprises a plurality of planes of boiler elements (1).
17. A composite boiler or heater element according to claim 16, wherein said plurality of planes are substantially parallel.

18. A waste heat recovery system comprising a high-gas-pressure zone and a gas-pressure reducing zone wherein the high-gas-pressure zone receives gas, such as flue gas, under pressure at an inlet (27) and provides said gas at high pressure to an inlet (39) to a gas-pressure reduction zone such that the gas leaves the gas-pressure reducing zone at an outlet (42) hereof under significantly reduced gas-pressure, wherein said high-pressure zone and/or said gas-pressure reducing zone comprise one or more boiler or heater elements to any of the preceding claims 1 to 12 and/or composite boiler or heater elements according to claim 13 or 14, whereby waste heat is recovered from said boiler or heater elements in the high gas-pressure zone or in the gas-pressure reduction zone or in both of these zones.
19. A waste heat recovery system according to claim 18, wherein the system furthermore comprises a low-gas-pressure zone, receiving gas at low pressure from said outlet (42) of the gas-pressure reduction zone and provides the gas at low pressure at an outlet (47) of the low-gas-pressure zone
20. A waste heat recovery system according to claim 18 or 19, wherein one or more of said zones comprise an arrangement of said boiler or heater elements or said composite boiler or heater elements consisting of a series connection of a pre-heater (economizer) stage followed by a an evaporator/boiler stage which is followed by a super-heater stage, such that pre-heated steam is provided from the pre-heater to the boiler of the evaporator/boiler, which provides steam to the super-heater, which provides super-heated steam at an outlet (48, 49, 50) of the super-heater.
21. A steam drum (22) internally comprising a number of boiler elements according to any of the preceding claims 1 to 13, wherein the outer surfaces of the casing (2) of the boiler elements function as evaporator tubes producing saturated steam in the steam drum (22).
22. A steam drum according to claim 21, wherein said steam is subsequently directed to and flow through the inner tubular elements (3) of the boiler elements for superheating the steam.
23. A boiler or heater element according to claim 1 comprising a casing (2) provided with an inlet (6) and an outlet (9), said casing (2) surrounding an inner tubular element (3) comprised of one or more first sections (3') extending substantially parallel to a longitudinal axis of the casing (2) and one or more second sections (3'') extending at an angle different from zero to said longitudinal axis
24. A boiler or heater element according to claim 23, wherein said angle is substantially 90 degrees.
25. A boiler or heater element according to claim 1, wherein the casing (2) comprises a number of surface sections (2', 2'', 2''') corresponding to the number of inner tubular elements (3), such that each individual of said subsections envelops a substantial portion of the outer circumferential surface of one of said inner tubular elements (3).

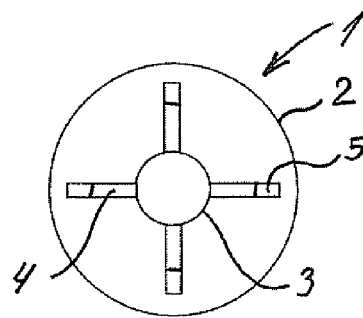
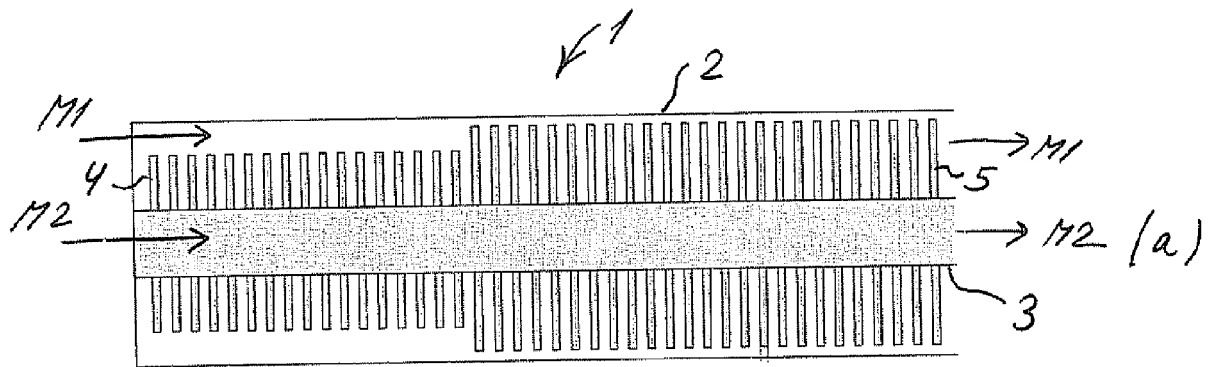


Fig. 1

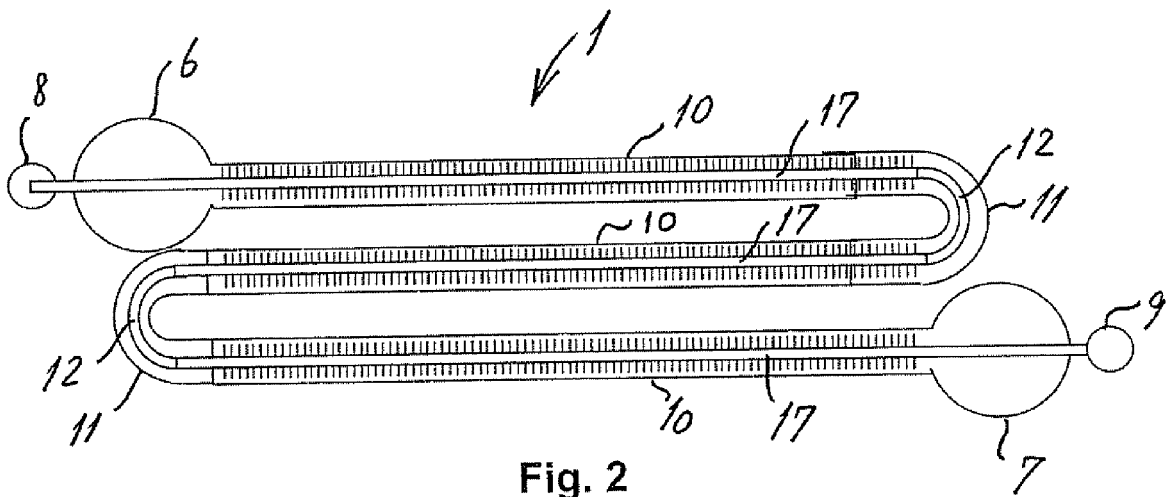


Fig. 2

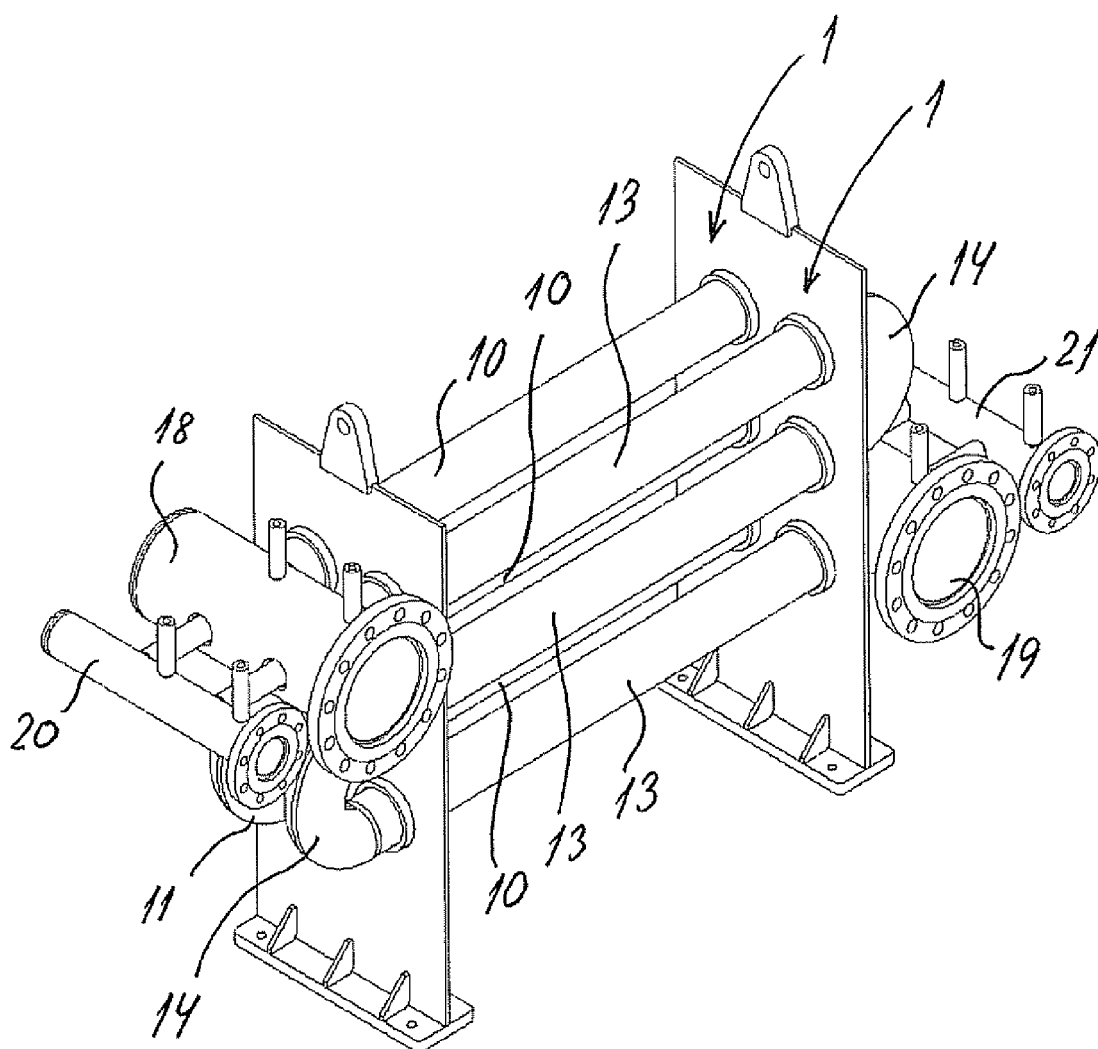


Fig. 3

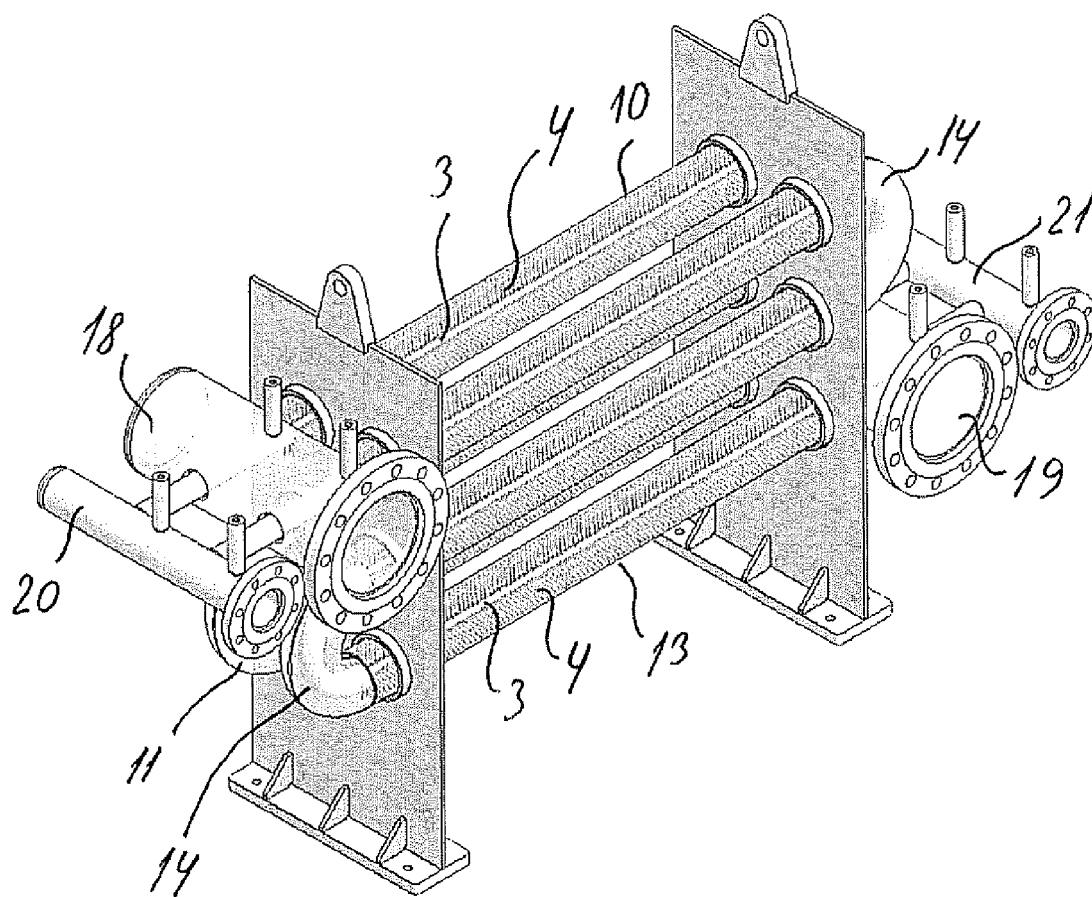


Fig. 4

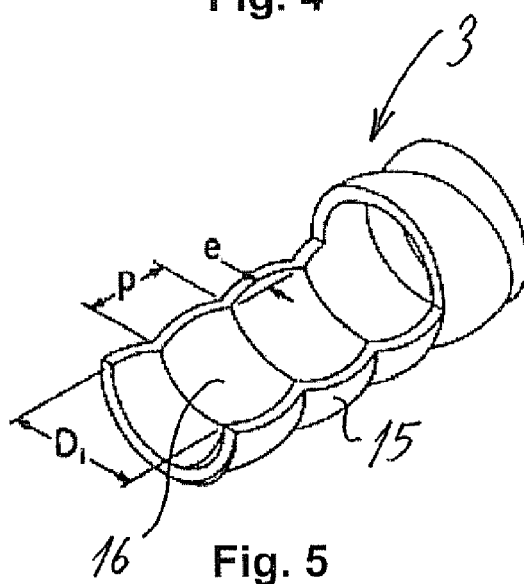


Fig. 5

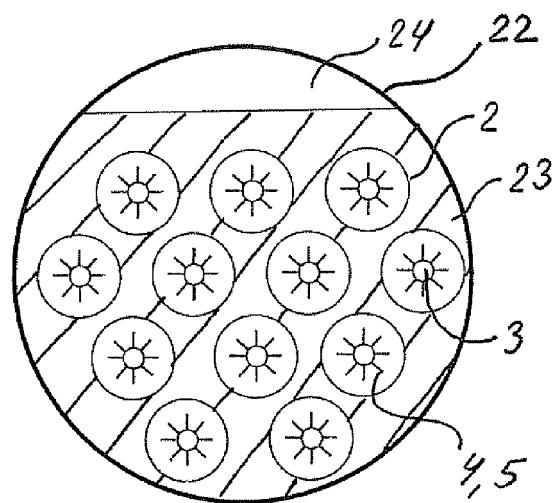


Fig. 6

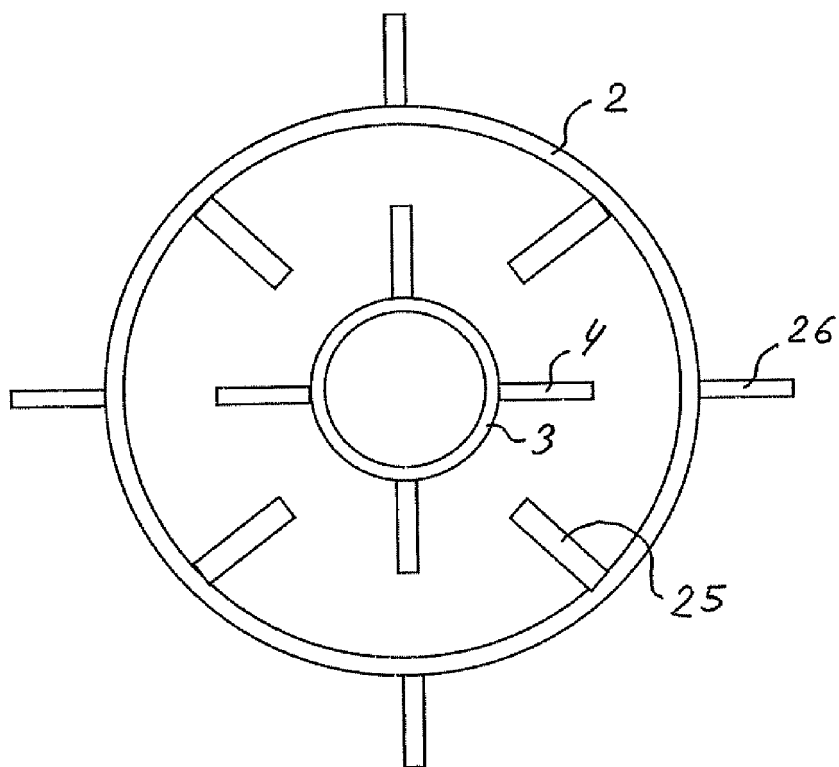


Fig. 7

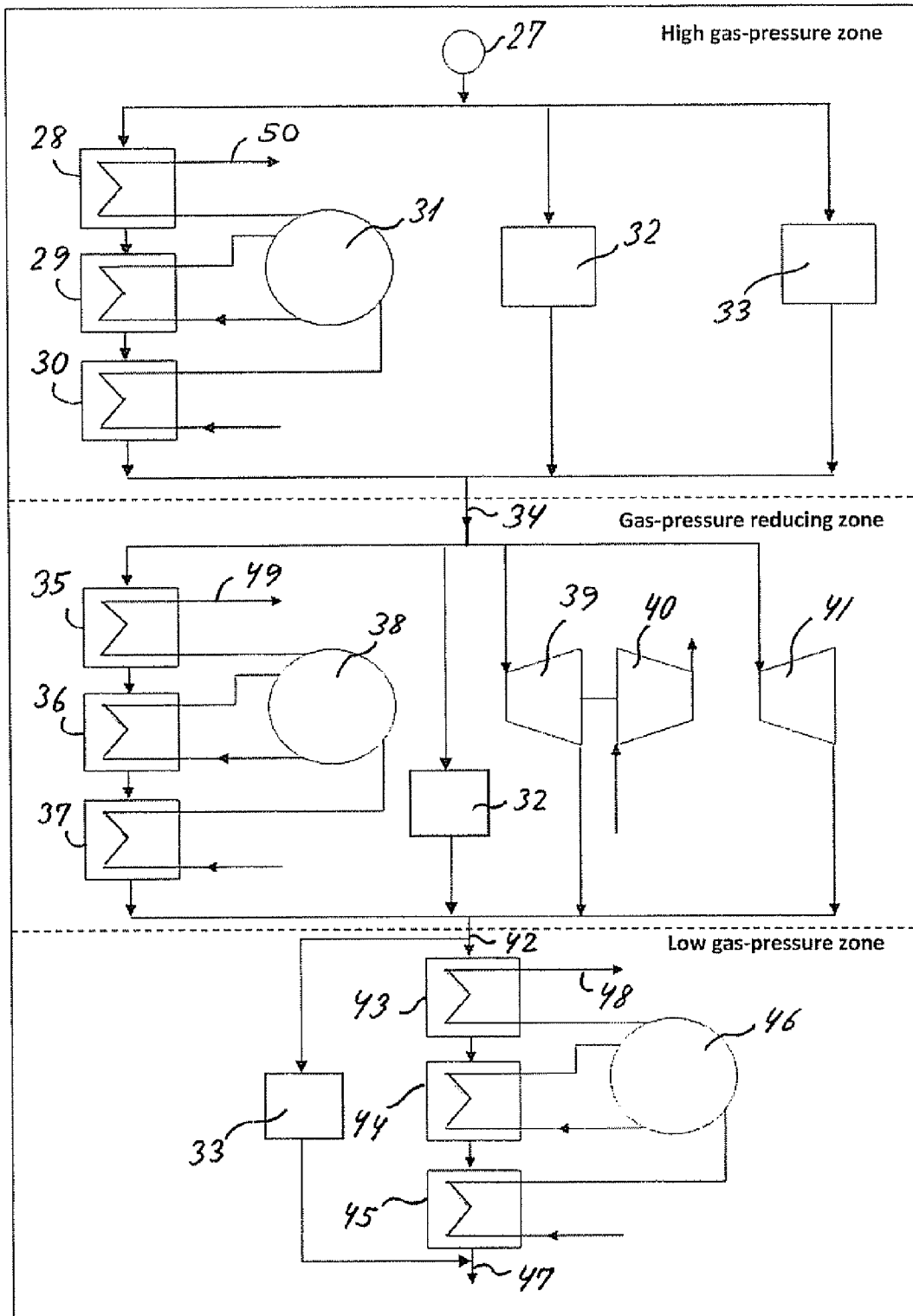


Fig. 8

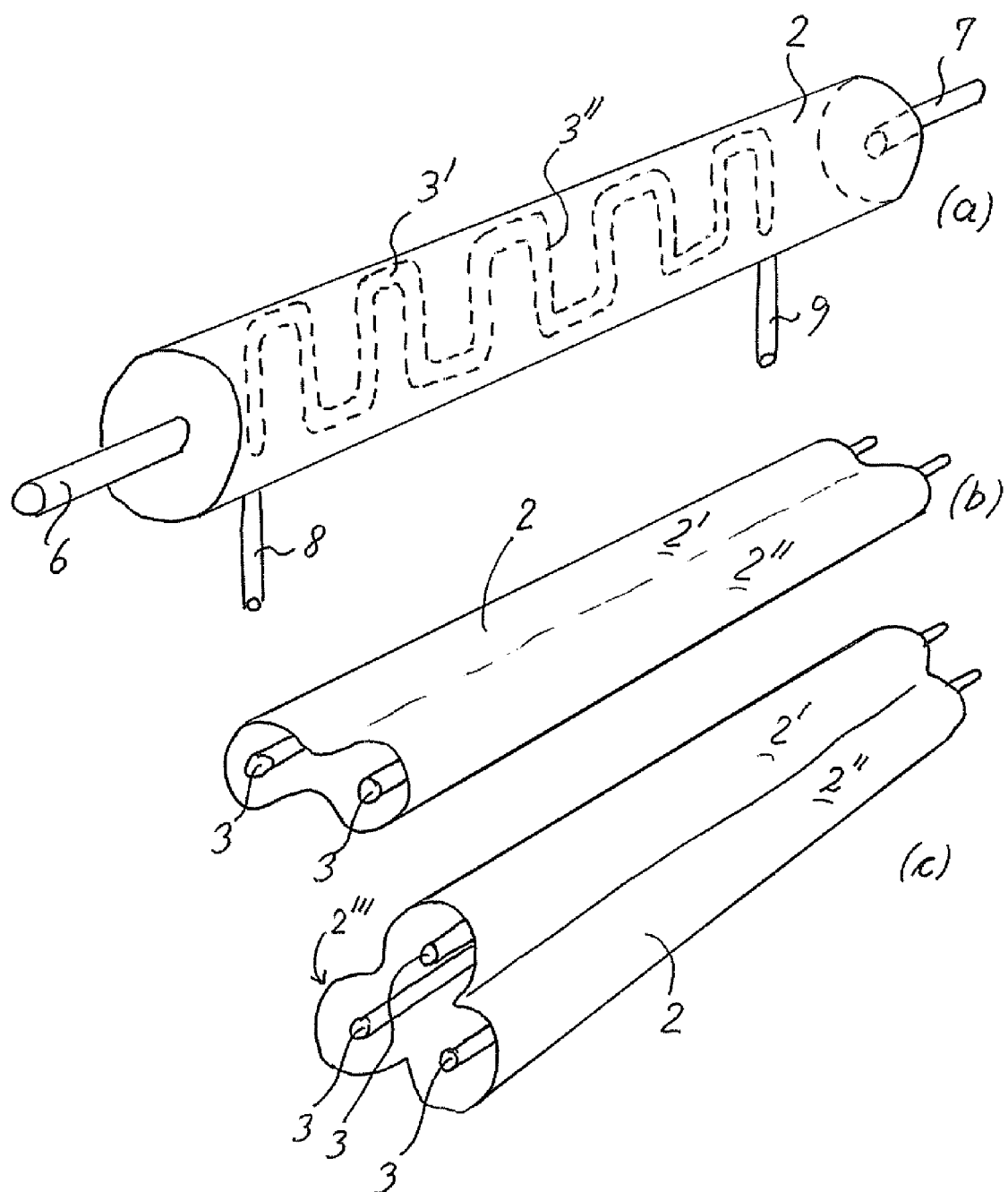


Fig. 9



EUROPEAN SEARCH REPORT

Application Number
EP 11 15 4294

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2010/146953 A1 (BHATTI MOHINDER S [US] ET AL) 17 June 2010 (2010-06-17) * pages 2-5 * * figures 1, 4-8 *	1-6,8, 11,23,24	INV. F24H1/41
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 June 2011	Examiner Schwaiger, Bernd
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.02 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
EP 11 15 4294

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 151 651 A1 (GIANNONI S P A [IT]) 10 February 2010 (2010-02-10) * columns 1,3,4 * * columns 14-18 * * figures 1-5 * -----	1-3,5,7,8,10-12	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		9 June 2011	Schwaiger, Bernd
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)



Application Number

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

see additional sheet(s)

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 11 15 4294

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-17, 23-25

boiler or heater element; composite boiler or heater element

2. claims: 1, 18-20

waste heat recovery system

3. claims: 1, 21, 22

steam drum

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-06-2011

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