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(54) Title: SPRAY-DRIER FOR THE PRODUCTION OF ATOMIZED CERAMIC POWDER FROM A WATER SUSPENSION OF CERAMIC MATERIAL

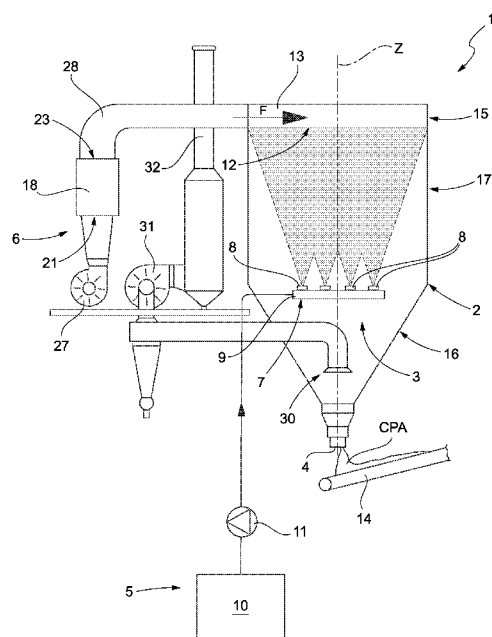


FIG. 3

(57) Abstract: A spray-drier (1) comprising: a main body (2), which delimits an atomization chamber (3); a feeding system (5) to feed a water suspension of ceramic material in to the atomization chamber (3), which comprises at least one spraying unit (7) to spray the water suspension of material; a heating system (6) to generate a hot gas flow (F) having a temperature of at least circa 400°C (in particular, ranging from circa 500°C to circa 600°C) using at least one electric heater (18); and a distribution device (12) for distributing said hot gas flow (F) inside said atomization chamber (3) so that it hits the sprayed water suspension of ceramic material, thus drying the solid ceramic material contained therein and generating atomized ceramic powder (CPA).



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"SPRAY-DRIER FOR THE PRODUCTION OF ATOMIZED CERAMIC POWDER
FROM A WATER SUSPENSION OF CERAMIC MATERIAL"

Cross-Reference to Related Applications

5 This Patent Application claims priority from Italian Patent Application No. 102022000016980 filed on August 8, 2022, the entire disclosure of which is incorporated herein by reference.

Technical Field

10 This invention is related to the field of the manufacture of ceramic products, such as, for example, tiles, ceramic slabs, dish ware, toilets, etc. In particular, this invention is applicable to the field of processing a water suspension of ceramic material, also known as barbotine, in
15 order to obtain atomized ceramic powder.

Background of the Invention

In the field of the production of ceramic articles, it is known to produce at least part of the atomized ceramic powder using spray-driers designed to produce a granular
20 material with suitable particle size features and residual humidity that make it suitable for forming ceramic articles, in particular basically flat ceramic articles, such as, for example, ceramic tiles and slabs. A known spray-drier typically comprises a main body that defines an atomization
25 chamber inside of which the processing of the above-mentioned water suspension of ceramic material (so-called barbotine) takes place to obtain atomized ceramic powder, which is then sifted and stored in special deposit silos, from where it is withdrawn to be used after an ageing period such as to allow
30 the uniform distribution of the humidity and temperature values among the granules of this atomized ceramic powder.

In still more detail, the spray-drier comprises: a feeding system configured to feed jets of water suspension of ceramic material at high pressure inside the atomization
35 chamber, generally via multiple nozzles; a heating assembly,

typically consisting of a natural gas, LPG, or liquid fuel burner, to provide heat and heat the air so as to produce a flow of hot air that has a temperature ranging between approximately 500°C to 600°C; and a hot air distributor placed at the top of the atomization chamber and configured to receive the flow of hot air from the heating assembly and distribute this hot air flow inside the atomization chamber according to certain paths, for example, by inducing the hot air to move with a swirling motion, so that the water suspension of ceramic material, sprayed from the nozzles, and the hot air flow, suitably distributed, meet and form atomized ceramic powder and discharge fumes, destined to be emitted into the atmosphere via a discharge chimney after having been suitably filtered and/or reduced, for example using separator cyclones, bag filter scrubbers, etc. The atomized ceramic powder, instead, once dried, falls downwards and is discharged via a discharge belt towards subsequent processing stations.

These spray-driers, though offering excellent performance, have some drawbacks, mainly relating to the environment and energy.

In a system for producing ceramic products, the spray-drier is, in fact, one of the most critical machines, together with the furnace, in terms of the environment and energy use since it is one of the machines that requires the greatest quantity of incoming energy and is responsible for the production of a large part of the carbon dioxide produced in the whole ceramic product production system, in particular approximately 30% of the total carbon dioxide produced by a system for manufacturing ceramic products.

The problems connected to carbon dioxide emissions are combined with the recent issues linked to growing difficulties in sourcing raw materials, such as fossil fuels, etc.

The purpose of this invention is to provide a spray-

drier that makes it possible to overcome, at least in part, the drawbacks of the prior art and that, at the same time, ensures similar performance to the known spray-driers.

Summary

5 In accordance with this invention, a spray-drier for the production of atomized ceramic powder from a water suspension of ceramic material is provided, according to what is claimed in the appended independent claim, and preferably, in any one of the claims depending directly or
10 indirectly on the above-mentioned independent claims.

The claims describe preferred embodiments of this invention forming an integral part of this description.

Brief Description of the Drawings

The invention is described below with reference to the
15 accompanying drawings that show some non-limiting embodiments of it, wherein:

- Figure 1 is a schematic perspective view of a spray-drier in accordance with a first embodiment of this invention;

20 - Figure 2 is a schematic perspective view of a spray-drier in accordance with an additional embodiment of this invention;

- Figure 3 is a schematic side view of a spray-drier of the type represented in Figure 1;

25 - Figure 3A is a schematic side view of a spray-drier in accordance with an additional embodiment of this invention; and

- Figures 4, 4A, 5, and 6 are schematic views of three different possible electric heater devices.

Detailed Description

In the attached figures, the reference number 1 denotes, as a whole, a spray-drier for the production of atomized ceramic powder CPA from a water suspension of ceramic material, also known in the sector as barbotine.

35 Specifically, advantageously but not limitatively, this

water suspension of ceramic material comprises a quantity ranging between approximately 30% and approximately 40% (in particular, approximately 33%; more in particular, approximately 32%) by weight of water and the remaining part
5 (in particular, at least approximately 67% by weight) of solid ceramic material. Advantageously but without imposing limits, the solid ceramic material comprises (in particular, consists of) clay, kaolin, feldspar, quartz sand and/or a combination thereof. Still more advantageously but not
10 limitatively, this water suspension of ceramic material has a density that can vary from approximately 1600 g/l to approximately 1750 g/l and a kinematic viscosity that can vary from approximately 5.0×10^{-6} m²/s to approximately 3.0×10^{-5} m²/s.

15 With particular reference to Figures 1 to 3, advantageously, the spray-drier 1 comprises a main body 2 that delimits an atomization chamber 3 and that comprises at least one discharge outlet 4 configured to allow the atomized ceramic powder CPA to leave the atomization chamber 3, the
20 which ceramic powder CPA, advantageously but without imposing limits, has a water content that can vary from approximately 4% to approximately 7% (in particular, equal to approximately 5%). Advantageously but without imposing limits, the main body 2 of the spray-drier 1 has a symmetry
25 axis Z that is basically vertical.

Advantageously (again with particular reference to Figures 1 to 3), the spray-drier 1 also comprises a feeding system 5 (schematically illustrated in Figure 3) that is configured to feed the above-mentioned water suspension of
30 ceramic material inside the atomization chamber 3 after having suitably sprayed it; and a heating system 6 configured to generate a hot gas flow F that has a temperature of at least approximately 400°C (in particular, ranging between approximately 500°C and approximately 600°C) and to send
35 this hot gas flow F inside the atomization chamber 3 so that

the hot gas flow F meets the sprayed water suspension of ceramic material causing the solid ceramic material contained in it to dry and generating atomized ceramic powder CPA.

5 In particular (advantageously but not limitatively), the feeding system 5 comprises at least one spraying unit 7, advantageously arranged inside the atomization chamber 3, and configured to spray the water suspension of ceramic material and send this sprayed water suspension of ceramic
10 material inside the atomization chamber 3 so as to form a rain of very fine drops of water suspension of ceramic material.

 According to some advantageous but non-limiting embodiments, like that illustrated in Figures 1 to 3, the
15 spraying unit 7 comprises (in particular, consists of) multiple nozzles 8, each of which is configured to send a jet of water suspension of ceramic material inside the atomization chamber 3 (as schematically illustrated in Figure 3), advantageously but not limitatively at a speed of
20 at least 15 metres per second (in particular, at a speed that can vary by at least approximately 15 metres per second up to at least approximately 50 metres per second; more specifically, from at least approximately 20 metres per second to at least approximately 40 metres per second) and/or
25 at an inlet pressure that can vary between approximately 15 bar to approximately 30 bar, so as to spray the water suspension of ceramic material and introduce multiple very fine drops of water suspension of ceramic material into the atomization chamber 3.

30 According to some advantageous but non-limiting embodiments (such as that schematically illustrated in Figure 3), the spraying unit 7 comprises multiple nozzles 8 arranged along a substantially annular crown (in particular, basically circular), whose centre lies on the symmetry axis
35 Z of the main body 2. In other words, advantageously but not

limitatively, the spraying unit 7 comprises multiple nozzles 8 arranged along a closed line that is substantially circular. More specifically, according to some advantageous but non-limiting embodiments (such as that illustrated in Figure 3), these nozzles 8 are arranged on a fixed support 9 that is circular, is arranged centred in relation to the symmetry axis Z, and, preferably but not necessarily, is made of stainless steel.

According to other advantageous but non-limiting embodiments (such as, for example, that illustrated in Figure 3A), the nozzles 8 are arranged on straight supports 33, which are also, preferably but not necessarily, made of stainless steel (including said nozzles) connected so as to overhang an inner wall of the main body 2 so as to be equally spaced apart. Still more advantageously but not limitatively, in this case too, these straight supports 33 are arranged along a substantially annular crown, still more advantageously a circular one, whose centre lies on the symmetry axis Z. According to some advantageous but non-limiting variants of this embodiment (i.e. of the embodiment that involves the nozzles 8 arranged on straight supports 33), each of these straight supports 33 is connected rotatably to the inner wall of the main body 2 to be able to rotate on itself, in particular around an axis that extends along the main extension direction of each straight support 33 (still more specifically, around an axis that is basically orthogonal to the symmetry axis Z; more specifically, around an axis that extends in the radial direction in relation to the main body 2). This makes it possible to adjust the emission direction of the jets of water suspension of ceramic material emitted by each nozzle 8, for example as a function of the type of water suspension of ceramic material.

It is understood that the substantially annular crown along which the nozzles 8 are arranged could be basically elliptical, or square, or irregular, as long as it is

configured so as to be centred in relation to the symmetry axis Z.

5 Still more advantageously but not limitatively, the nozzles 8 of the spraying unit 7 are oriented so that the respective water suspension of ceramic material jets are basically vertical and directed upwards (in particular, towards the upper portion of the atomization chamber 3).

10 Advantageously but not limitatively, the feeding system 5 comprises at least one collection unit 10, for example a basin or tank, a pumping assembly 11, advantageously formed from at least one piston pump, configured to withdraw the water suspension of ceramic material from the collection unit 10 and to pump it with a pressure that can vary from approximately 15 bar to approximately 30 bar to the spraying unit 7 (see Figure 3).

20 According to other advantageous but non-limiting embodiments that are not illustrated, the feeding system 5 also comprises a filter interposed between the pumping assembly 11 and the spraying unit 7 to filter the water suspension of ceramic material before introducing it into the atomization chamber 3.

25 Advantageously, the spray-drier 1 (more specifically, the above-mentioned heating system 6) also comprises a distribution device 12 configured to distribute the hot gas flow F inside the atomization chamber 3 so that it hits the sprayed water suspension of ceramic material, thus drying the solid ceramic material contained therein and generating atomized ceramic powder CPA.

30 According to some advantageous but non-limiting embodiments, the distribution device 12 comprises (in particular, consists of) at least one annular guide duct 13 configured to impart a swirling motion to the hot gas flow F in a spiral around the symmetry axis Z so as to enable the correct dehydration of the water suspension of ceramic material that meets, i.e. that, in use, is hit by this hot

gas flow F , and to obtain an atomized ceramic powder CPA having certain features in terms of particle size and/or humidity.

5 Still more advantageously but not limitatively, the distribution device 12 comprises multiple openings (not visible in the attached figures) to send the hot gas flow F towards the atomization chamber 3; multiple spiral-shaped ducts (centred in relation to the symmetry axis Z), and multiple deflectors (also not visible in the attached
10 figures) to guide the hot gas flow F towards the multiple openings.

According to alternative, advantageous but non-limiting embodiments, such as that illustrated in Figure 3A, the spray-drier 1 (in particular, the distribution device 12)
15 comprises a suction system 30, which, advantageously, is in fluidic connection with the atomization chamber 3, comprises, in turn, at least one aspirator 31, and is configured to distribute the hot gas flow F inside the atomization chamber 3. Specifically, advantageously but not
20 limitatively this suction system 30 is configured to pressurise the hot gas flow F fed by the heating system 6 and to impart a swirling motion to this hot gas flow F in a spiral around the symmetry axis Z so as to enable the correct dehydration of the water suspension of ceramic material that
25 meets, i.e. that, in use, is hit by this hot gas flow F , and to obtain an atomized ceramic powder CPA having features in terms of particle size and/or humidity. Advantageously but not limitatively, the discharge outlet 4, via which this atomized ceramic powder CPA leaves the atomization chamber
30 3, comprises (in particular, consists of) a discharge valve, which is known and not described or illustrated further here, configured to enable the controlled discharge of the atomized ceramic powder CPA. In addition, according to some advantageous but non-limiting embodiments (such as that
35 schematically illustrated in Figure 3), the spray-drier 1

also comprises at least one conveyor 14 that extends below the discharge outlet 4 and is configured to receive the atomized ceramic powder CPA from the discharge outlet 4 and convey it away from the spray-drier 1.

5 According to some advantageous but non-limiting embodiments, such as those illustrated in Figures 1, 2, and 3, the main body 2 comprises an upper portion 15 that is basically cylindrical, a lower portion 16 that is basically a truncated cone, and a central portion 17 that is basically
10 cylindrical that is interposed without gaps between the upper portion 15 and the lower portion 16 and that delimits the atomization chamber 3 (see, in particular, Figure 3). In this case, advantageously but without imposing limits, the above-mentioned distribution device 12 is arranged at the
15 upper portion 15, the spraying unit 7 is arranged along an interface section (i.e., transition section) between the lower portion 16 and the central portion 17 and the discharge outlet 4 is arranged at one end of the second, lower portion 15, arranged on the opposite part (i.e., on the opposite
20 side) compared to the central portion 16.

As already mentioned above, according to some advantageous but non-limiting embodiments, the spraying unit 7 is configured to send the sprayed water suspension of ceramic material in the form of vertical jets directed
25 towards the distribution device 12; specifically, towards the upper portion 15; still more specifically, upwards. In addition or alternatively, advantageously but without imposing limits, the distribution device 12 is configured to direct the above-mentioned hot gas flow F in the opposite
30 direction, thus towards the lower portion 16 (in particular, downwards). In this way, it is possible to increase the time that the water suspension of ceramic material (and, more specifically, the solid ceramic material) remains in the atomization chamber 3. This, the water suspension of ceramic
35 material, in fact is initially projected upwards in the

opposite direction (thus, in counter current) in relation to the hot gas flow F and then, once it reaches the highest end of the central portion 17, it re-crosses the atomization chamber 3 downwards, thus in the same direction as the hot gas flow F, substantially increasing the efficiency of the spray-drier in terms of thermal exchange.

In this discussion, the terms "high", "low", "upper" and "lower" are used with reference to the spray-drier 1, which has a longitudinal symmetry axis Z, and which rests on the ground so that the longitudinal symmetry axis Z is basically perpendicular to the ground (as illustrated in Figures 1, 2, and 3).

According to some advantageous but non-limiting embodiments, the main body 2 comprises (in particular, is made of) stainless steel, still more advantageously but without imposing limits, insulated with high-density mineral wool.

Advantageously, the above-mentioned heating system 6 comprises (in particular, consists of) at least one electric heater 18.

This makes it possible to reduce the carbon dioxide emissions and obtain significant energy savings, with the same performance. Advantageously, in fact, this electric heater 18 has a yield that reaches 95% (in particular, a yield that can vary from approximately 80% to approximately 90%).

According to some advantageous but non-limiting embodiments of this invention, such as those illustrated in Figures 4, 5, and 6, this electric heater 18 comprises, in turn: an outer casing 19 that delimits a heating chamber 20; an inlet 21 for feeding a gas inside the heating chamber 20; multiple electric heating elements 22 that extend inside the heating chamber 20 and are configured to transfer heat by Joule effect to this gas that is found (i.e. passes) inside the heating chamber 20 so as to generate the above-mentioned

hot gas flow F; and a discharge outlet 23 that is configured to enable the discharge of the hot gas flow F from the heating chamber 20 and is placed in fluid communication with the distribution device 12.

5 According to some advantageous but non-limiting embodiments (such as those illustrated), the inlet 21 and the discharge outlet 23 face each other and the electric heating elements 22 are interposed between the inlet 21 and discharge outlet 23 so as to be crossed (or struck) by the
10 gas to be heated. In this way, this gas to be heated will be heated while it passes through the heating chamber 20 through these electric heaters 22.

 Advantageously but without imposing limits, the electric heater 18 is configured to heat a gas flow that can
15 vary from approximately 4000 m³/h to approximately 200000 m³/h (in particular, from approximately 30000 m³/h to approximately 200000 m³/h; more in particular from approximately 30000 m³/h to approximately 80000 m³/h; still more advantageously equal to approximately 50000 m³/h) to
20 generate the above-mentioned hot gas flow F.

 According to some advantageous but non-limiting embodiments, this gas comprises (in particular, consists of) ambient air having at least 14% oxygen. Alternatively or in combination, the gas to be heated comprises (in particular,
25 consists of) recovered gas.

 According to some advantageous but non-limiting embodiments, the outer casing 19 of the electric heater 18 has a basically parallelepiped cross-section, for example a rectangular-shaped parallelepiped cross-section having the
30 following dimensions: 3000 x 2000 x 3000.

 According to some advantageous but non-limiting embodiments of this invention, at least part of these multiple electric heating elements 22 comprise (in particular, are made of) electric resistances 24 that extend
35 inside the heating chamber 20.

According to some advantageous but non-limiting embodiments, these electric resistances 24 are coil shaped (see, for example, Figure 5 or 6). Alternatively, these electric resistances are shaped like a spiral (see, for example, Figure 4).

In addition, according to some advantageous but non-limiting embodiments, these electric resistances are smooth, preferably but without limits, reinforced (see, for example, Figure 5).

According to other advantageous but non-limiting embodiments, the electric resistances have fins (see, for example, Figure 6). This makes it possible to increase the size of the heat exchange surface, increasing the thermal efficiency of the spray-drier 1.

Alternatively or in addition, advantageously but not limitatively, at least part of these multiple electric heating elements 22 comprise (in particular, consist of) an oblong resistive element 25, preferably but not necessarily, made of aluminium and/or ceramic, and a metal cover 26 that has a three-dimensional net-like structure, for example like a basket, and is arranged to at least partially wrap around, on the outside, this oblong resistive element 25 and to heat, by Joule effect, the gas that is found (i.e. that passes) inside the heating chamber 20. More advantageously but not limitatively, the metal cover 26 comprises (in particular, consists of) a wire comprising (in particular, made of) an iron-chrome-aluminium alloy or a nickel-chrome aluminium (more advantageously but without imposing limits, an iron-nickel-chrome alloy) or a combination thereof.

According to some advantageous but non-limiting embodiments, in this case, the electric heater 18 comprises (in particular, is) a known, electric air heating module.

According to some advantageous but non-limiting embodiments like that illustrated in Figures 1, 2, and 3, the heating system 6 comprises at least one pressurization

fan 27 configured to suck the above-mentioned gas (in particular, from the outside) and convey it towards the inlet of the electric heater 18 so as to circulate the gas to be heated inside the heating chamber 20; and a duct 28 interposed between the electric heater 18 and the distribution device 12 and configured to feed the hot gas flow F to the distribution device 12. Advantageously but without imposing limits, this duct 28, has an inlet section tangential to the main body that is basically cylindrical (see Figures 1, 2, and 3).

According to other advantageous but non-limiting embodiments, like that illustrated in Figure 3A, the spray-drier 1 comprises a duct 28 interposed between the electric heater 18 and the main body 2 to feed the hot gas flow F to the atomization chamber 3, where this hot gas flow F is pressurized by the above-mentioned suction system 30, in particular by the aspirator 31, without needing the fan 27. In this case, advantageously but without imposing limits, the duct 28 is grafted onto the top of the cylindrical main body 2 (in particular, to the top of the basically cylindrical upper portion 15) to send the hot gas flow F into the atomization chamber 3 (see Figure 3A). Advantageously but not limitatively, the duct 28 is made of steel, more advantageously it is insulated.

The use of a heating system 6 with electric heaters 18 of the type described above, significantly reduces the transmission of heat by radiation. This enables, among other things, the reduction of the amount of insulation necessary in the duct 28 to approximately 25%.

According to some advantageous but non-limiting embodiments, the heating system 6 comprises (in particular, consists of) multiple electric heaters 18 arranged in series, each of which is, advantageously but without imposing limits, made according to any of the embodiments described above.

According to some advantageous but non-limiting

embodiments, like that schematically illustrated in Figure 2, the heating system 6 also comprises a standard burner 29, for example using known fossil fuels (gas or liquid). In this case, advantageously but not limitatively, the gas to be heated first passes through the electric heater 18 and then through the standard burner 29. This enables greater control of the temperatures and volume of the hot gas flow F that is sent into the atomization chamber 3.

According to some advantageous but non-limiting embodiments, like those illustrated in Figures 3 and 3A, the spray-drier 1 comprises, in addition, a fume expulsion system 30 to eliminate discharge fumes from the atomization chamber 3 that are generated once the water suspension of ceramic material has dried. This expulsion system 30 is configured to convey these discharge fumes leaving the spray-drier 1, and to filter them and/or reduce them.

According to some advantageous but non-limiting embodiments, this expulsion system 30 comprises at least one aspirator 31 that sucks up these discharge fumes, at least one filtering and/or reduction device, for example a bag filter, to filter these discharge fumes, and a chimney 32 to send these fumes into the external environment.

According to some advantageous but non-limiting embodiments, such as that illustrated in Figure 3A, this fume expulsion system 30 is at least in part the same as the above-mentioned suction system 30.

According to an additional aspect of this invention, a production method for atomized ceramic powder CPA from a water suspension of ceramic material (advantageously but not limitatively made as described above in relation to the spray-drier 1) via the atomisation of the water suspension of ceramic material using a spray-drier 1 is provided, advantageously made as described above.

More specifically, advantageously but not limitatively, the production of atomized ceramic powder CPA occurs by

spraying a water suspension of ceramic material that comprises (in particular, consists of) at least approximately 30% (in particular, at least approximately 32%) by weight of water and the remaining part of solid ceramic material. Specifically, as already mentioned above in relation to the spray-drier 1, advantageously but not limitatively, the solid ceramic material comprises (in particular, consists of) clay, kaolin, feldspar, quartz sand and/or a combination thereof. Still more advantageously but without imposing limits, this water suspension of ceramic material has a density that can vary from approximately 1600 g/l to approximately 1750 g/l and a kinematic viscosity that can vary from approximately 5.0×10^{-6} m²/s to approximately 3.0×10^{-5} m²/s.

Advantageously, the production method for atomized ceramic powder CPA comprises the following steps: a feeding step, during which the above-mentioned feeding system 5 (advantageously but not limitatively carried out according to one of the embodiments described above) feeds (in particular, a defined quantity, i.e. a controlled or measured quantity of) a water suspension of ceramic material to the spray-drier 1 and the spraying unit 7 of this feeding system 5 sprays the water suspension of ceramic material and sends it, sprayed, inside the above-mentioned atomization chamber 3; a heating step, during which the heating system 6 (advantageously but not limitatively, carried out according to any one of the embodiments described above) generates a hot gas flow F that has a temperature of at least approximately 400°C (in particular, ranging between approximately 500°C and approximately 600°C); and a distribution step, during which a distribution device 12 distributes this hot gas flow F inside the atomization chamber 3 so that this hits the sprayed water suspension of ceramic material, thus inducing the drying of the solid ceramic material contained in it and generating atomized

ceramic powder CPA.

Advantageously, as already mentioned above in relation to the spray-drier 1, the heating system 6 comprises (in particular, consists of) at least one electric heater 18 (advantageously made according to one of the embodiments illustrated above). More advantageously but not limitatively, in these cases, during the heating step, the electric heater 18 heats a certain quantity of gas to generate the above-mentioned hot gas flow F; more specifically, the electric heater 18 heats a gas flow that can vary from approximately 4000 m³/h to approximately 200000 m³/h (in particular, 30000 m³/h to approximately 200000 m³/h; more in particular from approximately 30000 m³/h to approximately 80000 m³/h; still more in particular equal to approximately 50000 m³/h) to generate the above-mentioned hot gas flow F.

Advantageously but without imposing limits, when the distribution device 12 of the spray-drier 1 used to implement the production method comprises the above-mentioned annular guide duct 13, during the distribution step, the annular guide duct 13 imparts a swirling motion around the symmetry axis Z to said hot gas flow F.

Alternatively or in combination, advantageously but not limitatively, when the distribution device 12 of the spray-drier 1 used to implement the production method comprises a suction system 30, during the distribution step, this suction system 30 imparts a swirling motion around said symmetry axis Z to the hot gas flow F.

Advantageously but not limitatively, the production method also comprises: a gas-feeding sub-step, during which a gas is fed inside the heating chamber 20 of the electric heater 18 through the inlet 21 of this heating chamber 20; a heating sub-step (at least partially) simultaneous to the gas-feeding sub-step, during which the multiple electric heating elements 22 (that, as better explained in relation

to the spray-drier 1, are included in the electric heater 18 and) that extend inside the heating chamber 20 transfer heat by the Joule effect to the gas that is found inside the heating chamber 20 and generate, thus, the above-mentioned hot gas flow F; and a gas-discharge sub-step, during which this hot gas flow F leaves the discharge outlet 23 and is transferred to the distribution device 12.

According to some advantageous but non-limiting embodiments, the production method comprises, in addition: a suction step (at least partially) preceding the gas-feeding sub-step, during which a pressurization fan 27, which is part of the heating system 6, sucks the (in particular, a certain quantity/flow of) gas and conveys it towards the inlet 21 of the electric heater 18; and a transfer step (at least partially) simultaneous to the gas-discharge sub-step, during which the hot gas flow F coming out of the discharge outlet 23 crosses (in particular, moves through) the duct 28 interposed between the electric heater 18 and the distribution device 12.

The spray-drier 1 and the production method for producing atomized ceramic powder CPA described above has numerous advantages, of which we cite the following.

The use of a heating system 6 comprising (in particular, consisting of) an electric heater reduces the CO₂ emissions and energy consumption, with the same performance in terms of volume of hot gas sent into the atomization chamber 3 and of the temperature of this hot gas flow F.

In addition, the heating system 6 described above is easily adapted to the structure of prior art spray-driers equipped with gas or liquid fuel burners.

It should be noted, finally, that the use of an electric heater 18 of the type described above, compared to the use of gas or liquid fuel burners used in the prior art solutions, reduces the water content (the water being eliminated, as a matter of fact, as a waste product of the

combustion) encouraging the drying of the sprayed water suspension of ceramic material and, thus, the production of atomized ceramic powder CPA and reducing energy consumption.

C L A I M S

1. A spray-drier (1) for the production of atomized ceramic powder (CPA) from a water suspension of ceramic material, said spray-drier (1) comprises:

5 a main body (2), which delimits an atomization chamber (3) and comprises at least one discharge outlet configured to let the atomized ceramic powder (CPA) out of said atomization chamber (3);

10 a feeding system (5) to feed, into said atomization chamber (3), a water suspension of ceramic material comprising at least circa 30% by weight of water and the remaining part of solid ceramic material, which feeding system (5) comprises at least one spraying unit (7) configured to spray said water suspension of ceramic material
15 and introduce said sprayed water suspension of ceramic material into said atomization chamber (3);

a heating system (6) to generate a hot gas flow (F) having a temperature of at least circa 400°C (in particular, ranging from circa 500°C to circa 600°C);

20 a distribution device (12) configured to distribute said hot gas flow (F) inside said atomization chamber (3) so that it hits the sprayed water suspension of ceramic material, thus drying the solid ceramic material contained therein and generating atomized ceramic powder (CPA);

25

said heating system (6) comprising (in particular, consisting of) at least one electric heater (18);

30 the spray-drier (1) being **characterized in that** said at least one electric heater (18) comprises, in turn: an outer casing (19), which delimits a heating chamber (20); an inlet (21) to feed gas into said heating chamber (20); a plurality of electric heating elements (22), which extend inside said heating chamber (20) and are configured to transfer heat,
35 through Joule effect, to said gas located inside said heating

chamber (20), so that it generates said hot gas flow (F); and a discharge outlet (23), which is configured to let said hot gas flow (F) out of said heating chamber (20) and is in fluid communication with said distribution device (12); and
5 **in that** at least part of said electric heating elements (22) comprise (in particular, consist of) an oblong resistive element (25) and a metal cover (26) that has a three-dimensional net-like structure and is arranged so as to at least partially wrap, on the outside, said oblong resistive
10 element (25) and heat, through Joule effect, said gas located inside said heating chamber (20).

2. The spray-drier (1) according to claim 1, wherein said metal cover (26) comprises (in particular, consists of) a wire, which is made of an iron-chrome-aluminium alloy or
15 of a nickel-chrome alloy or of an iron-nickel-chrome alloy or of a combination thereof.

3. The spray-drier (1) according to claim 1 or 2, wherein at least part of said electric heating elements (22) comprise (in particular, consist of) electric resistances
20 (24), which extend inside said heating chamber (20).

4. The spray-drier according to any one of the preceding claims, wherein the heating system (6) comprises at least one pressurization fan (27) configured to suck said gas (G) and convey it towards said inlet (21) of said at least one
25 electric heater (18); and a duct (28), which is interposed between said at least one electric heater (18) and said distribution device (12) and is configured to feed said hot gas flow (F) into said atomization chamber (3) (in particular, up to said distribution device (12)).

30 5. The spray-drier (1) according to any one of the preceding claims, wherein:

said main body (2) has a substantially vertical symmetry axis (Z);

said spraying unit (7) comprises a plurality of nozzles
35 (8) arranged along at least one substantially annular crown

whose centre lies on said symmetry axis (Z); and

said distribution device (12) comprises at least one annular guide duct (13), which is configured to impart a swirling motion around said symmetry axis (Z) to said hot gas flow (F).

5
6. The spray-drier (1) according to claim 5, wherein said distribution device (12) comprises: a plurality of openings to lead the hot gas flow (F) towards said atomization chamber (3); a plurality of spiral-shaped ducts and a plurality of deflectors to guide said hot gas flow (F)
10 towards said plurality of openings.

7. The spray-drier (1) according to any one of the claims from 1 to 4, wherein:

said main body (2) has a substantially vertical symmetry
15 axis (Z);

said spraying unit (7) comprises a plurality of nozzles (8) along at least one substantially annular crown whose centre lies on said symmetry axis (Z); and

said distribution device (12) comprises a suction
20 system (30), which is configured to impart a swirling motion around said symmetry axis (Z) to said hot gas flow (F).

8. The spray-drier (1) according to any one of the preceding claims, wherein:

said main body (2) comprises a substantially
25 cylindrical first portion (15), a substantially conic second portion (16) and a substantially cylindrical central portion (17), which is interposed, without gaps, between the first portion (15) and the second portion (16) and delimits said atomization chamber (3);

said distribution device (12) is arranged at said first
30 portion (15); and

said discharge outlet (4) is arranged at an end of said second portion (16), which is opposite relative to the central portion (17).

35 9. The spray-drier (1) according to any one of the

preceding claims, wherein said heating system (6) comprises a plurality of electric heaters arranged in series.

10. A production method for producing atomized ceramic powder (CPA) from a water suspension of ceramic material using a spray-drier (1) made according to any of the previous
5 claims;

the production method comprises the following steps:

a feeding step during which said feeding system (5) feeds a water suspension of ceramic material comprising at
10 least circa 30% by weight of water and the remaining part of solid ceramic material into said spray-drier (1) and said spraying unit (7) sprays said water suspension of ceramic material and sends it, sprayed, into said atomization chamber (3);

15 a heating step, during which said heating system (6) generates a hot gas flow (F) having a temperature of at least circa 400°C (in particular, ranging from circa 500°C to circa 600°C); and

a distribution step, at least partially following said
20 heating step, during which a distribution device (12) distributes said hot gas flow (F) inside said atomization chamber (3) so that it hits the sprayed water suspension of ceramic material, thus drying the solid ceramic material contained therein and generating atomized ceramic powder
25 (CPA).

11. The production method according to claim 10, wherein said heating step comprises:

a gas-feeding sub-step, during which a gas is fed inside the heating chamber (20) of the electric heater (18) through
30 said inlet (21);

a heating sub-step at least partially simultaneous to the gas-feeding sub-step, during which the plurality of electric heating elements (22) that extend inside said heating chamber (20) transfer heat, through Joule effect, to
35 said gas that is inside said heating chamber (20) and

generate said hot gas flow (F); and

a gas-outlet sub-step, during which said hot gas flow (F) leaves said discharge outlet (23) and is transferred to said distribution device (12).

5 **12.** The production method according to claim 11 comprising: a suction step, at least partially preceding said gas-feeding sub-step, during which a pressurization fan (27), which is part of said heating system (6), sucks said gas (G) and conveys it towards said inlet (21) of said at
10 least one electric heater (18); and a transfer step, at least partially simultaneous to said gas-outlet sub-step, during which said hot gas flow (F) coming out of said discharge outlet (23) crosses (in particular, moves through) said duct (28) interposed between said at least one electric heater
15 (18) and said distribution device (12).

13. The production method according to any of the previous claims from 10 to 12 to produce atomized ceramic powder (CPA) from a water suspension of ceramic material using a spray-drier (1) made according to claim 5; wherein
20 during said distribution step, the annular guide duct (13) imparts a swirling motion around said symmetry axis (Z) to said hot gas flow (F).

14. The production method according to any of the previous claims from 10 to 12 to produce atomized ceramic
25 powder (CPA) from a water suspension of ceramic material using a spray-drier (1) made according to claim 6; wherein during said distribution step, said suction system (30) imparts a swirling motion around said symmetry axis (Z) to said hot gas flow (F).

30

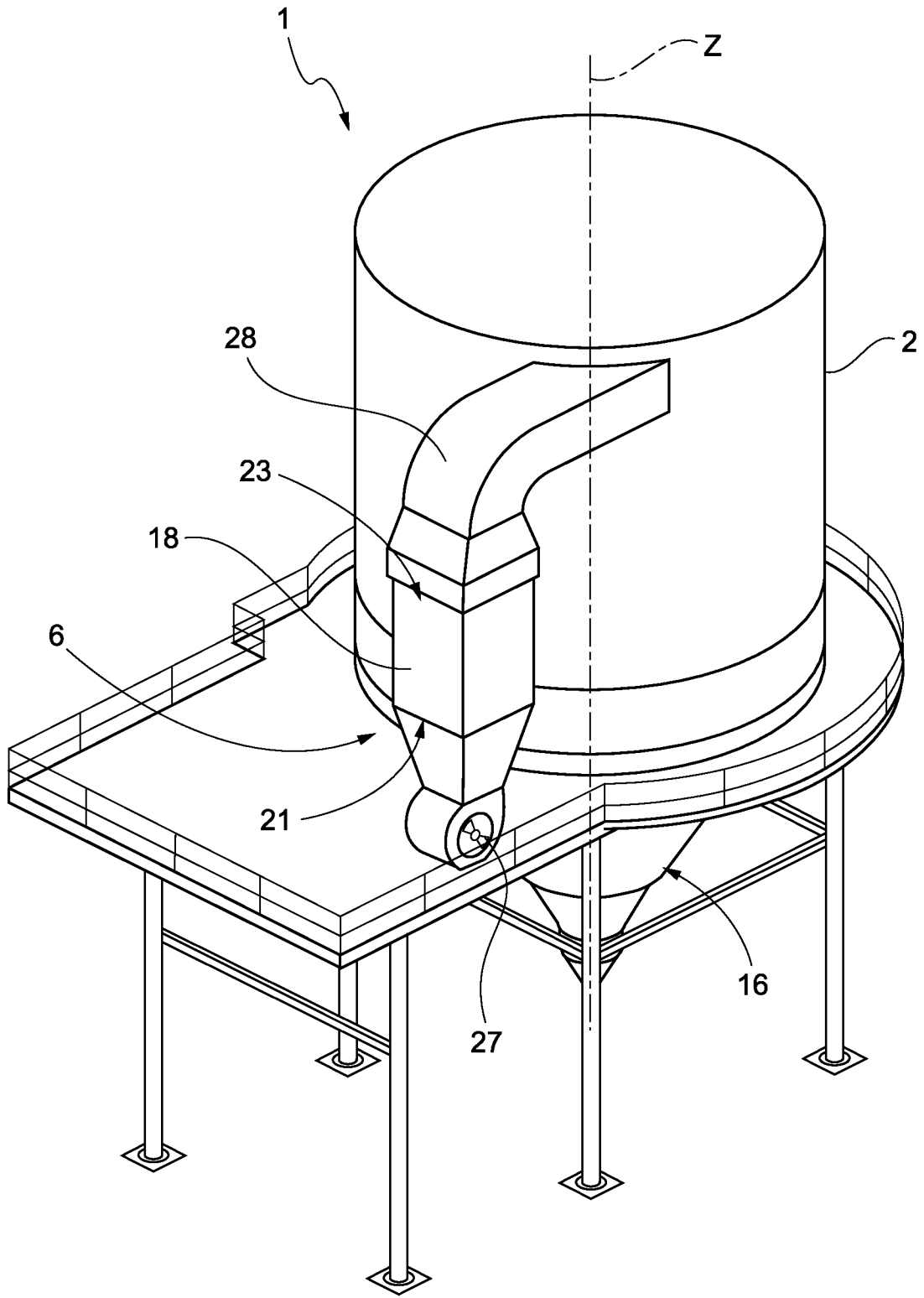


FIG. 1

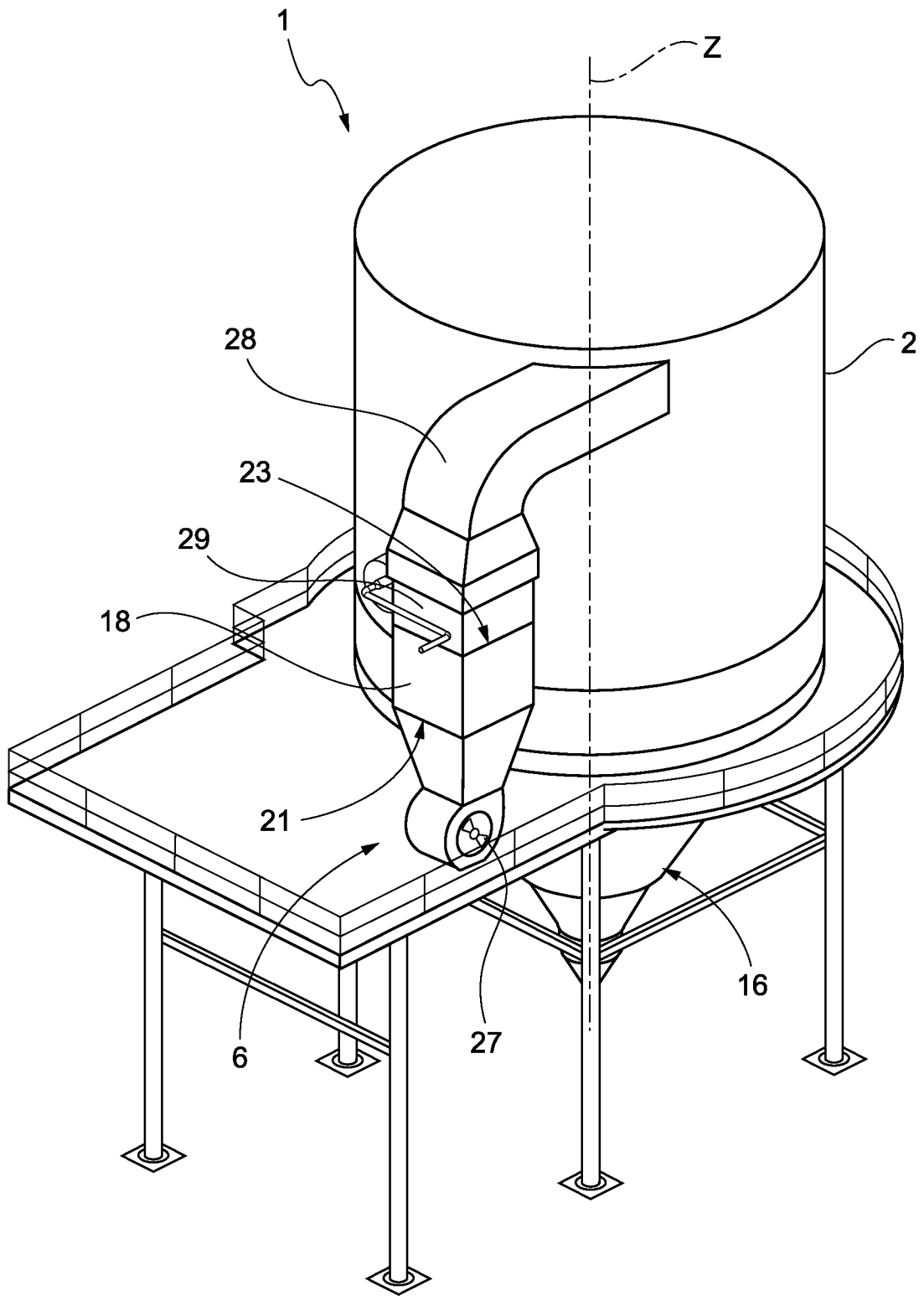


FIG. 2

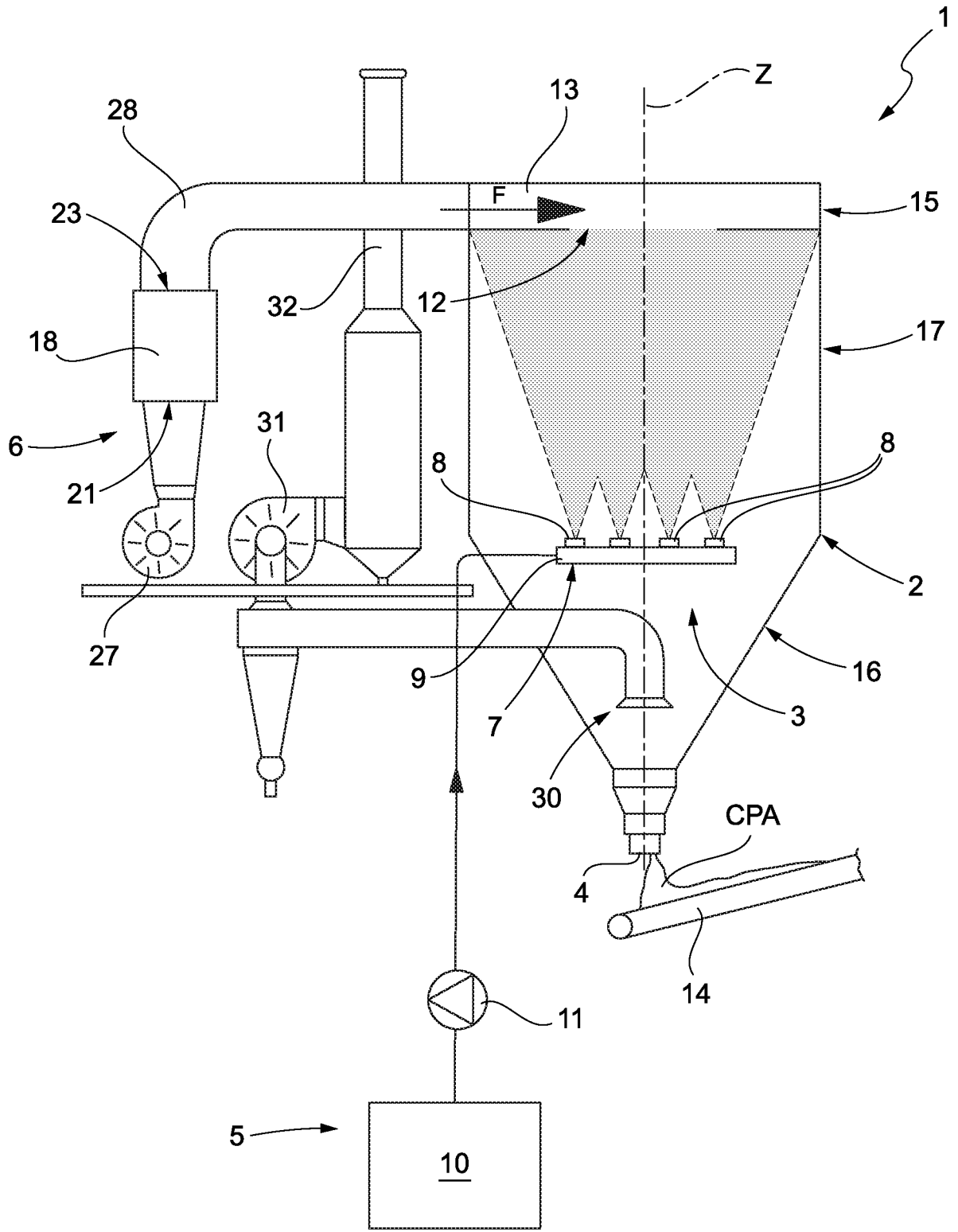


FIG. 3

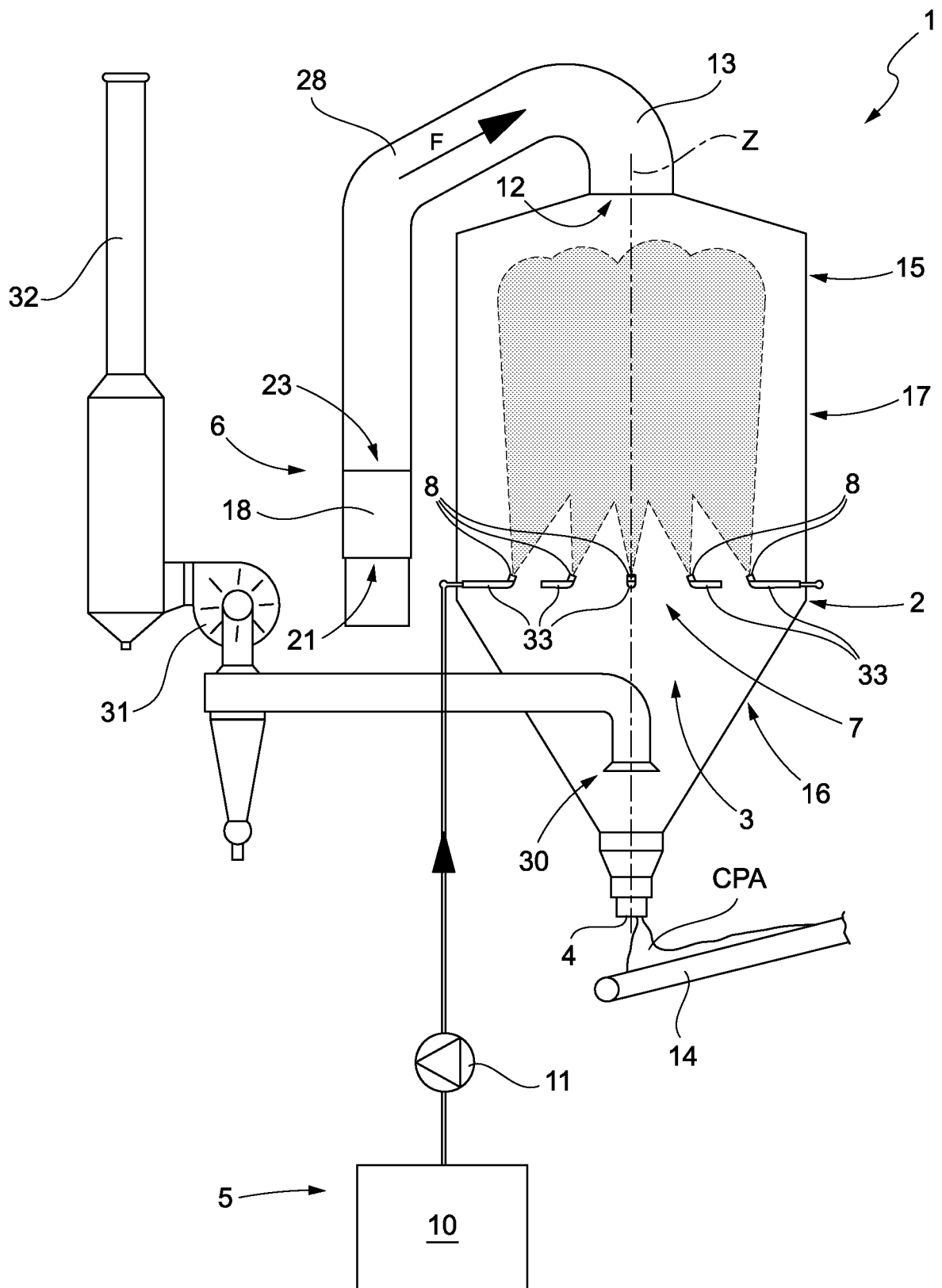


FIG. 3A

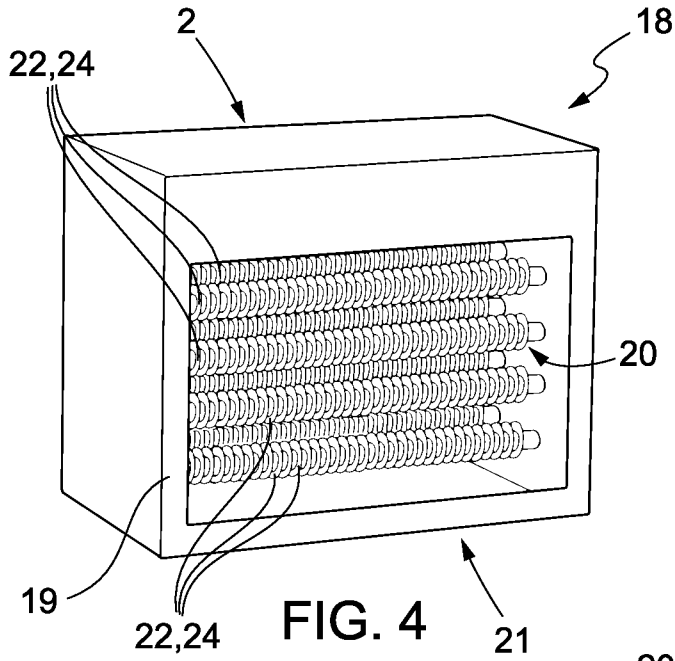


FIG. 4

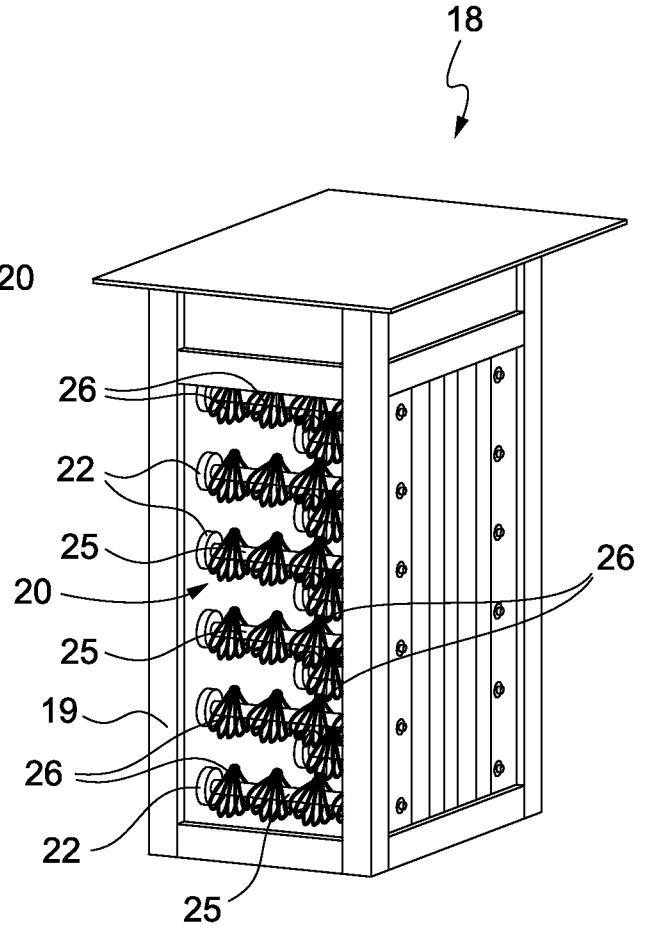


FIG. 4A

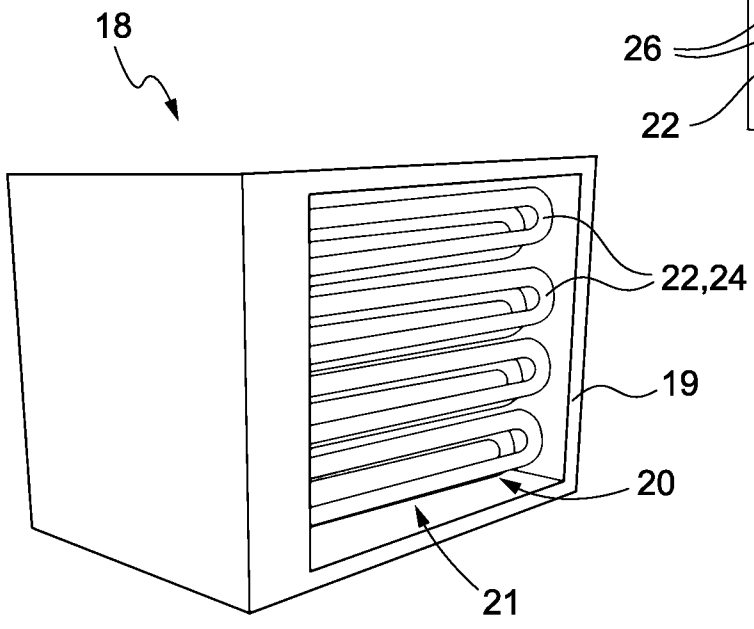


FIG. 5

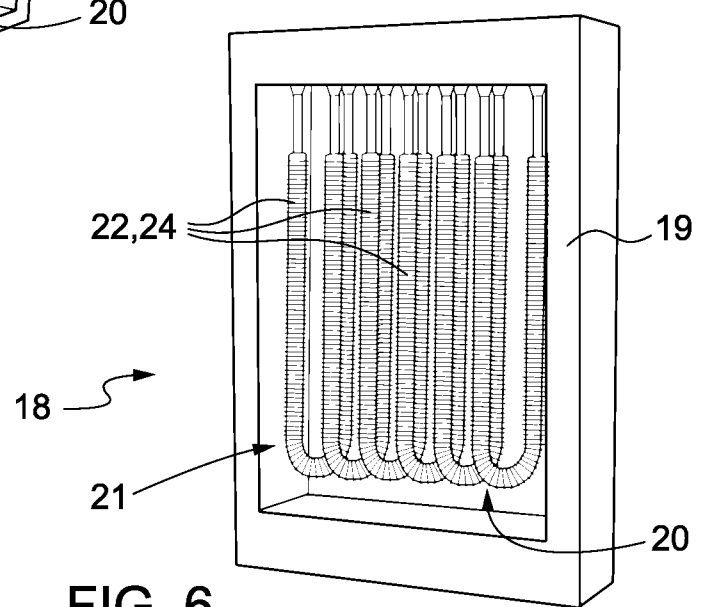


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/057948

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D1/00 B01D1/14 B01D1/18 B01J2/04 F26B3/12
H05B3/40
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)
B01D B01J F26B H05B

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.
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A	WO 2013/011167 A1 (UNIV SEVILLA [ES]; MADUENO LUNA ANTONIO [ES] ET AL.) 24 January 2013 (2013-01-24) figure 1 -----	1-14
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Further documents are listed in the continuation of Box C. See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 28 September 2023	Date of mailing of the international search report 17/10/2023
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Weber, Christian
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International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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