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Published:

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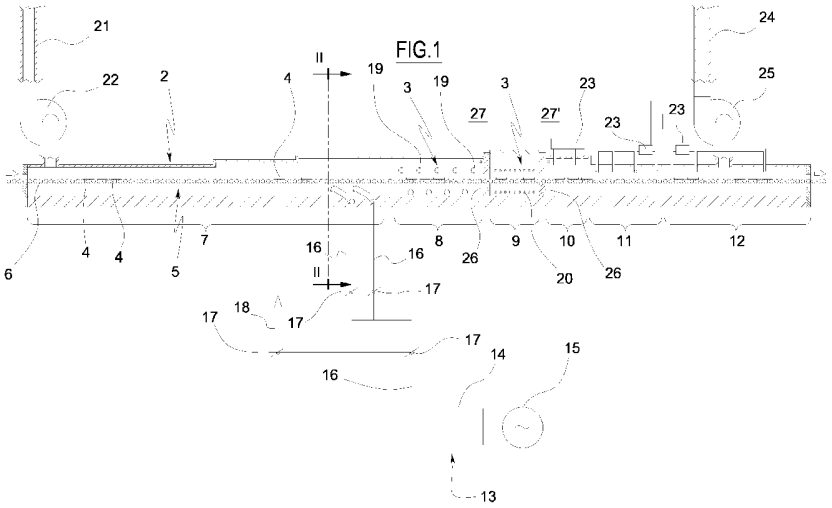
(54) **Title**: A KILN FOR FIRING CERAMIC PRODUCTS

FIG.1



(57) **Abstract**: A ceramics kiln comprising an insulated tunnel, means of transporting to advance ceramic products through the tunnel, and means for heating the tunnel, when the means for heating comprise at least a cogeneration group for heat and electrical energy, equipped with means for transferring at least a part of the generated heat into the tunnel.

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A KILN FOR FIRING CERAMIC PRODUCTS

Technical field

The present invention relates to a kiln for firing ceramic products, in particular a continuous counterflow kiln for firing ceramic products like ceramic tiles or ceramic slabs in general.

Background art

As is known, a ceramic kiln generally comprises an extended insulated tunnel inside of which ceramic products are continuously conveyed on suitable means of transporting, typically a system of parallel and adjacent motorized rollers on which the products are supported directly.

The tunnel is mainly divided into an initial section for heating and a second section for cooling ceramic products. Each section is in turn formed from a sequence of successive segments, the temperature of which varies on the basis of the relative position along the tunnel.

Thus, for example, the heating section comprises: a first segment defined as the "preheating area" for complete drying at low temperature (200°C to 400°C) of unfired ceramic products; a second segment defined as the "pre-firing area" in which temperatures in the order of 900°C to 1000°C are reached, with the aim of resolving certain problems in the firing of ceramic products, among which the combustion of organic substances, the elimination of combined water, the transformation of quartz, etc.; and a third segment referred to as the "firing zone" in which temperatures in the order of 1200°C to 1300°C are reached in order to achieve the actual firing of ceramic products.

The cooling section comprises a fourth segment of minor length (a few metres) referred to as the "fast cooling zone" in which the temperature falls rapidly to about 600°C; a fifth segment referred to as the "indirect cooling zone" in which the temperature falls to between 450°C and 500°C at a sufficiently slow rate to avoid breakage of materials caused by the transformation of quartz; and a sixth segment referred to as the "final cooling

zone" in which the temperature falls rapidly from 500°C until the ceramic products can be handled.

In the preheating and firing zones means are installed for heating the tunnel to the required temperatures, the means generally comprising high flame-speed gas burners with emission of combustion fumes directly into the tunnel.

The pre-firing, or pre-kiln, section is without burners and is heated by the combustion gases arriving from the preheating and firing zones as the result of a flow of gas in counterflow running down the tunnel in the opposite direction to the advancement direction of ceramic products. The counterflow is generally obtained through the locating of a flue at the start of the tunnel creating a low pressure area sufficient to generate the required gas current. The flue can be assisted or substituted with a ventilation system.

In the fast cooling and final cooling zones, means of direct cooling are often implemented by blowing air at ambient temperature directly into the tunnel.

An airflow is normally also induced down the tunnel in the same direction as the movement of ceramic products, from the quick cooling zone towards the tunnel exit. This parallel flow is generally achieved with a second flue located at the end of the tunnel and creating sufficient low pressure to induce the required current. Again the flue can be assisted or substituted with a ventilation system.

From the above explanation it can be deduced that basically the tunnel has low pressure zones in the terminal segments with approximately ambient pressure at an intermediate point, referred to as the "zero point", the position thereof along the tunnel adjustable by regulating the draught of the flues or the operation of the ventilators.

Each ceramics kiln is normally equipped with a series of accessory devices, including for example control systems, automatic mechanisms, and others, requiring an electrical power supply.

In particular, ceramics kilns of the type described above are known in which the firing area is heated with electrical elements, substituting the gas burners, in order to avoid the presence of combustion gases during the firing of

ceramic products.

In these kilns the various electrical devices are normally supplied with electrical current from the mains supply or generated by an alternator which in turn is driven by an internal combustion engine, for example a reciprocating engine powered by methane or Diesel.

Due to the high cost of mains supply electrical energy, the low yield of internal combustion engines, and the drastic increase in the cost of fossil fuels in recent years, it is obvious that the cost of operation of these ceramics kilns is extremely high and thus not always economically competitive.

An aim of the present invention is to obviate this disadvantage, providing a ceramics kiln and a method of management thereof that permit a more rational exploitation of the energy employed, a higher yield, and therefore economically more profitable.

A further aim of the present invention is to achieve this objective with a simple, rational, and economic solution.

These aims are attained by the characteristics of the invention as described in the independent claims. The dependent claims delineate preferred and/or particularly advantageous embodiments of the invention.

Disclosure of the invention

In general terms the invention provides a ceramics kiln comprising an insulated tunnel, means of transporting for advancing ceramic products along the tunnel, and means for heating the tunnel, with the means for heating comprising at least a cogeneration group for heat and electrical energy including means for transferring at least a part of the generated heat into the tunnel.

Thanks to the described configuration, the cogeneration group can be used to supply at least the various electrical devices of the ceramic kiln, while the heat produced during the generating of the electrical energy is effectively used to heat the tunnel, obtaining an improved overall energy balance and yield, with resulting advantages in terms of energy savings.

In an embodiment of the invention, the cogeneration group comprises a combustible fuel device for generating electrical energy, and means for

transferring at least a part of the heat accumulated in the exhaust gases produced by the combustible fuel device into the tunnel, following the reaction of the fuel during the generating of electrical energy.

In particular, the combustible fuel device can comprise a thermal engine, for example a reciprocating or rotary internal combustion thermal engine, mechanically connected to an electrical generator.

Alternatively the combustible fuel device could comprise a fuel cell, that is an electrochemical generator in which, in principle, a fuel (typically hydrogen) and an oxidant (oxygen or air) enter into combustion and from which continuous electrical current, water, and heat are produced.

Preferably the hot exhaust gases produced by the combustible fuel device are conveyed and emitted directly into the tunnel, preferably into the segment containing the preheating zone.

In a preferred embodiment of the invention, the electrical energy produced by the cogeneration group is used at least in part to supply electrical devices that further heat the tunnel, generally means that transform electrical energy into heat, such as for example electrical resistance elements.

The means for transforming electrical energy into heat are installed in a central segment of the tunnel, preferably in the segment containing the maximum temperature firing zone, downstream, in the sense of direction of movement of ceramic products, of the segment into which the exhaust gases are conveyed.

In this way the segment of tunnel heated electrically can be left without burners such that the internal atmosphere remains substantially inert and free of fumes (or gases) from direct combustion (water, carbon dioxide, and sulphur) which react with the glaze during firing and can result in surface defects on the ceramic products.

For the same purpose, in a preferred embodiment of the invention, the electrically heated segment is delimited inside the tunnel with two dividing elements which permit the passage of ceramic products but blocking the entry of fumes from the other zones of the tunnel.

It is also preferable that the tunnel comprises means for pressure balancing

such as to maintain pressure variation along the entire electrically heated segment between 0 and 5 mmH_2O.

In this way the pressure variation in this segment will always be insufficient to generate an air current capable of inducing the inflow of combustion gases from other sectors of the tunnel.

A minor pressure variation is, however, useful since it allows the creation of a minor controlled flow of air that clears the firing area of substances derived from sublimation at high temperatures (sodium and potassium chlorides, etc.) which, at certain concentrations, can cause surface damage to ceramic products.

In one embodiment of the invention, the means for pressure balancing comprise at least an auxiliary duct maintaining communication between the tunnel zones adjacent upstream and adjacent downstream of the electrically heated segment.

Alternatively, the means of pressure balancing could comprise two pressure sensors located respectively in the tunnel zones adjacent upstream and adjacent downstream of the electrically heated segment, together with automatic control devices that, on the basis of the pressure readings of the sensors, could regulate the means of ventilating for the venting of gases, these being the means of ventilating that generate the counterflow and parallel airflow in the tunnel described above.

Finally, a further embodiment of the invention foresees that the kiln comprises both the pressure sensors, located respectively in the tunnel zones adjacent upstream and adjacent downstream of the electrically heated segment, and at least an auxiliary duct establishing communication between the tunnel zones adjacent to the upstream and downstream ends of the electrically heated segment, providing improved regulation of pressures inside the kiln.

Further characteristics and advantages of the invention will better emerge from the detailed description made herein, provided by way of non-limiting example in the accompanying figures of the drawings.

Brief description of drawings

Figure 1 is a schematic view of a first embodiment of the invention.

Figure 2 is the cross-section II-II of figure 1.

Figure 3 includes temperature and pressure graphs for the length of the tunnel relative to the first embodiment of the invention.

Figure 4 is a partial view of a second embodiment of the invention.

Figure 5 is the cross-section V-V of figure 4.

Figure 6 includes temperature and pressure graphs from along the tunnel relative to the second embodiment of the invention.

Figure 7 is a third embodiment of the invention.

Best mode for carrying out the invention

Figure 1 illustrates a kiln 1 of continuous type comprising a tunnel 2, insulated, equipped internally with means 3 for heating the tunnel for the firing of ceramic products 4, which are advanced inside the tunnel 2 by suitable means for transporting 5, for example a motorized roller conveyor 6.

As already noted, the tunnel 2 is divided into various segments at different temperatures in order to subject the products being fired to a predefined cycle of firing, illustrated in 3; in particular the tunnel 2 comprises a first segment for preheating 7, in which products are heated from ambient temperature to approximately 350°C, a pre-firing segment 8 where products are heated to a temperature of approximately 1200°C, and a firing segment 9 where products are heated to a constant temperature of approximately 1220°C. Downstream of the firing segment 9 a process begins for cooling products, the products passing in sequence through a fast cooling segment 10 (from 1200°C to 600°C), an indirect cooling segment 11 (from 600°C to 450°C), and a final cooling segment 12, after which the temperature of the products exiting the kiln is approximately 50°C.

The kiln 1 also comprises a cogeneration group 13 for heat and electrical energy comprising essentially an internal combustion engine 14, mechanically connected to an alternator 15 for generating electricity whch will power at least the electrical devices of the kiln 1, as will be described in more detail herein.

Any excess electrical energy will be advantageously utilized to power other equipment of the production line.

Other embodiments of the invention involve the use of a gas turbine in place of the internal combustion engine 14.

The exhaust gases produced by the internal combustion engine 14 are conveyed through suitable ducting 16 into the tunnel 2 at the terminal portion of the preheating segment 7.

In particular, the ducting 16 opens into the preheating zone 7 below the roller conveyor 6 for the transport of products, as illustrated in figure 2.

The ducting 16 is provided with suitable on-off valves 17 that permit regulation of the flow of exhaust gases conveyed into the tunnel 2 or alternatively conveying the exhaust gases into an outlet 18 and releasing the gases into the atmosphere.

In the pre-firing segment 8 the means 3 for heating the tunnel 2 to the determined temperature comprise gas burners 19 with high flame speed and emission of combustion gases directly into the tunnel 2, while in the firing segment 9 the means 3 for heating the tunnel 2 comprise a series of electrically-heating elements 20, supplied with the electrical energy produced by the alternator 15 of the cogeneration group 13.

The preheating group is heated by the combustion gases drawn from the pre-firing segment and by the exhaust gases from the internal combustion engine 14, resulting from a counterflow current of air along the tunnel 2 in the opposite direction to the direction of transport of ceramic products. The countercurrent flow is induced by the presence of a flue 21 located at the start of the tunnel 2, creating a zone of low pressure in that area sufficient to induce the required current. The flue is provided with a ventilator system 22 which makes it possible to regulate the rate of flow of fumes and gases.

The fact that the exhaust gases are conveyed into the tunnel below the roller conveyor 6 and mix with the fumes from the pre-firing zone, which circulate prevalently at the top of the tunnel, encourages the circulation of fumes and the oxidization of the organic substances present in the ceramic mix in this initial phase of firing.

In the fast, indirect, and final cooling zones, means for cooling 23 are provided, powered by the alternator 15, the means 23 conveying air at ambient temperature directly or indirectly into the tunnel 2.

An airflow along the tunnel in the same direction as the transport of ceramic products is also comprised, flowing from the rapid cooling zone towards the product outlet end. This parallel flow is induced by a second flue 24 located at the end of the tunnel 2, creating sufficient low pressure in that zone to induce the required air current. Also in this case, the draught of the flue 24 is assisted by a ventilator system 25, powered by the alternator 15.

The two airflows inside the tunnel in opposite directions create low pressure zones at the kiln entrance and exit (approximately -12 mmH_2O), while the segment containing the firing zone of the kiln is at approximately ambient pressure. This prevents combustion fumes, which contain water, nitrogen oxides, sulphur oxides, and carbon dioxide, from reacting with the glaze on ceramic products during firing. Such reactions are extremely undesirable since they can cause surface defects on the products. In order to facilitate separation of the firing segment from the adjacent segments the invention includes the use of separating elements 26 that ensure an adequate opening for the transit of ceramic products but prevent or at least limit the passage of combustion fumes. Alternatively, or in addition to the dividing elements 26, the kiln is also provided with means for pressure balancing that maintain the pressure in the firing segment at a level close to atmospheric pressure, with maximum oscillations in the order of ± 0.3 mmH_2O.

In a first embodiment of the invention the means for pressure balancing comprise two pressure sensors 27, 27' located immediately upstream and downstream of the firing segment 9 and respectively associated to ventilators 22 and 25. In practice the activation of the ventilators is implemented, by way of normal control systems, on the basis of the pressure readings of the respective pressure sensors 27, 27', such as to maintain the pressure level close to the ambient level in proximity to the sensors 27, 27'.

Note that, as illustrated in figure 3, from a functional point of view the pressure inside the firing segment will never be constant and will undergo

small pressure variations, of benefit to the process since they enable evacuation of the volatile substances liberated during firing at high temperature, for example sodium and potassium chlorides.

Figure 4 is a second embodiment of the invention which differs from the first embodiment as regards the means for balancing pressure, without the use of pressure sensors but comprising at least one conduit 28 by-passing the firing segment 9, and establishing communication between the pre-firing segment 8 and the rapid cooling segment 10.

The by-pass conduit 28 enables equalization of the pressure upstream and downstream of the firing segment and regulates the speed of the ventilators such that the pressure levels at the ends of the firing segment are substantially the same and preferably correspond to ambient atmospheric pressure.

The by-pass conduit 28 has associated valves 28' serving to stop the flow of air and/or interrupt the connection.

The illustrated embodiment of the invention comprises a plurality of by-pass conduits 28 arranged in the thickness of the base wall of the tunnel 2, as illustrated in figure 5. Obviously the number of by-pass conduits 28 and their position can vary in other embodiments of the invention.

Finally, figure 7 is a schematic view of a further embodiment of the invention in which the means for pressure balancing comprise both the pressure sensors 27 and 27', and the by-pass conduits 28. This configuration has the advantage of permitting various forms of regulation of the pressure upstream and downstream of the firing segment 9 of the kiln 1.

The arrangement of heating the insulated tunnel by transferring into it at least a part of the heat generated by a cogeneration group for heat and electrical energy offers considerable energy savings compared with a traditional kiln, which obviously translates into financial savings on the cost of production of finished ceramic products. For a same production level it has been calculated that the use of the kiln of the invention, firing ceramic tiles in vitrified stoneware, offers savings of around 22% compared with the use of a traditional kiln. In addition there is the advantage of obtaining higher quality

products given that the electrically heated firing zone is free of combustion gases that could damage products during firing.

CLAIMS

1). A ceramics kiln comprising an insulated tunnel, means for advancing ceramic products through the tunnel, a thermal engine and a generator of electrical current powered by the thermal engine, said tunnel comprising a first inlet portion for the pre-heating of the ceramic products, a second intermediate portion for the high temperature cooking of the ceramic products and a third outlet portion for the controlled cooling of the ceramic products, characterized by comprising means for feeding at least one part of the combustion gases of said thermal engine to the downstream end of said first portion of the tunnel and to address said gases to the upstream end of said first portion, and further means for feeding at least one part of the electric energy produced by said electric generator to said second intermediate portion of the tunnel, means for transforming asid electric energy in heat being provided.

2). The kiln of claim 1, characterized in that said thermal engine is an internal combustion engine.

3). The kiln of claim 1, characterized in that said thermal engine is a gas turbine.

4) The kiln of claim 1 characterized in that the means for transforming at least a part of the electrical energy into heat comprise electrical resistance heating elements.

5) The kiln of claim 4, characterized in that the means for transforming the electrical energy into heat are installed in second intermediate portion of the tunnel.

6) The kiln of claim 1, characterized in that said second intermediate portion of the tunnel is separated from said first and from said third portion by separating walls having openings strictly necessary to allow the passage of

the ceramic products.

7) The kiln of claim 6, characterized in that it comprises balancing means for maintaining a variation of pressure along the second intermediate portion of the tunnel within a range of 0 to 5 mmH_2O.

8) The kiln of claim 7 characterised in that the balancing means comprise at least one auxiliary conduit which maintains the zones immediately upstream and immediately downstream of the second intermediate portion in mutual communication.

9) The kiln of claim 7, characterized in that the means for balancing comprise first means for ventilating which induce an air current flowing along the tunnel from the second intermediate portion in an opposite direction to the advancement direction of the ceramic products, and second means for ventilating which induce an airflow along the tunnel from the second intermediate portion thereof and flowing in a same direction as the advancement direction of the ceramic products, and means for controlling operation of the first means for ventilating and the second means for ventilating, which means for controlling are connected to at least two pressure sensors located in the zones immediately upstream and immediately downstream of the second intermediate portion of the tunnel.

10) The kiln of claim 1, characterized in that the means for transporting comprise a motorized roller system on which ceramic products are supported.

11). A method for management of a ceramics kiln comprising an insulated tunnel, with a first inlet portion for the pre-heating of the ceramic products, a second intermediate portion for the high temperature cooking of the ceramic products and a third outlet portion for the controlled cooling of the ceramic products, and conveying means for advancing said products within the tunnel, characterised by heating the said insulated tunnel by feeding into the tunnel at least one part of the combustion gases of the thermal engine and at least one part of the electric energy of an electric generator powered by the said thermal engine.

12) The method of claim 11, characterized by conveying the exhaust gases of the thermal engine directly into the first portion of the tunnel directed counterflow in respect of the advancing direction of the ceramic products.

13) The method according to claim 11 characterised in that at least one part of the electric energy of the electric generator powered by said thermal engine is conveyed to said second intermediate portion of the tunnel and transformed in heat by electric resistance devices.

14). The method of claim 11, characterized in that it comprises maintaining a pressure variation along the second intermediate portion of the tunnel in a range of between 0 and 5 mmH_2O.

15). The method of claim 15, characterized in that pressure is maintained within the the range by establishing a communication, via an auxiliary conduit, between a zone immediately upstream and a zone immediately downstream of the second intermediate portion.

16). The method of claim 15, characterized in that in order to maintain pressure within the range, pressure is measured in at least the zone immediately upstream and the zone immediately downstream of the second intermediate portion of the tunnel, and a first means of ventilation is controlled to induce an airflow along the tunnel from the second intermediate portion in an opposite direction to the advancement direction of the ceramic products, and a second means of ventilation is used to create an airflow along the tunnel in a same direction as the advancement direction of the ceramic products, control being adjusted according to the pressures measured.

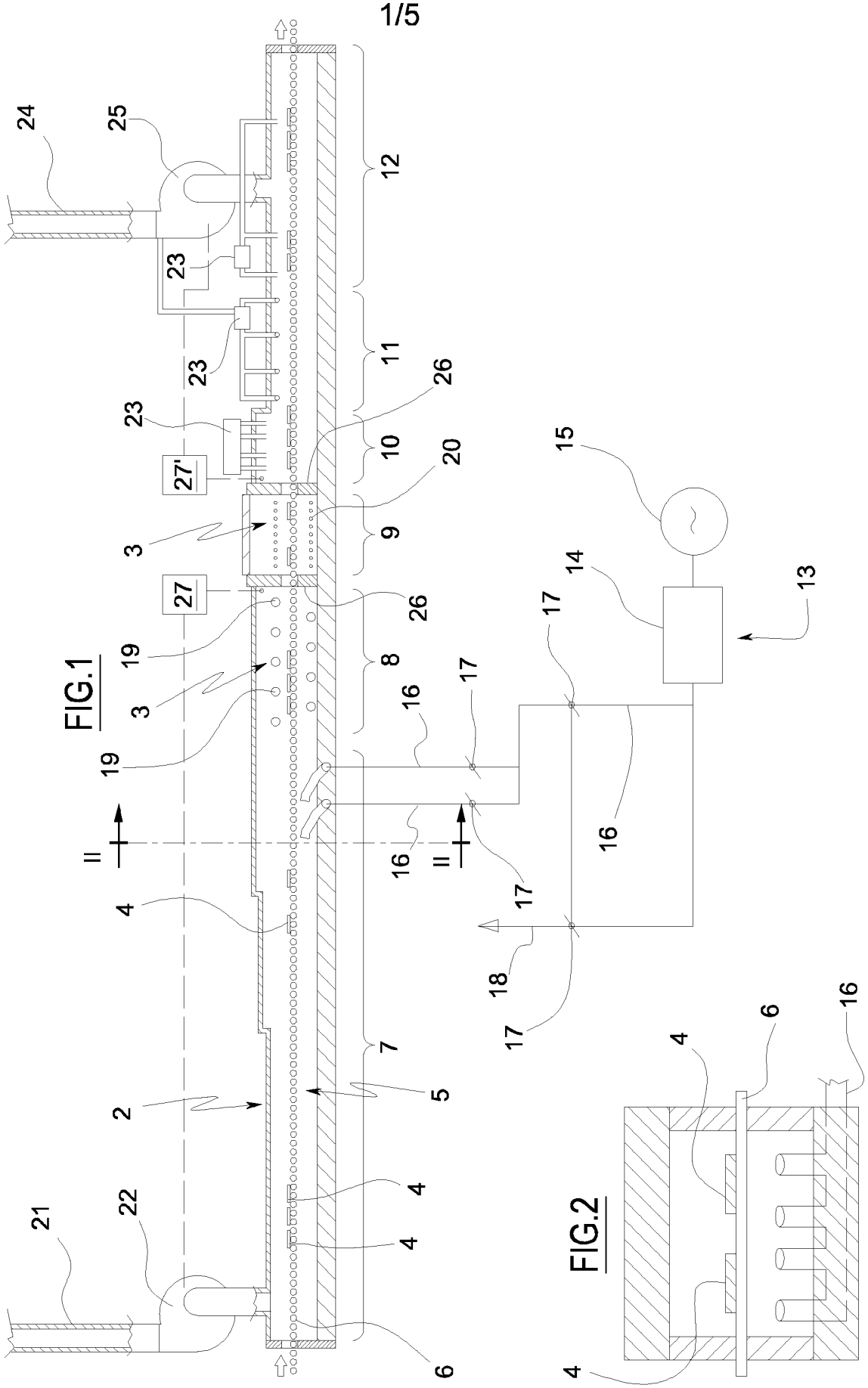
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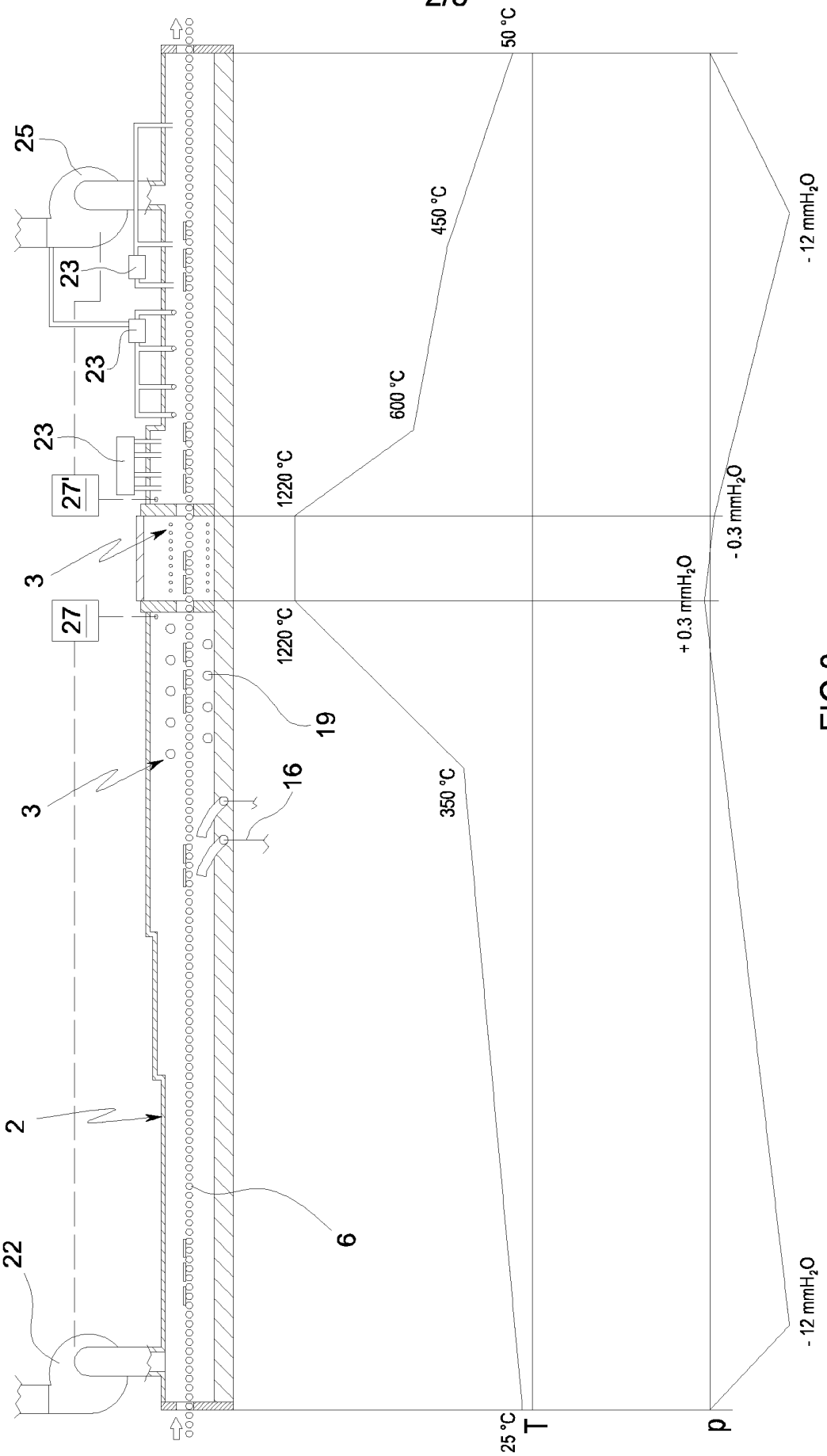
FIG.1

FIG.2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+ 0.3 mmH2O
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FIG.3

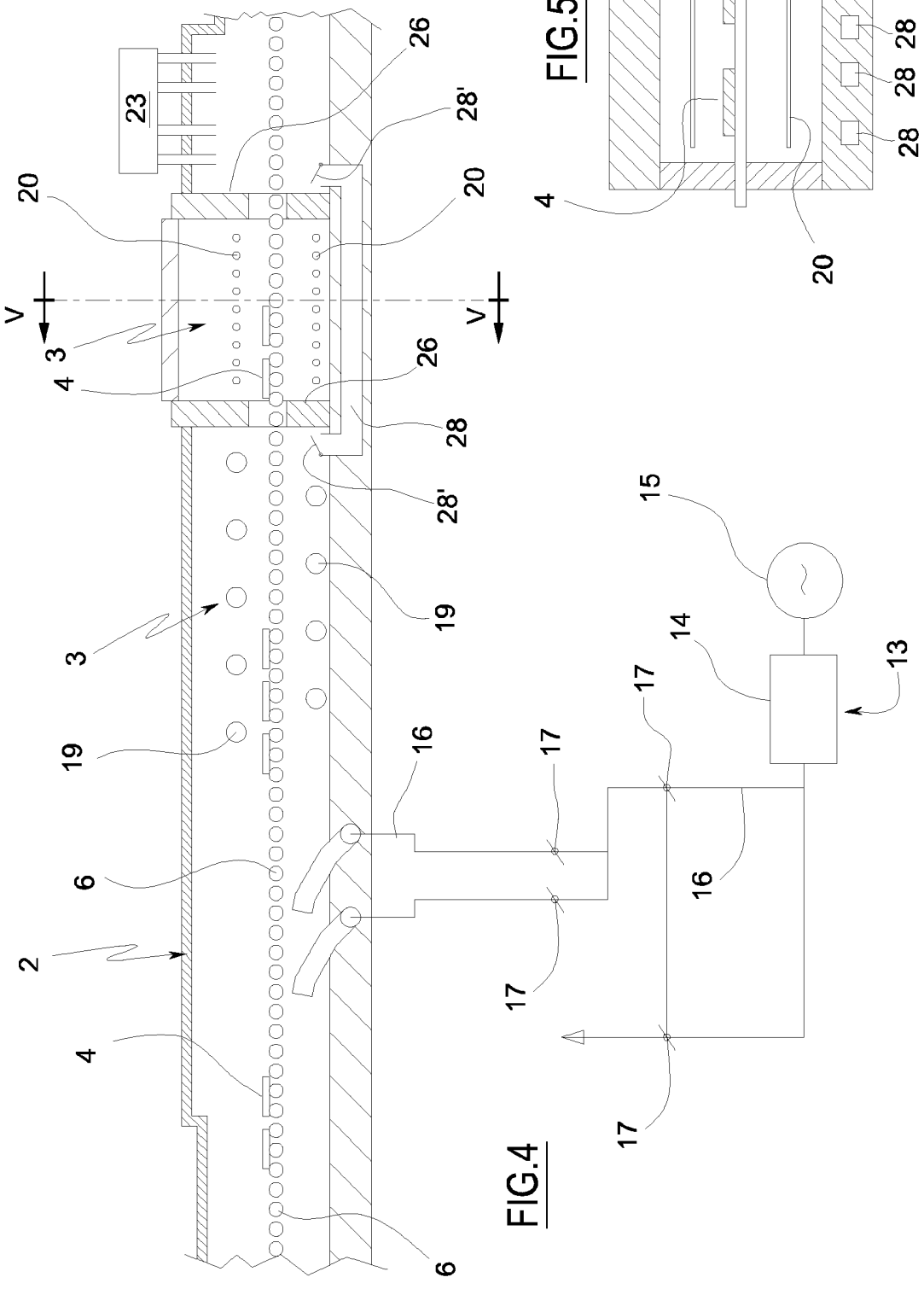
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FIG.4

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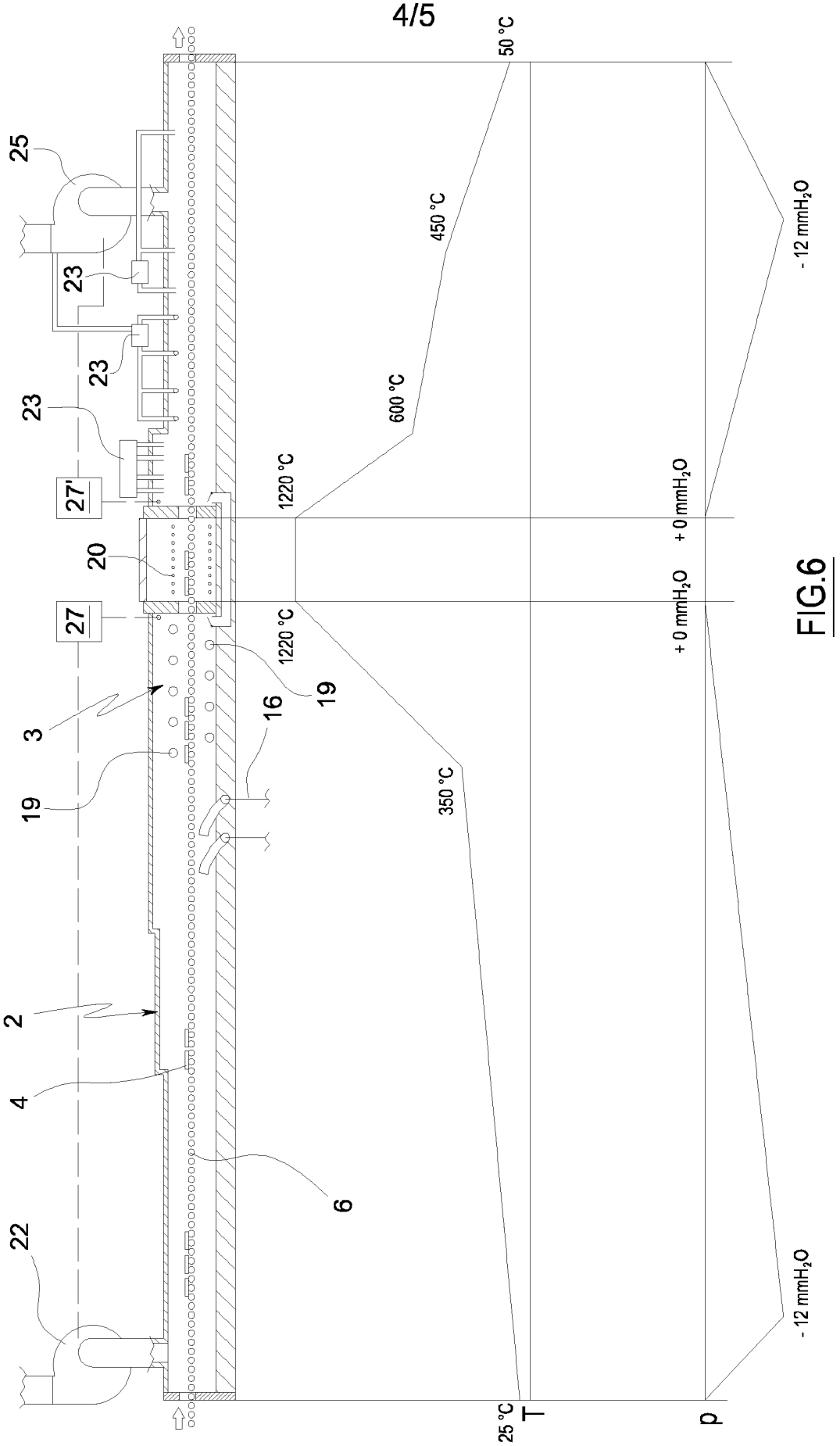
FIG.5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p

FIG.6

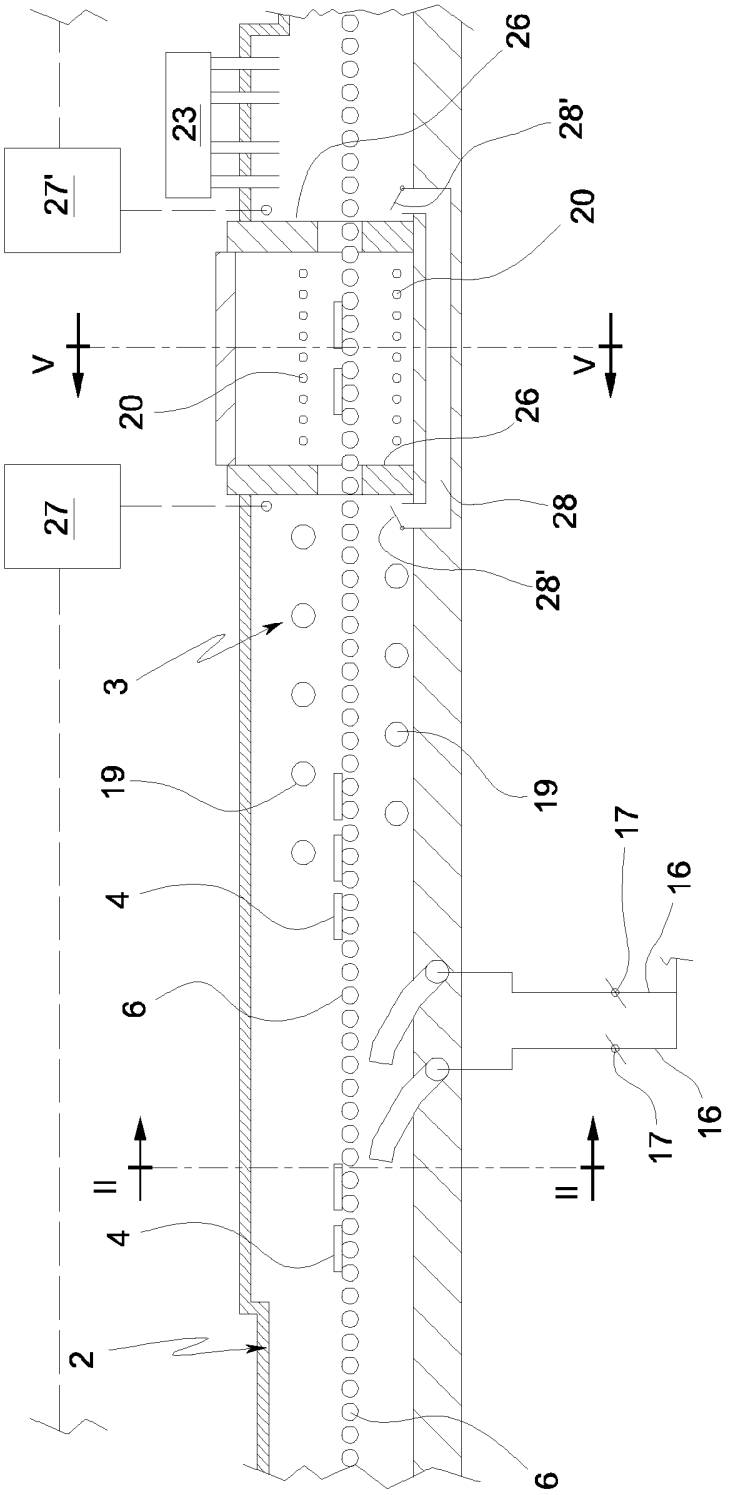

FIG.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/059417

A. CLASSIFICATION OF SUBJECT MATTER
INV. F27B9/36 F27B9/20 F27D17/00

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

B. FIELDS SEARCHED

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

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 practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	DE 42 42 086 A1 (HAESLER ANDREAS ING GRAD [DE]) 16 June 1994 (1994-06-16) the whole document	11 1
Y	DE 35 17 866 A1 (KELLER GMBH & CO KG [DE]) 20 November 1986 (1986-11-20) page 11, line 30 - page 13, line 5; figure 1 page 15, line 5 - line 10	1
A	DE 43 28 301 A1 (FHW BRENNTECHNIK GMBH [DE]) 2 March 1995 (1995-03-02) the whole document	1-16
A	DE 39 23 887 A1 (MANFRED LEISENBERG KG [DE]) 24 January 1991 (1991-01-24) claims 1-19; figure 1	1-16

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2009	22/10/2009

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/059417

C(Continuation). 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	EP 0 662 596 A (INNOVATHERM PROF DR LEISENBERG [DE]) 12 July 1995 (1995-07-12) the whole document	1-16

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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