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(54) **DEVICE AND METHOD FOR PRODUCT DRYING**

(57) The present invention relates to a device and method for the drying of products, which can also be used for the activation of resins covering said products, comprising a modular system having a scalable cross-section, formed by one or more non-metal filament infrared lamps with carbon fibre which are encapsulated in a single or twin quartz tube, the upper part of the tube being coated with a gold reflector and cooled with air, maximising the use of convective and fast-response radiant energy. The warm air generated can be recirculated by a first fan and propelled for use, said warm air being applied against the product by diffusers, such that the vapours extracted are incinerated by an incineration device before being released to the outside.

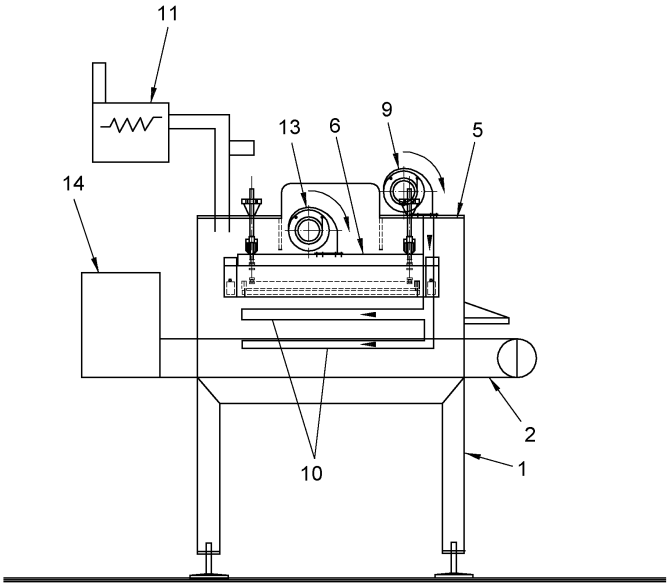

FIG. 1

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Description

OBJECT OF THE INVENTION

[0001] This invention, as expressed in the title of this descriptive report, refers to a device and method for the drying of products, in which the apparatus comprises a tunnel structure with one or more support modules which include infrared (IR) radiation emitters arranged above a conveyor belt which holds the products to be dried with the emitters; these products to be dried include laminar materials, bulk products or coverings, and the invention can also be applied to the activation of resins covering said products.

[0002] The aim of the invention is to achieve high performances of up to 80/90% during the product drying process and a considerable reduction in the curing time of more than 30/40%, compared to similar processes, and 200/300% compared to convection systems. A further objective of the invention is to eliminate emissions of polluting gases.

[0003] Consequently, a technical problem to be solved is the high electrical energy consumption of conventional apparatus for product drying; the apparatus in this invention achieves high energy efficiency, and also solves the problem of emissions of gases into the atmosphere.

[0004] A further technical problem to be solved is the occasional burns generated by conventional drying methods, such that the apparatus of the invention achieves a proportional and uniform distribution of the heat generated by the emitters, preventing said burns, and thus avoiding have to discard finished items.

BACKGROUND OF THE INVENTION

[0005] The application of infrared radiation, colloquially referred to as "IR", is a widely known heating and warming technique, used in different fields such as silk screen printing, vulcanisation, paint drying, heating of foods, blowing of PET-type plastics, ink drying, etc.

[0006] Other drying is carried out traditionally by radiating tubes heated by gas burners, such as the Italian patent with publication no. IT 1225094, or incandescent plates such as the US patent with publication no. US 4906180, based on the elimination of surface moisture.

[0007] Also known is a method and drying of cast parts, with the use of various phases of pre-heating, maintenance and subsequent heating, as is the case of the German patent with publication no. 3406789 for treatment of paint-coated work pieces by direct and intensive diffuse radiation, and a device for the elimination of the moisture generated by the drying, based on the use of reflectors, and air current recovered by convection for the drying, which has a complicated geometry.

[0008] Unlike the Spanish patent P0236609, from 1957, in the invention which concerns us the temperature of the object is not adjusted solely by changing the height of a lamp in relation to the object to be dried, but by regulating the voltage and thereby adjusting the temperature of the filament. Usually used for this are "SSR" solid state regulators, which adjust the phase sequence in automatic mode, with direct reference of the temperature of the object or its coating, or in manual mode with a potentiometer, or analogue output.

[0009] The method of transport usually used to move parts, slabs, plates or bulk products can be, for example, a conveyor belt. In the case of bulk products or light products, these conveyor belts may be made of Teflon or silicone. For construction materials, a transport using rollers, chains or mesh may be used; in this case, a geared motor, or motorised drum, driven or given commands from an electrical panel, is responsible for adjusting the speed, allowing continuous, static or intermittent work. In this way, controlled energy, also called irradiance, is irradiated onto objects, and can be adjusted according to the number of emitters, exposure time, height and installed power, in a direct or diffuse manner.

[0010] Another type of emitters like those used in Spanish patent with application no. P200702733, also called short-wave emitters, of the visible type, halogen, also called close infrared; although these allow a rapid response, they are highly dependent on colour, and their radiation is very aggressive on heat-deformable materials, such as belts, plastics, coverings and strips. Consequently, their use is restricted to heating or drying of surface moisture for short exposure times. Their tungsten filament is incandescent and, thanks to the halogen gas, they have a high colour temperature of up to 2450 K, with wavelengths between 0.7 and 2.2 microns, usually 1.2 microns. They are used to a great extent in many sectors, although this means a higher energy consumption which causes, in the case of incorrect irradiation on objects, breaks and hot points caused by the thermal gradients generated and by the effect of optical absorption.

[0011] The patent with publication no. WO 2013/182714 refers to a method and facility for curing plastic resins by thermal radiation for laminar construction materials, to precipitate the phenomenon of molecular cross-linking of the adhesive and the hardener of the plastic resin infiltrating and covering cracks, defects and irregularities in the parts to be treated, adjustable to the required level of irradiance. In a first stage, the part is pre-heated using infrared rays with a certain radiation frequency of between 1 and 2 microns and a temperature of between 50°C and 60°C. In a second stage, the resin is impregnated and the third stage is curing with wavelengths of between 2.2 and 3.5 microns.

[0012] Unlike the aforementioned patents, the device of the invention has reflective supports made of stainless steel and cooled using a low-pressure fan, which is necessary for the internal and thermal protection of the device of the invention, because of the high temperatures of the filament and the high power density reached.

DESCRIPTION OF THE INVENTION

[0013] In order to meet the objectives and avoid the disadvantages referred to in the previous paragraphs, the invention proposes a device and method for drying products, in which the device comprises a frame supporting a conveyor belt for parts to be dried using infrared radiation lamps integrated in reflectors supported on support modules that can be regulated in terms of height and position, which are arranged above the higher branch of the conveyor belt which travels through the inside of a tunnel structure; the inside of this structure houses the reflectors together with the infrared radiation lamps.

[0014] The rapid response carbon fibre lamps emit infrared radiation with a wavelength of between 2.2 and 2.8 microns, preferably 2.5 microns; colour temperature of between 700 and 800 K and a power density of between 30 and 35 kw/m^2

[0015] Said lamps are arranged in parallel and equidistant from each other; they are arranged lengthwise, in the same direction as the movement of the parts to be dried transported by the conveyor belt.

[0016] The reflectors and the lamps are supported on the support modules which form a surrounding casing, to be found inside the tunnel structure.

[0017] The hot air generated in the tunnel structure is recirculated via a first fan which blows the hot air against the upper and/or lower face of the parts to be dried by means of diffusers.

[0018] The reflectors included in the lamps are cooled by second fans which suck air in from the outside into the support modules.

[0019] The device in the invention also includes a gas burner which incinerates the gases generated inside the tunnel structure, before they are released into the atmosphere.

[0020] The support modules are made of stainless steel, with a high brightness reflector which is resistant to rusting caused by vapours or gases released by the processes.

[0021] The lamps are encapsulated in quartz tubes, the upper part of which is coated with a gold reflector, and cooled with air propelled by the second fans.

[0022] The method for product drying comprises the following phases:

- Activating the second fans to suck air from the outside into the interior space of the support modules containing the emitters with the infrared radiation lamps.
- Activating the gas burner until it reaches a minimum temperature of 850°C.
- Activating the infrared radiation lamps.
- Introducing the parts to be dried into the tunnel structure via the conveyor belt.
- Activating the first fan to extract hot air from inside the support modules, to then propel it onto the parts to be dried through the diffusers.

[0023] Carbon fibre, as the heating element, is a pure black coloured type of material which has the advantages of rapid heating, with small thermal hysteresis, and even heating, a long heat radiating transfer distance and rapid heat exchange speed. It has an average life of 6000 hours and the light flow is much smaller than that of other electric heating tubes. The electrical conversion efficiency can reach more than 95%. It can be heated in 1 or 2 seconds, and after 5 seconds the surface temperature can reach 300-700°C. With the same volume and power conditions, compared to other normal or electric ceramic heating tubes, it requires less time to reach the nominal temperature.

[0024] With a maximum working temperature ≤500°C, the life of the carbon fibre increases by 20%. In addition, the carbon emitters are much better absorbed by water, because of the absorption spectrum of the material.

[0025] Unlike other types of emitters, such as resistances, or medium wave or long wave emitters, whose regulation is slow, with high thermal inertia of up to 4 minutes, they are only recommended in control processes with reference to the air temperature value, similar to that used in gas burners or radiating plates, with "K" type, "J" type or "PT100" type probes, with no control of the temperature of the object.

[0026] Hereinafter, in order to give a better understanding of the description, the object of the invention has been detailed in a series of drawings that are an integral part of the report and are for illustration purposes and without limitation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Figure 1. - Shows an elevated view of the product-drying device, which is the object of the invention. A further object of the invention is the drying process. In this view, the infrared radiation lamps are arranged in the same direction as the movement of parts to be dried, transported by a conveyor belt.

Figure 2. - Shows a similar view to the previous figure, in which the device incorporates various support modules supporting reflectors with infrared radiation lamps, compared to a single support module incorporated in the device in figure 1.In this case, the lamps are arranged perpendicular to the movement of the conveyor belt.

Figure 3. - Shows a plan view of two adjacent and extendable infrared radiation modules arranged above a conveyor belt holding parts which receive the heat from the lamps to perform the drying.

Figure 4. - Shows a view similar to the one represented in figure 3, in which the infrared radiation lamps are arranged perpendicular to the movement of the parts to be dried carried on the conveyor belt.

Figure 5. - Shows an elevated, cross-section view of the reflectors with their infrared radiation lamps.

DESCRIPTION OF A SAMPLE EMBODIMENT OF THE INVENTION

[0028] Considering the numbering adopted in the figures, the product-drying device comprises a frame (1) which supports a conveyor belt (2) for parts (3) to be dried using support modules (6) which hold emitter reflectors (4) and infrared radiation lamps (7), in which said support modules (6) are arranged above the upper branch of the conveyor belt (2) which carries the parts (3) to be dried. The lamps (7), apart from having the function of drying the parts (3), also activate the resins which some of these parts (3) have on one of their faces.

[0029] The conveyor belt (2) moves through the inside of a tunnel structure (5), inside which there are stainless steel support modules (6) forming surrounding casings, in such a way that these support modules (6) contain the reflectors (4) including the parallel lamps (7) which emit the infrared radiation; the latter are arranged lengthwise in the direction of movement of the parts (3) to be dried, carried on the conveyor belt (2) as shown in figure 3.

[0030] In another embodiment, the lamps (7) are arranged perpendicular to the lengthwise movement of the parts (3) to be dried, carried on the conveyor belt (2) as shown in figure 4.

[0031] The infrared lamps (7) have a non-metallic, carbon fibre filament and are also encapsulated in single or twin quartz tubes (8), the upper part of which is coated with a gold reflector (8a), and air-cooled, maximising the use of convective and fast-response radiant energy.

[0032] The hot air generated is recirculated by means of a first fan (9) and blown to be used on the upper and/or lower side of the parts (3) to be dried via diffusers (10), and the vapours extracted are burned using a gas incinerator (11) before being transferred outside. The gas incinerator (11) connects with the inside of the tunnel structure (5) through an anterior duct (12). Said first fan (9) extracts the hot air from inside the tunnel structure (5) and then blows it onto the parts (3) through the diffusers (10).

[0033] Second blower fans (13) are also provided, which suck air from outside into the support modules (6) as a controlled means of cooling the infrared radiation reflectors (4).

[0034] The device of the invention is complemented with an external power source (14) to power the battery of infrared radiation lamps (7).

[0035] The support modules (6) are made of stainless steel, with a high brightness reflector (4) which reduces the attack or rusting caused by vapours or gases produced by the processes; the pressure and the flow rate of injected air is sufficient to renew the volumes surrounding the cables, and the holding elements, and also prevents condensation on the quartz tubes (8) themselves, particularly on their reflectors (8a), and the air generated is projected through small diameter holes for greater efficiency.

[0036] Each support module (6) can be made of steel according to standard AISI 304B, 310 or 316L, if required to comply with the regulations, or as a requirement in special conditions such as power supply, saline environment, chemical attack, etc.

[0037] The gas incinerator (11) reaches a temperature of around 870°C to prevent vapours or solvents from escaping to the outside.

[0038] Another technical problem not solved in the patent with publication no. WO/ES2013/182714 is that air renewal alone does not guarantee against the risk of explosion in inflammable atmospheres. Consequently, a requirement of this device of the invention is that the solvent content must not exceed 25% of the lower explosion limit, which corresponds to 0.4% by volume of solvents in the interior atmosphere, which can also be reduced with preheating phases of the material prior to the resin impregnation or painting stage.

[0039] Our device solves this by preventing start-up until the second blower fans have performed a sweep and keeping the fans in operation throughout the process.

[0040] Thanks to the gas incinerator (11) with controlled extraction, and the use of diffusers (10) to recirculate the hot air, performances of greater than 80-90% are achieved in drying processes, and a reduction in curing time of more than 30-40%; this is compared to similar processes, and the figure rises to 200-300% compared to convention systems, as mentioned in previous sections.

[0041] It is known that medium and long waves are sensitive to air currents, and an extraction close to the reflectors (4) would lose efficiency because of the unused convective energy generated.

[0042] A power study indicates that the power density of 20-50kw/m^2, and more specifically of 30-35 kw/m^2, installed, allows correct regulation and ensures the long life of the lamps.After the trials, in a sample embodiment, a prototype formed by two reflectors (4) with six lamps (7) of 2000W each was provided for; these lamps were distributed over an area of 0.6m x 0.6m, as represented in figures 3 and 4.

[0043] In the sample embodiment described in the previous paragraph, the distance between the emitter lamps (7) is 100mm, and their useful length is 600mm, leading to the deduction that the power density is 3.3w/cm^2.

[0044] With the cycle of two minutes to reticulate, this supposes a maximum consumption per m^2 of 1,11kwh/m^2 and an estimated consumption of 70% which is equivalent to 0.777kwh/m^2.

[0045] When used for evaporation of water for the drying of bulk products, such as pellets and porous materials, the average consumption obtained is 0.8/1.2 kwh/kg of water.

[0046] The device of the invention has the advantages of uniform drying, is only mildly aggressive for sensitive materials, offers the possibility of working with conveyor belts, with no hot points, but of high speed thanks to the wavelength of the infrared radiation, which is not solved

with other types of emitters. In addition, the use of a low volume of filler air and greater recirculation with recovered air gives performances of greater than 90%.

Claims

1. A device for product drying, comprising a frame which supports a conveyor belt for parts to be dried using infrared radiation lamps integrated in reflectors held in support modules arranged above the upper branch of the conveyor belt which passes through a tunnel structure, inside which the support modules are found; **characterised in that**:

   - the carbon fibre lamps (7) emit infrared radiation with a wavelength of between 2.2 and 2.8 microns, preferably 2.5 microns; colour temperature of between 700 and 800 k and a power density of between 30 and 35 kw/m^2;
   - the lamps (7) are integrated in the reflectors (4), which are in turn held in the support modules (6) which form a surrounding casing, to be found inside the tunnel structure (5);
   - the hot air generated inside the tunnel structure (5) is recirculated via a first fan (9) which blows the hot air to be used and blown against the upper and/or lower face of the parts (3) to be dried by means of diffusers (10);
   - the reflectors (4) integrated in the lamps (7) are cooled by second fans (13) which suck air from the outside into the support modules (6).

2. A device for product drying, according to claim 1, **characterised in that** it comprises a gas burner (11) which burns the gases generated inside the tunnel structure (5), before releasing them into the atmosphere.

3. A device for product drying, according to any of the previous claims, **characterised in that** the lamps (7) are arranged in parallel directions, equidistant from each other; where said lamps are arranged in the lengthwise direction of the movement of the parts (3) to be dried, carried on the conveyor belt (2);

4. A device for product drying, according to any of the previous claims 1 or 2, **characterised in that** the lamps (7) are arranged in a direction perpendicular to the movement of the parts (3) to be dried, carried on the conveyor belt (2).

5. A device for product drying, according to any of the previous claims, **characterised in that** the support modules (6) are made of stainless steel, with a high brightness reflector (4) which is resistant to rusting from vapours or gases given off by the processes.

6. A device for product drying, according to any of the previous claims, **characterised in that** the lamps (7) are encapsulated inside quartz tubes (8), the upper part of which is coated with a gold reflector (8a), and cooled with air blown by the second fans (13).

7. A method for product drying, according to the previous claims, **characterised in that** it comprises the following phases:

   - activating the second fans (13) to suck air from the outside into the support modules (6) housing the emitters (4) with the infrared radiation lamps (7);
   - activating the infrared radiation lamps (7);
   - introducing the parts (3) to be dried into the tunnel structure via the conveyor belt (2);
   - activating the first fan (9) to extract hot air from inside the support modules (6), to then propel it onto the parts (3) to be dried through the diffusers (10).

8. A method for product drying, according to claim 7, **characterised in that** it comprises an additional phase which consists of activating the gas burner (11).

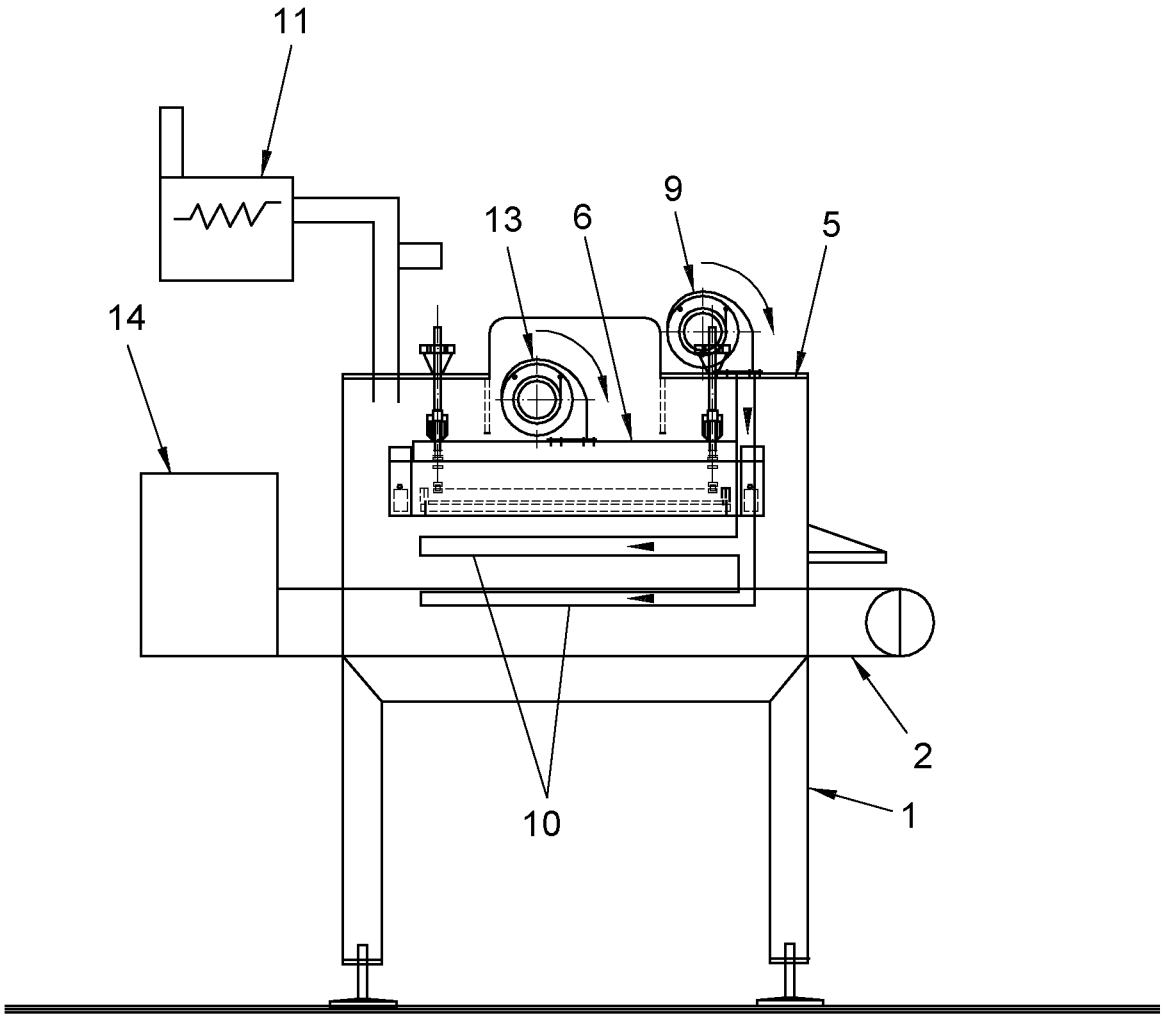

FIG. 1

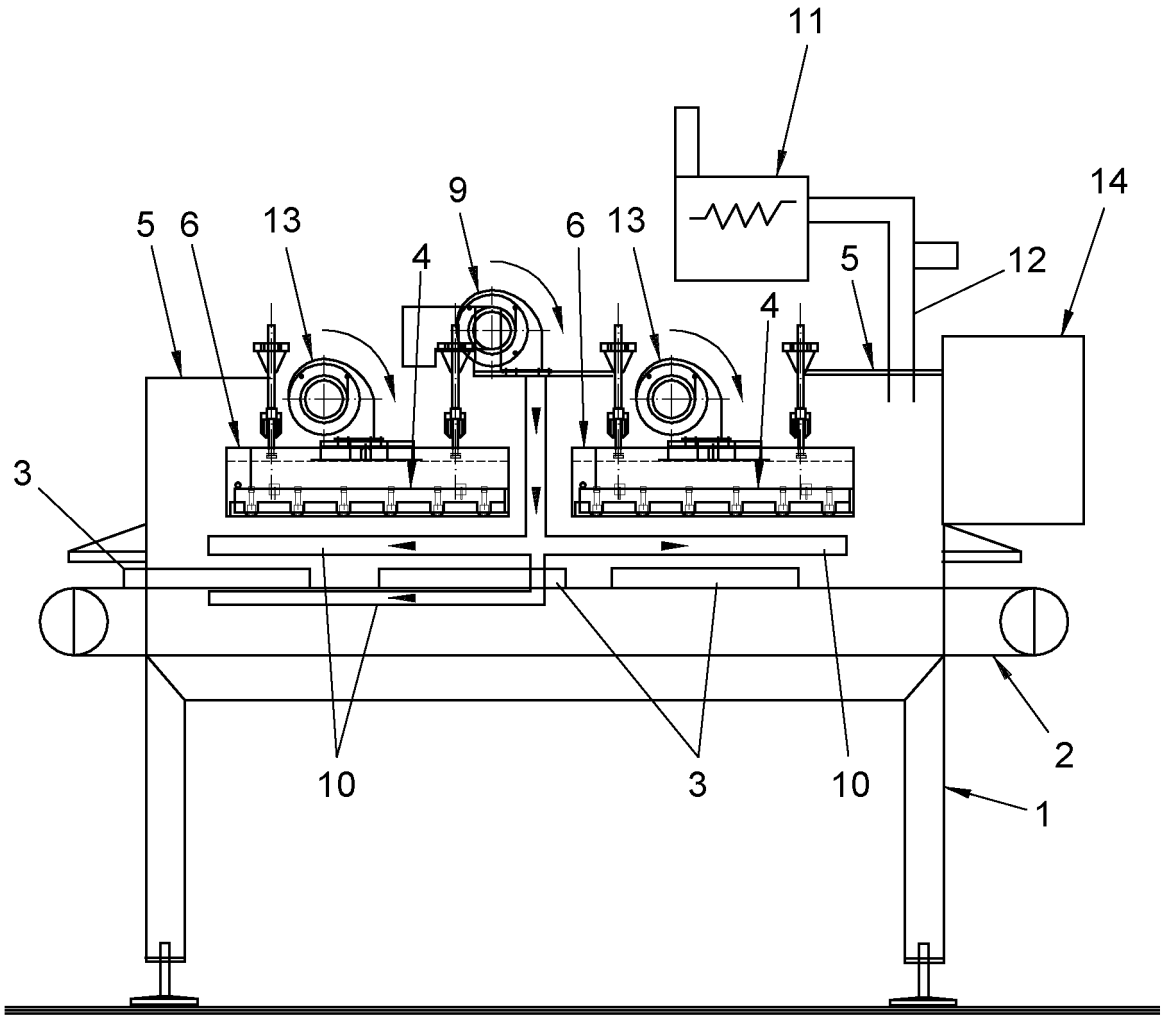

FIG. 2

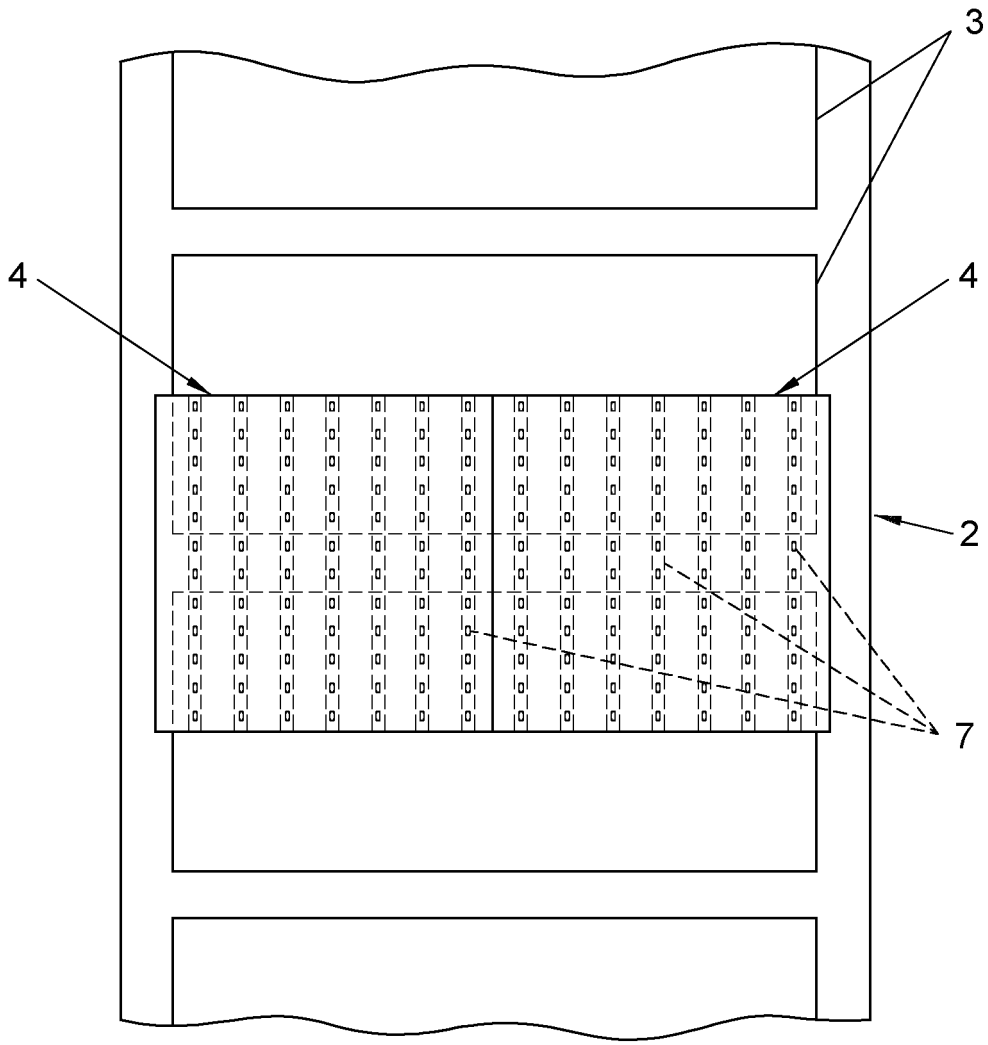

FIG. 3

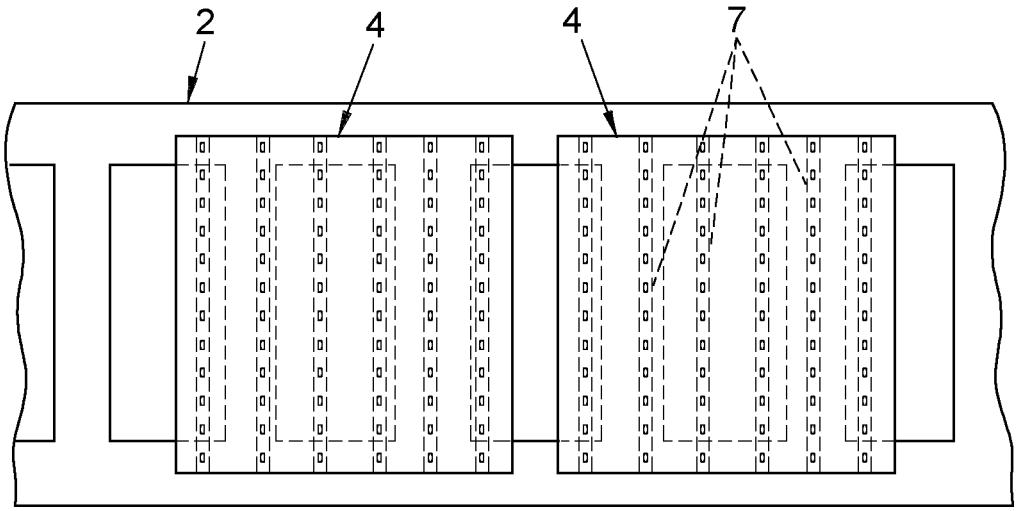

FIG. 4

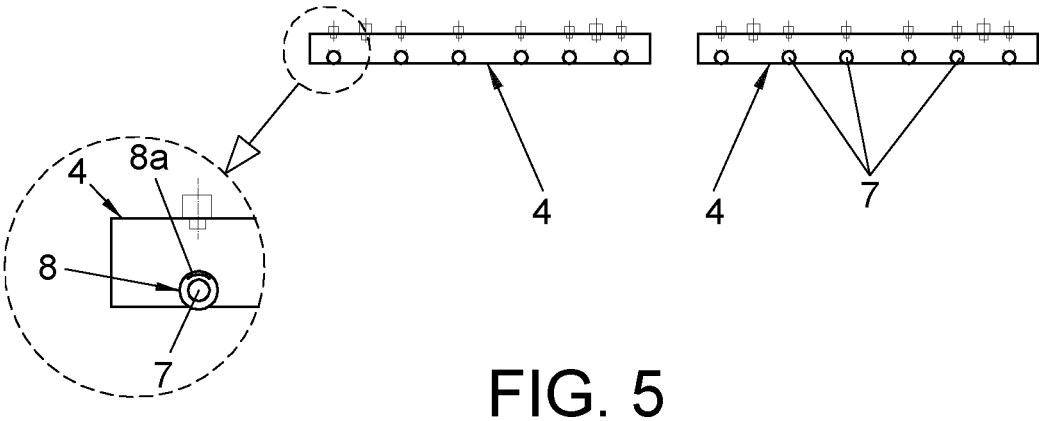

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2014/070742

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)
F26B

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)

EPODOC, INVENES

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ES 2330599 A1 (BULMA TECNOLOGIA S L) 11/12/2009, the whole document.	1-8
Y	CN 201706866U U (SICHUAN ZHONGCELIANGYI CO LTD) 12/01/2011, the whole document.	1-8
A	JP 2013076508 A (NGK INSULATORS LTD) 25/04/2013, the whole document.	1, 6
A	WO 2013182714 A1 (BULMA TECNOLOGIA S L ET AL.) 12/12/2013, the whole document.	1
A	US 3474544 A (HOLDEN ARTHUR S JR ET AL.) 28/10/1969, the whole document.	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"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 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
29/10/2014	**(30.10.2014)**
Name and mailing address of the ISA/ OFICINA ESPAÑOLA DE PATENTES Y MARCAS Paseo de la Castellana, 75 - 28071 Madrid (España) Facsimile No.: 91 349 53 04	Authorized officer J. Celemín Ortiz-Villajos Telephone No. 91 3495493

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/ES2014/070742

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
ES2330599 A1	11.12.2009	NONE	
CN201706866U U	12.01.2011	NONE	
JP2013076508 A	25.04.2013	NONE	
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US3474544 A	28.10.1969	NONE	

Form PCT/ISA/210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES2014/070742

CLASSIFICATION OF SUBJECT MATTER

F26B3/30 (2006.01)
F26B17/04 (2006.01)
F26B15/18 (2006.01)

Form PCT/ISA/210 (extra sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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- US 4906180 A **[0006]**
- DE 3406789 **[0007]**
- ES P0236609 **[0008]**
- ES P200702733 **[0010]**
- WO 2013182714 A **[0011]**
- ES 2013182714 **[0038]**