(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

PCT

(43) International Publication Date
4 September 2008 (04.09.2008)

(10) International Publication Number
WO 2008/104859 A2

(51) International Patent Classification:
F23C 6/04 (2006.01)

(21) International Application Number:
PCT/IB2008/000422

(22) International Filing Date:
27 February 2008 (27.02.2008)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
PD2007A000066 28 February 2007 (28.02.2007) IT

(71) Applicant *(for all designated States except US)*: **EASY INTERNATIONAL S.R.L.** [IT/IT]; P.zza S. Ambrogio 16, I-20123 Milano (IT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ABATE, Valerio** [IT/IT]; Via Genova, 15, I-21047 Saronno (IT). **BIANCHI, Michela** [IT/IT]; Via Nirone, 10, I-20123 Milano (IT). **CONTI, Alberto** [IT/IT]; Via Nirone, 10, I-20123 Milano (IT).

(74) Agent: **GALLO, Luca**; Gallo & Partners S.r.l., Via Trieste, 49, I-35121 Padova (IT).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,

[Continued on next page]

(54) Title: BOILER AND METHOD FOR OPERATING SAID BOILER

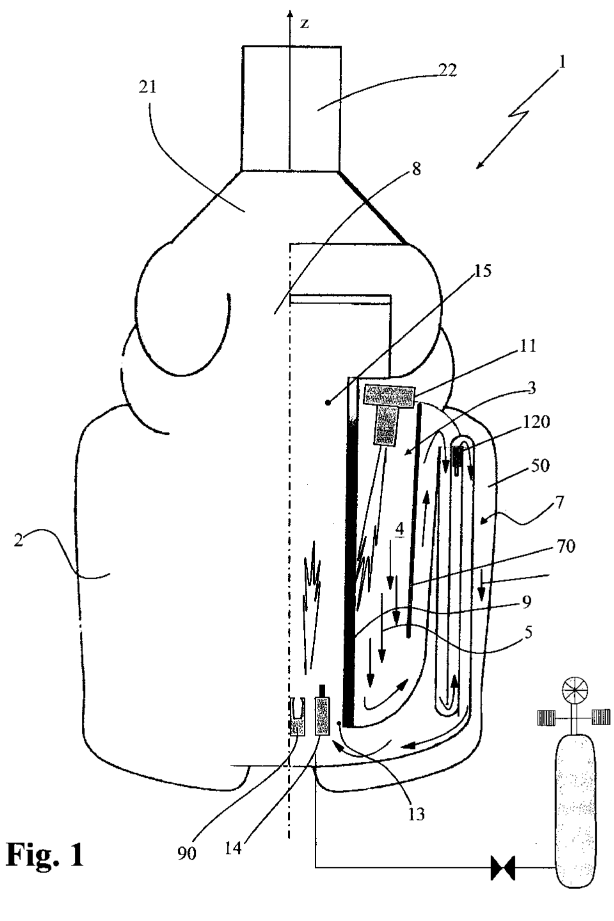

Fig. 1

(57) Abstract: Boiler comprising a support structure, a burner mounted on said support structure, susceptible to burn a mixture of comburent air and fuel for generating a flow of hot fumes and means for transferring heat from the above-mentioned fumes to a hydraulic circuit of a carrier fluid, water in particular. Such heat transferring means are provided with at least a first heat exchanger and at least a second heat exchanger susceptible to exchange heat with the hot fumes in sequence. The boiler comprises at least one pipe made of ceramic material arranged inside the burner, susceptible to convey the fumes between the first exchanger and the second exchanger, and a plurality of nozzles for introducing the mixture. The nozzles are arranged spaced from each other inside the burner, around the above-mentioned pipe and are susceptible to generate a flame in contact with the outer surface of the pipe.

WO 2008/104859 A2

NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

BOILER AND METHOD FOR OPERATING SAID BOILER

DESCRIPTION

Field of application

The present invention relates to a boiler and a method for operating said boiler according to the introduction of the main claim.

The boiler herein is intended to be advantageously used for conventional purposes, where a carrier fluid is required, such as water for example, for heating rooms or for producing hot water for sanitary use.

Background art

As is known, boilers presently available on the market provide for heat exchange between a heat source made up of hot fumes produced in a burner upon combustion of a fuel such as a gas or an oil derivative, and a carrier fluid, usually water, which is adapted to carry the heat taken up from the fumes up to the users for various purposes generally for heating rooms or for producing hot water for sanitary use.

Heat-exchange between the fumes and the carrier fluid usually occurs through a cast iron or steel exchanger at temperatures typically below 900° C. At such temperatures, the heat exchange within the exchanger occurs due to thermal convection and radiation phenomena in a substantially equivalent manner.

The amount of air employed usually exceeds the gas amount in order to carry out a particularly oxidizing reaction meant to fully exploit the combustion of the fuel.

In order to increase the efficiency of boilers of the known type condensation boilers have been recently introduced, which not only exploit the heat deriving from combustion (low heat value l.h.v.) but also the latent heat of water vapor contained in the exhaust gases (high heat value). Therefore, this technique allows exploiting energy which would otherwise be discharged from the flue together with exhaust gases. During condensation latent heat is transferred from the gases to the water. By exploiting this technique, the temperature of the exhaust gases, which are discharged from the boiler, is only slightly higher than the temperature of the water returning to the boiler thus allowing achieving high efficiencies.

The condensation of moisture present in the fumes depends on the temperature of the water returning to the boiler but also on the residual oxygen content of the combustion fumes.

Boilers of the known type do not ensure stoichiometric chemical reactions and at these temperatures they give rise to a number of combustion products, resulting in the diffusion of a number of pollutants into the atmosphere.

Typically, pollutants emitted from boilers are of gaseous type, such as ozone, nitrogen oxides, sulfur dioxide etc. and of solid type, such as unburnt particles, condensation aggregates, carbon particles etc.

In order to reduce pollutants in boiler gases, devices were conceived to be arranged downstream of the boiler to intercept the fumes.

An example of such a device is described in the patent DE 19824204 which uses a catalyst to separate gaseous pollutants. Another example of a device is described in the patent DE 19627028 which provides for the use of a ceramic filter to separate pollutant particles and of a catalyst to separate gaseous particles.

Such known devices negatively affect the overall efficiency of the heat production system and since they operate downstream of the boiler burner they do not allow optimizing the combustion of the latter.

Indeed, particles of unburnt gases in particular that are released during combustion seriously affect the heat exchange inside the exchanger, thus reducing the efficiency of the boiler.

Presentation of the invention

In this situation, a main object of the present finding is therefore to overcome the drawbacks encountered in boilers of the known type, by providing a boiler as well as a method for operating said boiler which allow increasing the efficiency of the boiler.

Another object of the present finding is to provide a boiler as well as a method for operating said boiler which can reduce the production of pollutants.

Another object of the present finding is to provide a boiler as well as a method for operating said boiler operatively totally safe.

A further object of the present finding is to provide a boiler which is easy to install and operatively totally reliable.

A further object of the present finding is to provide a boiler of particularly reduced dimensions with respect to the power produced.

Brief description of the drawings

The technical characteristics of the finding, according to the above objects, can be easily appreciated from the content of the appended claims and the relevant advantages shall be clearer from the following detailed description, provided with reference to the attached drawings, which represent a strictly exemplifying and non limiting embodiment thereof, wherein:

- figure 1 shows an overall schematic view of the boiler subject of the present invention with a part in cross-section to highlight other parts better;
- figure 2 shows a cross-section view of the boiler subject of the present invention with some parts cut away to highlight other parts better;

- figure 3 shows a perspective view of an enlarged detail of the boiler subject of the present invention relating to the fuel-comburent air supply unit;
- figure 4 shows a perspective view of an enlarged detail of the boiler subject of the present invention relating to a plate exchanger.

Detailed description of a preferred embodiment

In accordance with the figures of the attached drawings, the boiler subject of the present finding is generally indicated with 1.

The boiler comprises a support structure 2, which can be of a per se entirely traditional type and it is preferably intended to provide a support on the ground, and a burner 3 mounted on the support structure 2, in whose combustion chamber 4 a comburent air and fuel mixture is injected, by means of a suitable supply unit 10, for generating a flow of hot fumes indicated by arrows 5 through oxidation reactions.

The enthalpy generated by the combustion present in the fumes is transferred to a carrier fluid 6 of a hydraulic circuit (not illustrated in detail), preferably made up of water, by means of suitable heat exchange means that, according to the present invention, are obtained in at least two subsequent stages through a first and a second heat exchanger indicated with 7 and 8, respectively.

The first exchanger 7 comprises in particular a jacket 50 inside which fume pipes run, indicated with 60 in the boiler example of figure 2 not perfectly corresponding to that of the boiler illustrated in figure 1.

According to the idea underlying the present invention a ceramic material pipe 9 is provided inside the combustion chamber 4 to convey the fumes between the first exchanger 7 and the second exchanger 8 while the supply unit 10, in turn, is formed by a plurality of nozzles 11 arranged spaced from each other inside the burner 3, around the pipe 9 and susceptible to generate a flame adapted to lick or to contact the outer surface of the pipe 9.

In this manner, the ceramic material pipe 9 reaches very high temperatures typically comprised in the range between 1200 and 2200°C and preferably between 1500 and 1800°C.

According the preferred and non limiting embodiment illustrated in the attached drawings, the combustion chamber 4 of burner 3 has an annular shape with the pipe 9 coaxially arranged therein along the vertical axis Z. The nozzles 11 of the supply unit 10 are arranged around the pipe 9 in one or more substantially circular trajectories, and they are directed in such a manner to touch the pipe 9 with the flame generated by the mixture emitted in a downward direction substantially along the whole length of the pipe 9 to make temperatures even along its entire extension.

Advantageously, the ceramic material chosen is silicon carbide.

In order to facilitate temperature uniformity along the entire pipe 9, the supply unit 10 is made up of several nozzle groups 11 (three groups according to the example of the drawings attached) arranged on concentric rings 12 and each directed with the nozzles 11 so as to reach the pipe 9 with the flame at different heights.

The high temperature attained by the pipe 9 determines a high radiation pressure susceptible to transmit a high enthalpy to the shell of the first exchanger 7, which increases the efficiency of the boiler 1.

Advantageously, in order to direct the flame and hot combustion fumes along the pipe 9 provided for is a transport wall 70, partly delimiting the combustion chamber 4, advantageously substantially concentric with the pipe 9 and open at the lower end to allow recirculation of fumes towards and into the first exchanger 7, as indicted by the arrows in figure 1.

As is known, the energy transmitted by radiation follows a law according to which it varies as fourth power of temperature.

The use of ceramics in the boiler allows achieving very high temperatures capable of radiating high thermal powers thus increasing the efficiency of heat exchanges with the carrier fluid. A further advantage of ceramics lies in the low oxidation thereof and hence in the long durability of the parts made from this material.

The high temperature attained by the pipe 9 together with the high thermal inertia cause a rapid combustion of any unburnt particles which may come into contact with the same.

Furthermore, the juxtaposition of the groups of nozzles 11 at the edges of the flames, determines higher chances of burning all the unburnt particles, which would otherwise typically gather in the coldest spots of the flame.

The mixture introduced by the nozzles 11 is such to create a non stoichiometric combustion, which is poor in oxygen as compared to the stoichiometric reaction, and such to leave a small percentage of unburnt gases, for example around 0.1 ‰ up to some percentage. The fumes produced (sin gas) contain water vapor CO_2 and H_2 and thus still hold some usable energy.

Such combustion is inherently safe with respect to the explosion hazards of a stoichiometric combustion.

Hot fumes produced by the combustion cool down upon contact with the first exchanger 7 which surrounds the combustion chamber 3 as an outer shell.

The first exchanger 7 lowers the temperature of the fumes to a range between

700 and 900°C, thus creating conditions for the production of pollutants such as reducing agglomerates, unburnt gases and carbon particles in particular.

The first exchanger 7 is advantageously provided by several spaces delimited by septa or by jackets or liquid transport pipes within which fume pipes are arranged.

In an area crossed by the fumes of the first exchanger 7 where a stabilized flow is present, a lambda probe 120 is inserted, capable of detecting the amount of oxygen present in the fumes downstream of the burner 3 through the analysis of the radiations emitted. The aim of such probe 120 will be made clear hereinafter.

Once it has left the first exchanger 7, the flow of fumes enters into the pipe 9 through its first end 13 arranged in the lower part of the boiler 1.

The fumes are reheated instantaneously inside the pipe 9 to enable a post-combustion so as to burn said pollutants and unburnt gases.

Preferably, the pipe 9 has a temperature on its outer surface ranging from 1500 to 1900°C and a temperature on the inner surface ranging from 800 to 1200°C.

The above-mentioned post-combustion is facilitated by the introduction into the pipe 9 from its lower end 13, of an amount of oxygen by means of at least one injector 14 and at a rate preferably comprised between 0.3 and 0.6 m^3/h. Such introduction is regulated in an accurate manner by the lambda probe 120, which detects the amount of oxygen required by the fumes to carry out a completely stoichiometric final combustion leading to the complete combustion of all unburnt gases.

Still, through the detection of oxygen present in the burnt gases produced by the first combustion, the same lambda probe 120 or a different probe or sensor determines instead the control of the mixture introduced by the nozzles to create the first non stoichiometric combustion, which will be slightly poor in oxygen as already mentioned. Preferably, the mixture shall be kept with a low amount of oxygen according of the detection abilities of the lambda probe.

It should also be preferred, although not exclusively, to introduce oxygen instead of air to avoid the inclusion of nitrogen which could lead again to the formation of unwanted compounds.

In addition, preferably provided for is an ionization igniter 90, arranged in proximity of said injector 14 at the base of the pipe 9 where post-combustion starts.

The system for introducing the amount of oxygen shall only absorb a power of up to 1 kw and preferably comprises a compressor, a dehumidifier, a dehumidified compressed air tank, a molecular sieve separator and an oxygen tank.

The initiation of post-combustion in pipe 9 is further facilitated by providing a plasma torch or a 1-3 kw power post-combustor nozzle for introducing fuel also arranged at the first end 13 of pipe 9.

Moreover, also the irradiation of the inner wall of the pipe 9 facilitates the combustion of the fumes passing through the same pipe within a period of time preferably comprised between 0.6 and 1 second and preferably about 0.8 sec.

Therefore, during the stoichiometric post-combustion, the fumes exiting the ceramic pipe were cleared of the unburnt particles still present and also all the carbon particles accumulated in the low temperature step (about 800 °C) following cooling down in the first exchanger 7 were burnt.

Advantageously, experimental data revealed very low emissions of both gaseous and solid pollutants exiting the boiler subject of the present invention.

The hot fumes exiting the second end 15 of the pipe 9 made of ceramic material pass through the second exchanger 8 to transfer heat to the carrier fluid which has already been advantageously partially heated in the first exchanger 7.

The boiler 1 is kept under depression through a fan 21 arranged downstream of the second exchanger 8 along the discharge flue of the fumes 22.

The second exchanger 8 is an exchanger having superimposed plates 16 contained within a cylindrical jacket 17, longitudinally passed though by carrier fluid channels 18 and transversally by the fumes.

Advantageously, in order to increase the heat exchange in the second exchanger 8, the flow of fumes enters into the central opening 19 and it is directed by suitable closures 40 to pass through the plates 16 horizontally up to the outer jacket 17, as indicated by the arrows in figure 4, hence finding its way onto the upper layer of plates 16 as the carrier fluid passes through the vertical pipes 18 connected at their ends to U-shaped connectors 20.

The second exchanger mainly serves to adjust the temperature of the fumes to an ideal operating value (for example 95°) below the dew temperature to recover all the condensation energy and at the same time sufficient to allow the normal discharge of fumes. Such ideal temperature is maintained through feedback of the operation of the second exchanger based on the temperature value in such a manner that when the temperature drops below the set ideal value a lower water flow circulation occurs in the second exchanger, and on the contrary when the temperature rises above such value a greater liquid circulation occurs in the second exchanger.

Obviously, the temperature value of the fumes is detected by means of a special sensor arranged in their path.

Advantageously, a single heat exchange water circuit may be provided, in which the flow of carrier fluid is directed in a regulated manner to the second exchanger through a valve. Therefore, two exchanger bodies are preferably provided being totally distinct and separated and supplied by a single heat exchange circuit.

In accordance with a preferred characteristic of the boiler 1, the nozzles 11 are arranged on the rings oriented to determine a flow of fumes in the combustion chamber 4 having a helical trajectory around the pipe 9.

Through the effect of simple kinetic energy, such trajectory determines a vortex filter effect leading to the mechanical separation of the larger mass particles, which can be easily collected at the bottom of the boiler and then discharged during regular maintenance operations.

Advantageously, in accordance with a variation embodiment of the present invention, the walls of the pipe 9 made of ceramic material have a porosity adapted to allow a clean and filtered hot gas flow to pass through the pipe, which increases the temperature thus facilitating post-combustion.

A further object of the present invention is a method for operating the boiler described above which comprises a first combustion step for generating hot fumes intended for exchanging thermal power with a carrier fluid in a first exchanger and for heating a pipe made of ceramic material, a second combustion step inside said pipe of unburnt residues and pollutants present in the fumes and an amount of oxygen introduced into said pipe at a rate controlled by a lambda probe.

The finding thus conceived therefore achieves the intended objects.

Nevertheless, it may take, in its practical embodiment, other forms and configurations different from that illustrated above without departing from the present scope of protection. Moreover all the details may be replaced by technically equivalent elements, and the forms, dimensions and materials used may vary depending on the requirements.

CLAIMS

1. Boiler comprising:

- a support structure;

- a burner mounted on said support structure, susceptible to burn a mixture of comburent air and fuel for generating a flow of hot fumes;

- means for transferring heat from said fumes to an hydraulic circuit of a carrier fluid such as water in particular, said means for transferring heat being provided with at least a first heat exchanger and at least a second heat exchanger and susceptible to exchange heat with said hot fumes in sequence;

characterized in that it comprises:

- at least one ceramic material pipe arranged inside said burner, susceptible to convey said fumes from said first exchanger to said second exchanger;

- a plurality of nozzles for introducing said mixture arranged spaced from each other inside said burner, around said pipe and susceptible to generate a flame in contact with the outer surface of said pipe.

2. Boiler according to claim 1, characterized in that the combustion of said mixture is poor in oxygen with respect to the stoichiometric reaction leaving unburnt gases in a percentage such to avoid explosion phenomena, and characterized in that said first exchanger lowers the temperature of said fumes to a range of temperatures comprised between 700 and 900°C, thus creating conditions for the production of pollutants such as reducing agglomerates, and particles especially carbon particles.

3. Boiler according to claim 1, characterized in that inside said pipe a post-combustion occurs to burn said unburnt gases and said pollutants.

4. Boiler according to claim 3, characterized in that said post combustion is

facilitated by introducing into said pipe, through at least one injector, an air flow or an oxygen flow.

5. Boiler according to claim 3, characterized in that said post combustion is facilitated by a plasma torch or a mixture post-combustor nozzle arranged inside said pipe, to trigger the combustion of said pollutants.

6. Boiler according to claim 3, characterized in that said air or oxygen flow introduced into said pipe is controlled by a lambda probe adapted to detect the amount of oxygen present in the fumes downstream of the burner 3 through analysis of the emitted radiations.

7. Boiler according to claim 1, characterized in that the outer surface of said pipe ranges from 1500 to 1900°C.

8. Boiler according to claim 1, characterized in that the inner surface of said pipe ranges from 800 to 1200°C.

9. Boiler according to claim 1, characterized in that said plurality of nozzles is arranged in groups of nozzles each oriented to reach with the flame the pipe at different heights.

10. Boiler according to claim 1, characterized in that the nozzles of said plurality of nozzles are oriented in a manner to determine a flow of fumes having a helical pattern around said pipe.

11. Boiler according to claim 1, characterized in that said first exchanger comprises a jacket for containing carrier fluid in which a plurality of fume pipes are immersed.

12. Boiler according to claim 1, characterized in that said second exchanger is arranged at the exit from the second end of said pipe and has a plurality of plates contained inside a cylindrical jacket longitudinally passed through by carrier

fluid channels and transversally passed through by said fumes.

13. Boiler according to claim 1, characterized in that said second exchanger regulates the fume exit temperature to an operating value below the dew temperature by means of a feedback control based on the value of the fume temperature to regulate accordingly the water flow rate in the second exchanger in order to maintain the above operating value of the temperature in the fumes.

14. Method for operating the boiler according to one or more of the preceding claims characterized in that it comprises a first combustion step for generating hot fumes intended for exchanging thermal power with a carrier fluid in a first exchanger and for heating a ceramic material pipe, a second combustion step inside said pipe of unburnt residues and pollutants present in the fumes and an amount of oxygen introduced into said pipe at a rate controlled by a lambda probe.

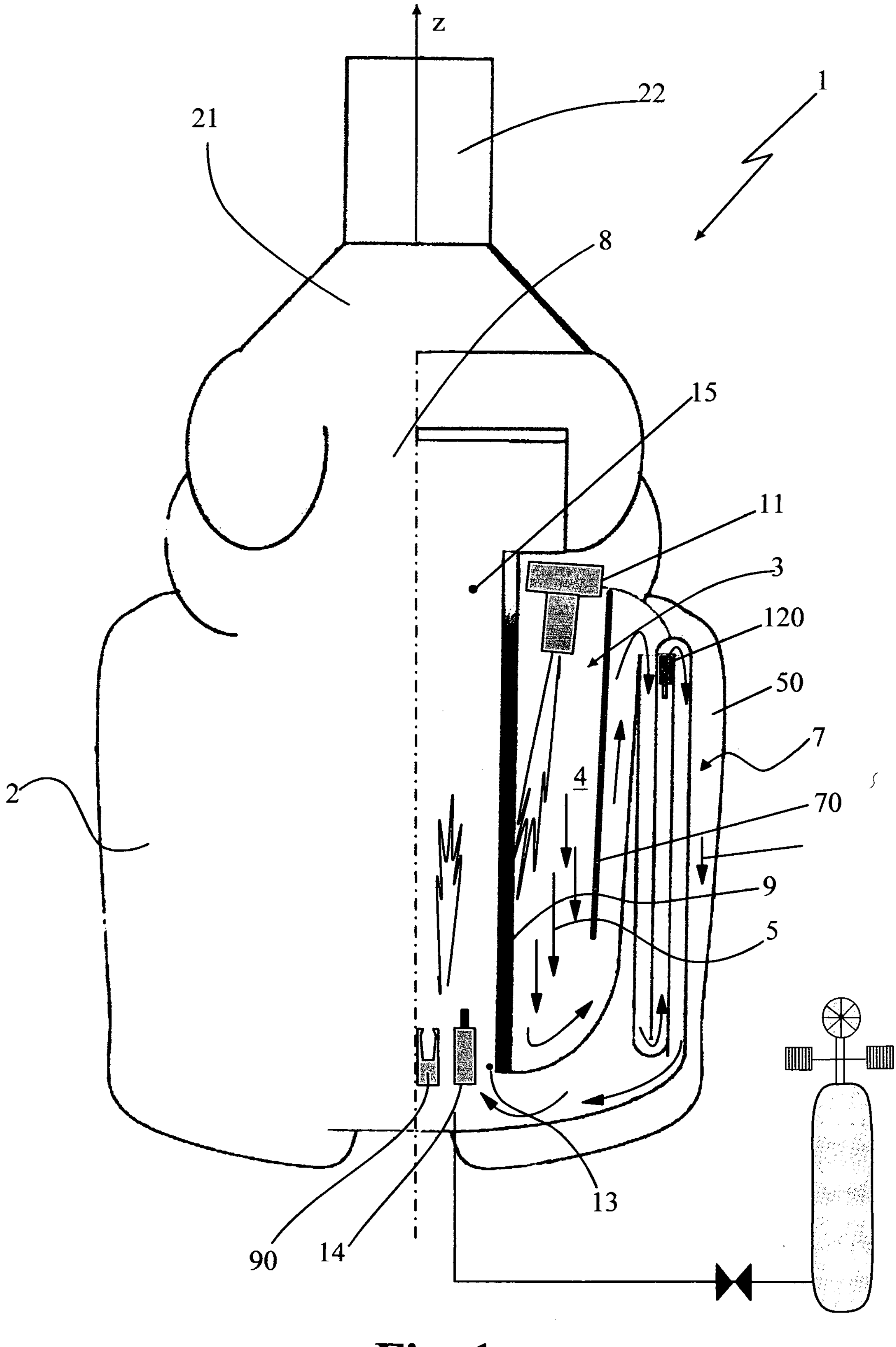

Fig. 1

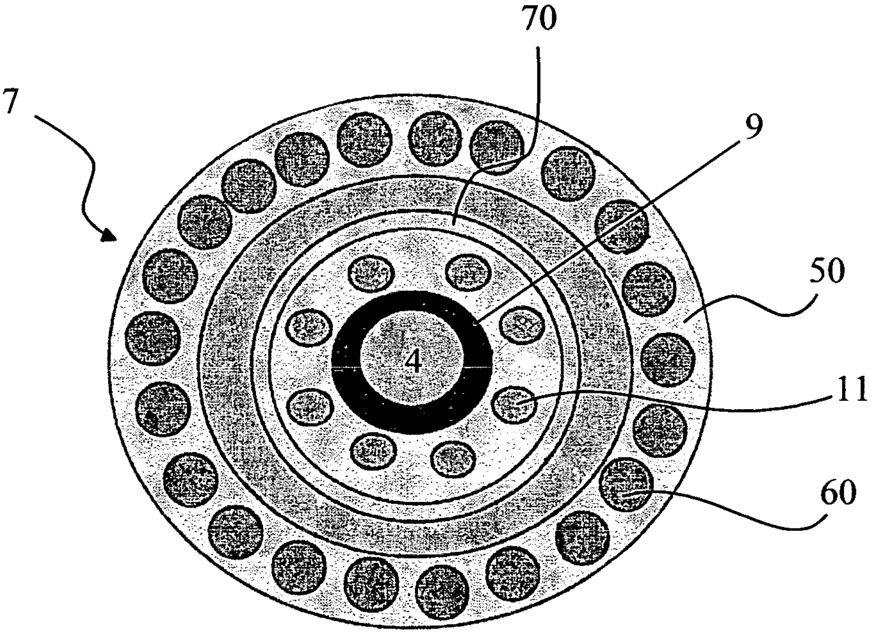

Fig. 2

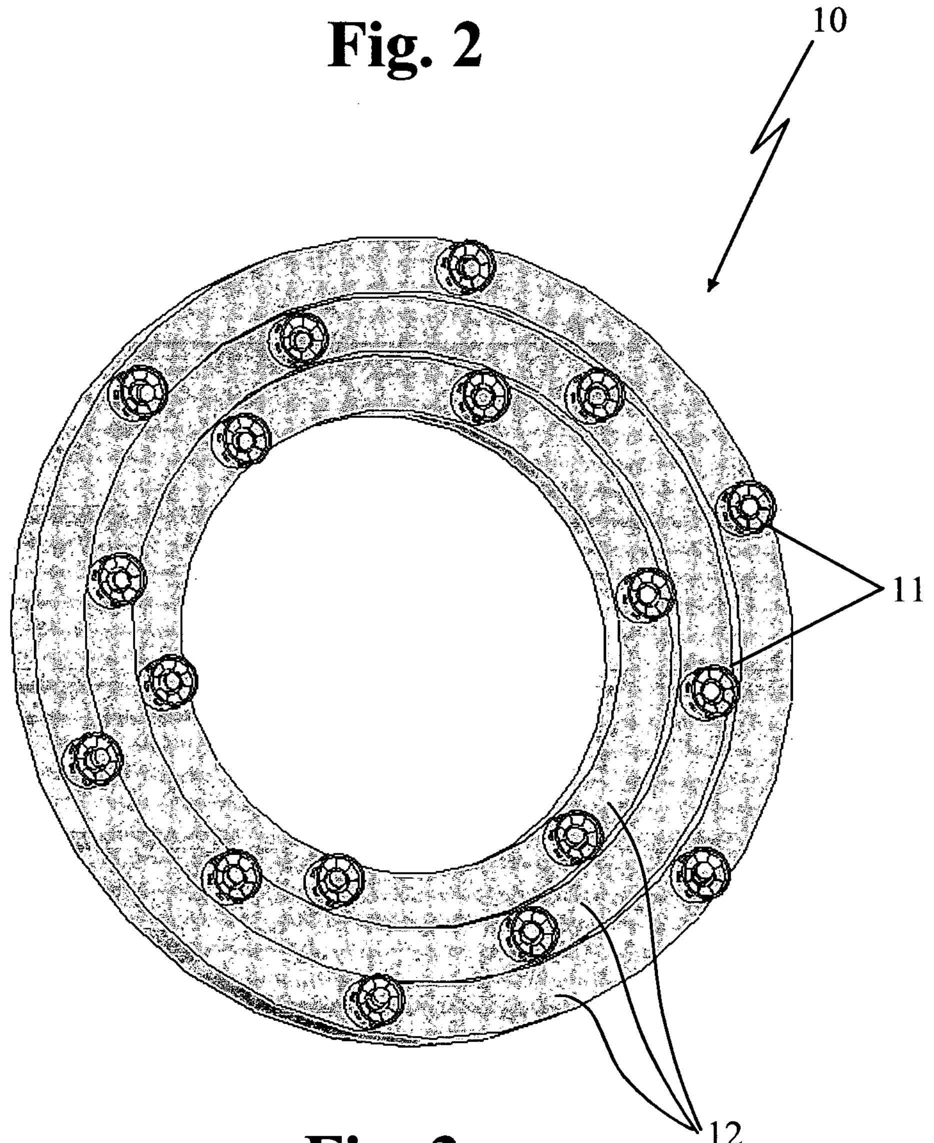

Fig. 3

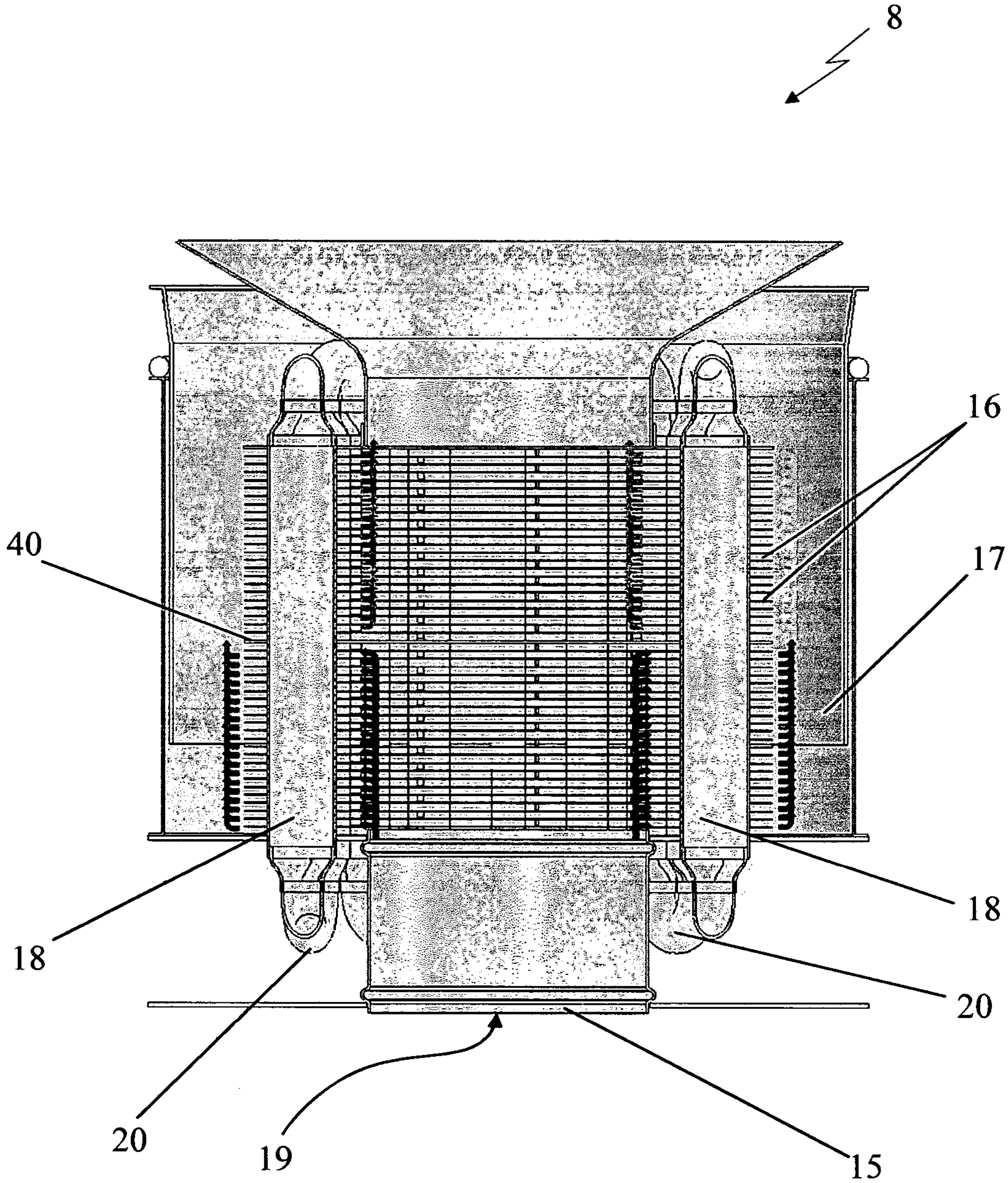

Fig. 4