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(54) **A tunnel kiln for ceramic products**

Tunnelofen für Keramikprodukte

Four tunnel pour produits en céramique

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## Description

**[0001]** The invention relates to a tunnel kiln for ceramic products.

**[0002]** In more detail, the present invention relates to a tunnel kiln provided with a roller conveyor on which the ceramic products are located, the products being, for example, tiles.

**[0003]** As is known, tunnel kilns are heated using two series of burners, one on each side of the tunnel, generally functioning with methane gas, which are located on the lateral walls of the tunnel and facing towards the opposite walls.

**[0004]** On each side of the tunnel there are preferably two lines of burners, one above and one below then roller conveyor.

**[0005]** The burners are supplied in groups, set in derivation, by a single gas conduit, and each group of burners is supplied via a cock which is controlled by temperature control systems.

**[0006]** The tile firing cycle is determined with great precision using a firing diagram which enacts a progressive heating of the tiles starting from the kiln entrance, with the tiles remaining for a predetermined time at a predetermined temperature, and the controlled cooling of the tiles before they reach the kiln exit.

**[0007]** Various types of burner are known, as well as various characteristic arrangements of the burners with the aim of obtaining perfect control of the kiln functioning; however the progressively growing sizes of the transversal sections of the kilns, and the use of ever-more rapid firing times in order to increase hourly production rates, have brought to light some functional defects of the traditional kilns which compromise their efficiency.

**[0008]** In particular, the limitations of traditional kilns emerge where the transversal section of the tunnel kiln exceeds certain dimensions.

**[0009]** In very wide tunnel kilns, there is an inconvenient distribution of the temperature in the transversal section, where there are generally higher temperatures in the centre than in proximity of the walls.

**[0010]** This inevitably leads to firing defects in the tiles advancing close to the tunnel walls, which defects emerge as dimensional and shape defects, such as the lack of planarity; all of which leads to an increase in waste products.

**[0011]** To reduce this phenomenon, research has been made by the applicant into special types of burners which are aimed at advantageously heating the inside of the tunnel with inclusion of the areas in proximity of the tunnel lateral walls.

**[0012]** In particular, in IT1287626, by the same applicant, a tunnel kiln is described having two series of burners exhibiting different characteristics, where a first series of burners is destined prevalently to heat the central zone and a second series of burners is destined prevalently to heat the zone close to the tunnel walls.

**[0013]** In the above-described kiln, the gas flow rate

to the burners for prevalently heating the zone close to the tunnel walls is commanded by a valve controlled by a control system which modulates the gas flow rate according to the temperature measured by special thermocouples located internally of the tunnel, in proximity of the lateral walls.

**[0014]** Unfortunately, the measurements of the thermocouples located on the lateral walls are often influenced by the turbulence present along the walls and by the closeness of the burners themselves. This means that the measuring of the temperature values, which are in fact correct with regard to the exact point where the measuring is done, are considerably out with regard to the temperatures in the immediate vicinity of the tiles on the rollers. Indeed, in a same zone along the lateral wall, though operating at a substantially homogeneous temperature, at different points there are considerably different temperature measurements.

**[0015]** Therefore the use of thermocouples located along the lateral walls of the tunnel does not lead to an efficient regulation of the system.

**[0016]** Further, EP1500889A1 discloses a tunnel kiln for ceramic products, comprising a series of lateral burners with flames directed on a plane parallel to the walls of the kiln, means for detecting the dimensions and flatness of the tiles emerging from the kiln, and means for regulating the operating parameters of the kiln as a function of the detected defects.

**[0017]** There is, for the above reasons, a strongly-felt need to provide a tunnel kiln for ceramic products which provides an efficient regulation, without the drawbacks in the prior art, in order to obtain ceramic products having dimensional characteristics which are as close as possible to the design specifications, in the ambit of a simple and rational constructional solution.

**[0018]** The aim of the present invention is to provide a tunnel kiln for ceramic products having structural and functional characteristics which satisfy the requirements and which at the same time obviate the drawbacks mentioned with reference to the prior art.

**[0019]** The aim is attained by the tunnel kiln for ceramic products as described in claim 1 of the present application.

**[0020]** The dependent claims delineate preferred and particularly advantageous embodiments of the tunnel kiln for ceramic products of the invention.

**[0021]** Further characteristics and advantages of the invention will better emerge from a reading of the following description, provided by way of non-limiting example with the aid of the accompanying figures of the drawings, in which:

- figure 1 is a side view of a tunnel kiln of the present invention;
- figure 2 is an enlarged partial section along II-II of figure 1;
- figure 3 is an enlarged partial section along II-II of figure 2.

**[0022]** With reference to the above-mentioned figures of the drawings, 1 denotes in its entirety a tunnel kiln for ceramic products as in the present invention.

**[0023]** The kiln 1 is formed, in a very general description, by two opposite lateral walls 2, a base 3 and a vault 4.

**[0024]** A known-type roller conveyor 5 is located internally of the kiln 1, which roller conveyor 5 advances the ceramic products, which in the example are tiles 100.

**[0025]** Two lines of gas burners 31 and 32 are arranged on each lateral wall 2 of the tunnel, respectively above and below the roller conveyor 5.

**[0026]** The burners of each line are located internally of holes 6 afforded in the lateral wall 2 of the kiln 1.

**[0027]** Each line of burners comprises two series of different burners, respective 51 and 52, the burners of each series being intercalated with the burners of the other series.

**[0028]** There are thus four lines 31, 32 of burners, two on one wall and two on the other wall. Each line 31, 32 is composed of two series of burners. The burners of the two series of each line are intercalated among themselves and with the burners of the other line located on the same wall, and with the burners of the same series which are part of the coplanar line arranged on the facing wall.

**[0029]** In particular, the burners 51, which we shall term axial burners, are exclusively provided with a nozzle producing an axially-directed flame such as prevalently to heat the central zone of the tunnel, while the burners 52, which we shall term radial burners, are provided with a plurality of radial-flame nozzles such as prevalently to heat the zone proximal to the lateral wall of the tunnel.

**[0030]** Alternatively, the radial burners 52, apart from having radial-flame nozzles, can also be provided with an axial-flame nozzle.

**[0031]** All of the burners, axial and radial, are sourced from a common conduit 60 for supply of combustible gas, as occurs with traditional kilns.

**[0032]** Each series of burners 51 or 52 can conveniently be divided into sectors which interest different thermal zones of the kiln, each of which being provided with its own means for regulating and control, which for the sake of simplicity are not illustrated herein, and all sourcing from the gas supply conduit 60.

**[0033]** Heat control elements 70 are positioned in each of the thermal zones, which can be thermocouples or thermal probes. The elements 70 are advantageously positioned centrally, in the example at the vault 4 and the base 3, and the signals they emit are sent to the devices for regulation and control of the heat power, not illustrated herein.

**[0034]** In the present invention, and as visible in figure 2, the axial burners 51 source from a common conduit 510 for air supply on which usual means for regulation and control (not illustrated) are placed, while the radial burners 52 source from a different air-supply conduit 520.

**[0035]** In particular, further conduits 524 branch off from the conduit 520, each further conduit 524 leading

to a single burner 52 of the second series.

**[0036]** In the illustrated embodiment, the air-supply conduit 520 is intercepted by a motorised valve 521 placed upstream of the conduits 524 and connected to a control unit 522 which is programmed to regulate the pressure of the air current and thus the flow rate in supply to the respective radial burners 52.

**[0037]** In particular, the control unit 522 regulates the air pressure to be sent to the radial burners, and therefore the air flow, in accordance with signals received from special means 523, of which more herein below, which detect the out-of-size dimensions of the products exiting the kiln 1 with respect to the tile 100 design specifications.

**[0038]** In substance, in the presence of defects detected in the tiles 100, positioned on the sides and exiting from the kiln 1, the control unit 522, having received the signals from the means for detecting 523, intervenes immediately, changing the quantity of air supplied to the radial burners 52 and thus modifying the temperature thereof. This is obtained by keeping the gas flow to the radial burners 52 constant, which is the same as the supply to the axial burners 51, thus keeping the heat power supplied constant.

**[0039]** Naturally, the necessary changes in air flow will be of small entity and therefore there will be no negative disturbance to the overall functioning of the kiln 1.

**[0040]** In order to obtain an optimal regulation, the control unit 522 constantly receives the pressure values via pressure transducers 81, 82 located respectively on the supply line 510 to the axial burners 51 and on the supply line 520 to the radial burners 52.

**[0041]** For the aims of the present invention, the detecting of "defects" in the tiles 100 can be done by a member of personnel who operates on a keyboard connected to the control unit 522, or via an automatic detecting system of the calibre and planarity of the tiles, of the type described in Italian application ITRE20060007, by the same applicant, which is not reiterated in detail herein.

**[0042]** Obviously any other means suitable for detecting tile defects and sending a corresponding signal to the control system 522 can be used.

**[0043]** The signal sent to the control system 522 is converted in to pressure difference values to be achieved between the two air currents respectively supplied to the axial burners 51 and the radial burners 52.

**[0044]** In operation, the kiln 1 is started up, maintaining the same air pressure in supply to the axial and radial burners. Thereafter, and only in the presence of defects in the tiles exiting the kiln 1, detected by the means 523 for detecting, the control unit sends a signal to the valve 521 to open or close to a greater degree in accordance with the pressure change requested, which pressure change is advantageously calculated by the control unit 522 according to the signal, representing the defect in the tiles, received from the means for detecting 523.

**[0045]** In substance, the initial functioning parameters change, by a small amount.

**[0046]** Alternatively to the use of a valve 521 regulating several radial burners 52, for example the burners in a determined heating zone, as described above, a valve can be used for each radial burner 52, which valves can be located on the conduits 524. In this case, for each regulation valve a corresponding pressure transducer is provided, located downstream of the valves, which sends the signal to the control system 522.

**[0047]** As the control system 522 uses pressure transducers to control the pressure difference between the air current respectively to the axial burners 51 and to the radial burners 52, the pressure transducers can be substituted by special systems for detecting the pressure difference  $\Delta P$  which directly send the  $\Delta P$  value to the control system 522.

**[0048]** Naturally the kiln 1 is managed overall by a central electronic unit which the control unit 522 too is managed by.

**[0049]** As can be appreciated from the foregoing description, the tunnel kiln for ceramic products of the present invention satisfies the requirements and obviates the drawbacks outlined in the introductory part of the present description with reference to the prior art.

**[0050]** Thanks to the modulation of the air flow rate to the radial burners commanded by a single control unit, the kiln 1 of the present invention confers on all the exiting tiles the dimensions and planarity required, with no distinction between the tiles coming from the central zones or the lateral zones of the kiln, and with a consequent considerable reduction in waste.

**[0051]** Further, the kiln of the present invention can easily be realised using traditional kilns with small structural modifications.

**[0052]** Obviously an expert in the field, with the aim of meeting special and specific contingent requirements, might make numerous modifications and changes to the tunnel kiln for ceramic products as described above, as far as they fall within the ambit of protection of the invention as it is defined in the following claims.

## Claims

1. A tunnel kiln (1) for ceramic products comprising two opposite lateral walls (2), a horizontal roller conveyor (5) destined to support and advance a layer of tiles (100) internally of the kiln (1), a first series of burners (51) and a second series of burners (52) arranged aligned along the two lateral walls and facing towards the opposite wall, each burner (51) of the first series (51) being provided exclusively with a nozzle producing an axial flame such as to heat a central zone of the tunnel while each burner (52) of the second series is provided with at least a radial-flame nozzle such as to heat a zone which is proximal to the lateral wall of the tunnel, each burner (51, 52) of the first and the second series being connected to a common conduit (60) of combustible gas and respectively to

a first (510) and a second (520) conduit of a comburent, **characterised in that** it comprises

- means (523) for detecting a dimensional out-of-size with respect to a design project specification for the products exiting the kiln (1),
- a control unit (522) for receiving data arriving from the means (523) for detecting,
- means for regulating (521) a flow rate of the comburent to the burners (52) of the second series located on the second conduit (520) of the comburent, the means for regulating (521) of the comburent flow rate being controlled by the control unit (522) which is programmed to command the means for regulating (521) according to the data received from the means for detecting (523), said data being converted into pressure difference values to be achieved between the two comburent, flows respectively supplied to the axial burners (51) and the radial burners (52).

2. The kiln (1) of claim 1, wherein the second conduit (520) of the comburent comprises a manifold from which a plurality of conduits (524) of the comburent branch off, each conduit (524) leading to a single burner (52) of the second series of burners.
3. The kiln (1) of claim 2, wherein the means for regulating (521) are located on each of the conduits (524) which supply the burners (52) of the second series.
4. The kiln (1) of claim 2, wherein the means for regulating (521) are located on the manifold of the comburent.
5. The kiln (1) of claim 1, wherein the second series of burners (52) is formed by a plurality of burners located alternately with the burners (51) of the first series.
6. The kiln (1) of claim 1, wherein the burners (52) of the second series further comprise a nozzle having an axial flame.
7. The kiln (1) of claim 1, wherein each lateral wall (2) comprises two lines (31, 32) of the burners, one (31) of which is above the roller conveyor (5) and one (32) of which is below the roller conveyor (5)
8. The kiln (1) of claim 7, wherein, along each line (31, 32), the burners of the first series and the second series are arranged alternated to one another.
9. The kiln (1) of claim 1, wherein the means (523) for detecting comprise an automatic system for detecting a calibre and/or a planarity of the ceramic product exiting from the tunnel.

10. The kiln (1) of claim 1, wherein the means for regulating the flow rate comprise a motorized valve (521).
11. The kiln (1) of claim 1, further comprising means for detecting the pressure (81, 82) located respectively on the first conduit and the second conduit of the comburent, the means for detecting the pressure being connected to the control unit (522).

### Patentansprüche

1. Tunnelofen (1) für keramische Erzeugnisse umfassend zwei gegenüberliegende Seitenwände (2), eine waagrechte Rollenbahn (5), das zum Tragen und Befördern einer Schicht von Fliesen (100) im Innern des Ofens (1) bestimmt ist, eine erste Reihe von Brennern (51) und eine zweite Reihe von Brennern (52), die aufeinander gefluchtet entlang der beiden Seitenwände und zur gegenüberliegenden Wand zugewandt ausgerichtet sind, wobei jeder Brenner (51) der ersten Reihe (51) ausschließlich mit einer Düse versehen ist, die eine axiale Flamme erzeugt, um den mittleren Bereich des Tunnels zu erhitzen, während jeder Brenner (52) der zweiten Reihe mit mindestens einer Radialflammdüse versehen ist, um den Bereich nahe der Seitenwand des Tunnels zu erhitzen, wobei jeder Brenner (51, 52) der ersten und der zweiten Reihe an eine gemeinsame Brenngas-Leitung (60) und jeweils an eine erste (510) und eine zweite (520) Verbrennungsmittel-Leitung angeschlossen ist,  
**dadurch gekennzeichnet, dass** er Folgendes umfasst:

- Mittel (523) zum Erfassen einer Übergroße gegenüber einer Entwurfsspezifikation für die den Ofen (1) verlassenden Erzeugnisse,
- ein Steuergerät (522) für den Empfang der von den Mitteln (523) zum Erfassen eingehenden Daten,
- Mittel zum Regeln (521) des Verbrennungsmittel-Durchsatzes zu den Brennern (52) der zweiten Reihe, die in der zweiten Verbrennungsmittel-Leitung (520) angeordnet sind, wobei die Mittel zum Regeln (521) des Verbrennungsmittel-Durchsatzes vom Steuergerät (522) gesteuert werden, welches programmiert ist, um die Mittel zum Regeln (521) entsprechend den von den Mitteln zum Erfassen (523) eingehenden Daten zu steuern, wobei die Daten in Druckdifferenzwerte umgewandelt werden, die zwischen den beiden Verbrennungsmittel-Durchflüssen erreicht werden müssen, die jeweils den Axialbrennern (51) und den Radialbrennern (52) zugeführt werden.

2. Ofen (1) nach Anspruch 1, wobei die zweite Verbren-

nungsmittel-Leitung (520) eine Sammelleitung umfasst, von welcher mehrere Verbrennungsmittel-Leitungen (524) abzweigen, wobei jede Leitung (524) zu einem einzelnen Brenner (52) der zweiten Reihe von Brennern führt.

3. Ofen (1) nach Anspruch 2, wobei die Mittel zum Regeln (521) auf jeder einzelnen der Leitungen (524) angeordnet sind, die die Brenner (52) der zweiten Reihe versorgen.

4. Ofen (1) nach Anspruch 2, wobei die Mittel zum Regeln (521) auf der Verbrennungsmittel-Sammelleitung angeordnet sind.

5. Ofen (1) nach Anspruch 1, wobei die zweite Reihe von Brennern (52) aus mehreren Brennern besteht, die abwechselnd zu den Brennern (51) der ersten Reihe angeordnet sind.

6. Ofen (1) nach Anspruch 1, wobei die die Brenner (52) der zweiten Reihe außerdem eine Düse mit einer Axialflamme umfassen.

7. Ofen (1) nach Anspruch 1, wobei jede Seitenwand (2) zwei Reihen (31, 32) von Brennern umfasst, von denen eine (31) oberhalb der Rollenbahn (5) und die andere (32) unterhalb der Rollenbahn (5) angeordnet ist.

8. Ofen (1) nach Anspruch 7, wobei die Brenner der ersten Reihe und der zweiten Reihe entlang jeder Reihe (31, 32) wechselweise zueinander angeordnet sind.

9. Ofen (1) nach Anspruch 1, wobei die Mittel (523) zum Erfassen ein automatisches System zum Erfassen des Formats und/oder der Ebenheit des den Tunnel verlassenden Keramikerzeugnisses umfasst.

10. Ofen (1) nach Anspruch 1, wobei die Mittel zum Regeln des Durchsatzes ein Motorventil (521) umfasst.

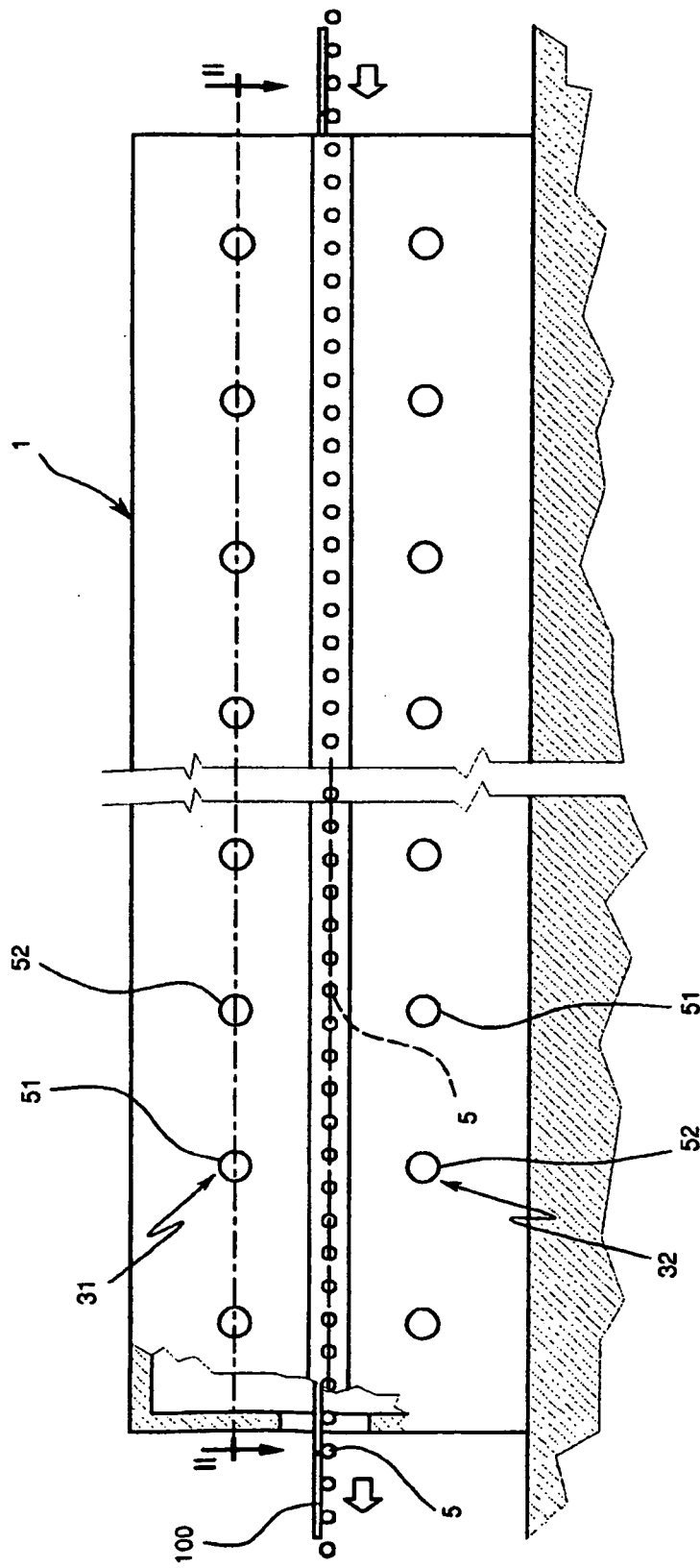
11. Ofen (1) nach Anspruch 1 außerdem umfassend Mittel zum Erfassen des Drucks (81, 82), die jeweils auf der ersten und der zweiten Verbrennungsmittel-Leitung angeordnet sind, wobei die Mittel zum Erfassen des Drucks mit dem Steuergerät (522) verbunden sind.

### Revendications

1. Four tunnel (1) pour produits céramiques comprenant deux parois latérales opposées (2), un convoyeur à rouleaux horizontaux (5) destiné à soutenir

et à faire avancer une couche de carreaux (100) à l'intérieur du four (1), une première série de brûleurs (51) et une seconde série de brûleurs (52) disposés de manière alignée le long des deux parois latérales et orientés vers la paroi opposée, chaque brûleur (51) de la première série (51) étant muni exclusivement d'une buse produisant une flamme axiale de telle sorte à chauffer une zone centrale du tunnel tandis que chaque brûleur (52) de la seconde série est muni d'au moins une buse à flamme radiale de telle sorte à chauffer une zone qui est proximale par rapport à la paroi latérale du tunnel, chaque brûleur (51, 52) de la première et seconde série étant relié à un conduit commun (60) de gaz combustible et respectivement à un premier (510) et un second (520) conduit d'un comburant, **caractérisé en ce qu'il comprend**

- des moyens (523) de détection de dépassement de taille dimensionnelle par rapport à un cahier des charges de conception pour les produits sortant du four (1),
  - une unité de contrôle (522) pour recevoir des données en provenance des moyens (523) de détection,
  - des moyens de régulation (521) d'un débit de comburant en direction des brûleurs (52) de la seconde série situés sur le second conduit (520) du comburant, les moyens de régulation (521) du débit de comburant étant contrôlés par l'unité de contrôle (522) qui est programmée pour commander les moyens de régulation (521) selon les données reçues des moyens de détection (523), lesdites données étant converties en valeurs de différence de pression à atteindre entre les deux flux de comburant fournis respectivement aux brûleurs axiaux (51) et aux brûleurs radiaux (52).
2. Four (1) de la revendication 1, dans lequel le second conduit (520) du comburant comprend un collecteur à partir duquel bifurque une pluralité de conduits (524) de comburant, chaque conduit (524) menant à un seul brûleur (52) de la seconde série de brûleurs.
  3. Four (1) de la revendication 2, où les moyens de régulation (521) sont situés sur chacun des conduits (524) qui alimentent les brûleurs (52) de la seconde série.
  4. Four (1) de la revendication 2, où les moyens de régulation (521) sont situés sur le collecteur du comburant.
  5. Four (1) de la revendication 1, où la seconde série of brûleurs (52) est formée d'une pluralité de brûleurs s'alternant avec les brûleurs (51) de la première série.
  6. Four (1) de la revendication 1, où les brûleurs (52) de la seconde série comprennent en outre une buse ayant une flamme axiale.
  7. Four (1) de la revendication 1, où chaque paroi latérale (2) comprend deux lignes (31, 32) de brûleurs, dont une (31) est au-dessus du convoyeur à rouleaux (5) et une (32) est au-dessous du convoyeur à rouleaux (5)
  8. Four (1) de la revendication 7, où, le long de chaque ligne (31, 32), les brûleurs de la première série et de la seconde série sont disposés de manière alternée les uns aux autres.
  9. Four (1) de la revendication 1, où les moyens (523) de détection comprennent un système automatique de détection d'un calibre et/ou d'une planéité du produit céramique sortant du tunnel.
  10. Four (1) de la revendication 1, où les moyens de régulation du débit comprennent une vanne motorisée (521).
  11. Four (1) de la revendication 1, comprenant en outre des moyens de détection de la pression (81, 82) situés respectivement sur le premier conduit et le second conduit du comburant, les moyens de détection de la pression étant reliés à l'unité de contrôle (522).



**FIG.1**

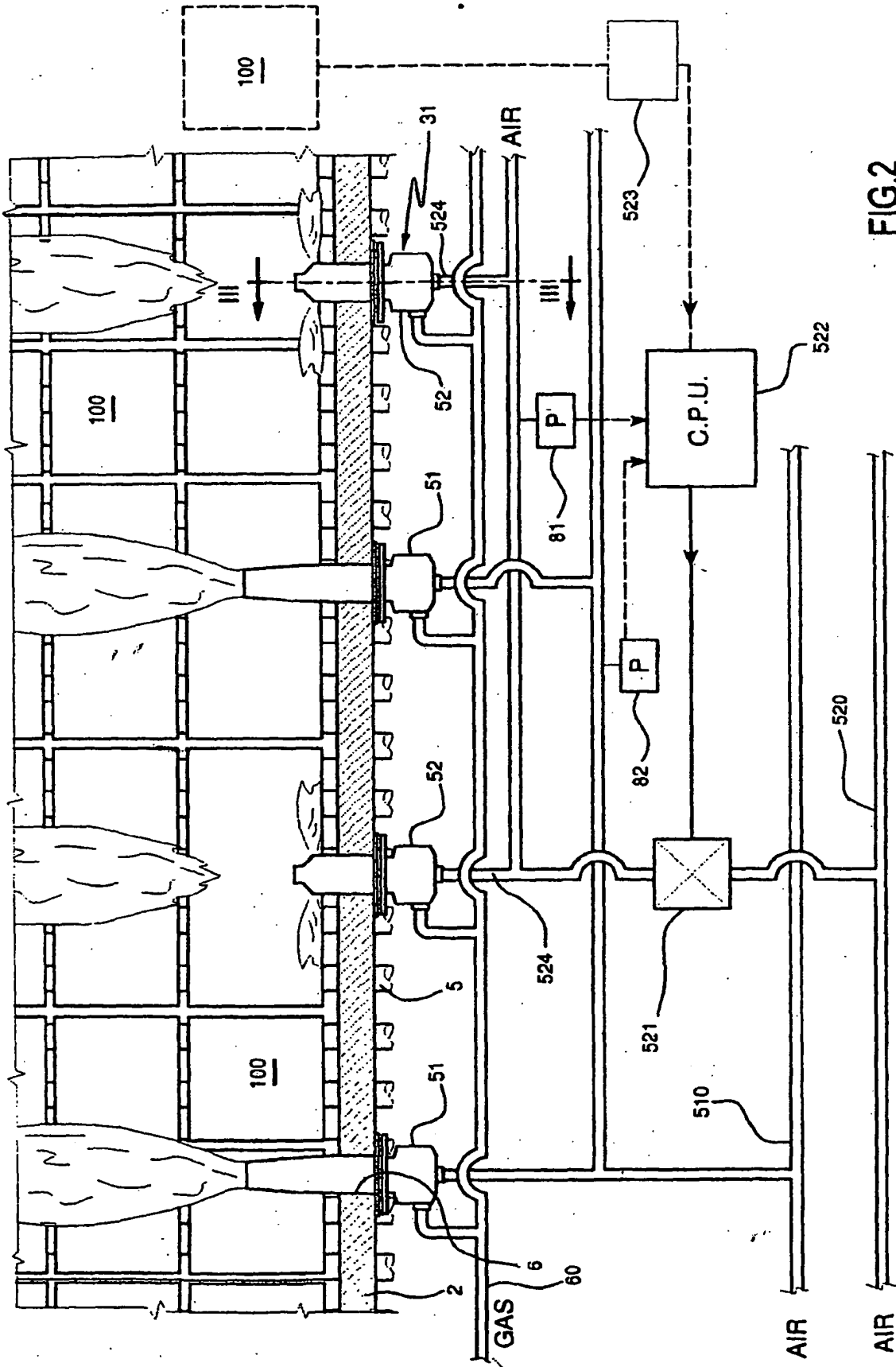
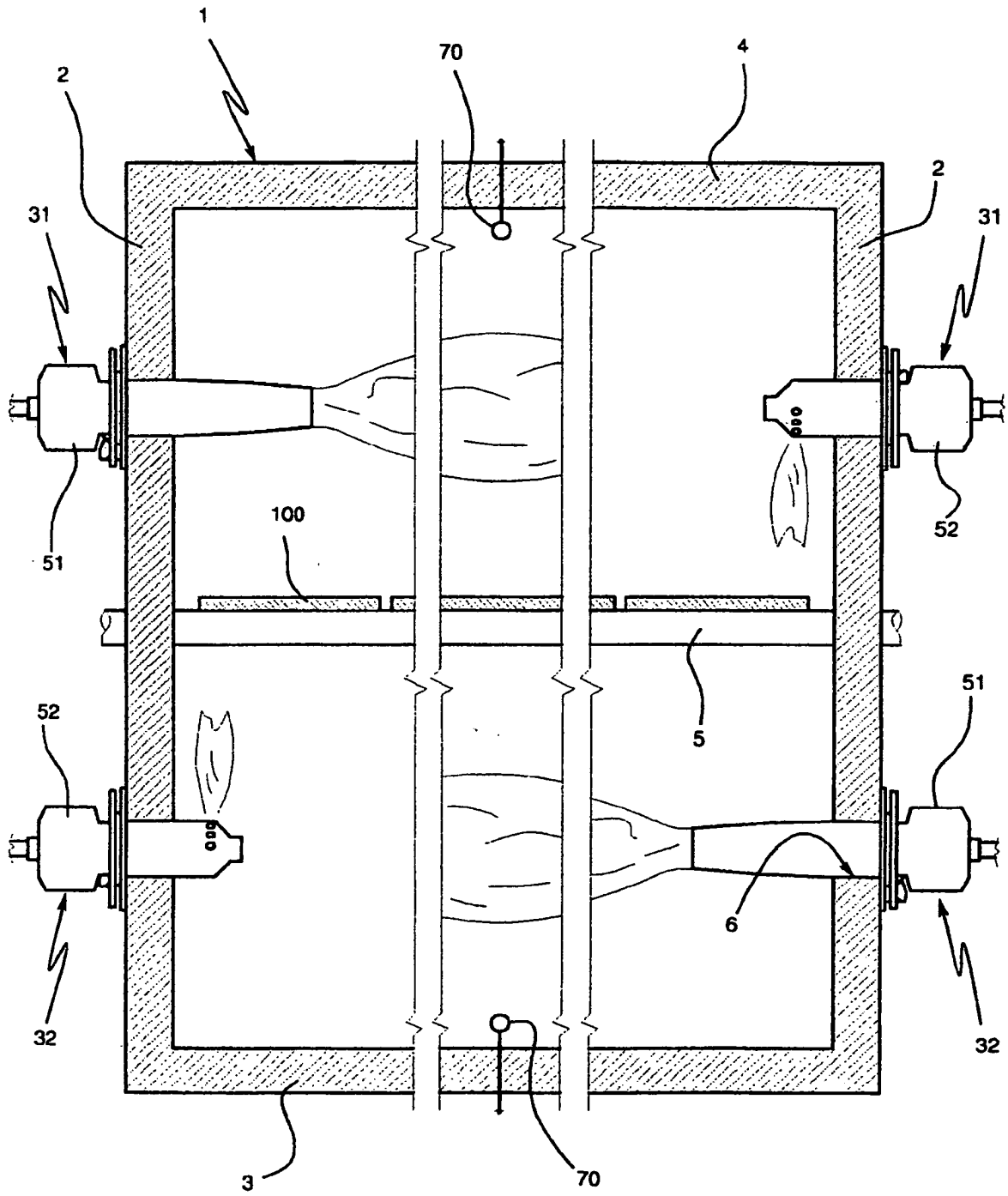


FIG.2





**FIG.3**

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- IT 1287626 [0012]
- EP 1500889 A1 [0016]