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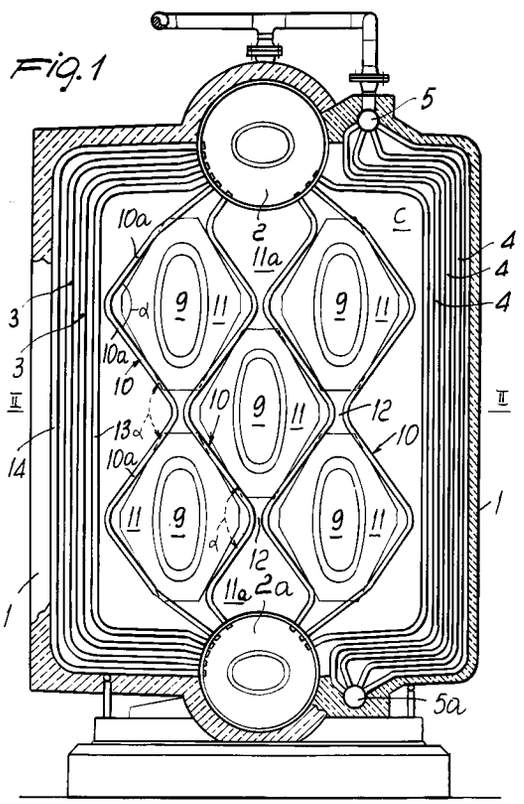
(54) Heat generator, particularly for steam generation, of the low nitrogen-oxide type, with multiple chambers formed by fluid tubes, using radiant gas burners.

(57) Thermal generator, particularly for the generation of steam, of the fluid-tube type that uses a plurality of radiant gas burners made of ceramic fiber or the like. The generator comprises a quincuncial arrangement of the radiant burners (9) and a structure with multiple combustion chambers (11) that is formed by means of walls (10) which are constituted by subvertical tubes provided with membranes and are shaped so as to form wide alternating curves with such curvature radii (α) as to form, around each burner (9), a radiation chamber (11) having a substantially quadrangular shape; all the chambers (11) are mutually contiguous and arranged quincuncially, whereas the tubes that form the membrane-fitted walls (10) are connected to the horizontal cylindrical bodies (2,2a) so as to form the evaporation walls of the radiant section with uniform irradiation from both sides of the walls (10).

Fig. 1



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The present invention relates to a heat generator, particularly for steam generation, of the fluid-tube type that uses a plurality of radiant gas burners, made of ceramic fiber or the like, which are associated with contoured means that allow to divide the combustion chamber into contiguous chambers having such a shape that they are substantially shielded from each other.

Currently, as is known, among the various types of gas burners that radiate in the infrared, the most widely used are porous ones made of ceramic fiber, which are constituted by a microporous matrix of small-diameter fibers of ceramic materials, through which the appropriately premixed gaseous fuel and air flow.

Ignition occurs on the outermost surface without producing a visible flame: only a bright orange incandescence can be detected. The innermost part of the ceramic layer remains at the temperature of the reagents, whereas the surface stabilizes at 900-1100°C, depending on the thermal environment that affects the burner. The thermal power produced is transmitted mainly (over 50%) by radiation; this characteristic of radiating much of the energy generated by combustion, combined with uniformity both in energy distribution and in the distribution and excellent mixing of fuel and comburent, reduces the maximum combustion temperature and accordingly reduces the emission of nitric oxides.

The nitric oxide emission levels generally observed with ceramic burners in tested applications are between 10 and 20 ppmv, i.e. 80% lower than those detected in conventional burners.

It is also known that by applying further refinements in the design and management of these burners, the nitric oxide emissions can be reduced further, allowing to comply with the strictest limits. These low levels can be maintained within a wide burner operating range.

The combustion mechanisms taking place on the surface of the burner furthermore considerably reduce CO emissions.

Ceramic-fiber burners can be produced in various shapes: small burners are generally shaped like cylindrical tubes with a hemispherical end. Larger burners, generally used for applications in boilers with a fluid-tube furnace, are generally constituted by modular segments joined by means of ceramic flanges and having a flattened cross-section, typically rhomboidal or elliptical. Since the thermal power produced by an individual burner is directly proportional to the combustion surface, in theory said surface can extend indefinitely. In actual fact, the other functions of the burner (fuel distribution) and of the heat generator (heat exchange with the heat transfer medium) must be considered.

Therefore, for these applications, as for conventional systems, it is often convenient to provide more than one burner, obtaining multi-burner combustion systems; in this manner one furthermore extends the overall adjustment range of the heat generator.

Generally, therefore, ceramic-fiber radiant burners have the following advantages for the user:

a) the possibility to control emissions with lower costs than those of other methods using conventional burners;

b) quick response to load variations, offered by the extremely low heat inertia of the burners;

c) uniformity of the heating action, since the radiant flux is distributed uniformly along the outer surface of the ceramic-fiber burner; and

d) lack of combustion noise.

Accordingly, the main criteria to be fulfilled in designing heat generators that use ceramic-fiber radiant burners consist in:

1) exploiting the radiant emission of the ceramic burner in an optimum manner;

2) minimizing or avoiding mutual irradiation among the ceramic burners;

3) providing a geometry that allows to contain dimensions and simultaneously optimizes the efficiency and the emissions of the generator.

As is known, conventional heat generators are typically constituted by a combustion chamber (radiant section), where the fuel oxidation reactions take place substantially until they are complete, and by a convective section, where the high-temperature combustion products transfer their enthalpy with a predominantly convective process.

In these heat generators using diffusion flame burners, the contribution of radiation to the exchange processes is relatively higher in the combustion chamber due to the relatively high flame temperatures and due to the fact that the walls are exposed to all of the flames. Furthermore, in the case of turbulent diffusion flames, heat energy production is linked to the volume occupied by the flame; in other words, when planning the size of the generators, volumetric combustion intensity must be taken into account.

When using radiant burners, heat energy is instead produced on the radiant surface, in a layer having a negligible thickness (less than a few millimeters). In size planning the surface combustion intensity has to be considered. Accordingly, in order to provide heat generators with power ratings of industrial interest (from one megawatt upward), it has already been proposed to divide the combustion chamber into several smaller separate chambers, known as irradiation chambers.

Accordingly, the aim of the present invention is to provide a heat generator of the fluid-tube type that uses radiant gas burners located within mul-

tiple contiguous chambers and is conceived and structured so as to allow, by virtue of the particular arrangement of its burners and irradiation chambers, to utilize in the best possible manner the radiant emission of the individual ceramic burners, to avoid as much as possible mutual irradiation among the burners of the individual cells, and to contain dimensions without negatively affecting the efficiency and uniformity of the radiant emissions.

Another object of the invention is to provide a structure with multiple chambers for said heat generator, conceived so as to optimize the internal spaces of the combustion chamber and of the entire generator, allowing to achieve very high efficiency levels combined with easy manufacture and assembly of the fluid tubes.

Another object of the invention is to provide a multiple-chamber heat generator which is conceived so as to also allow the use of radiant burners made of materials other than ceramic fiber and so as to also allow changes in the shape and mutual placement of the individual radiant cells in order to shield said cells substantially completely.

This aim, these objects and others which will become apparent from the following description are achieved by a heat generator of the convection tube-nest type connected to two or more horizontal cylindrical bodies which is provided with the associated economizer and steam superheater and uses a plurality of radiant gas burners made of ceramic fiber or the like, said generator having, according to the present invention, a quincuncial arrangement of said radiant burners and a cellular structure, within the combustion chamber, formed by means of walls which are constituted by subvertical tubes provided with membranes and are shaped so as to form wide alternating curves with such curvature radii as to form, around each burner, a combustion chamber having a substantially quadrangular shape, said chambers being all mutually contiguous and arranged quincuncially, the tubes that form said membrane-fitted walls being instead connected to said horizontal cylindrical bodies so as to form the evaporation walls of the radiant section with uniform irradiation from both sides of said walls.

More particularly, said membrane-fitted walls forming the quincuncial combustion chambers have the shape of a vertical plane which is curved alternately in two directions so as to have straight wall portions arranged alternately in opposite pairs that are such as to allow the straight wall portions of two opposite membrane-fitted walls to form substantially quadrangular chambers mutually contiguous and arranged symmetrically with respect to the vertical median plane of the generator, the alternating curves between each pair of straight and contiguous portions of said walls being formed with angles wider than 90° and so that the bisecting line of said angles is horizontal or tilted up to 30° with respect to the horizontal.

The curvature points of a membrane-fitted wall can furthermore be shifted downward with respect to those of the opposite wall, so as to allow, by placing said opposite points mutually adjacent, a partial overlap of said points that can fully shield each pair of contiguous chambers; furthermore, a membrane-fitted tube wall, suitable to form three fume turns, is provided between said radiant section and the convective section.

Further characteristics and advantages of the present invention will become apparent from the following detailed description of one of its possible practical embodiments, given with reference to the accompanying drawings, which are given by way of non-limitative example and wherein:

figure 1 is a transverse sectional view (taken along the plane I-I of figure 2) of a heat generator manufactured according to the present invention;

figure 2 is a horizontal longitudinal sectional view of the generator of figure 1, taken along the plane II-II of figure 1;

figure 3 is a longitudinal sectional view of figure 2, taken along the plane III-III at right angles to the section of figure 2; and

figure 4 is a transverse sectional view of another embodiment of the generator according to the present invention.

With reference to the above figures, the generator illustrated therein is, as regards its general structure, of a known type, whereas the particular arrangement of the burners, the structure of the combustion chambers and part of the convective section constitute the improvement according to the present invention.

Accordingly, said heat generator is of the type having subvertical fluid tubes with cylindrical bodies with natural circulation and the associated superheater and economizer tube nests.

Said generator is in fact constituted by a boiler with a jacket 1 made of insulating material and accommodating, in an upward region, a hollow longitudinal cylindrical body 2; the upper ends of the tube nest 3 and other walls formed with membrane-fitted tubes, which will be better described hereinafter, are connected to the lower end of said body 2.

Below the boiler 1 there is a second hollow cylindrical body 2a in which converge the lower ends of the tubes directed toward the upper body 2 and the other membrane-fitted walls, which as mentioned will be explained hereinafter.

The generator is furthermore provided with steam superheating tubes 4, possibly symmetrical (figure 1), arranged in multiple rows connected to

respective distribution manifolds: an upper one 5 and a lower one 5a. The rear wall B (figures 2-3) of the generator has a conventional fume collecting box 6 connected to a water preheater-economizer 7. A stack 8 for removing the fumes is also provided on the rear side B and laterally to the generator.

In a steam generator of this type, the improvement according to the invention consists in using, within the combustion chamber designated by the letter C in figure 1, a plurality of radiant gas burners of a known type, preferably having an oval or elliptical transverse cross-section, which are arranged so as to form a quincunx of modulus 2 + 1 + 2 + 1 etc. and, more generally, n + (n-1) + n + etc. More particularly, as clearly shown in figure 1, the five radiant burners 9 have the same dimensions, are arranged so that their axes are mutually parallel and substantially equidistant from each other; their quincuncial arrangement allows to provide heat generators of the same type with a wide range of power ratings, utilizing in the best possible manner the characteristics of surface combustion and the uniformity in the distribution of the heat flux.

Said burners 9 are then individually enclosed in radiation chambers 11 which are formed by evaporation walls 10, each of which is constituted by subvertical tubes arranged side by side and mutually connected by fins so as to form fume-tight continuous walls.

Each finned wall 10 is substantially shaped like a broken line or like a line with alternating curvatures so as to form, by means of two pairs of mutually opposite walls 10, the individual chambers 11, each of which encloses a burner 9.

The curvature angles α between two contiguous straight segments 10a are identical for all the membrane-fitted walls 10 and are wider than 90°; the bisecting line of the individual angles is horizontal or even inclined up to 30° with respect to the horizontal.

The individual radiation chambers are therefore constituted by four straight portions 10a of two opposite membrane-fitted walls 10; these portions form substantially quadrangular or rhomboidal chambers which are also arranged quincuncially and are substantially completely shielded from each other since free space is reduced to a few millimeters in the regions 12 between each pair of opposite angles α ; furthermore the path of the fumes is not interrupted between two vertically contiguous chambers.

The particular quincuncial arrangement of the burners 9 and of the radiant chambers 11 allows in practice to maximally optimize the coupling of the burners and the boiler, placing radiant surfaces and irradiated surfaces opposite to each other along the maximum extension that is compatible with the other functions of the burners and of the heat generator.

Also according to the invention, a shielding wall 13 is interposed between the chambers 11 and the tube nest 3 and is formed by vertical tubes mutually connected by fins, so as to prevent the escape of the fumes released by the radiation chambers. In the same manner, on the outside of the convective tube nest 3 there is a finned wall 14 with vertical tubes that also prevents the escape of the fumes. Therefore, these finned walls 13 and 14, together with the evaporation walls 10 that form the chambers 11, allow to obtain three fume paths: one inside the radiant chambers 11, another between the chambers and the inner membrane-fitted wall 13 (in the opposite direction with respect to the preceding path) and the third one through the tubes of the evaporation section 3. These paths are designated by the letters D-E-F in figure 4.

Finally, in order to allow connection of the three fume paths, within the front wall A and the rear wall B of the generator there is a finned wall with vertical tubes 15 and respectively 16 (figure 2) allowing the fumes F1 to deviate from their initial path until they reach the collection box 6.

In practice it has been observed that the provision of three fume paths, together with the quincuncial arrangement of the burners and of the associated cells, allows to optimize the internal spaces of the boiler and to achieve very high efficiency levels, approximately 93%, in addition to allowing easy manufacture and assembly of the tubes.

Furthermore, the quincuncial arrangement of the radiation chambers also allows to fully shield two contiguous chambers, lowering the curvature point of one evaporation wall with respect to the opposite one formed by the opposite evaporation wall and then placing them mutually adjacent so as to achieve a partial overlap that can totally shield the two contiguous cells.

According to the invention, it is also possible to place a burner that is smaller than the others in the partial chambers 11a arranged above and below the central burner (figure 1).

Finally, the quincuncial arrangement of the burners and of the associated radiation chambers can also be provided in generators having three cylindrical bodies, as shown in figure 4; in the same manner, the same arrangement can be used within heat generators with a D-shaped structure in which the upper cylindrical body 2 and the lower one 2a are arranged laterally and in which the convective tube nest is arranged only on one side of the generator.

From what has been described above it is evident that structurally and functionally equivalent modifications and variations can be made to the

invention as described and illustrated without abandoning the protective scope of said invention.

For example, the heat generator according to the present invention can be used as a heat generator for heating heat-dissipating fluids.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. Heat generator, particularly for steam generation, of the convection tube-nest type connected to one, two or more horizontal cylindrical bodies (2,2a) which is provided with an economizer (7) and steam superheater and uses a plurality of radiant gas burners made of ceramic fiber or the like, characterized in that it has a quincuncial arrangement of said radiant burners (9) and a multiple-chamber structure (11), within the combustion chamber (C), formed by means of walls (10) constituted by subvertical tubes provided with membranes and are shaped so as to form wide alternating curves with such curvature radii as to form, around each burner (9), a radiation chamber (11) having a substantially quadrangular shape, said chambers (11) being all mutually contiguous and arranged quincuncially, the tubes that form said membrane-fitted walls (10) being instead connected to said horizontal cylindrical bodies (2,2a) so as to form the evaporation walls of the radiant section with uniform irradiation from both sides of said walls.

2. Generator, according to claim 1, characterized in that said membrane-fitted walls (10) forming said radiation chambers (11) are curved alternately in both directions so that straight wall portions (10a) of two opposite membrane-fitted walls (10) form a V shape so as to produce substantially quadrangular chambers (11) that are mutually contiguous and are arranged symmetrically with respect to the vertical median plane of the generator.

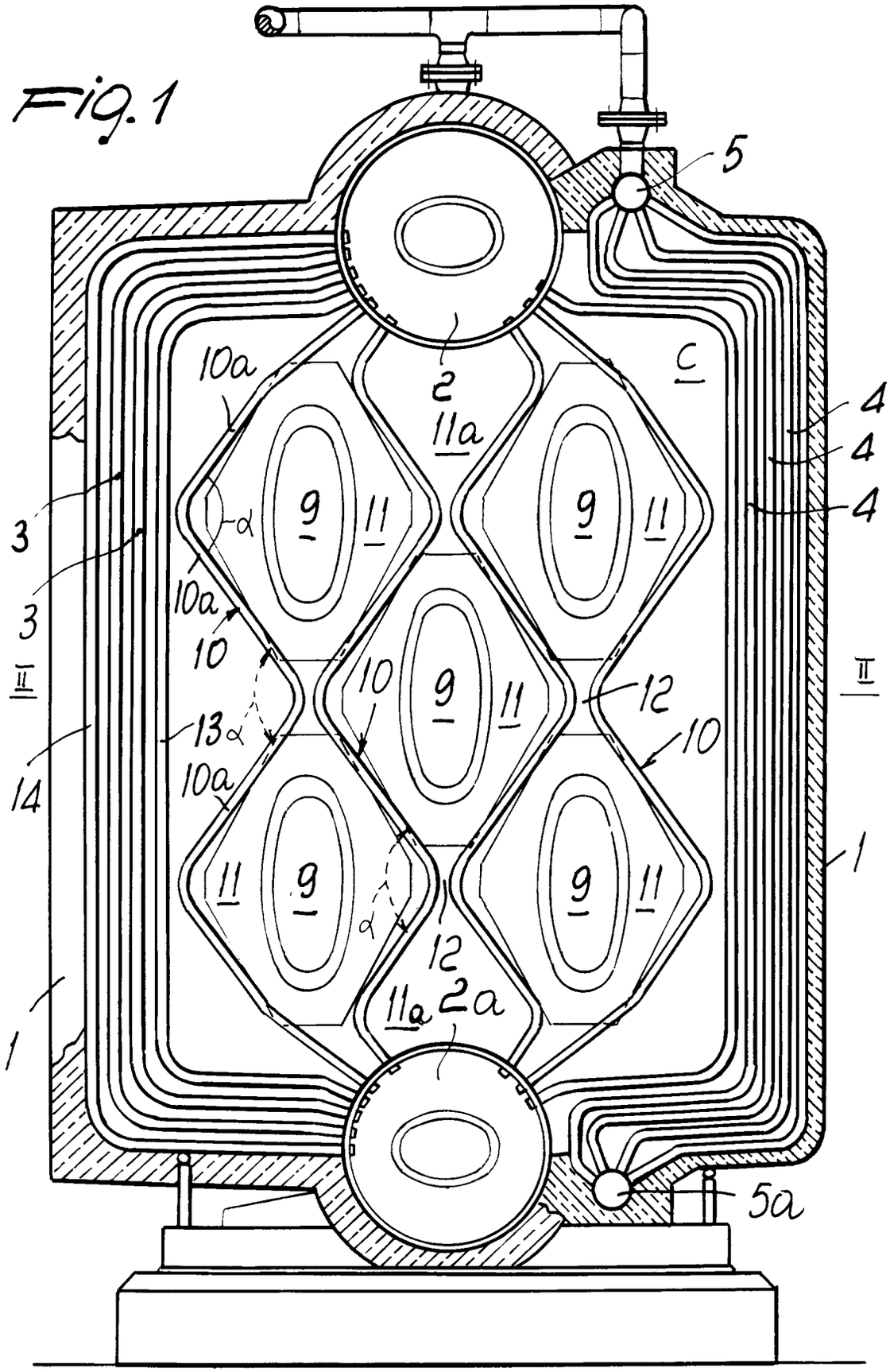
3. Generator according to claims 1 and 2, characterized in that the curvature angles (α) of each pair of said straight and contiguous portions (10a) of each membrane-fitted wall (10) are wider than 90°, the bisecting line of said angles being horizontal or even tilted up to 30° with respect to the horizontal.

4. Generator according to claims 1 to 3, characterized in that a first membrane-fitted tube wall (13) is provided between the section constituted by said radiation chambers (11) and the section of the convective tube nest (3) and a second membrane-fitted tube wall (14) is provided between said tube nest (3) and the inner side wall (1) of the boiler, said membrane-fitted walls (13,14) being such as to form three paths (D,E,F) for the fumes (F1) released by said radiant section.

5. Generator according to one or more of the preceding claims, characterized in that the curvature points of one membrane-fitted evaporation wall (10) can be shifted downward with respect to those of the opposite wall and then be placed mutually adjacent so as to obtain a partial overlap of said points that can completely shield each pair of contiguous chambers (11).

6. Generator according to the preceding claims, characterized in that it is possible to insert a radiant burner that is smaller than the other burners within the partial chambers (11a) formed by the evaporation walls (10) arranged above and below the central burner.

Fig. 1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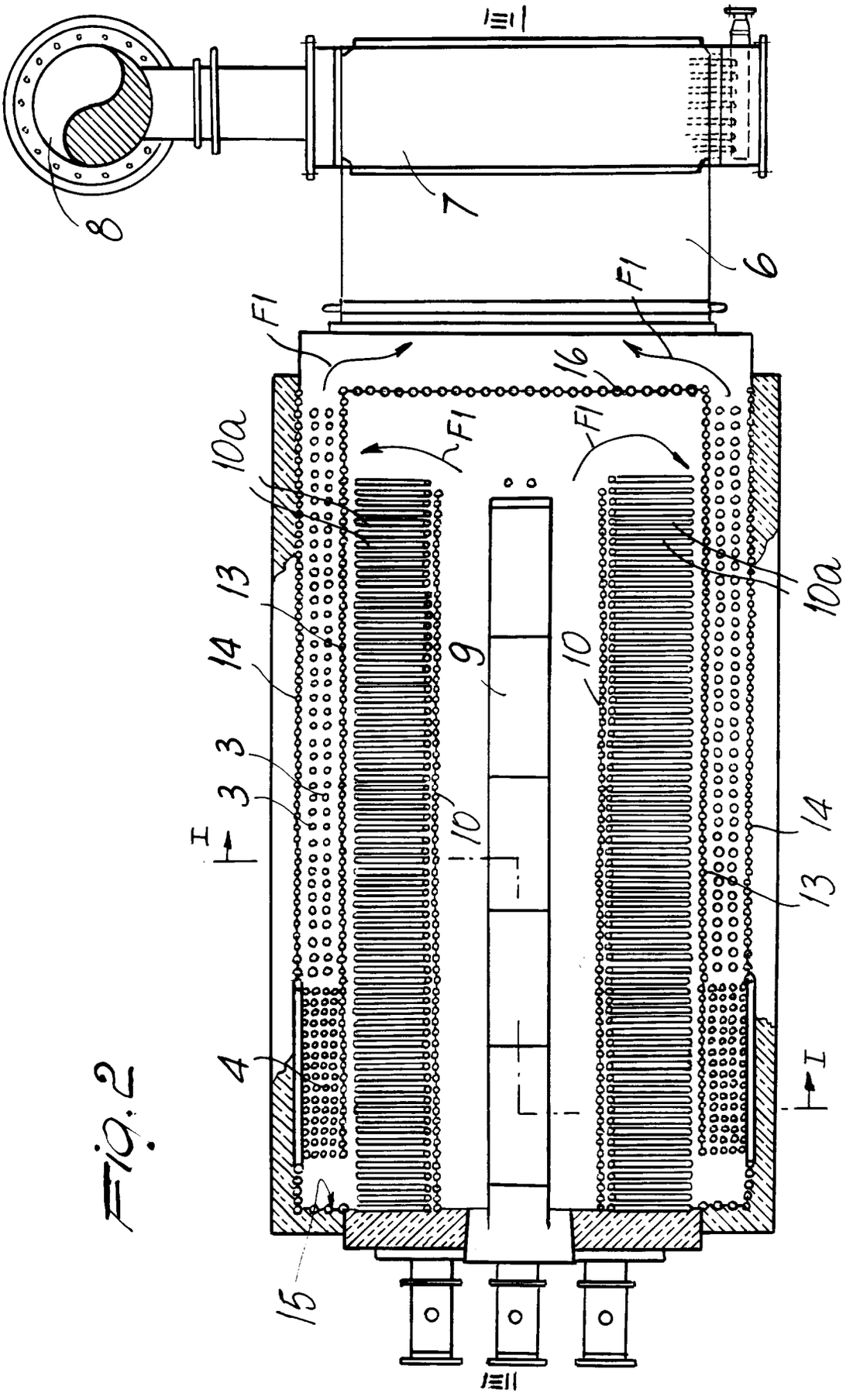
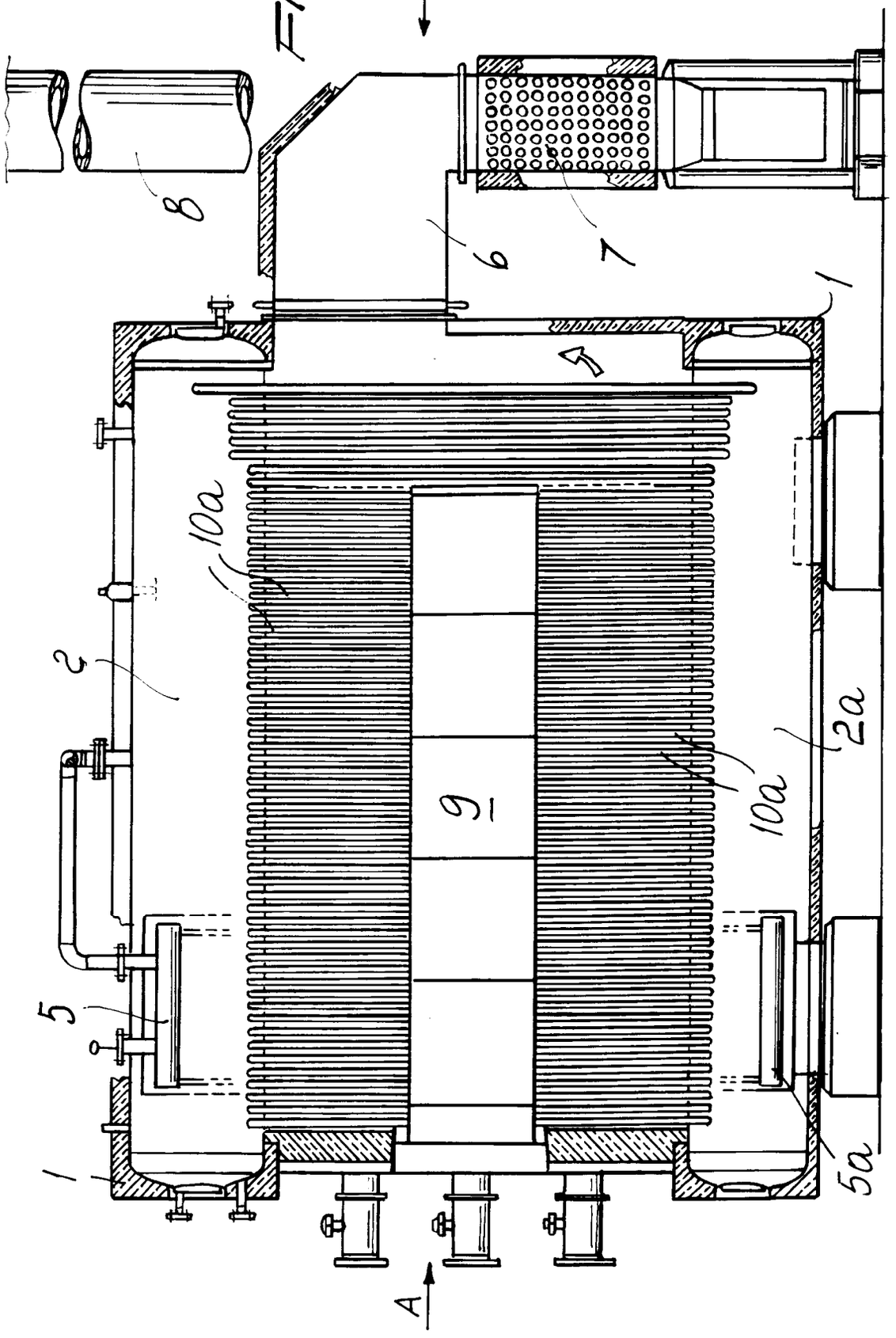


Fig. 2

Fig.3



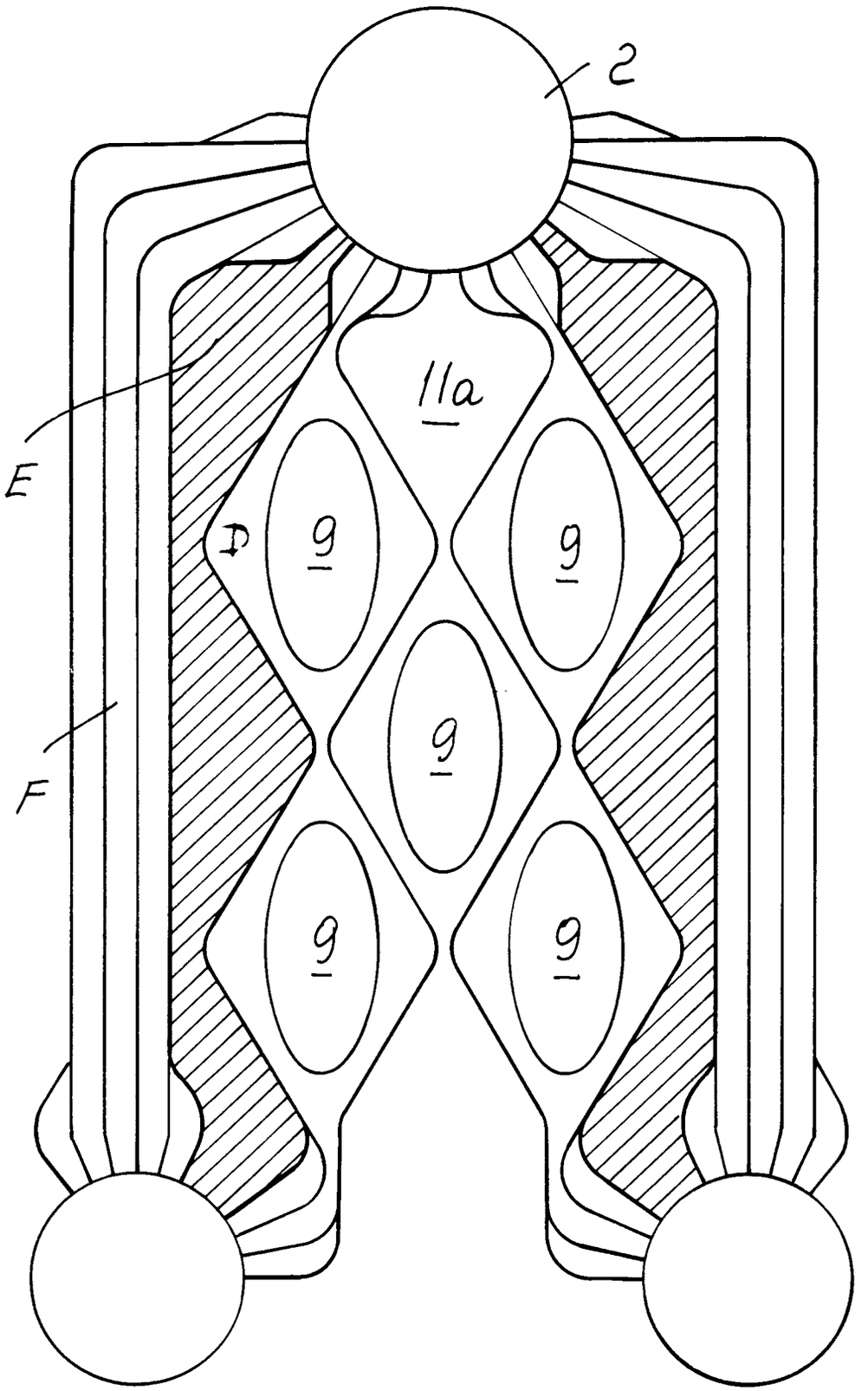


Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 4179

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 233 030 (GAS RESEARCH) * page 1, paragraph 1; figures * * abstract *	1	F22B31/00 F22B37/40
A	US-A-3 289 642 (SCHOPPE) * the whole document *	1	
A	GB-A-868 379 (REPPEL) * page 2, line 62 - line 93; figures *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F22B
F23D
F24H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 August 1994	Van Gheel, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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