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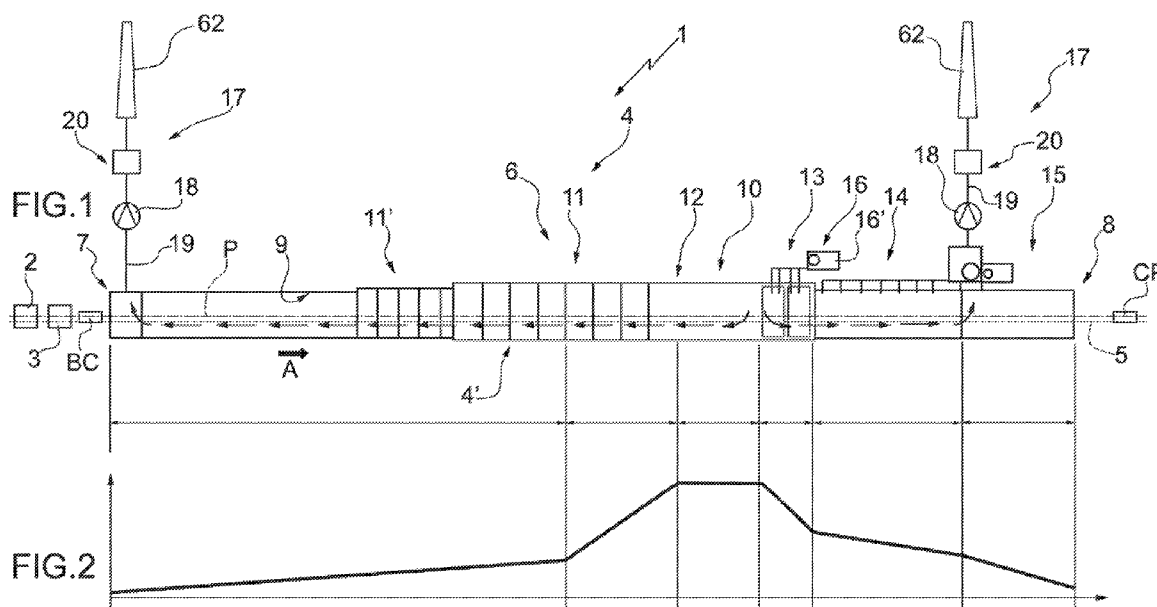
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(54) Title: METHOD AND KILN FOR THERMALLY TREATING BASIC CERAMIC ARTICLES



(57) Abstract: A method and kiln for the thermal treatment (in particular for the firing) of basic ceramic articles (BC); the kiln (4) comprises a conveying device for conveying the basic ceramic articles (BC) along a given path (P) through a firing chamber (6), in the area of which the basic ceramic articles (BC) are heated; compounds (in particular organic compounds) evaporated from the basic ceramic articles (BC) are removed in the form of gas from the chamber (6), condensed in a water-containing fluid (22) and separated following flocculation so as to obtain a treated liquid (25); said treated liquid (25) is basified and recycled to obtain the water-containing fluid.



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"METHOD AND KILN FOR THERMALLY TREATING BASIC CERAMIC ARTICLES"CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from Italian Patent Application
5 No. 102017000083666 filed on 21/07/2017, the disclosure of which
is incorporated by reference.

TECHNICAL FIELD

The present invention relates to a kiln and a method for
thermally treating (in particular, for firing) basic ceramic
10 articles. The present invention, furthermore, relates to a plant
and a method for the production of ceramic products.

CONTEXT OF THE INVENTION

In the field of the production of ceramic articles, for example
ceramic tiles and flagstones, it is known to use plants provided
15 with pressing equipment, in which basic ceramic articles are
obtained from a semi-dry mixture (typically the humidity varies
from 5% to 7%); a decoration device, which decorates the basic
ceramic articles; and a sintering kiln in which the basic ceramic
articles are fired at high temperature so as to obtain final
20 ceramic products.

Some sintering kilns of known type comprise a tunnel and a
conveying device to convey the basic ceramic articles along a
given path through the tunnel. The tunnel comprises a pre-
heating area, a firing area and a cooling area.

25 Each of these kilns also comprises a heating device to heat the
basic ceramic articles during conveying of the basic ceramic
articles through the tunnel so as to obtain treated ceramic
articles. The kiln also comprises a cooling device adapted to
cool the treated ceramic articles during conveying through the
30 cooling area; and a gas extraction device, which is adapted to
extract the gases present in the tunnel at a respective
extraction station typically positioned at an entrance to the
tunnel.

Operation of the extraction device causes a flow of the gases
35 present in the tunnel. The hot gases move from the firing chamber
towards the extraction station.

In some cases, the decoration device is adapted to decorate an upper surface of the basic ceramic articles (pressed articles, but not fired) by means of inkjet digital printing. In these cases, the inks used comprise pigments, conductive polar fluids (like water) and non-polar solvents (organic solvents; oils or other hydrocarbons).

The decoration device can furthermore be adapted to also apply an enamel undercoat on the basic ceramic articles (on which the decoration is made and) which, in some cases, comprises further non-polar carriers (hydrocarbons). In use, the decoration device applies 10 g/m² to 20 g/m² of decorative ink and 80 g/m² to 150 g/m² of enamel on the surface of the manufactured ceramic articles.

This important quantity of non-polar solvents (organic solvents) evaporates from the basic ceramic articles that pass through the kiln, and is partially subjected to cracking and reforming, recombining into new chemical compounds (usually smaller molecules), partly combusted and partly entrained by the gas flow towards the extraction station. However, the compounds not completely oxidized are undesired and require further treatments to prevent them reaching the external environment. These not completely oxidized chemical compounds are often characterised by a strong odour and could also be irritant or even toxic. Furthermore, the fumes coming out of the tunnel frequently also contain inorganic acids (such as, for example, hydrochloric acid, hydrofluoric acid and sulphuric acid).

A treatment commonly used to reduce these problems is post-combustion of the gases collected by means of a post-combustor of the kiln.

However, these post-combustors have to process a large quantity of gases produced. Therefore, said post-combustors are bulky and costly and entail evident plant costs and costs for operation (energy) and maintenance. Furthermore, the post-combustors are not particularly effective for eliminating the inorganic acids. WO2010012636 describes a kiln for firing ceramic products comprising an insulated channel (tunnel), transport means for

feeding the products through the channel and means for heating the channel.

From the above, it emerges that the need is still felt, among other things, to reduce the environmental impact (due to the release of substances and/or to energy consumption) of the solutions proposed so far for the thermal treatment (firing) of ceramic articles.

The object of the present invention is to provide a kiln and a method for the thermal treatment (in particular, for firing) of basic ceramic articles and a plant and a method for producing ceramic articles which allows to overcome, at least partially, the drawbacks of the known art and are, at the same time, easy and inexpensive to produce.

SUMMARY

According to the present invention a kiln, a method and a plant are provided according to the following independent claims and, advantageously, according to any one of the claims depending directly or indirectly on the independent claims.

BRIEF DESCRIPTION OF THE FIGURES

The present invention will now be described with reference to the accompanying drawings, which illustrate a non-limiting embodiments thereof, in which:

- figure 1 is a schematic lateral view of a plant according to the present invention;

- figure 2 schematically illustrates the temperatures in various areas of the kiln of the plant of figure 1; and

- figure 3 schematically illustrates the pressures in various areas of the kiln of the plant of figure 1;

- figure 4 schematically illustrates a part of figure 1;

- figures 5 and 6 schematically illustrate different embodiments of the part of figure 4.

DETAILED DISCLOSURE

In figure 1, the number 1 indicates overall a plant for the production of final ceramic products CP, such as ceramic tiles or flagstones. In particular, the plant 1 is adapted to obtain basic ceramic articles BC from a semi-dry mixture; and ceramic

products CP by means of thermal treatment of the basic ceramic articles BC, in particular by means of heating and subsequent cooling of the basic ceramic articles BC.

According to some non-limiting embodiments, the plant 1 comprises pressing equipment 2 (known per se and not further described herein) adapted to obtain basic ceramic articles BC (known per se) by pressing a ceramic powder (a semi-dry mixture, in particular having a humidity varying between 5% and 7%).

Advantageously but not necessarily, the plant 1 comprises a decoration device 3, which is adapted to apply a decoration on the basic ceramic articles BC, in particular on an (upper) surface of the basic ceramic articles BC; and a kiln 4 (in particular, a tunnel kiln) for firing the basic ceramic articles BC so as to obtain (at the end of cooling) the final ceramic products CP.

According to some non-limiting embodiments, the plant 1 also comprises a drying station (known per se and not illustrated) arranged between the pressing equipment 2 and the decoration device 3.

In particular, the basic ceramic articles BC comprise ceramic powder.

The plant 1 (more precisely the kiln 4) further comprises a conveying assembly 5 (in particular, a roller conveyor) adapted to convey the basic ceramic articles BC along a given path P (in a feed direction A). The conveying assembly 5 is schematically illustrated in figure 1 by a broken line.

The kiln 4 further comprises (at least) one thermal treatment chamber 6 arranged along the given path P. In particular, the path P extends through an inlet station 7 (through which, in use, the basic ceramic articles BC enter the thermal treatment chamber 6) and an outlet station 8 (through which, in use, the final ceramic products CP leave the thermal treatment chamber 6).

In particular, the path P extends from the pressing equipment 2 and through the decoration device 3 and through at least one portion of the thermal treatment chamber 6. More precisely, the

path P extends through the chamber 6, between the inlet station 7 and the outlet station 8.

Advantageously but not necessarily, the device 3 comprises at least one ink-jet head (known per se and not illustrated), which is adapted to emit one or more ink jets towards the basic ceramic articles BC, in particular on the (upper) surface of the basic ceramic articles BC, during the conveying thereof through the device 3. Preferably, the device 3 is also adapted to apply, in particular before application of the ink, a base enamel on the basic ceramic articles BC, in particular on the (upper) surface of the basic ceramic articles BC.

In particular, the ink comprises solid particles (inorganic pigments; e.g. mixtures of oxides of metal chromophores), conductive polar fluids (for example water) and non-polar solvents (organic solvents; for example, oils or other hydrocarbons). The base enamel has further non-polar components (in particular, hydrocarbons).

In particular, the device 3 is adapted to apply 10 g/m² to 20 g/m² of ink and 80 g/m² to 150 g/m² of base enamel on the (upper) surface of the basic ceramic articles BC.

More in particular, in use, 55% to 65% liquid components and 35% to 45% solid components are applied on the (upper) surface of the basic ceramic articles BC.

Therefore, the basic ceramic articles BC decorated by the device 3 comprise organic compounds, in particular hydrocarbons, and inorganic compounds (in a non-negligible quantity). Said basic ceramic articles BC are fed, in use, to the chamber 6.

In particular, the kiln 4 (is a tunnel kiln and) has a firing channel 9 (delimited, at least partially, by the chamber 6) which extends along the given path P. More precisely, the conveying assembly 5 extends at least partially into the firing channel 9 to convey the basic ceramic articles BC through said firing channel 9.

The kiln 4 further comprises at least one heating device 4' (only partially illustrated in figure 1) adapted to heat the basic ceramic articles BC (from an initial temperature to a

firing temperature) enforcing, in particular maintaining (during the conveying thereof along the path P), a temperature of at least 500°C (in particular at least 900°C, more in particular at least 1000°C) in at least one firing area 10 (through which the path P extends at least partially) of the thermal treatment chamber 6.

In particular, unless specified to the contrary, when reference is made to a temperature of a chamber and/or of an area of a chamber, it is meant the temperature inside said chamber and/or area measured for example with an appropriate sensor (for example a thermocouple) and not a temperature of the basic ceramic articles BC and ceramic products CP.

According to some non-limiting embodiments, the heating device 4' comprises at least one heating unit (known per se and not illustrated), in particular selected from the group consisting of: free flame burner, tube radiant heater (e.g. tube radiant heater with holes and/or radiant heater with built-in heat exchanger), electric resistor, infrared radiation source, laser radiation source, microwave source, radiofrequency source and a combination thereof. In particular, said heating unit is arranged inside the chamber 6. According to specific non-limiting embodiments, the heating unit is chosen from the group consisting of: free flame burner, tube radiant heater and a combination thereof. Advantageously but not necessarily, the heating device 4' comprises a plurality of heating units as defined above.

An example of a heating unit of the radiant tube type with holes is described in the patent ES2193829B1 of the same applicant. An example of a heating unit of the radiation type with built-in heat exchanger is described in WO2015/015263.

More precisely, the thermal treatment chamber 6 comprises a pre-heating area 11' and a pre-firing area 11. The pre-heating area 11' extends from the inlet station 7 to the pre-firing area 11 along the path P. The pre-firing area 11 extends from the pre-heating area 11' to an intermediate station 12 of the chamber 6, said station 12 being interposed between the station 7 and

the station 8, more precisely between the pre-firing area 11 and the firing area 10. In other words, the area 11 extends from the inlet station 7 to the firing area 10.

Even more precisely, the firing area 10 is directly adjacent
5 (without interruption) to the (immediately downstream of the) pre-firing area 11.

In particular, the thermal treatment chamber 6 further has a rapid cooling area 13 interposed between the firing area 10 and the outlet station 8. More in particular, the rapid cooling area
10 13 extends (immediately - without interruption) downstream of the area 10 along the path P.

Advantageously but not necessarily, the heating device 4' is adapted to create a temperature gradient (increasing in the direction A) in the pre-heating area 11'. In particular, the
15 temperature varies from approximately 20-30°C at the inlet station 7 to approximately 300-400°C at one end of the area 11' opposite the inlet station 7.

Additionally or alternatively, the heating device 4' is adapted to create a temperature gradient (increasing in the direction
20 A) in the pre-firing area 11. In particular, the temperature varies from approximately 300-400°C in the pre-heating area 11' to approximately 900-1300°C in the firing area 10.

According to some non-limiting embodiments, the chamber 6 also comprises an indirect cooling area 14, in particular arranged
25 (immediately - without interruption) downstream of the area 13 along the given path P.

Advantageously but not necessarily, the chamber 6 also comprises a final cooling area 15, in particular arranged downstream of the area 13 along the given path P. In particular, the final
30 cooling area 15 is arranged (immediately - without interruption) downstream of the area 14 along the given path P.

According to some embodiments, the kiln 4 comprises at least one cooling device 16 adapted to reduce the temperature of the basic ceramic articles BC during conveying along the path P (in order
35 to obtain ceramic products CP).

More precisely, the cooling device 16 is adapted to determine a

temperature gradient (decreasing in the direction A) in the rapid cooling area 13. In particular, the temperature varies from approximately 1000°C-1300°C at one end of the area 13 opposite the inlet station 8 to approximately 500°C-700°C at one end of the area 13 opposite the area 10.

According to some non-limiting embodiments, the cooling device 16 is further adapted to determine a temperature gradient (decreasing in the direction A) in the indirect cooling area 14. In particular, the temperature varies from approximately 500°C-700°C at one end adjacent to the area 13 to approximately 350°C-450°C at the opposite end.

According to some non-limiting embodiments, the cooling device 16 is furthermore adapted to determine a temperature gradient (decreasing in direction A) in the final cooling area 15 so that the temperature in the area of the outlet station 8 is between 40°C and 120°C.

More precisely, the cooling device 16 comprises a cooling assembly 16', which is fluidically connected at the rapid cooling area 13 and is adapted to direct (introduce) a cooling fluid, in particular air (cold), into the chamber 6 (on the basic ceramic articles BC). In this way the temperature gradient is obtained in the rapid cooling area 13.

Advantageously but not necessarily, the device 16 comprises a further cooling assembly adapted to cool the basic ceramic articles BC in an indirect manner (with micro-blowers or heat dissipation tubes) during feeding thereof in the indirect cooling area 14.

According to some non-limiting embodiments, the device 16 also comprises a further cooling assembly to cool the basic ceramic articles BC in an indirect manner (with one or more blowers) during feeding thereof in the final cooling area 15.

The kiln 4 further comprises at least one removal assembly 17 to remove compounds (in particular comprising organic compounds), evaporated from the basic ceramic articles BC, in the form of gas from the thermal treatment chamber 6.

In particular, the compounds evaporated from the basic ceramic

articles BC and then removed from the chamber 6 comprise organic compounds and inorganic acids (for example, hydrochloric acid, hydrofluoric acid and sulphuric acid).

According to specific non-limiting embodiments (like the one
5 illustrated in figure 1), the kiln 4 comprises (at least) two removal assemblies 17 which are similar to each other and, in particular, substantially identical. In particular, a first removal assembly 17 is arranged at the inlet station 7 and a second removal assembly 17 is arranged upstream of the outlet
10 station 8 (and downstream of the firing area 10), more specifically in the final cooling area 15 (more precisely, at the end of the final cooling area 14 and the beginning of the area 15). In the following description, what is said with reference to a single removal assembly 17 will apply to all the
15 (or part of the) removal assemblies 17.

In some particular and non-limiting cases, the kiln comprises one single removal assembly 17 at the sole inlet station 7.

Advantageously but not necessarily, the removal assembly 17 comprises at least one movement device 18, which is fluidically
20 connected to the thermal treatment chamber 6 and is adapted to generate a flow, in particular by suction, from the thermal treatment chamber 6. In particular, the movement device 18 comprises a suction unit (more precisely, a fan).

According to some non-limiting embodiments, the removal assembly
25 17 comprises a duct 19 which extends from the thermal treatment chamber 6 towards the outside. The movement device 18 is arranged along the duct 19.

The removal assembly 17 further comprises a treatment assembly
30 20 (in particular arranged along the duct 19) for the compounds removed (from the chamber 6).

With particular reference to figure 2, the treatment assembly
20 comprises (at least) one collecting device 21, which is adapted to collect at least part of the compounds removed (from the thermal treatment chamber 6) by means of a fluid 22
35 containing water so as to obtain a composition 23 (in particular, liquid) containing at least part of the compounds removed; (at

least) one separation device 24, which is adapted to remove at least part of the compounds removed from the water of the composition 23 so as to obtain a treated liquid 25 containing at least part of the water of the composition 23; and (at least) one basification device 26, which is adapted to reduce the acidity of the treated liquid 25 so as to obtain a further treated liquid 27.

In particular, the composition 23 is an emulsion, a suspension, a solution or a combination thereof. In some specific non-limiting cases, the composition 23 comprises (in particular, is) an emulsion.

According to some non-limiting embodiments, the collecting device 21 is adapted to collect at least part of the removed compounds condensing them (so as to obtain the composition 23 - in particular, an emulsion).

Advantageously but not necessarily, the collecting device 21 comprises at least one sprayer 28 adapted to spray a liquid containing water (in particular, the treated liquid 27) to obtain the fluid 22 containing water.

In particular, the collecting device 21 comprises an abatement tower 29 inside which, in particular, the liquid containing water is sprayed (in particular, the treated liquid 27) to obtain the fluid 22 containing water. The tower 29 comprises an opening 30 arranged at an upper end of said tower 29 and an opening 31, which is arranged at a lower end of the tower 29 and through which, in use, the composition 23 passes.

According to some specific and non-limiting embodiments, the tower 29 has a height of approximately 15 metres and a width (diameter) of approximately 2 metres.

Typically, the separation device 24 (in particular the tower 29) is connected to the duct 19 so that the compounds removed and coming from the chamber 6 (in particular, at a temperature of approximately 140°C with a flow rate of approximately 12000 Nm³/h) are fed to the separation device 24 (in particular to the tower 29).

In use, in particular, the fumes which have not been "trapped"

by the fluid 22 come out (in particular, at a temperature of approximately 80°C) of the opening 30.

According to some non-limiting embodiments, the collecting device 21 also comprises an intermediate tank 32, which is
5 connected to the tower 29 (in particular, to the lower end of the tower 29) in particular by means of a duct 33.

The treatment assembly 20 further comprises a connection device 34 to take the composition 23 from the collecting device 21 (in particular, from the tank 32) to the separation device 24. The
10 connection device 34 comprises a duct 35 and a movement unit 36 (in particular, a pump) to convey the composition 23 along the duct 35 from the collecting device 21 to the separation device 24.

According to some non-limiting embodiments, the separation
15 device 24 comprises a feeding unit 37 to feed at least a flocculant and/or at least a polyelectrolyte (and/or at least a surfactant and/or at least a non-polar solvent) to the composition 23 so as to cause at least part of the removed compounds to dissociate (in particular, flocculate) (so as to
20 obtain removed and dissociated compounds - in particular, flocculates - F); and a parting unit 38 (in particular, mechanical) to remove (in particular, mechanically) at least part of the dissociated (and flocculated) compounds F from the water of the composition 23 so as to obtain the treated liquid
25 25.

In particular, the parting unit 38 is adapted to remove with mechanical instruments at least part of the removed and flocculated compounds F (on the surface of the water of the composition 25). More in particular, the parting unit 38 is
30 adapted to remove by scraping at least part of the removed and flocculated compounds F (on the surface of the water of the composition 25).

More precisely, the parting unit 38 comprises a plurality of fingers (blades) which, when they move in the area of the upper
35 part of the water of the composition 23, remove at least part of the removed and flocculated compounds F.

According to some non-limiting embodiments, the parting unit 38 comprises a belt (or a chain or a band) closed in a loop and mounted on a pair of pulleys, at least one of which is motorized to move the belt (with continuous motion).

- 5 In some non-limiting cases, the feeding unit 37 comprises a sub-unit 39 to feed the flocculant and a sub-unit 40 to feed (the flocculant and/or) the polyelectrolyte (and/or a surfactant and/or a non-polar solvent).

According to some non-limiting embodiments, the separation
10 device 24 comprises a tank 41 to contain the composition 23. Advantageously but not necessarily, the separation device 24 comprises a bubbler 42 to cause a gas (in particular, air) to bubble in the content of the tank 41.

According to some non-limiting embodiments not illustrated, the
15 parting unit 38 is adapted to part any precipitated (and flocculated) material from the bottom of the tank 41. More precisely, the parting unit 38 is adapted to remove at least part of the dissociated and precipitated (and flocculated) compounds F from the bottom of the tank 41.

20 Advantageously but not necessarily, the tank 41 comprises an inner wall 43, which is provided with a lower opening 44 and divides the tank 41 into a first portion 45, at which the connection device 34 is adapted to feed the composition 23 and the feeding unit 37 is adapted to feed the flocculant and/or the
25 polyelectrolyte (and/or the surfactant and/or the non-polar solvent), and a second portion 46, at which the parting unit 38 and the bubbler 42 are adapted to operate.

Advantageously but not necessarily, the treatment assembly 20 comprises a cooling device 47, which is adapted to cool the
30 treated liquid 25. The basification device 26 is adapted to reduce the acidity of the treated liquid 25 coming from the cooling device 47 so as to obtain the liquid 27.

In particular, the cooling device 47 comprises a cooling tower (in particular, adapted to remove approximately 200000 kcal/h
35 so that the treated liquid 25 coming out of the cooling device 47 has a temperature of approximately 25°C).

According to some non-limiting embodiments, the treatment assembly 20 comprises a connection device 48 to take the treated liquid 25 from the separation device 24 (in particular from the tank 41; more in particular from the bottom of the portion 46) to the cooling device 47; and a connection device 49, comprising a relative duct, to take the cooled treated liquid 25 from the cooling device 47 to the basification device 26.

In particular, the connection device 48 comprises a duct 50 and a movement unit 51 (more precisely a pump) to move the treated liquid 25 along the duct 50.

Advantageously but not necessarily, the treatment assembly 20 comprises a recirculation device 52, which is adapted to use at least part of the treated liquid 27 to make up at least part of the fluid 22 containing water. In particular, the recirculation device 52 is adapted to supply approximately 15000 L/h of treated liquid 27 (at a temperature of approximately 25°C) to the collecting device 21.

According to some non-limiting embodiments, the treatment assembly 20 (more in particular, the recirculation device 52) further comprises at least one replenishment device 53 which is adapted to add water (in particular, approximately 700 L/h) to the treated liquid 25 and/or to the treated liquid 27.

According to some non-limiting embodiments, the basification device 26 comprises a container 55 (in particular, a tank; more in particular with a volume of approximately 150 m³), which is adapted to receive the treated liquid 25 and the water coming from the replenishment device 53. In particular, the basification device 26 is connected to the cooling device 47 (by means of the connection device 49).

Advantageously but not necessarily the basification device 26 comprises a pH sensor 56, which is adapted to detect the pH of the treated liquid 25 (more precisely, of the content of the container 55). In particular, the basification device 26 also comprises a control unit (of per se a known type and not illustrated), which is adapted to control a feeder 57 of a basification compound (for example NaOH or Ca(OH)₂ or a buffer

substance) according to what is detected by the sensor 55.

In particular, the recirculation device 52 comprises (at least) one duct 58, extending from the basification device 26 (more precisely, from the container 55) to the collecting device 21 (more precisely, to the sprayer 28) and movement unit 59 (in particular, a pump) to convey the treated liquid 27 along the duct 58.

Advantageously but not necessarily, a further treatment assembly 20 (more precisely, a removal assembly 17) is positioned at the above-mentioned drying station arranged between the pressing equipment 2 and the decoration device 3.

With particular reference to figures 5 and 6, according to some non-limiting embodiments, the kiln 4 (more precisely, the treatment assembly 20) comprises at least a smokestack 62 and an outlet duct 67, which extends from the opening 30 to the stack 62.

Advantageously but not necessarily, the kiln 4 also comprises a movement unit 68 (in particular, a fan) to convey the fumes (which, typically, have a temperature of approximately 70°-90°C; more precisely, approximately 80°C) from the opening 30 to the stack 62 (in particular, along the cited outlet duct 67).

According to some embodiments (figure 5), the kiln 4 (more precisely, the treatment assembly 20) comprises at least one activated carbon filter 61 (in particular, a battery of activated carbon filters arranged in series). In particular, the movement unit 68 is arranged between the activated carbon filter 61 and the stack 62.

The activated carbon filter 61 (known per se) has a high adsorption capacity of numerous chemical species, including the volatile organic compounds (in particular hydrocarbons). The activated carbons owe their effectiveness to their particular morphology with high specific surface area (500 to 1000 m²/gram). Being an adsorption process, there is a "saturation" effect of the filter, which after a certain period (in general a few months) requires replacement (and if necessary regeneration at specialist plants).

Alternatively or in addition to the activated carbon filter 61, a filter containing zeolites is provided.

Advantageously but not necessarily, the kiln 4 (in particular, the treatment assembly 20) comprises a dehumidification system 60 adapted to reduce the water vapour content in the fumes coming out of the opening 30 which, in particular, are fed to the activated carbon filter 61.

In this way (by reducing the humidity of the fumes), the operation of the activated carbon filter 61 is improved. The fumes coming out of the activated carbon filter 61 are therefore substantially purified, cold and with low humidity content.

According to some non-limiting embodiments (figure 6), the kiln 4 (in particular, the removal assembly 17) also comprises a process unit 69 for treating (purifying at least partially) the substances coming from the thermal treatment chamber 6 upstream of the treatment assembly 20.

In particular, the process assembly 69 is adapted to reduce the compound content, in particular comprising organic compounds (more in particular evaporated from the basic ceramic articles BC, in the form of gas from the thermal treatment chamber 6) fed to the treatment assembly 20.

Advantageously but not necessarily, the process assembly 69 comprises a purification device 64, which is adapted to bring the substances, coming from the chamber 6, into contact with a particulate material, in particular comprising (consisting of) (particles of) activated carbon and/or zeolite. In this way, the concentration of compounds is reduced, in particular comprising organic compounds (more in particular evaporated from the basic ceramic articles BC, in the form of gas from the thermal treatment chamber 6), fed to the treatment assembly 20.

Additionally or alternatively, the particulate material comprises (consists of) lime (in powder). The lime is adapted to reduce the acidity (in particular, by reacting with the acids present; more in particular, hydrochloric, hydrofluoric and/or sulphuric acid) of what is fed to the treatment assembly 20.

Advantageously but not necessarily, the kiln 4 (in particular,

the removal assembly 17; more in particular, the process assembly 69) comprises a sleeve filtering device 63, which is arranged upstream of the treatment assembly 20 and is adapted to filter the substances fed to the treatment assembly 20 (in particular, retaining the solid particles - reacted lime and activated carbons - which, more in particular, will be discharged to landfill).

In this case (embodiment of figure 6), the kiln 4 has a relatively low plant engineering cost (more precisely, the embodiment of figure 6 has a production cost lower than that of the embodiment of figure 5 which, however, has a cost connected with the exhausted activated carbons and/or zeolites).

It should be noted that, normally but not necessarily, the substances coming from the chamber 6 along the duct 19 have a temperature of approximately 200°C.

Advantageously but not necessarily, the kiln 4 (in particular, the removal assembly 17; more in particular, the process assembly 69) comprises a cooling device 65, which is arranged upstream of the purification device 64 to reduce the temperature (in particular to a temperature lower than approximately 150°C; more in particular, to a temperature of approximately 130°-150°C; more precisely, to approximately 140°C) of the substances fed (by means of the duct 19) to the purification device 64. In this way, the purification device 65 (more precisely, the activated carbon and/or the zeolite contained therein) works more efficiently.

In use, while the compounds removed (from the chamber 6) pass through the duct 19, the mentioned particulate material is extracted (in particular, by means of a Venturi tube of the purification device 64; more in particular, from one or more silos) and brought into contact with said compounds in a collector (of the purification device 64). At this point, at least a part of the compounds removed (from the chamber 6) interacts with the particulate material (in particular, reacts with the lime to obtain substantially neutral compounds and/or is adsorbed by the activated carbon and/or by the zeolites). The

particulate material continues its action once deposited inside the sleeve filtering device 63 (more precisely, on the filtering sleeves of said device). The gaseous part crosses the sleeve filtering device 63 and is fed by means of the movement device 5 18 to the treatment assembly 20.

Advantageously but not necessarily (figures 5 and 6), the kiln 4 (in particular, the treatment assembly 20; more in particular, the recirculation device 52) comprises a reverse osmosis filtering system 66, which is adapted to reduce (after the pH 10 has been basified - substantially neutralized - by the basification device 26) the salt content (which could accumulate during use) in the treated liquid 27.

In particular, the reverse osmosis filtering system 66 is arranged along the duct 58.

15 A method for the thermal treatment (in particular, for firing) of basic ceramic articles BC is also provided; the method comprises: (at least) one heating step, during which the basic ceramic articles BC are heated while they are at least in an area 10 of a thermal treatment chamber 6; (at least) one 20 conveying step, during which the basic ceramic articles BC are conveyed (from an inlet station 7 to an outlet station 8 of the thermal treatment chamber 6) along a given path P extending through the firing area 10 of the thermal treatment chamber 6. During the heating step, the firing area 10 has a temperature 25 of at least 500°C (in particular at least 900°C, more in particular at least 1000°C). Advantageously but not necessarily, during the heating step, the firing area 10 has a temperature of up to 1300°C.

In particular, the basic ceramic articles BC comprise ceramic 30 powder.

The method further comprises (at least) one removal step, during which compounds (in particular comprising organic compounds) evaporated (in particular, during the heating step) from the basic ceramic articles BC are removed in the form of gas from 35 the thermal treatment chamber 6 so as to obtain removed compounds; (at least) one collecting step, during which at least

part of the removed compounds are collected by means of a fluid 22 containing water so as to obtain a composition 23, in particular an emulsion, containing at least part of the removed compounds; and (at least) one separation step, during which at least part of the removed compounds, in particular organic compounds, are parted from the water of the composition 23 so as to obtain a treated liquid 25 containing at least part of the water of the composition 23.

In particular, the basic ceramic articles BC comprise organic compounds, in particular hydrocarbons (in a non-negligible quantity). Typically, the basic ceramic articles BC comprise inorganic compounds.

According to some non-limiting embodiments, the basic ceramic articles BC have (in particular, on an own surface thereof) pigments, conductive polar fluids (like water) and/or non-polar solvents (organic solvents; oils or other hydrocarbons). More precisely, the basic ceramic articles BC have (in particular, on an own surface thereof) an ink (and/or an enamel).

According to specific non-limiting embodiments, the basic ceramic articles BC have on an own surface thereof (upper) 10 g/m² to 20 g/m² of ink and, additionally or alternatively, 80 g/m² to 150 g/m² of base enamel.

In particular, the method also comprises (at least) one basification step, during which the acidity of the treated liquid 25 is reduced so as to obtain a treated liquid 27. More in particular, during the basification step, a basification compound (for example NaOH or Ca(OH)₂ or a buffer substance) is fed to the treated liquid 25.

In particular, the compounds evaporated from the basic ceramic articles BC and, then, removed from the chamber 6 comprise organic compounds and inorganic acids (for example, hydrochloric acid, hydrofluoric acid and sulphuric acid).

Advantageously but not necessarily, the method comprises (at least) one recirculation step, during which at least part of the treated liquid 27 is used to make up at least part of the fluid 22 containing water. In particular, the fluid 22 containing

water is obtained by spraying of the treated liquid 27.

According to some non-limiting embodiments, the separation step comprises at least one dissociation sub-step, during which at least part of the compounds removed dissociate from the water of the composition 23; and at least one parting sub-step (in particular, mechanical), during which the compounds removed and dissociated are at least partially parted (in particular, mechanically) from the water of the composition 23 so as to obtain the treated liquid 25.

Advantageously but not necessarily, the dissociation sub-step comprises a flocculation step during which at least part of the compounds removed are caused to flocculate (so as to obtain removed and flocculated compounds F), in particular by means of the addition of at least one flocculant and/or at least one polyelectrolyte (and/or at least one surfactant and/or at least one non-polar solvent) to the composition 23.

Advantageously but not necessarily, during the separation step (in particular, during the dissociation sub-step) a gas (in particular, air) is caused to bubble in the composition 23.

Advantageously but not necessarily, the method also comprises (at least) one cooling step, during which the treated liquid 25 is cooled. In particular, during the basification step, the acidity of the liquid treated 25 and cooled, is reduced, so as to obtain the treated liquid 27.

Advantageously but not necessarily, the method also comprises (at least) one replenishment step, during which water is added to the treated liquids 25 and 27. In particular, the fluid 23 containing water is obtained by spraying of the treated liquid 27.

Advantageously but not necessarily, the method comprises at least one treatment step, during which at least part of the compounds, evaporated from the basic ceramic articles BC (and removed - in the form of gas - from the chamber 6), are brought into contact with a particulate material selected from the group consisting of: lime (in powder), (particles of) activated

carbons, (particles of) zeolites and a combination thereof.

According to some non-limiting embodiments, the treatment step precedes the collecting step. Alternatively, the treatment step succeeds the collecting step.

5 According to some non-limiting embodiments, the treatment step is implemented using at least one filter comprising activated carbons and/or zeolites (e.g. the activated carbon filter 61). Alternatively or additionally, the treatment step is implemented by bringing at least part of the compounds, evaporated from the
10 basic ceramic articles BC (and removed - in the form of gas - from the chamber 6) directly into contact with free particles of activated carbons and/or zeolites. In these cases, advantageously but not necessarily, during the treatment step, a filter is used for the removal of particulate (e.g. the sleeve
15 filtering device 63).

Advantageously but not necessarily, the method is implemented by a kiln 4 as described above.

According to a further aspect of the present invention, a treatment assembly 20 is provided as described above.

20 The present invention has several advantages with respect to the state of the art. In particular, in accordance with the present invention it is possible to purify the gases coming out of a kiln for firing ceramic articles, in an efficient and inexpensive manner. Said purification allows removal of at least
25 part of the organic compounds and inorganic acids present in said fumes. It should furthermore be noted that the present invention can also be applied to existing kilns.

Unless explicitly indicated otherwise, the contents of the references (articles, books, patent applications etc.) mentioned
30 in this text are referred to here in full. In particular, the mentioned references are herein incorporated by reference.

CLAIMS

1.- A method for the thermal treatment (in particular, for the firing) of basic ceramic articles (BC); the method comprises:

5 at least one heating step, during which the basic ceramic articles (BC) are heated while they are in at least one firing area (10) of a thermal treatment chamber (6);

at least one conveying step, during which the basic ceramic articles (BC) are conveyed along a given path (P) extending
10 through the firing area (10) of the thermal treatment chamber (6); during the heating step, the firing area (10) has a temperature of at least 500°C, in particular at least 900°C;

at least one removal step, during which compounds (in particular comprising organic compounds and inorganic acids), evaporated
15 from the basic ceramic articles (BC), are removed in the form of gas from the thermal treatment chamber (6) so as to obtain removed compounds;

the method being characterized in that it comprises at least one collecting step, during which at least part of the removed
20 compounds are collected by means of a water-containing fluid (22) so as to obtain a composition (23), in particular an emulsion, containing at least part of the removed compounds;

at least one separation step, during which at least part of the removed compounds, in particular of the organic compounds, are
25 parted from the water of the composition (23) so as to obtain a first treated liquid (25) containing at least part of the water of the composition (23); and

at least one basification step, during which the acidity of the first treated liquid (25) is reduced so as to obtain a second
30 treated liquid (27).

2.- The method according to claim 1 and comprising at least one recirculation step, during which at least part of the second
treated liquid (27) is used to make up at least part of the water-containing fluid (22); in particular, the water-containing
35 fluid (22) is obtained through spraying of the second treated liquid (27).

3.- The method according to claim 1 or 2, wherein the separation step comprises at least one dissociation sub-step, during which at least part of the removed compounds disassociate themselves from the water of the composition (23); and at least one parting sub-step, during which the removed and disassociated compounds are at least partially parted from the water of the composition so as to obtain the first treated liquid (25).

4.- The method according to claim 3, wherein the disassociation sub-step comprises a flocculation step, during which at least part of the removed compounds are caused to flocculate, in particular by adding to the composition (23) at least one additive selected in the group consisting of: at least one flocculant, at least one polyelectrolyte, at least one surfactant, at least one non-polar solvent, and a combination thereof.

5.- The method according to claim 3 or 4, wherein, during the disassociation step, a gas is caused to bubble in the composition (23).

6.- The method according to any one of the preceding claims, and comprising at least one cooling step, during which the first treated liquid (25) is cooled; during the basification step, the acidity of the cooled first treated liquid (25) is reduced so as to obtain the second treated liquid (27).

7.- The method according to any one of the preceding claims, and comprising at least one recirculation step, during which at least part of the second treated liquid (27) is used to make up at least part of the water-containing fluid (22); and at least one replenishment step, during which water is added to the first treated liquid (25) or to the second treated liquid (27); in particular, the water-containing fluid (22) is obtained through spraying of the second treated liquid (27).

8.- A kiln for the thermal treatment (in particular, for the firing) of basic ceramic articles; the kiln (4) comprises: a conveying assembly (5) for conveying the basic ceramic articles (BC) along a given path (P); at least one thermal treatment

chamber (6), which is arranged along the given path (P) and has an input station (7) and an output station (8); at least one heating device (4'), which is adapted to heat the basic ceramic articles (BC) enforcing a temperature of at least 500°C, in particular at least 900°C, in at least one firing area (10) of the thermal treatment chamber (6); and at least one removal assembly (17) to remove compounds (in particular comprising organic compounds), evaporated from the basic ceramic articles (BC), in the form of gas from the thermal treatment chamber (6); the kiln (4) being characterized in that the removal assembly (17) comprises at least one treatment assembly (20) for the treatment of the removed compounds;

the treatment assembly (20) comprises at least one collecting device (21), which is adapted to collect at least part of the removed compounds by means of a water-containing fluid (22) so as to obtain a composition (23), in particular an emulsion, containing at least part of the removed compounds;

at least one separation device (24), which is adapted to part at least part of the removed compounds from the water of the composition (23) so as to obtain a first treated liquid (25) containing at least part of the water of the composition (23); and

at least one basification device (26), which is adapted to reduce the acidity of the first treated liquid (25) so as to obtain a second treated liquid (27).

9.- The kiln according to claim 8, wherein the treatment assembly (20) comprises a recirculation device (52), which is adapted to use at least part of the second treated liquid (27) to make up at least part of the water-containing fluid (22); in particular, the collecting device (21) comprises at least one sprayer (54), which is adapted to spray the second treated liquid (27) so as to obtain the water-containing fluid (22).

10.- The kiln according to claim 8 or 9, wherein the separation device (24) comprises at least one feeding unit (37) to feed at least one flocculant and/or at least one polyelectrolyte to the composition (23) so as to cause at least part of the removed

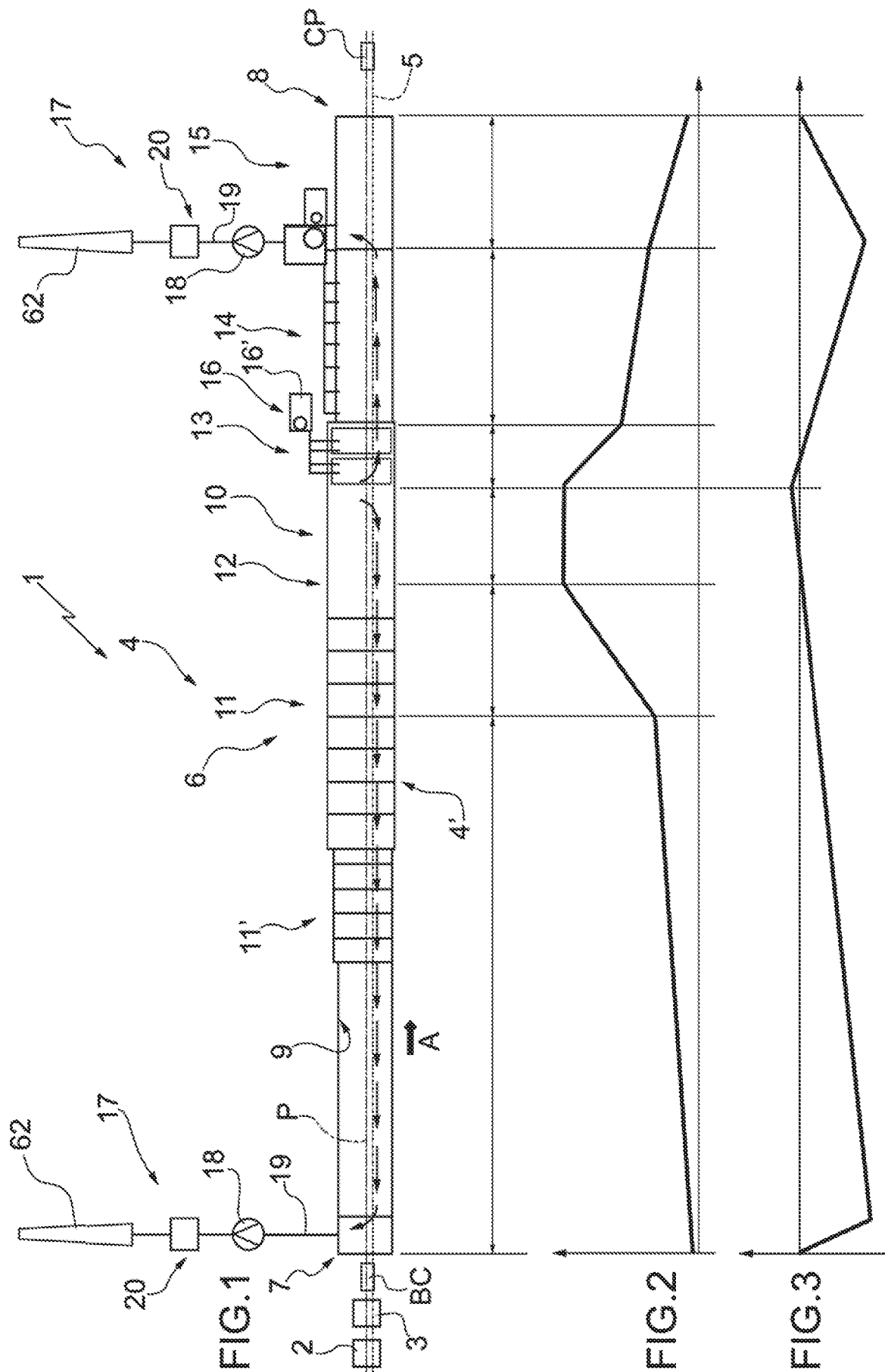
compounds to flocculate; and a parting unit (38) to part at least part of the removed and flocculated compounds (F) from the water of the composition (23) so as to obtain the first treated liquid (25).

5 11.- The kiln according to any one of the claims from 8 to 10, wherein the separation device (24) comprises a tank (41) to contain the composition (23); and at least one bubbler (42) to cause a gas to bubble in the content of the tank (41); the parting unit (38) being adapted to remove an upper portion of
10 the composition (23) (in particular, at least part of the removed and flocculated compounds).

12.- The kiln according to any one of the claims from 8 to 11, wherein the treatment assembly (20) comprises a cooling device (47), which is adapted to cool the first treated liquid (25);
15 the basification device (26) is adapted to reduce the acidity of the first treated and cooled liquid (25) so as to obtain the second treated liquid (27).

13.- The kiln according to any one of the claims from 8 to 12, wherein the treatment assembly (20) comprises a recirculation
20 device (52), which is adapted to use at least part of the second treated liquid (27) to make up at least part of the water-containing fluid (22); in particular, the treatment assembly (20) further comprises at least one replenishment device (53), which is adapted to add water to the first treated liquid (25)
25 and/or to the second treated liquid (27); in particular, the collecting device (21) comprises at least one sprayer (28), which is adapted to spray the second treated liquid (27) so as to obtain the water-containing fluid (22).

14.- A plant for the production of ceramic products (CP) starting
30 from basic ceramic articles (BC); the plant (1) comprises a decoration device (3), which is adapted to decorate the basic ceramic articles (BC) with an ink comprising organic compounds, and a kiln (4) according to any one of the claims from 8 to 13.



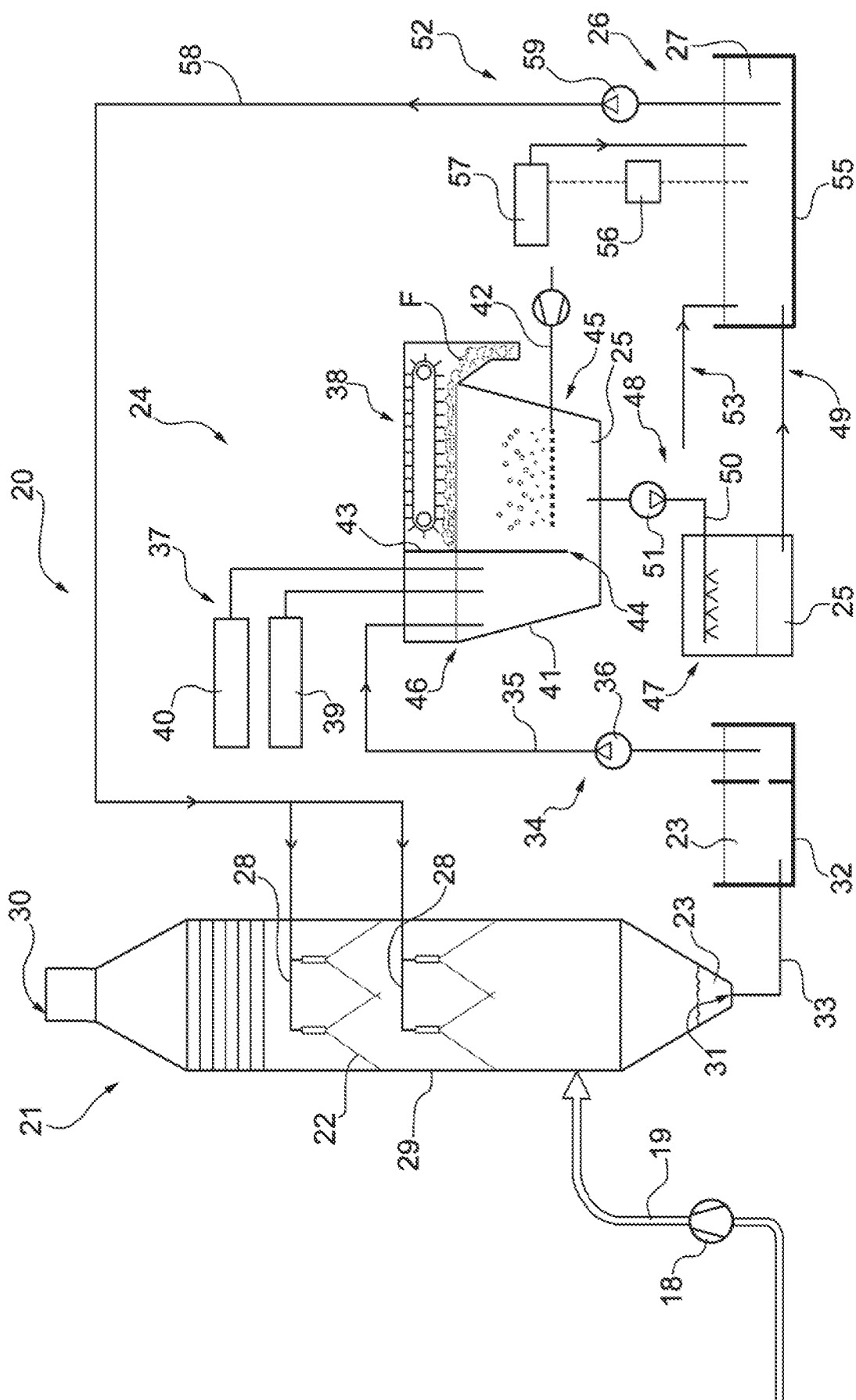
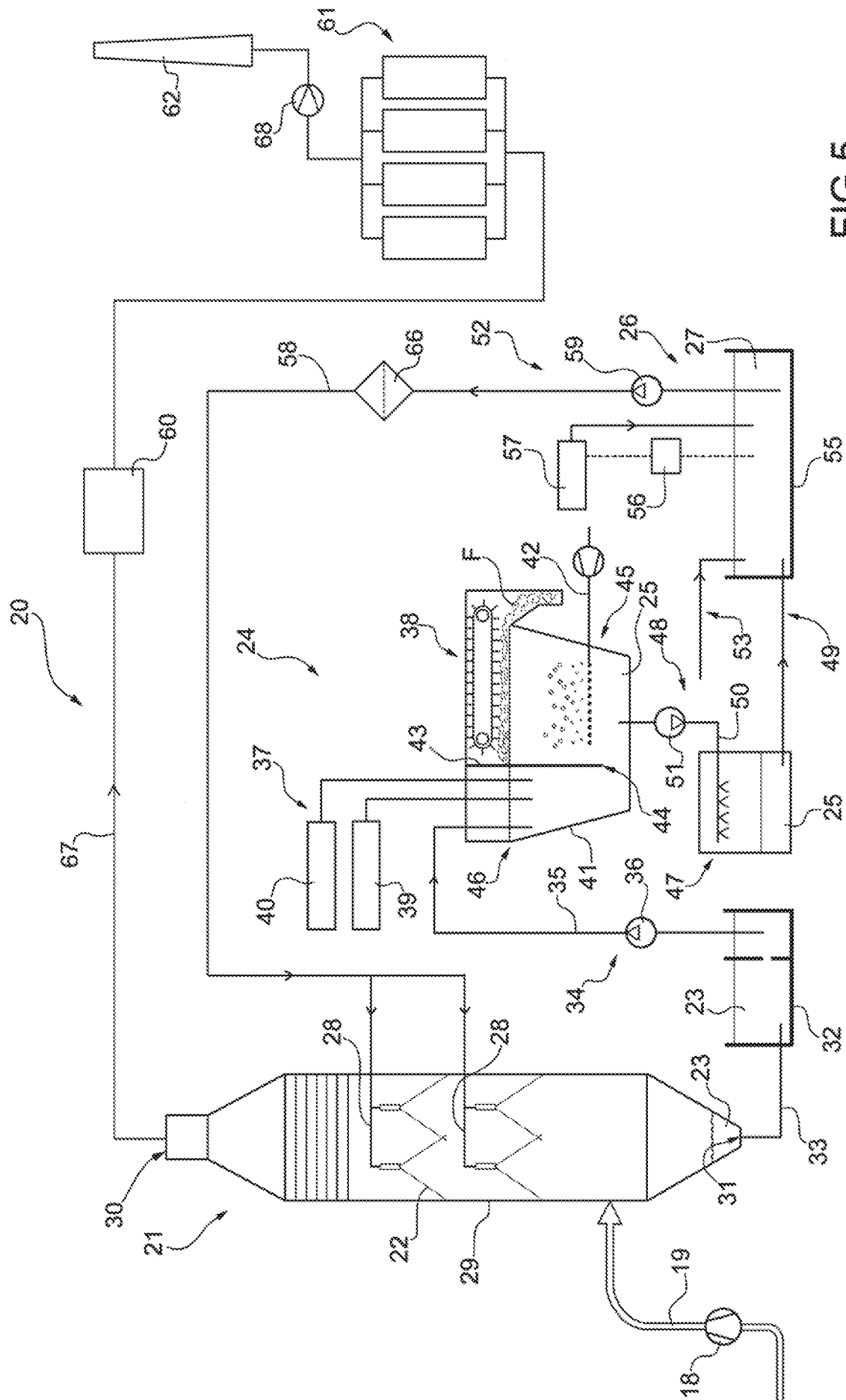


FIG.4



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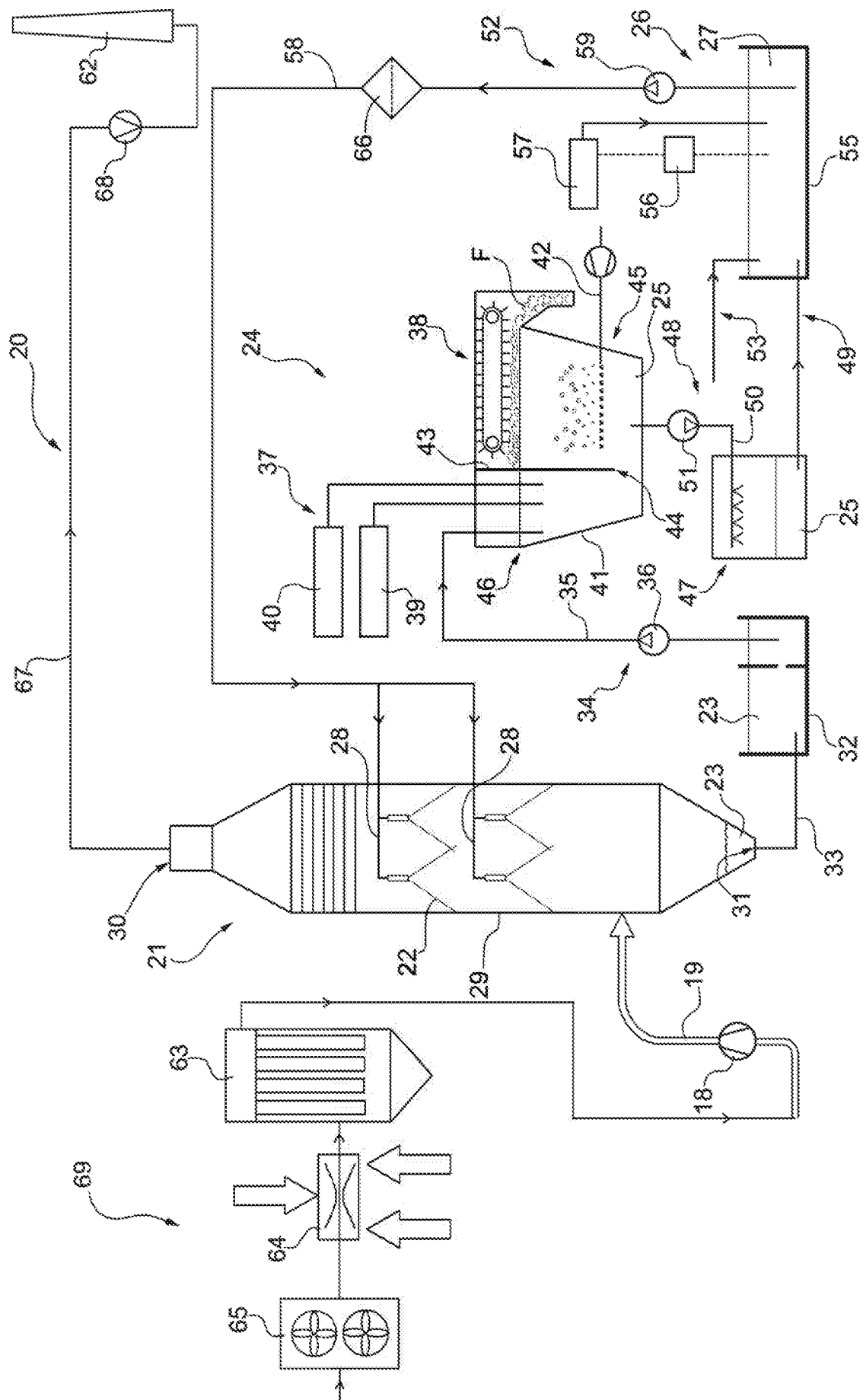


FIG.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/055468

A. CLASSIFICATION OF SUBJECT MATTER INV. F27B9/30 B01D53/40 B01D53/44 B01D53/78 F27D17/00 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 F27B F27D		
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		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2010/012636 A1 (SACMI [IT]; ACERBI PIERUGO [IT]) 4 February 2010 (2010-02-04) page 1, line 1 - page 2, line 6 page 6, line 12 - page 7, line 32 figures 1, 3	1-14
Y	WO 2012/084480 A1 (SIEMENS VAI METALS TECH GMBH [AT]; HECKMANN HADO [AT]; SCHMIDT ULRIKE) 28 June 2012 (2012-06-28) page 15, line 31 - page 16, line 22 figures 2, 3 page 1, line 4 - line 11 ----- -/--	1-14
☒ Further documents are listed in the continuation of Box C. ☒ 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 "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
26 September 2018		05/10/2018
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 Jung, Régis

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2018/055468

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011/033359 A1 (PAPENHEIM GEORG [DE] ET AL) 10 February 2011 (2011-02-10) figure 1 paragraph [0001] - paragraph [0003] paragraph [0018] paragraph [0044] - paragraph [0048] -----	1-14
Y	JP 2011 173075 A (NICHIO ENGINEERING KK) 8 September 2011 (2011-09-08) figure 1 paragraph [0001] - paragraph [0004] paragraph [0015] - paragraph [0022] -----	1-14

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Information on patent family members

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