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(54) **Title:** FURNACE PLANT AND PROCESS FOR TREATING FURNACE GAS

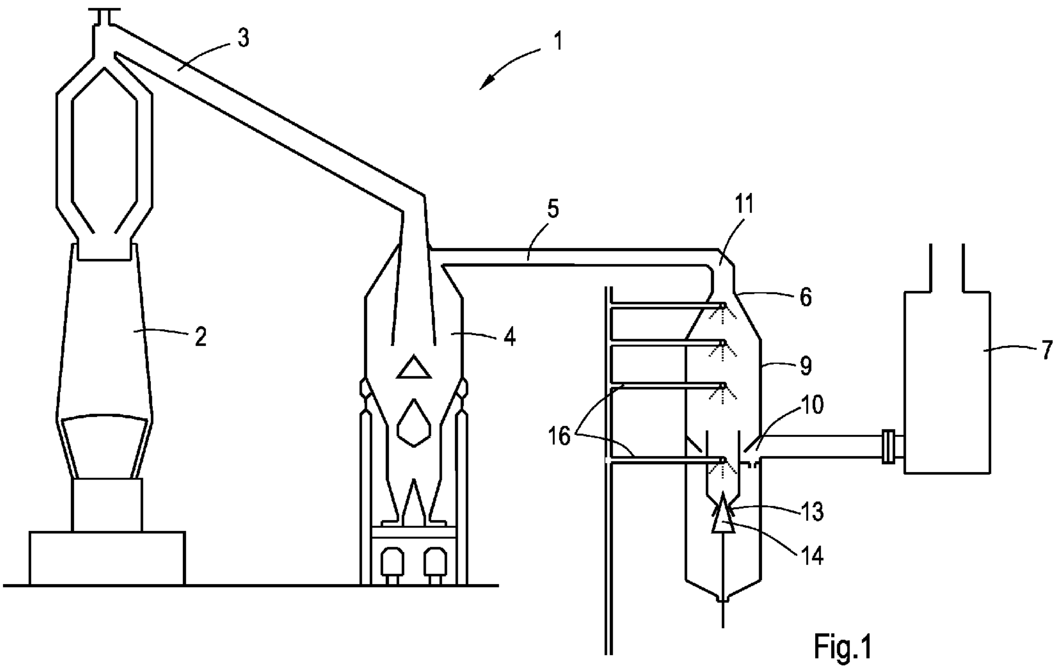

Fig.1

(57) **Abstract:** Process and furnace plant for production of liquid metal. The furnace comprises an apparatus (1) for treatment of furnace gas. The apparatus comprises a wet scrubber, preferably a venturi scrubber (6), such as an air gap scrubber, with an outlet connected to a mist eliminator (7) comprising a non-swirling separating device (30, 36), for example a Sulzer Mellachevron™ and optionally a second non-swirling separating device comprising a knitmesh combined with a second Sulzer Mellachevron™. Optionally, the demister (7) may comprise an inlet diffuser, such as a vane-type inlet device, in particular a Shell Schoepentoeter™ (22).

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[Continued on next page]

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FURNACE PLANT AND PROCESS FOR TREATING FURNACE GAS

The present invention pertains to a furnace plant for the production of liquid metal and a process for treating furnace gas produced by such furnaces. Such processes include blast furnace processes, electric arc furnace (EAF) processes, basic oxygen furnace (BOF) processes or direct reduced iron (DRI) processes.

Blast furnace gas leaving the blast furnace contains pollutants, including solid dust particles, which need to be removed. The same problem occurs with gases produced with other liquid steel or iron production processes. Removal of these components is typically done by wet scrubbing by using a venturi scrubber, such as an annular gap scrubber.

A venturi scrubber is a type of wet scrubber using an inlet gas stream to atomize the liquid used to scrub the gas stream. A venturi scrubber typically comprises a converging section, a throat, and a diverging section. The gas stream enters the converging section. In the flow direction gas flow velocity increases as the area decreases. Scrubbing liquid is typically introduced either at the throat or at the entrance to the converging section. The gas stream passes the throat with extremely high flow velocity and atomizes the scrubbing liquid to produce a fog of tiny droplets. Dust is removed from the gas stream in the diverging section where it mixes with the fog. In the diverging section the gas stream slows down again. An annular gap scrubber is a specific type of venturi scrubber having an adjustable annular throat. The throat area is adjusted by moving a plunger up or down in the throat. Gas flows through the annular gap and atomizes liquid that is sprayed onto the plunger or swirled in from the top. An example of such an annular gap scrubber is disclosed in GB 1,362,306.

Gas leaving the venturi scrubber contains gaseous and solid pollutants entrained in the scrubbing water which is carried by the gas flow as small droplets. The droplets are polluted water which needs to be separated from the gas flow and to be collected for further treatment. The droplet content also reduces the suitability of the gas for further use, e.g., in downstream burners, e.g., of an expansion turbine. Vaporization of droplets in an expansion turbine causes droplets carrying solids to produce deposits on the turbine blades that leads to vibrations and unbalance within the turbine. Within burners the droplets in the gas will tend to evaporate which causes heat loss.

Hitherto, the droplet content in gas leaving the scrubber is reduced by using a cyclone mist eliminator comprising a static swirler, particularly in view of the very small droplet size in the atomized mist leaving the venturi scrubber. Moreover, cyclones typically require only little maintenance. In a cyclone droplets are separated by centrifugal force imparted by the swirler. An example of a gas cleaning installation comprising an annular gap scrubber with a mist eliminator is disclosed in “Modern Blast Furnace (BF) And Converter (BOF) Gas Cleaning - A Report of State-of-the-art Technology” by F. Reufer and C. Davidi, available on the website http://seaisi.org. Another example of such a furnace is disclosed by the article “Wet vs Dry Gas Cleaning In The Steel Industry”, by H.C. Henschen, Journal of the Air Pollution Control Association, 18:5, p 338-342.

In the prior art gas treatment systems of steel production sites using annular gap scrubbers and cyclone mist eliminators the droplet concentration is typically reduced to about 5000 mg/Nm^3. Although this is a substantial reduction of the droplet content there is still a need to reduce the droplet content of the furnace gas even further.

It is an object of the present invention to achieve a substantial further reduction of the residual dust loaded droplets content in furnace gases.

The object of the invention is achieved with a furnace plant comprising a furnace for production of liquid metal and a discharge line for furnace gas with a wet scrubber, preferably a venturi scrubber (6), and a mist eliminator (7) downstream of the wet scrubber. The mist eliminator comprises at least one non-swirling separating device. Such a non-swirling separating device can for example be a mesh-type and/or vane-type separator, excluding swirlers and cyclones. The non-swirling separating device catches droplets in the gas flow and can for instance comprise a mesh and/or vanes shaped to let the droplets impinge onto their surfaces. The caught droplets are separated by impacting and drained by gravity, rather than by centrifugal force. The pressure drop over a venturi scrubber creates a mist with very small droplets. It was found that such atomized and dust-loaded droplets could be separated very efficiently using non-swirling mist eliminators.

In a specific embodiment, the mist eliminator may comprise an inlet diffuser for leveling the gas flow before it passes the non-swirling separating devices. Such a diffuser may for example be a vane-type inlet diffuser, such as a Shell Schoepentoeter™ or Schoepentoeter Plus™, commercially available from Sulzer. Examples of such devices are disclosed in GB 1,119,699, US 8,070,141 and EP 2 243 529 A1. Diffusion and levelling of the gas flow improves the separating efficiency of downstream separators. Additionally, the diffuser itself will also catch and separate droplets and reduce the droplet content.

For completeness sake it is noted that the product bulletin ".demisters R us." by Techim, version of July 27, 2011, discloses a combination of a vane inlet device with a mesh mist eliminator and a vane mist eliminator. The expression "demister", used in this publication, is used in the art as a synonym for the expression "mist eliminator". A similar combination is also disclosed in US 8,657,897. Hitherto it has not been proposed to use such combinations with a venturi scrubber or with a steel or iron production furnace or to use such a combination to remove solid particles from a gas flow.

US 6,083,302 discloses a wet scrubber with a downstream mist eliminator for desulfurization of a gas flow. It does not disclose or suggest using such a combination with a steel or iron production furnace or to remove solid particles from a gas flow.

One of the advantages of using non-swirling separating devices instead of a cyclone, is that a multi-stage separation can be carried out. For instance, the non-swirling separating devices may comprise a serial arrangement of an upstream non-swirling separating device for larger droplets and a downstream non-swirling separating device for smaller droplets. It has been found that this significantly improves the efficiency of droplet removal.

Very good results are obtained if the upstream non-swirling separating device comprises a vane-type mist eliminator, e.g, a mist eliminator comprising at least one series of parallel baffles profiled to define zigzag flow paths, such as a Chevron-type coalescer. Suitable Chevron-type coalescers are for example Mellachevron® coalescers, available from Sulzer. Such separators are particularly effective for separating larger droplets, e.g., droplets having a droplet size of at least about 15 µm. The pressure drop over a

Chevron-type coalescer will generally be at least about 2.9 mbar, e.g., at most about 3.6 mbar.

Particularly effective for the removal of smaller droplets are non-swirling separating devices with an inflow section comprising a combination of a wire mesh, such as a grid mesh or knit mesh, and an outflow section comprising a vane-type mist eliminator, in particular a Chevron coalescer, more in particular a Sulzer Mellachevron® coalescer. Examples of commercially available suitable wire mesh separators include KnitMesh™ Wire Mesh Mist Eliminators, Sulzer KnitMesh V-MISTER™, KnitMesh XCOAT™, or the High-Performance KnitMesh™ 9797 Mist Eliminator, all available from Sulzer. In such wire mesh separators small droplets coalesce to form larger droplets which can be separated more efficiently in a subsequent vane-type separator. The pressure drop over such a knit mesh coalescer will generally be at least about 3.6 mbar, e.g., at most about 6 mbar.

Very good results were obtained by using a mist eliminator comprising a vessel housing a serial arrangement of, viewed in flow direction of the treated gas, an upstream vane inlet device, in particular a Shell Schoepentoeter™ or Schoepentoeter Plus™, followed by a first Chevron mist eliminator, in particular a Sulzer Mellachevron™ and subsequently a non-swirling separating device having an inlet section comprising a knit mesh separator, in particular a Sulzer Knitmesh™ mist eliminator and an outlet section comprising a second Chevron-type mist elimination, in particular a Sulzer Mellachevron™. It has been found that such an arrangement enables a reduction of the droplet concentration to a level as low as about 100 mg/Nm^3, which is about 50 times lower than the prior art systems using axial-flow cyclone mist eliminators.

The pressure drop over a Shell Schoepentoeter™ will generally be at least about 9.3 mbar, e.g., at most about 11.2

mbar. The total pressure drop of the combination of a Shell Schoepentoeter™ inlet device, a Chevron-type coalescer and a knit mesh will generally be at least about 21.7 mbar, e.g., at most about 27.4 mbar.

Good results are obtained if the gas flow through the non-swirling separating devices is substantially vertical. However, other arrangements, such as a horizontal arrangement, can also be used, if so desired.

At the inlet of the mist eliminator, more particularly at the inlet of the vane inlet device, the pressure may for example typically be about 3 bar or less.

The wet scrubber may for example be an annular gap scrubber. An example of such an annular gap scrubber is disclosed in US 4,375,439.

Optionally, the furnace may comprise one or more dry dust catchers upstream of the wet scrubber. Such a dust catcher may for example comprise a gravity dust catcher and/or a cyclone.

The invention does not only relate to a liquid metal production furnace plant as such but also to a process for treatment of furnace gas discharged from a furnace for the production of liquid metal. As explained above, the gas is first treated in a wet scrubber, preferably a venturi scrubber, more preferably an annular gap scrubber, and subsequently in a mist eliminator comprising at least one non-swirling separating device. Larger droplets can for example be separated in an upstream separating device and subsequently smaller droplets are separated in a downstream separating device. Optionally, the furnace gas is first passed via an inlet diffuser, such as a Shell Schoepentoeter™.

The furnace gas typically comprises at least 15 vol. % carbon monoxide, e.g. at most 80 vol.% carbon monoxide, and at least about 10 vol. % of carbon dioxide, e.g., at most 30 vol.% of carbon dioxide and about 0 - about 20 vol.% of hydrogen. For instance blast furnace gas usually contains about 15 - 35 vol% of carbon monoxide, about 20 - 30 vol% of carbon dioxide and about 3 - 20 vol% of hydrogen. Gas from basic oxygen furnaces typically comprises about 50 - 80 vol% of carbon monoxide and about 10 - 30 vol% of carbon dioxide. The lower heating value (LHV) can be between about 3 to about 12 MJ/Nm3. The LHV of blast furnace gas is for instance typically about 3 - 5 MJ/Nm3, whereas the LHV of gas from basic oxygen furnaces is typically about 9 - 12 MJ/Nm3.

The dust content of the furnace gas may be as high as 15 g/m3 before it enters the wet scrubber. After leaving the mist eliminator, the dust content can be as low as 5 mg/Nm3 or even lower.

Dust born by furnace gas typically has a mean particle size (D50) below 10 µm, measured in accordance with ISO 13320:2009.

In liquid steel or iron production the dust in furnace gas mainly contains a mixture of iron(III)oxide and carbon and less than 5 wt% of zinc.

The plant of the present disclosure is used for the production of liquid metal, in particular liquid steel or iron, but it may also be used for other liquid metals, such as aluminum, nickel, zinc or copper.

The invention is further explained with reference to the accompanying drawings, showing an exemplary embodiment.

Figure 1: shows a furnace plant for liquid steel or iron production;

Figure 2: shows a mist eliminator of the furnace of Figure 1;

Figure 3: shows the Shell Schoepentoeter™ of the mist eliminator of Figure 2;

Figure 4: shows a first non-swirling separating device of the mist eliminator of Figure 2;

Figure 5: shows schematically internals of the device of Figure 4;

Figure 6: shows a second non-swirling separating device of the mist eliminator of Figure 2.

Figure 1 shows a furnace plant 1 for the production of steel or iron. The furnace plant 1 comprises a blast furnace 2 connecting to a discharge line 3 at its top end for the discharge of blast furnace gas. The discharge line 3 opens downwardly into a dry dust catcher 4, where a first portion of the dust is separated by gravity. Alternatively, or additionally, one or more cyclones can be used here. Subsequently, the remaining gas flows through a second discharge line 5 to an annular gap scrubber 6. Downstream of the annular gap scrubber 6, the gas flows into a mist eliminator 7.

The annular gap scrubber 6 comprises a vertical cylindrical vessel 9 with a furnace gas outlet 10 and a furnace gas inlet 11 at its upper end. In the interior of the vessel 9 are annular gap devices 13. The annular gap devices 13 are tapered and comprise a frustoconical plug 14 which can be moved to adjust the width of an annular gap between the plug 14 and the annular gap device 13. Upstream of the annular gap devices 13 is a series of spray nozzles 16 in a pre-scrubber.

The mist eliminator 7 is shown in more detail in Figure 2 and comprises a vertical cylindrical vessel 17 with a lateral inlet 18 at a lower side of the vessel 17 and an outlet 20 at the top of the vessel 17. The inlet 18 comprises a Shell Schoepentoeter Plus™ inlet diffuser 22, shown in more detail in Figure 4.

In top view the Shell Schoepentoeter Plus™ 22 converges from the inlet side to the opposite side of the vessel 17. The Shell Schoepentoeter Plus™ 22 has closed top and bottom surfaces 24, 25 and two vertical side faces defined by a series of vertical parallel vanes 27 between the top and bottom surfaces 24, 25. The vertical vanes 27 are provided with a row of inclined catching rims 29 (not shown in Figure 3) to reduce the risk of re-entrainment of separated droplets. Such rims 29 are disclosed in detail in US 8,070,141 and EP 2 243 529.

At a distance above and downstream of the Shell Schoepentoeter Plus™ 22 is a first Sulzer Mellachevron™ mist eliminator 30, with a height of about 140 mm in the flow direction. The flow velocity at this point is for instance about 4 - 5 m/s. The pressure drop is typically about 2,5 - 3,5 mbar.

The Sulzer Mellachevron™ mist eliminator 30 is shown in more detail in Figure 4. In the shown embodiment the device comprises four vertical filter elements 31 in a square arrangement. Gas flows into the square via the open bottom side and subsequently it flows through the filter elements 31 (see the arrows in Figure 2). Other arrangements of the filter elements 31 can also be used.

The internals of the filter elements 31 of the Sulzer Mellachevron™ mist eliminator separator 30 (see Figure 5) comprises a series of parallel baffles or partitions 32 bent to define vertical zigzag shaped channels 33, inhibiting a straight vertical gas flow and guiding the gas flow C to follow a meandering flow path, as shown schematically in Figure 2. The corners 34 of the zigzag channels 33 are provided with bent strips 35 with bent top ends pointing in the counterflow direction.

Downstream of the Sulzer Mellachevron™ 30 is a second non-swirling separating device 36, shown in more detail in Figure 6. This non-swirling separating device 36 comprises two opposite symmetrically arranged elements 40, both having an inflow section 41 with a vertically arranged layer of knitted metal wires 43, and an outflow section 42 comprising a second Sulzer Mellachevron™ mist eliminator 44. The elements 40 are arranged vertically with the outflow sections 42 facing each other. Between the layer of knitted metal wires 43 and the Sulzer Mellachevron™ 43 is an air gap. Flow velocity at this point is for instance about 4 - 5 m/s. The thickness of the knit mesh may for example be about 100 mm. The knit mesh density may for example be about 180 - 200 kg/m^3, e.g., about 192 kg/m^3. The pressure drop is typically about 4,6 - 6 mbar.

In use fresh furnace gas enters the annular gap scrubber 6 via the furnace gas inlet 11. The sprayers 16 spray a co-current spray of water into the gas flow. All of the gas flows through the annular gap devices 13. The water entrains gaseous and solid pollutants. Droplets of water flow upwardly with the gas flow to the outlet 10.

The gas flow carrying the droplets leaves the annular gap scrubber 6 at the outlet 10 and enters the mist eliminator 7 via the Shell Schoepentoeter Plus™ inlet diffuser 22. The vertical vanes 27 of the Shell Schoepentoeter Plus™ level the gas flow. A first part of the droplets in the gas flow impinges on the vanes 27 of the Shell Schoepentoeter Plus™ 22 and is drained by gravity to the bottom 38 of the vessel where it is discharged via a water outlet 40.

Subsequently, the gas flow arrives at the Sulzer Mellachevron™ 30. The gas flow into the square arrangement and leaves this square via the filter elements 31. In the filter elements 31 the gas flow is deflected a number of times in the zigzag channels 33. Droplets impinge onto the baffles 32 and the bent strips 35 and are drained in a perpendicular manner by gravity. This separates in particular the larger droplets from the gas flow. The separated droplets flow down to the bottom 38 of the vessel and are discharged via the water outlet 40.

The gas flow leaving the Sulzer Mellachevron™ 30 still contains very small dust-loaded droplets. The gas flow flows upwardly and is forced to pass the knit mesh inflow section 41 of the second non-swirling separating device 36, where the small droplets coalesce to form larger droplets. The gas flow carries the larger droplets to the downstream Sulzer Mellachevron™ 44 at the outflow section 42, where most of the remaining droplets are separated from the gas flow. Downstream of the second non-swirling separating device 36 the gas flow leaves the mist eliminator 7 at the outlet 20. At this stage the discharged gas flow has a droplet concentration of about 100 mg/Nm^3, or even less. This is about 50 times lower than the droplet concentration using a conventional cyclone mist eliminator. With a flow of blast furnace gas of 600,000 Nm$^{3/h}$ and an evaporation enthalpy of 2,500 kJ/kg, the net gain of thermal energy would be 2,042 kW. With 355 operational days per year the annual net gain thermal energy would be 17,395 MW/h, corresponding to a net gain electrical power of 6,436 MWh/y with a typical electrical efficiency of 37 %.

CLAIMS

1. Furnace plant (1) comprising a furnace (2) for production of liquid metal and a discharge line for furnace gas with a wet scrubber, preferably a venturi scrubber (6), and a mist eliminator (7) downstream of the wet scrubber, wherein the mist eliminator comprises at least one non-swirling separating device (30, 36).

2. Furnace plant according to claim 1, wherein the mist eliminator (7) comprises an inlet diffuser, such as a vane-type inlet device, in particular a Shell Schoepentoeter™ (22).

3. Furnace plant according to claim 1 or 2, wherein the non-swirling separating device comprises a serial arrangement of an upstream non-swirling separating device (30) for larger droplets and a downstream non-swirling separating device (36) for smaller droplets.

4. Furnace plant according to claim 3, wherein the upstream non-swirling separating device (30) comprises at least one series of parallel baffles profiled to define zigzag flow paths, such as a Sulzer Mellachevron™ mist eliminator.

5. Furnace plant according to claim 3 or 4, wherein the downstream non-swirling separating device comprises a grid mesh and/or knit mesh (36) with a second vane-type mist eliminator, such as a Sulzer Knitmesh™ mist eliminator combined with a Sulzer Mellachevron™ mist eliminator.

6. Furnace plant according to any preceding claim, wherein the wet scrubber comprises a venturi scrubber, e.g., an annular gap scrubber (7).

7. Furnace plant according to any preceding claim, wherein the liquid metal is steel, iron, aluminum, nickel, zinc or copper, preferably steel or iron.

8. Process for treatment of furnace gas discharged from a furnace (2) for the production of metal, wherein the gas is first treated in a wet scrubber (6), preferably a venturi scrubber, and subsequently in a mist eliminator comprising at least one non-swirling separating device (30, 36).

9. Process according to claim 8, wherein the mist eliminator comprises a serial arrangement of at least an upstream non-swirling separating device (30) and a downstream non-swirling separating device (36).

10. Process according to claim 8 or 9, wherein the upstream separating device comprises a vane-type mist eliminator, such as a Sulzer Mellachevron™ mist eliminator (30).

11. Process according to claim 8, 9 or 10, wherein the downstream non-swirling separating device comprises a grid mesh and/or knit mesh (36) with a vane-type mist eliminator, such as a Sulzer Knitmesh™ mist eliminator and a Sulzer Mellachevron™ mist eliminator.

12. Process according to any one of claims 8 - 11, wherein the venturi scrubber is an annular gap scrubber (6).

13. Process according to any one of claims 8 - 12, wherein the furnace gas flow is levelled downstream of the venturi scrubber and upstream of the non-swirling separating devices, e.g., by means of an inlet diffuser, such as a Shell Schoepentoeter™ (22).

14. Process according to any one of the preceding claims 8 - 13, wherein the liquid metal is steel, iron, aluminum, nickel, zinc or copper, preferably steel or iron.

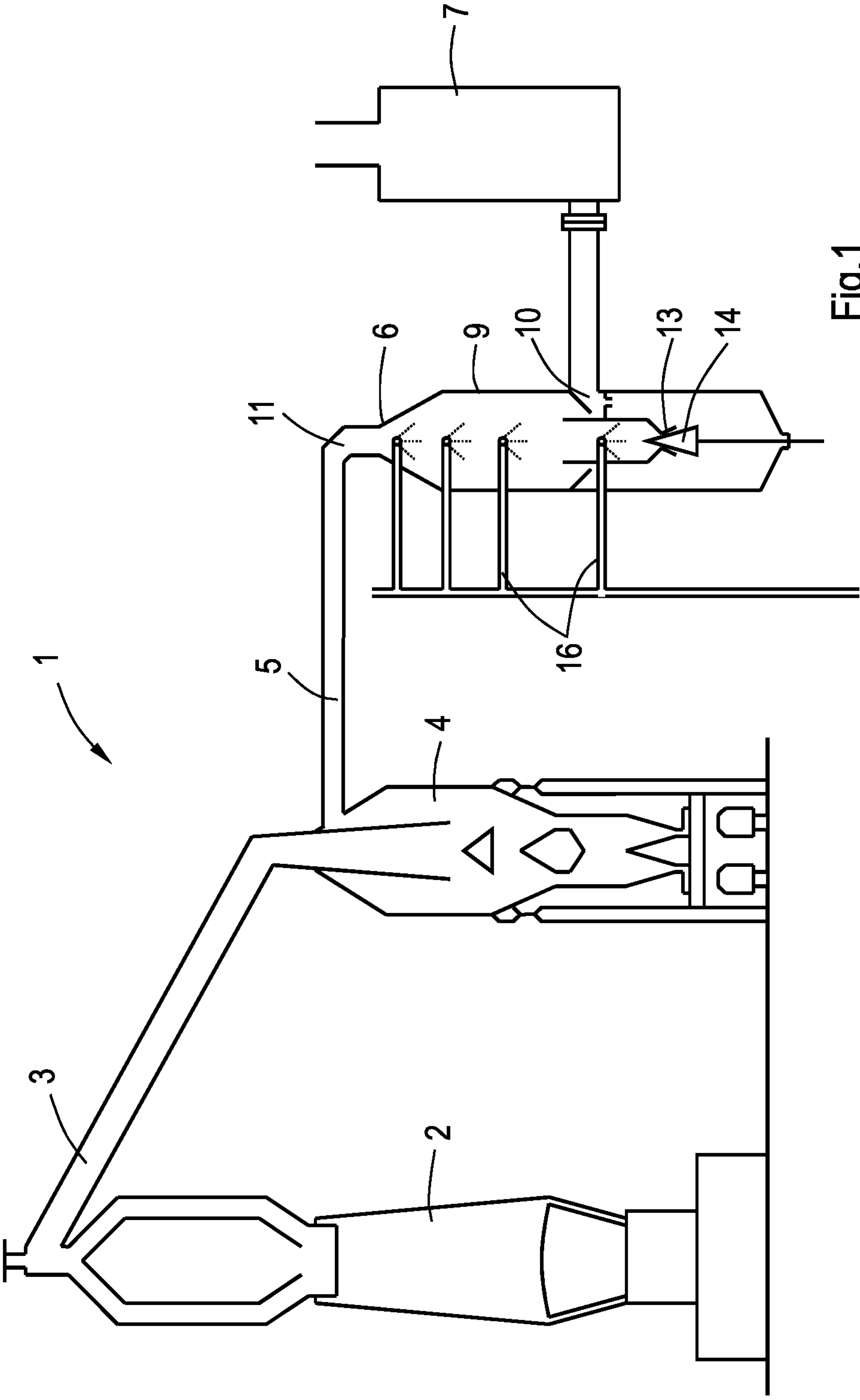

Fig.1

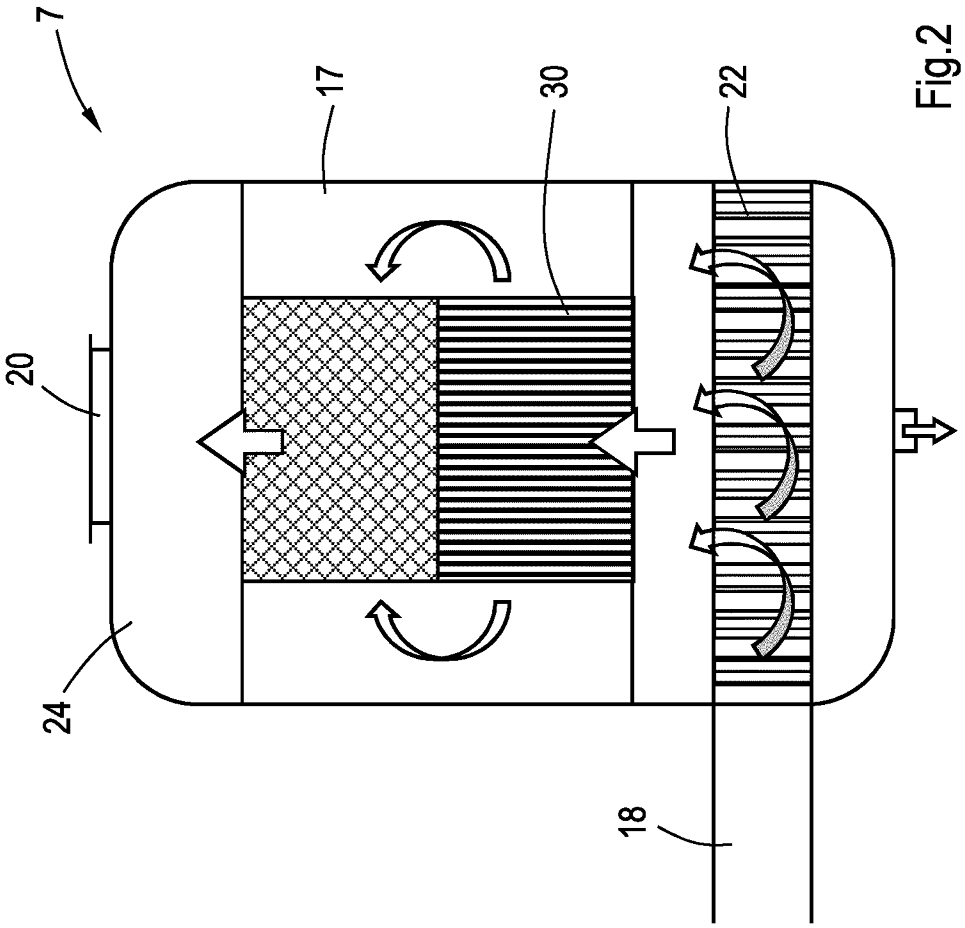

Fig.2

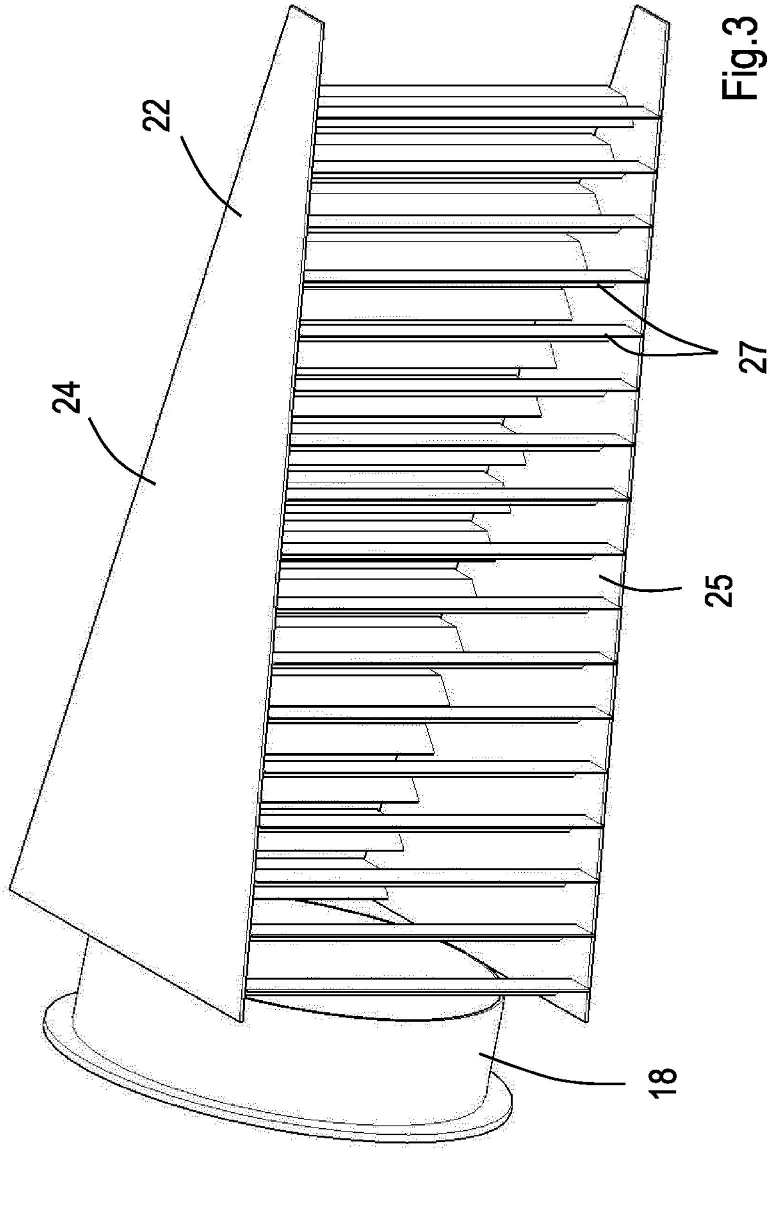

Fig.3

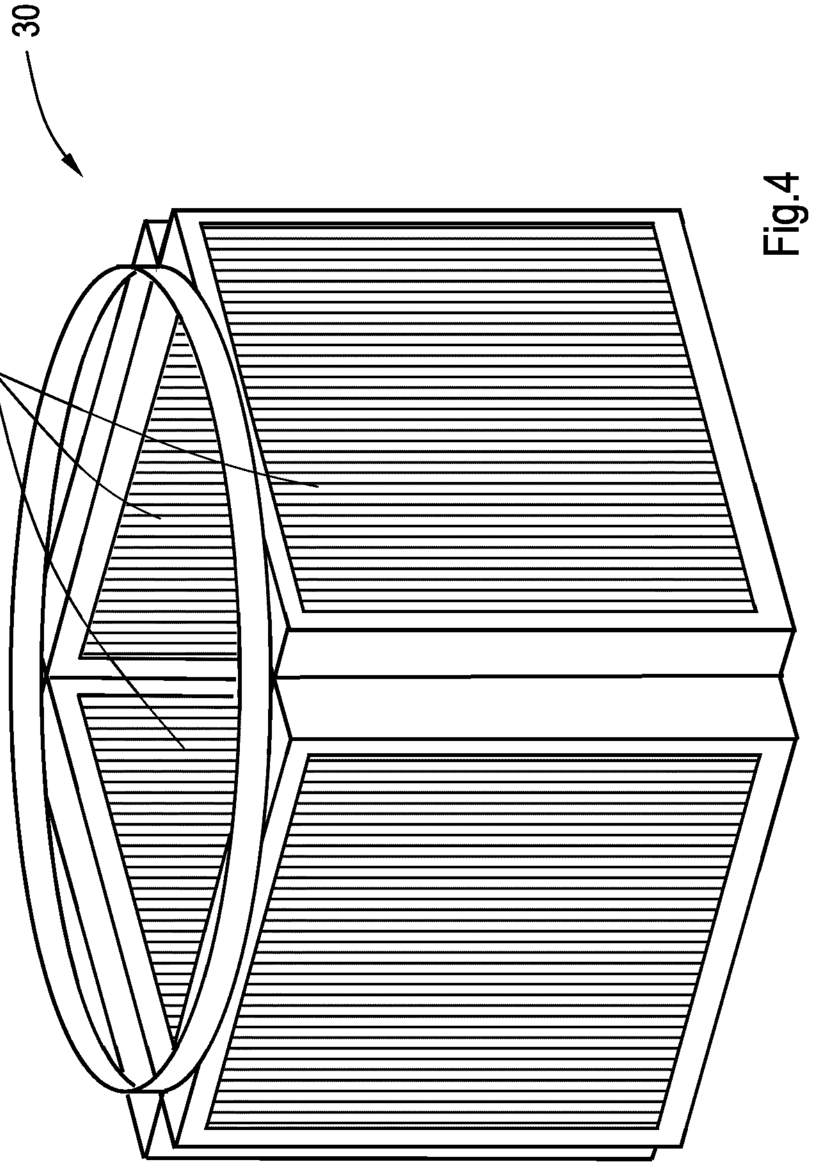

Fig.4

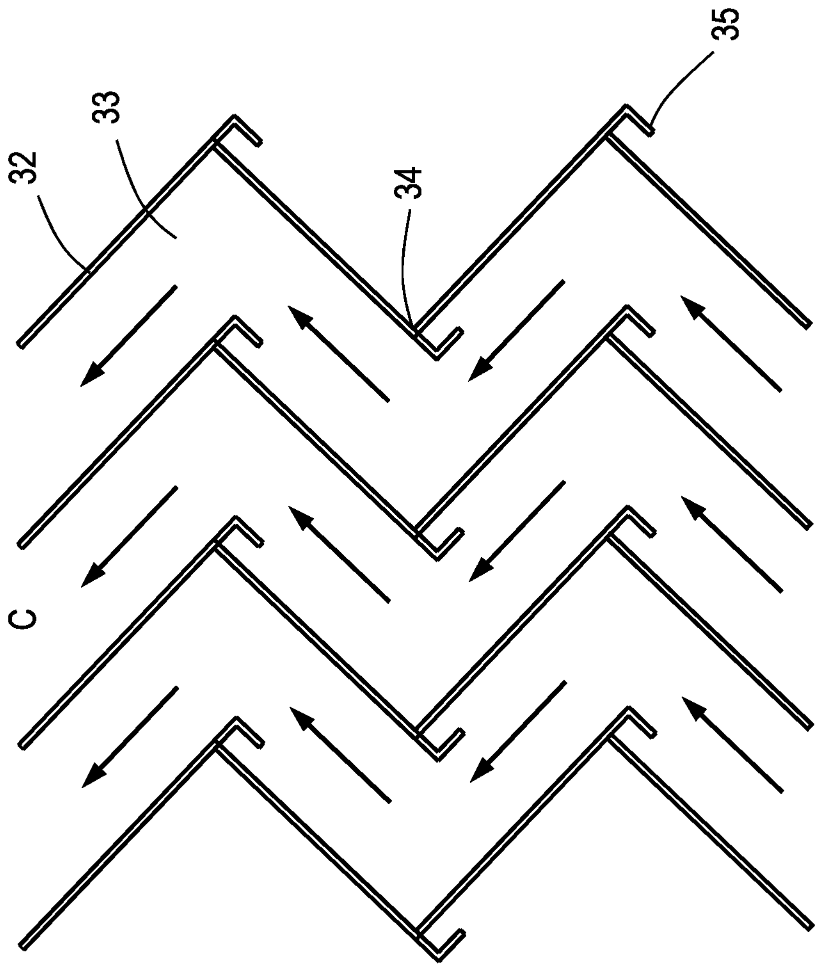

Fig.5

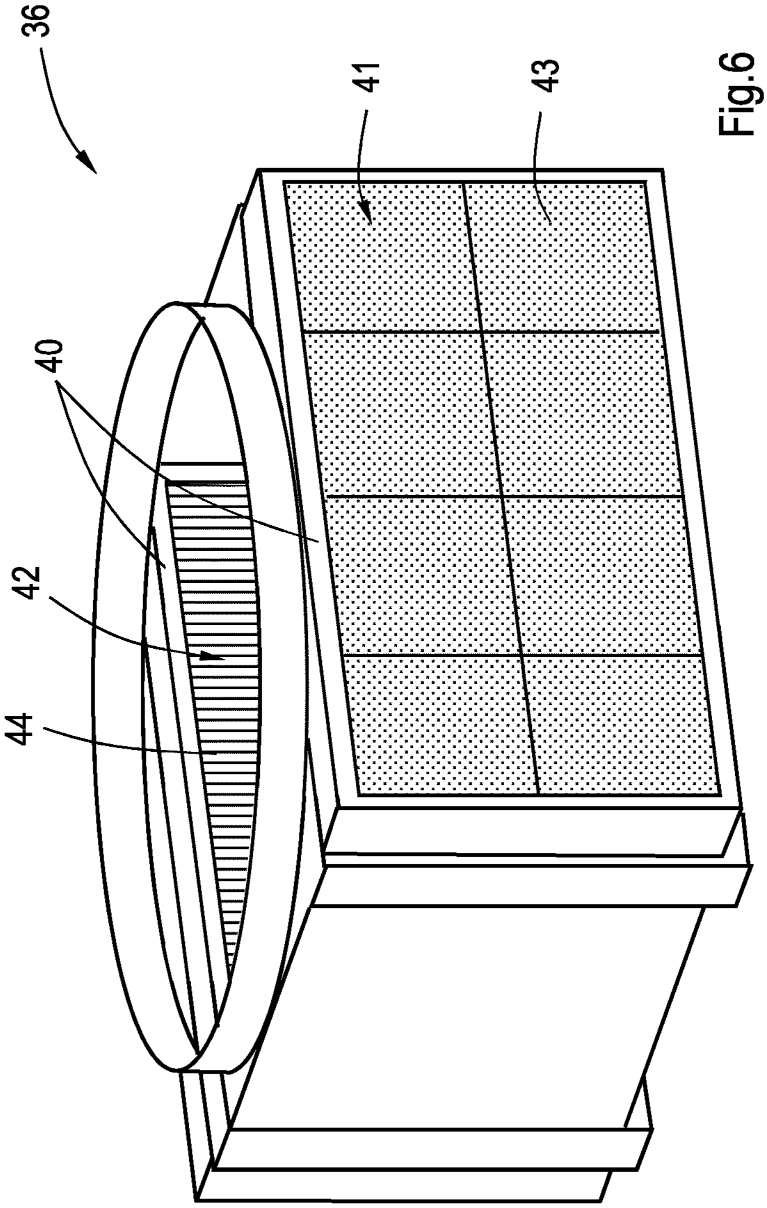

Fig.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/061398

A. CLASSIFICATION OF SUBJECT MATTER
INV. F27D17/00 C21B7/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F27B F27D C21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 28 20 728 A1 (BISCHOFF GASREINIGUNG) 15 November 1979 (1979-11-15) page 3, line 1 - page 4, line 10 page 10, line 23 - page 11, line 26 figures 1, 2 -----	1-14
X	DE 43 01 886 A1 (EISENGIESEREI UND MASCHINENFAB [DE]) 21 July 1994 (1994-07-21) column 1, line 1 - line 7 column 3, line 4 - line 40 figure 1 -----	1-14
X	US 4 957 512 A (DENISOV VLADIMIR F [SU] ET AL) 18 September 1990 (1990-09-18) column 1, line 1 - column 13 column 6, line 20 - column 7, line 6 figure 1 ----- -/--	1-14

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
18 July 2017	25/07/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/061398

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 162 293 A (GODO SEITETSU [JP]) 29 January 1986 (1986-01-29) page 1, line 5 - line 19 page 4, line 25 - page 5, line 1 figures 1, 5 -----	1-14
A	WO 2005/018780 A2 (FLASH TECHNOLOGIES N V; FMC TECHNOLOGIES CV [US]; LARNHOLM PER-REIDAR) 3 March 2005 (2005-03-03) page 1, line 1 - line 10 page 10, line 1 - line 32 figures 1, 2, 6 -----	1-14
A	US 2007/277485 A1 (MACKENZIE DOUGLAS [CA] ET AL) 6 December 2007 (2007-12-06) column 1, line 14 - line 23 column 3, line 17 - line 45 figures 1, 2, 5-7 -----	1-14
A	WO 2013/182748 A1 (OUTOTEC OYJ [FI]) 12 December 2013 (2013-12-12) page 1, line 1 - line 17 page 8, line 24 - page 9, line 29 figures 1, 4, 5, 6 -----	1-14

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/061398

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
DE 2820728	A1	15-11-1979	NONE			
DE 4301886	A1	21-07-1994	NONE			
US 4957512	A	18-09-1990	DE	3927701	A1	28-02-1991
			US	4957512	A	18-09-1990
GB 2162293	A	29-01-1986	DE	3524171	A1	23-01-1986
			FR	2567999	A1	24-01-1986
			GB	2162293	A	29-01-1986
			JP	S6129686	A	10-02-1986
			JP	S6231272	B2	07-07-1987
			US	4619693	A	28-10-1986
			US	4692113	A	08-09-1987
WO 2005018780	A2	03-03-2005	AT	536215	T	15-12-2011
			AU	2004266073	A1	03-03-2005
			EP	1663448	A2	07-06-2006
			NL	1024149	C2	23-02-2005
			US	2007044437	A1	01-03-2007
			WO	2005018780	A2	03-03-2005
US 2007277485	A1	06-12-2007	CA	2549105	A1	30-11-2007
			US	2007277485	A1	06-12-2007
WO 2013182748	A1	12-12-2013	AU	2013273405	A1	27-11-2014
			CA	2872666	A1	12-12-2013
			CN	104411382	A	11-03-2015
			EA	201491926	A1	29-05-2015
			FI	125659	B	31-12-2015
			US	2015165364	A1	18-06-2015
			WO	2013182748	A1	12-12-2013