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Published:
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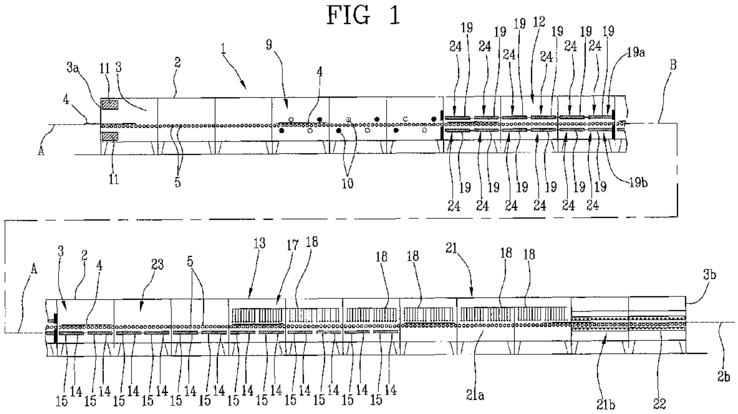
(54) Title: A KILN FOR SLABS MADE OF A CERAMIC MATERIAL

FIG 1



(57) Abstract: A kiln for slabs made of a ceramic material, comprises a support structure (2) defining a longitudinal conduit (3) developing along a prevalent development direction (A), a firing station (12) internal of the conduit (3) in which a slab (4) remains at a predetermined firing temperature for a predetermined period of time and a preliminary cooling station (13) internal of the conduit (3) and operatively located downstream of the firing station (12). A plurality of rollers (5) located side-by-side and parallel along the prevalent development direction (A) is connected to the support structure (2) and defines a sliding surface (B) of the slab (4), movement means (6) of the rollers enable transport of the slab (4) from the firing station (12) to the preliminary cooling station (13). The rollers (5) arranged in the preliminary cooling station (13) each exhibit an end (5a) which is connected to the drive means (6) via an elastic joint (7) and the preliminary cooling station (13) further exhibits a succession of electric heating resistance elements arranged along the prevalent development direction (A) below the rollers (5).

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Description

A Kiln for Slabs made of a Ceramic Material

Technical Field

The present invention relates to a kiln for slabs made of a ceramic material. The present invention is applicable in heat treatments required for realisation of slabs of ceramic material, preferably slim slabs.

The term "slim slabs" refers to slabs wherein the thickness is much less significant than the other two dimensions.

Background Art

In the prior art, slabs made of ceramic material are realised using special gas-fired industrial kilns.

More precisely, these kilns are subdivided into a plurality of work stations in which the slabs pass in successive stages in order to transform the raw, or unfired ceramic material, into a finished product.

The above-described kilns comprise a roller plane moved by special motor means, which plane draws the slabs made of ceramic material through all the work stations continuously, with a substantially constant advancement velocity.

In particular, kilns of this type exhibit a hollow main structure defining a longitudinal conduit in which the roller plane is arranged.

The roller plane is typically formed by rollers that are rotatably associated to the main structure of the kiln and are reciprocally aligned.

In particular, the rollers exhibit a first end rested on a bearing, and a second end enmeshed in a transmission element.

The stations in which the heat treatments are carried out are generally arranged internally of the conduit and, in general terms, perform the stages of heating, firing and cooling.

The heating stage is commonly finished in a heating station in which the slabs are brought by the kiln inlet temperature up to a predetermined firing temperature via the use of free-flame burners fired by gas or diesel fuel.

Once the firing temperature has been reached, the slabs pass into a firing station, in which they remain at the temperature for a predetermined period of time. The temperature is maintained by means of use of further free-flame burners located in proximity of the conduit walls.

At this point, the slabs commence a cooling process which is sub-divided into three sub-stages.

In the prior art, the kilns comprise a rapid cooling station immediately downstream of the firing, in which cooling station the slabs are quickly brought from the firing temperature to a predefined lower temperature by means of cold jets of air, typically at ambient temperature.

The air in question is introduced by a ventilator via a series of tubes arranged alternatively above and below the roller plane.

Thereafter, a slow cooling station performs a further lowering of the temperature of the slabs by means of a plurality of heat exchangers, typically of the air-air type, or by natural cooling.

Finally, the slabs are cooled to a kiln outlet temperature by large quantities of cold air introduced via blower or ventilator means.

In the rapid cooling station a jet of air disadvantageously also invests a lower portion of the roller plane.

Such jet of air at ambient temperature, when striking the roller from below, cools the portion of roller not in contact with the slab. On the contrary, the upper portion of roller, in contact with the slab, is heated thereby, leading to a temperature difference between an upper generatrix and a lower generatrix of the roller which causes the roller to flex.

Further, as the roller has an end which is constrained and an end which is rested, deforms asymmetrically when subjected to these heat stresses.

As the roller plane defines a rest and sliding surface of the surfaces, the flexing of the rollers leads to a deformation of the rest surface.

As in the first stage of cooling the slabs are still plastically deformable, the deformation of the rest surface leads to a corresponding plastic deformation of the slab, whose quality suffers because of this.

Note that this problem is particularly relevant in the case of slim slabs, i.e. when the thickness of the slab is almost insignificant with respect to the other two dimensions.

Further, the kilns of the prior art pass rapidly from the firing station to the cooling station.

In fact, for a not insignificant period of time the slabs have a front portion invested by a jet of air at ambient temperature, and a rear portion under the action of the burners, creating a difference of temperature internally of the slab which generates tensions that can cause the slab even to break.

Note that this disadvantage is particularly accentuated when the slabs to be treated are slim and have an important longitudinal development.

In this context, the technical objective underlying the present invention is to provide a kiln for slabs made of ceramic material which obviates the drawbacks in the prior art as described herein above.

In particular, an aim of the present invention is to make available a kiln for slabs made of a ceramic material which is able to limit the damage to the slabs, especially if slim.

In particular, an aim of the present invention is to make available a kiln for slabs made of ceramic material which enables the planarity of the slabs to be maintained.

Further, a further aim of the present invention is to realise a kiln for slabs made of ceramic material which limits the possibility of breakage of the slabs during the heat treatments.

The set technical task and the specified aims are substantially attained by a kiln for slabs made of ceramic material, comprising the technical characteristics as set out in one or more of the accompanying claims.

Disclosure of Invention

Further characteristics and advantages of the present invention will more fully emerge from the following non-limiting description of a preferred but not exclusive embodiment of a kiln for slabs made of ceramic material, as illustrated in the accompanying figures of the drawings, in which:

figure 1 is a schematic view of a kiln for slabs made of ceramic material according to the present invention;

figure 2 is a section view of a first station of a kiln for slabs made of ceramic material according to the present invention;

figure 3 is a section view of a second station of a kiln for slabs made of ceramic material of the present invention;

figure 4 is a detailed view of a kiln for slabs made of ceramic material according to the present invention.

With reference to the accompanying figures, 1 denotes a kiln for slabs made of ceramic material according to the present invention.

The kiln of the present invention is preferably used for realising slim slabs 4, i.e. slabs 4 in which the thickness is almost insignificant with respect to the other two dimensions.

By “slim slab” reference is made to a slab 4 exhibiting a thickness which does not exceed 1% of the width of the slab 4, i.e. the transversal dimension to an advancement direction of the slab 4.

By way of example, the slabs to which the present text makes reference exhibit widths comprised between 800 mm and 1500 mm.

Consequently, the above-mentioned slabs 4 have thicknesses of less than 10 mm.

In particular, the slabs 4 have thicknesses comprised between 3 and 6 mm.

The kiln 1 comprises a hollow support structure 2 defining a conduit 3 developing along a longitudinal prevalent development direction A.

The conduit 3 develops longitudinally straight, starting from an inlet mouth 3a of a slab 4 and leading to an outlet mouth 3b.

A plurality of stations are located in succession internally of the conduit 3; being a plurality of heat-treatment stations in which the slabs 4 transit in successive stages of heating, firing and cooling.

A plurality of rollers 5 is also arranged in the conduit 3, flanked to one another in parallel along the prevalent development direction “A” and defining a rest surface for the slab 4.

The rest surface is preferably substantially flat and horizontal.

Further, the rollers 5 are orientated transversally of the prevalent development direction “A” and are rotatably associated to the support structure 2 about a rotation axis thereof.

In this way, the rollers 5 define a sliding surface “B” of the slab 4 on which the slab 4 slides internally of the conduit 3 along the prevalent development direction “A”.

Note that the rest surface coincides with the sliding surface “B”.

The kiln 1 further comprises movement means 6 of the rollers 5 which set the rollers 5 in rotation with the aim of transporting the slab 4 along the conduit 3 into the various heat treatment stations.

In particular, the rollers 5, thanks to the movement means 6, give the slabs 4 an advancement velocity comprised between 0.1 and 10 m/min.

In still more detail, the advancement velocity of the slabs 4 is comprised between 0.5 and 6.5 m/min.

The heat treatment stations are, as mentioned above, located in succession along the conduit 3.

A heating station 9 takes the slab 4 of ceramic material from the raw state to a predetermined firing temperature.

In detail, the slab 4 enters the kiln through the access mouth 3a of the conduit 3 and advances by means of the rollers 5 in the heating station 9.

A plurality of gas burners 10 located internally of the heating station 9 causes the raising of the temperature in the kiln, and consequently of the slab 4.

More precisely, the gas burners 10 are arranged along the walls 3c of the conduit 3.

In the illustrated embodiment, a plurality of aspirating ports 11 are positioned in proximity of the access mouth 3a to aspirate the fumes generated by the gas burners 10.

This advantageously enables the fumes to move in counter-current direction with respect to the advancement direction of the slabs 4, thus optimising the heating of the slabs 4.

Downstream of the heating station 9, preferably adjacent thereto, a firing station 12 is arranged, in which each slab 4 is maintained at the predetermined firing temperature for a predefined period of time.

By way of example, the temperature of the firing station is maintained between 1100 °C and 1300 °C according to the type of slab 4.

In the present invention, the firing station 12 is electrically powered.

In particular, the firing station 12 exhibits a plurality of electric heaters 24 arranged in succession along the prevalent development direction "A" and located at least in part above and at least in part below the sliding surface "B" of the slabs 4, and preferably below the rollers 5.

This advantageously enables a uniform and homogeneous firing of the slab 4.

Further, the use of electric heaters 24 thus arranged enables limiting the amount of energy used for the firing, as there are fewer dissipating phenomena and the control of the temperature is simpler.

The heaters 24 preferably comprise a first series 19a of panels 19 arranged above the sliding surface "B" and a second series 19b of panels 19 arranged below the rollers 5.

In the illustrated embodiment, each heater 24 comprises a plurality 20 of panels 19 arranged in a predetermined number transversally of the prevalent development direction "A".

More precisely, such plurality 20 of panels 19 are orthogonal to the prevalent development direction "A" and are flanked to one another along the prevalent development direction "A".

In the illustrated embodiment, each heater 24 comprises three panels 19, arranged such as to cover the whole breadth of the slabs 4, i.e. the dimension which is transversal to the prevalent development direction "A".

The panels 19 of the firing station 12 are orientated parallel to the sliding surface "B" of the slab 4 and arranged in succession along the prevalent development direction "A".

This advantageously enables maintaining the temperature uniform in the whole firing station, including the rollers 5.

Note that by keeping the temperature of the rollers 5 uniform, differences in the internal temperature of the rollers are avoided, which might otherwise cause flexion thereof, and consequently the loss of planarity of the slabs 4.

A preliminary cooling station 13 is positioned successively to the firing station 12.

In the present invention, the preliminary cooling station 13 is arranged immediately downstream of the firing station 12.

In such preliminary cooling station 13 the slab 4 is brought from the firing temperature to a lower temperature, such that it leaves the plastic state.

The "plastic state" is defined by a range of temperatures in which the material becomes easily modellable, and thus subject to deformation even due to a small stress thereon.

The preliminary cooling station 13 exhibits a plurality of electric heating elements 14 arranged in succession along the prevalent development axis "A" below the rollers 5.

By positioning the heating elements 14 below the rollers 5 it is advantageously possible to minimise the flexion of the rollers 5 due to a temperature difference between an upper portion 5c of each roller 5 in contact with the slab 4 and a lower portion 5d of each roller 5 facing the electric heating element 14.

In other words, this configuration enables balancing the temperature between an upper generatrix and a lower generatrix of the roller 5.

The slab 4, once it has exited the firing station 12, is at a high temperature, close to firing temperature, and consequently it tends to heat up the rollers 5 considerably, in a contact zone.

The presence of the electric heating elements 14 below the rollers 5 enables heating the lower portion 5a of the rollers 5 such that internal tensions are not created within the rollers 5, which would cause them to flex.

This advantageously enables maintaining the planarity of the sliding surface "B", and consequently the slabs 4.

In more detail, in the preliminary cooling station 13 the temperature of the slabs 4 falls by natural convection, i.e. without any help of ventilating means generating a flow of cold air in the direction of the slabs 4.

In more detail, in an initial zone 23 of the preliminary cooling station 13 the temperature falls naturally, i.e. without the aid of cooling means of any type, and the heating elements 14 have the sole function of slowly accompanying the reduction in temperature in order to balance the internal temperature of the rollers 5.

The preliminary cooling station 13 further comprises a terminal zone 17 in which at least a heat exchanger 18 is located such as to maintain the air inside the terminal zone 17 at a predetermined temperature.

In other words, the terminal zone 17 of the preliminary cooling station 13 cools the slabs 4 with the aid of the heat exchanger 18.

This detail helps the cooling of the slabs to be accelerated once the slabs 4 have left the plastic state.

By way of example, the slabs 4 enter the initial zone 23 of the preliminary cooling station 13 at a temperature of about 1100-1200 °C and exit it at about 700 °C.

Still by way of example, the slabs 4 enter the zone at a temperature of about 700 °C and leave it at about 350 °.

In the illustrated embodiment, the terminal zone 17 of the preliminary cooling station 13 exhibits a plurality of heat exchangers 18 of the air-air type, arranged above the sliding surface "B" of the slabs 4.

The heating elements 14 can be supplied differently along the prevalent development direction “A” in order to generate a temperature progression which is precise and predefined starting from the firing temperature.

In more detail, the heating elements 14 are current- or tension-controlled differently from one another along the prevalent development direction “A” in order to precisely follow the decreasing temperature progression of the slabs 4.

This advantageously enables limiting temperature differences between a front portion 4a of the slab 4 situated in the preliminary cooling station 13 and a rear portion 4b of the slab still situated in the firing station 12.

This advantage is particularly evident when working with slabs 4 having a relevant length.

In other words, the presence of controlled heating elements 14 reduces the possibility of breakage of the slabs 4 due to heat shock in the passage from firing to cooling.

In the preferred embodiment, the electric heating elements 14 are panels 15 orientated parallel to the sliding surface “B” of the slab 4 and arranged in succession along the prevalent development direction “A”.

Similarly to the heaters 24 of the firing station 12, each heating element 14 of the preliminary cooling station 13 comprises a plurality 16 of panels 15 arranged in a predetermined number transversally of the prevalent development direction “A”.

More precisely, the plurality 16 of panels 15 are orthogonal to the prevalent development direction “A” and are flanked to one another along the prevalent development direction “A”.

In the illustrated embodiment, each heating element 14 comprises three panels 15, arranged such as to cover the whole breadth of the slabs 4, i.e. the transversal dimension to the prevalent development direction “A”.

The panels 15 of the preliminary cooling station 13 are orientated parallel to the sliding surface "B" of the slab 4 and are arranged in succession along the prevalent development direction "A".

In the present invention, each of the rollers 5 exhibits an end 5a and a further end 5b, opposite to one another.

In particular, each roller 5 is connected to the movement means 6 at the end 5a.

Both the ends 5a, 5b of each roller 5 are rotatably connected to the support structure 2.

In particular, both the end 5a and the further end 5b of each roller 5 are rotatably connected to the support structure 2 by means of spatially-orientable constraining elements 8.

The expression "spatially-orientable constraining elements 8" relates to a constraining element 8 which enables, at least in part, a rotation about all three of the Cartesian axes.

This advantageously enables the roller 5 to deform symmetrically if subjected to the above-mentioned heat stresses, due to differences of internal temperatures of the roller 5.

In the illustrated embodiment the constraining element 8 comprises an idle wheel 25 on which the roller 5 rests.

In detail, the constraining element 8 of the end 5a comprises a connecting body 27 solidly constrained to the end 5a of the roller 5.

The connecting body 27 is beaker-shaped and mounted coaxially to the respective roller 5 at the end 5a thereof.

Obviously the connecting element 27 and the idle roller 25 are in revolving and counter-rotating contact.

Further, in the kiln of the present invention, at least the rollers 5 arranged in the preliminary cooling station 13 are connected to the movement means 6 by means of an elastic joint 7.

In particular, the end 5a of the rollers 5 arranged in the preliminary cooling station 13 is connected to the movement means 6 by means of an elastic joint 7.

All the rollers 5 present in the conduit 3 are preferably connected to the movement means 6 at the end 5a thereof, by means of an elastic joint 7.

In still more detail, the connecting body of the constraining element 8 of the end 5a of each roller 5 is connected to the elastic joint 7.

The presence of the elastic joint 7 advantageously enables rotations of the end 5a about the three Cartesian axes, preventing the connection between the roller 5 and the movement means 6 from making the whole assembly rigid.

In other words, the presence of an elastic joint 7 at the end 5a which connects the roller 5 to the movement means 6 enables the roller 5 to have a deformation due to heat shock which is substantially symmetrical.

In the illustrated embodiment, the elastic joint 7 comprises a spiral spring 7a having a first end 7c connected to the movement means 6 and a second end 7b connected to the end 5a of the roller 5, and more precisely to the connecting body of the constraining element 8.

Further, the rollers 5 exhibit a section that is transversal to the prevalent development direction “A”, which section has a cogged profile.

The term “cogged profile” means that the transversal section is star-shaped, or shaped as a cogwheel.

This advantageously enables reducing to a minimum the contact zone between the hot slab 4 and the roller 5, limiting the heat exchange between the two.

Downstream of the preliminary cooling station 13, and preferably adjacent thereto, the kiln 1 exhibits a final cooling station 21.

The final cooling station 21 is, like the other stations, located in the conduit 3 and develops from the preliminary cooling station 13 to the outlet mouth 3b.

In particular, an initial portion 21a of the final cooling station 21 exhibits a plurality of heat exchangers 18, preferably of the air-air type.

Further, the heat exchangers 18 of the final cooling station 21 are preferably arranged above the sliding surface “B” of the slabs 4.

A final portion 21b of the final cooling station 21 comprises ventilating organs 22 for introducing considerable flows of coolant air into the kiln.

By way of example, the ventilating organs 22 can be blower tubes or axial ventilators.

The invention attains the set aims and provides important advantages.

The presence of the elastic joints between the rollers and the movement organs, together with the presence of the resistance elements below the rollers, considerably limits the deformation phenomenon of the rollers during the preliminary cooling stage, and consequently enables the planarity of the slabs to be maintained.

Further, the presence of independently controlled and powered resistance elements enables a decreasing temperature profile to be obtained which slowly accompanies the natural cooling of the slab, preventing damage to the slab due to heat shock in passing from firing to cooling.

Further the firing station thus conformed, i.e. with resistance elements located above and below the rollers, enables the temperature to be kept uniform in the whole firing station, comprising the rollers, preventing flexion thereof.

Claims

1. A kiln for slabs made of a ceramic material, comprising:

a support structure (2) defining a longitudinal conduit (3) developing along a prevalent development direction (A);

a firing station (12) internal of the conduit (3) in which a slab (4) remains at a predetermined firing temperature for a predetermined period of time;

a preliminary cooling station (13) internal of the conduit (3) and operatively located downstream of the firing station (12);

a plurality of rollers (5) located side-by-side and parallel along the prevalent development direction (A); the rollers (5) being connected to the support structure (2) and defining a sliding surface (B) of the slab (4);

movement means (6) of the rollers (5) for transporting the slab (4) from the firing station (12) to the preliminary cooling station (13),

characterised in that at least the rollers (5) arranged in the preliminary cooling station (13) each exhibit an end (5a) which is connected to the drive means (6) via an elastic joint (7); at least the rollers (5) arranged in the preliminary cooling station (13) each exhibiting a further end (5b) which is rotatably connected to the main structure (2) by means of an orientable constraining element (8); said preliminary cooling station (13) further exhibiting a plurality of electric heating elements (14) arranged in succession along the prevalent development direction (A) below the rollers (5), said electric heating elements (14) comprising panels (15) orientated parallel to the sliding surface (B) of the slab (4) and arranged in succession along the prevalent development direction (A).

2. The kiln of claim 1, characterised in that each heating element (14) comprises a plurality (16) of panels (15) arranged transversally of the prevalent development direction (A), in a predetermined number; each heating element (14) being flanked to a following heating element (14).

3. The kiln of any one of the preceding claims, characterised in that said electric heating elements (14) can be differently supplied along the prevalent development direction (A).

4. The kiln of any one of the preceding claims, characterised in that the firing station (12) exhibits a succession of electric heaters (24) arranged along the prevalent development direction (A) and located at least partly above and at least partly below the sliding surface (B) of the slab (4).

5. The kiln of claim 4, characterised in that the heaters (24) comprise a first series (19a) of panels (19) arranged above the sliding plane (B) and a second series (19b) of panels (19) arranged below the rollers (5).

6. The kiln of any one of the preceding claims, characterised in that the rollers (5) exhibit a transversal section with respect to the prevalent development direction (A) which has a cogged profile in order to reduce a contact surface between the roller (5) and the slab (4).

7. The kiln of any one of the preceding claims, characterised in that the preliminary cooling station (13) exhibits a terminal zone (17) comprising at least a heat exchanger for maintaining the air internally of the terminal zone (17) at a prefixed temperature level.

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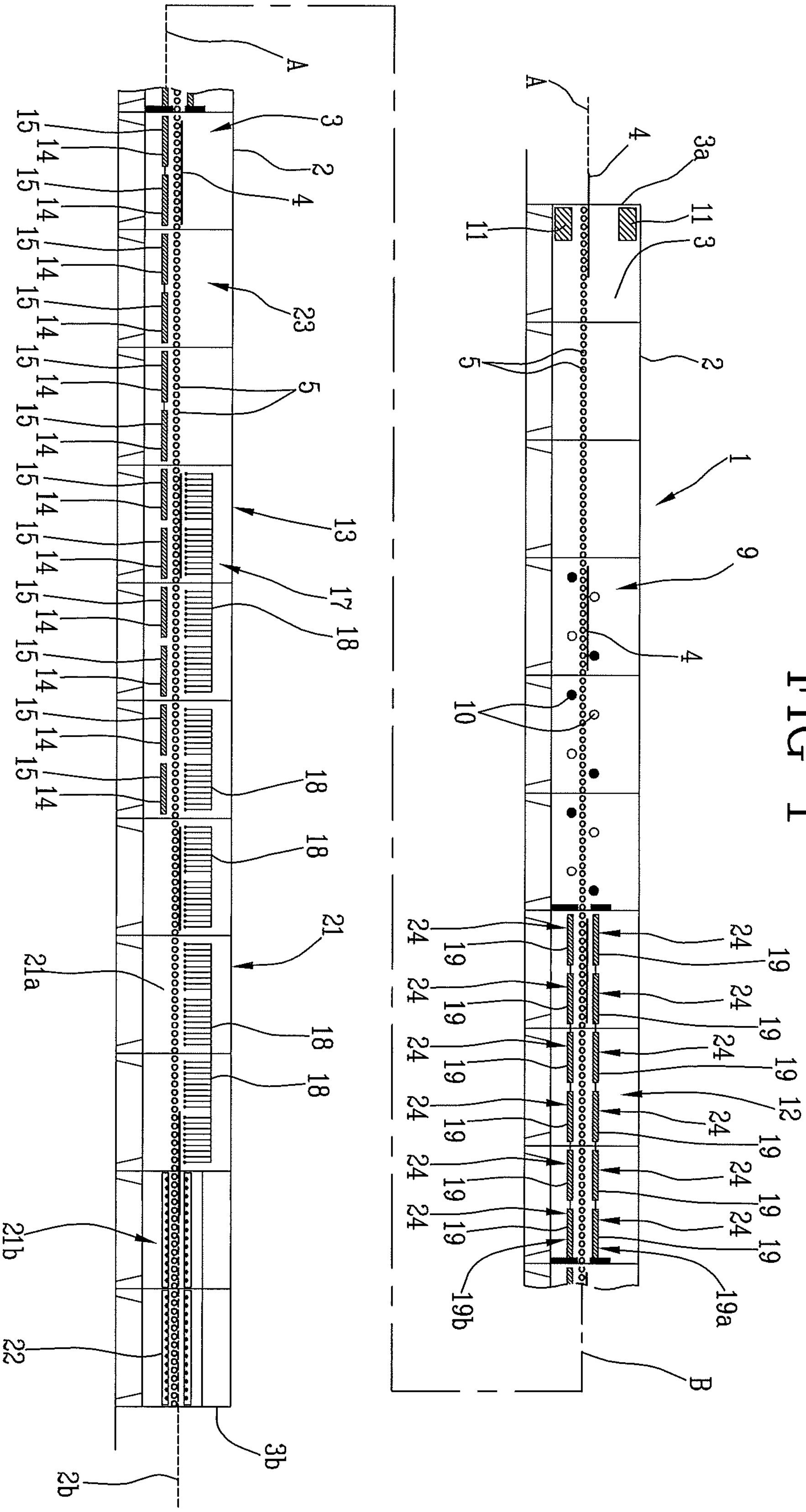
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FIG 1

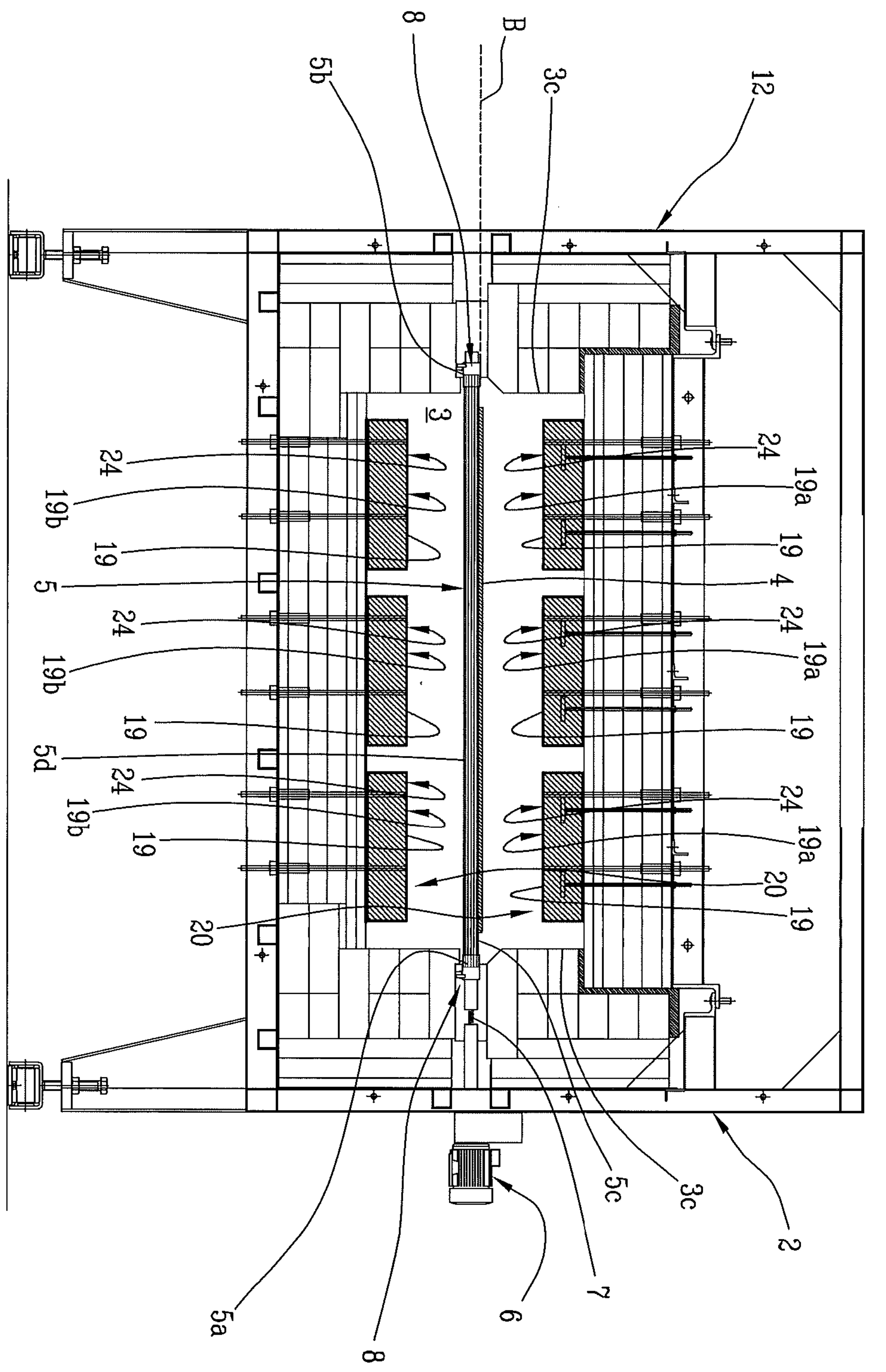

FIG 2

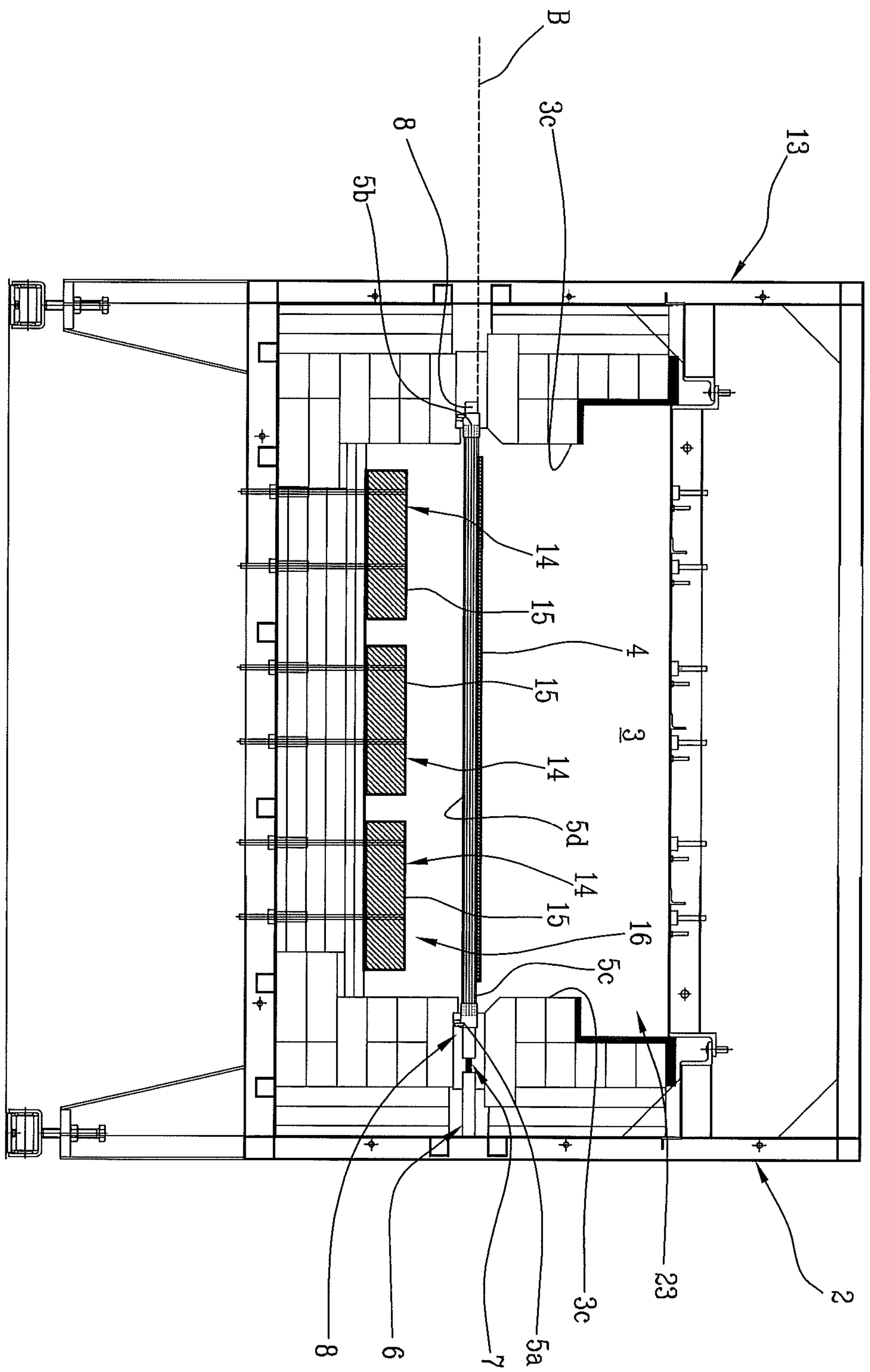

FIG 3

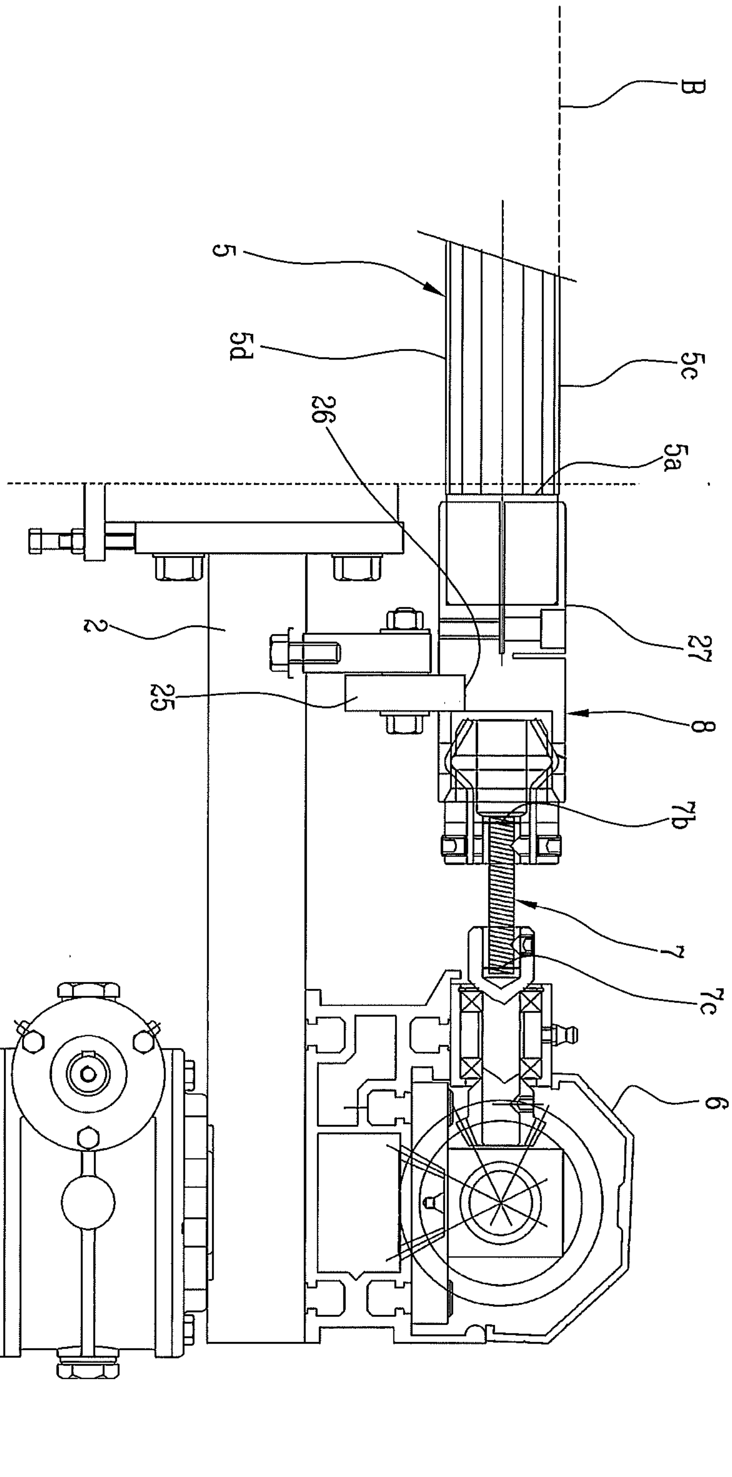

FIG 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2010/055858

A. CLASSIFICATION OF SUBJECT MATTER
INV. F27B9/12 F27B9/24 F27B9/36 B22D11/128 C21D9/00
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)
F27B B22D C21D

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.
Y	JP 2008 116072 A (MATSUSHITA ELECTRIC IND CO LTD) 22 May 2008 (2008-05-22) figures 1, 2b, 5 * abstract	1-7
Y	EP 1 055 619 A1 (GRUPPO BARBIERI & TAROZZI SRL [IT]) 29 November 2000 (2000-11-29) figures 1,2 claim 1 * abstract	1-7
Y	DE 10 2005 033776 A1 (ELIOG KELVITHERM INDUSTRIEOFEN [DE]) 18 January 2007 (2007-01-18) figure 1 * abstract	1-7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
11 March 2011	18/03/2011

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

Information on patent family members

International application No
PCT/IB2010/055858

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