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## (54) Controlled curing process of concrete parts in cells and relevant curing cell

(57) The present invention refers to a curing process, and relevant curing cell, used for quick curing of concrete parts, with the possibility of adjusting the temperature reached by the parts in the curing cell once the concrete setting reaction has started.

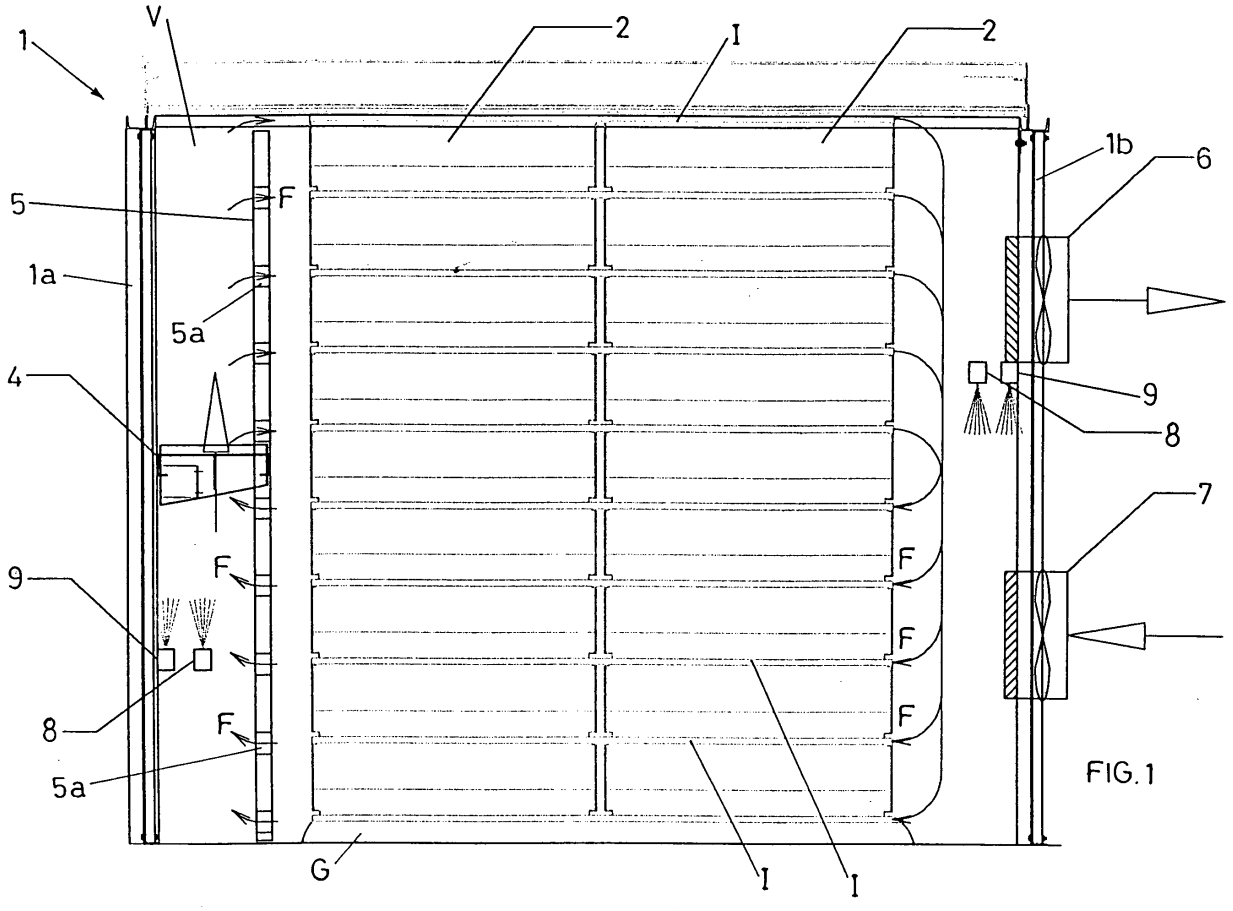


FIG. 1

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## Description

**[0001]** The present patent application refers to a controlled curing process of concrete parts in cells, and to the curing cell used for the process.

**[0002]** As it is known, once they have been cast in formworks, concrete parts must be subjected to a process commonly defined as "curing" in order to harden and acquire compression strength.

**[0003]** Curing of concrete parts can be natural, when the process is performed by simply exposing concrete parts in the open air, or forced, when the process is performed artificially.

**[0004]** Although natural curing ensures excellent technical-functional characteristics, this natural curing process requires very long time, and this is not compatible with the requirements of mass production.

**[0005]** This has determined the large diffusion of forced curing, which is performed by keeping concrete parts in enclosed insulated spaces to considerably accelerate the starting and execution time of concrete hydration reaction.

**[0006]** More precisely, steam is introduced inside the enclosed spaces (which basically consist in cells) to increase the internal temperature and accelerate the start of concrete setting reaction.

**[0007]** Being of exothermic type, the reaction inside the insulated cell "automatically" reaches the high temperatures that ensure concrete curing.

**[0008]** Nevertheless, the temperature reached inside the insulated cells cannot be controlled and, especially in case of high external temperature, the reached value is too high.

**[0009]** Practically speaking, this is a very negative drawback: in spite of suitable hardness, the infinite compression strength of concrete parts obtained with this process is considerably lower than the strength of parts obtained with natural curing at a lower temperature.

**[0010]** European standards have been recently issued to regulate the curing process of concrete parts used in heavy duty conditions (such as railway sleepers). The standards set very exact limitations for the temperatures reached by concrete while curing, imposing temperature-time limit curves according to the type of concrete.

**[0011]** In view of the above, traditional forced curing processes are no longer practicable due to their incapacity to guarantee the required specifications of concrete parts.

**[0012]** The purpose of the present invention is to devise a curing process, together with relevant curing cell, used for quick curing of concrete parts within the aforementioned temperature-time limit curves in any time of the year, independently from external temperature variations.

**[0013]** More precisely, according to the new process of the invention concrete parts are stored in the cell and heated at the beginning of the operational cycle. Heat is extracted during the development of the setting reaction, while ensuring air moisture close to saturation (being this a necessary condition for correct concrete curing) and uniform conditions anywhere in the cell.

**[0014]** The cell used for the curing process of the invention is characterised by a series of fans for introduction-extraction and recirculation of air, and by a series of nozzles used to spray water and steam; it being provided that these devices operate according to predefined modes according to the specific conditions of the accelerated curing process of concrete parts.

**[0015]** According to an alternative embodiment of the same process, the reduction of the air temperature during the concrete setting reaction is obtained by means of the cooling action of a heat exchanger associated with the curing cell, thus eliminating the cyclic change of air (internal-external) in the cell.

**[0016]** It appears evident that the presence of the heat exchanger eliminates the need of fans for air introduction and extraction, as well as the need of long expensive piping required to connect the fans with the outside of the building where the curing cell is located.

**[0017]** For major clarity the description of the invention continues with reference to the enclosed drawings, which are intended for purposes of illustration only and not in a limiting sense, whereby:

- figure 1 is a side view of the curing cell used for the process of the invention, after removing one of the walls to show the internal structure of the cell;
- figure 2 is a top view of the cell, after removing the upper lid;
- figure 3 is a cross-section of the cell with vertical plane III-III of figure 2;
- figure 4 is a side view of an alternative embodiment of the curing cell used for the process of the invention, after removing one of the walls to show the internal structure of the cell;
- figure 5 is a top view of the cell shown in figure 4;
- figure 6 is a cross-section of the cell shown in figure 5 with plane V-V.

**[0018]** With reference to the aforementioned figures, the cell (1) used for the process of the invention is provided with insulated walls. One of the walls can be removed to introduce and extract stacks of formworks (2) where concrete parts are cast. The figures show the presence of a gap (I) between the formworks (2) of each stack to favour air circulation.

**[0019]** With reference to figure 2, each of the formworks (2) has four different parallel cavities in order to form railway sleepers (T).

**[0020]** In the embodiment shown in the aforementioned figures, the removable wall of the cell (1) coincides with the roof, which basically acts as a lid (3) that can be handled by means of an overhead crane.

**[0021]** A gap (I) (of a few centimetres) exists between the internal side of the lid (3) and the formworks (2) in the upper section of the stack, being the same as the

gaps (I) between two formworks. An identical gap (I) also exists at the base of the stack of formworks (2); the stacks rest on two parallel guides (G) fixed to the bottom of the cell (1).

**[0022]** The internal side of the front wall (1 a) of the cell (1) is provided with a series of axial fans (4) that ensure air circulation and favour the creation of a continuous laminar flow through the gaps (I) between the formworks (2), as shown by the arrows (F) in figure 1.

**[0023]** In the preferred embodiment of the invention shown in the aforementioned figures, the series of circulation fans (4) is situated in a narrow space (V) bordered by the front wall (1 a) and a counter-wall (5) with a series of transversal slots (5a) regularly spaced at the same distance as the gaps (I) and aligned with the gaps (I).

**[0024]** The purpose of the slotted wall (5) is to ensure uniform air flows through the gaps (I) of the formworks (2), without having to increase the distance between the series of recirculation fans (5) and the stacks of formworks (2).

**[0025]** The back wall (1 b) is provided with one or more fans (6) used to extract air from the cell (1) and one or more fans (7) used to introduce external air.

**[0026]** Each of the walls (1a, 1b) is provided with two rows of spraying nozzles (8, 9); the first series is composed of nozzles (8) used to spray steam and the second series is composed of nozzles (9) used for water fogging.

**[0027]** According to the process of the invention, after loading the cell (1) with formworks (2) and closing the upper lid (3), the fans (4) for the recirculation of internal air start operating, together with the steam spraying nozzles (8), until the temperature required to start the concrete setting reaction is reached inside the cell (1).

**[0028]** The first stage of the process of the invention is performed by suitably adjusting the quantity of steam introduced in the cell (1) in order increase the concrete temperature according to the temperature-time curve established for the specific concrete parts from time to time.

**[0029]** However, the start of the concrete setting reaction generates a considerable quantity of heat that increases the concrete temperature, with the risk of completing the curing process with no control on the temperature-time curve.

**[0030]** Thanks to the solution provided by the present invention, the temperature increase of concrete parts can be controlled by interrupting the introduction of steam and by operating the nozzles (8) used for water fogging. As a matter of fact, during sudden evaporation, water fogging spontaneously absorbs the heat generated during the concrete setting reaction, thus reducing the concrete temperature increase.

**[0031]** Moreover, the introduction of water allows to maintain high levels of relative air moisture in the cell (1).

**[0032]** As soon as air circulation in the cell (1) is no longer capable of acting as cooling fluid for the concrete parts being cured, due to moisture saturation and high temperature values, the fans (6, 7) start operating to extract hot air saturated with moisture from the cell (1) and introduce cool dry air from the outside.

**[0033]** The fans (6, 7) operate in intermittent mode and, if necessary, perform air change cycles while concrete parts are cured in the cell (1).

**[0034]** In order to optimise the air change ensured by the fans (6, 7), the fans (6, 7) are preferably connected to pipes ending outside the cell (1) and situated at considerable mutual distance.

**[0035]** This eliminates any possible interference between the flow of hot air extracted from the cell (1) by the fan (6) and the flow of cool air introduced in the cell (1) by the fan (7). Obviously, interference between the two flows would increase the temperature and moisture of the external air introduced in the cell (1), thus reducing the beneficial effect aimed at optimising the climatic conditions of the cell.

**[0036]** The suitable adjustment of the quantity of water sprayed inside the cell (1) and the quantity of air changed by the fans (6, 7) permits to comply with the temperature-time curves in any weather condition.

**[0037]** Of course, the adjustment of the operating parameters of the cell can be performed manually for experimental purposes only. The industrial application of the process of the invention requires the presence of a control unit used to set the most suitable operation of components, according to concrete temperature, air temperature and moisture in the cell, temperature and moisture of the external air introduced in the cell, based on the specific operational modes of the process.

**[0038]** As mentioned above, figures 4, 5 and 6 refer to an alternative embodiment of the process of the invention, which eliminates the need for cyclic air change inside the curing cell (1) and consequently eliminates the presence of the fans (6, 7) used to extract air saturated with moisture from the cell and introduce cool dry air in the cell, respectively.

**[0039]** As shown in the aforementioned figures, this embodiment of the cell (1) is provided with a heat exchanger (10) fed with cold water or refrigerating fluid in direct expansion.

**[0040]** In particular, the exchanger (10) is mounted on the internal side of a wall of the cell (1), and the refrigerating unit (10a) is mounted on the external side of the cell.

**[0041]** As mentioned earlier, the exchanger (10) starts operating as soon as an excessive temperature increase of the concrete parts being cured inside the cell (1) is sensed, in order to reduce the temperature of circulating air inside the cell (1).

**[0042]** To that end, the exchanger (10) operates in intermittent mode, just like the fans (6, 7) used in the preceding embodiment of the cell (1).

## Claims

1. Controlled curing process of concrete parts in cells, of the type comprising the introduction of concrete parts contained in formworks (2) in an insulated cell

(1) and the introduction of steam in the cell (1) to increase the concrete temperature according to a predefined temperature-time curve, **characterised by** the fact that:

- the formworks (2) are stacked in the cell (1) in such a way that a gap (I) with constant height exists above and below each formwork (2) for the passage of air laminar flows
- the air with steam contained inside the cell (1) circulates through the gaps (I) between the formworks (2)
- the introduction of steam in the cell (1) is interrupted when concrete parts reach the starting temperature of the setting reaction and water fog is sprayed in the cell (1) when concrete parts exceed the predefined temperature value and /or the moisture of the air inside the cell (1) drops below the predefined value.
- the air temperature in the cell (1) is reduced as soon an excessive temperature increase of the concrete parts is sensed in the cell (1).

**2.** Process as defined in claim 1, **characterised by** the fact that air temperature in the cell (1) is reduced by changing the internal air with cool dry external air.

**3.** Process as defined in claim 1, **characterised by** the fact that the air temperature in the cell (1) is reduced by directly cooling the air.

**4.** Cell used to perform the curing process of the invention as defined in claims 1 and 2, of the type provided with insulated walls, one being a removable wall (3), and nozzles (8) for steam introduction, **characterised by** the fact that it comprises:

- one or more fans (4) for air circulation mounted on the front (1a) and/or back wall (1 b)
- one or more (6) used to extract internal air and one or more fans (7) used to introduce external air, both mounted on the back (1 b) and/or front wall (1 a)
- rows of water fog nozzles (9) mounted on the front and back walls (1a, 1 b)
- a pair of raised guides (G) on the bottom of the cell (1) to support stacks of formworks (2)
- means used to sense the temperature of the concrete parts loaded in the cell (1)
- means used to sense the temperature and moisture rate of the air in the cell (1)
- means used to sense the temperature and moisture rate of the air outside of the cell (1).

**5.** Cell used to perform the curing process of the invention as defined in claims 1 and 3, of the type provided with insulated walls, one being a removable wall (3), and nozzles (8) for steam introduction, **characterised by** the fact it comprises:

- one or more fans (4) for air circulation mounted on the front (1a) and/or back wall (1b)
- one heat exchanger (10) for direct cooling of internal air
- rows of water fog nozzles (9) mounted on the front and back walls (1 a, 1 b)
- a pair of raised guides (G) on the bottom of the cell (1) to support stacks of formworks (2)
- means used to sense the temperature of the concrete parts loaded in the cell (1)
- means used to sense the temperature and moisture rate of the air in the cell (1)

**6.** Cell as defined in claims 4 or 5, **characterised by** the fact that it is equipped with an electronic control unit used to automatically activate the stages of the process according to real-time information sensed by the temperature and moisture detection means and in compliance with the predefined temperature-time curve.

**7.** Cell as defined in one or more of the claims 4 to 6, **characterised by** the fact that the series of fans (4) for air circulation is situated in a narrow space (V) bordered by the front wall (1 a) and a counter-wall (5) provided with a series of regularly spaced transversal slots (5a) aligned with the gaps (I) between two formworks in each stack loaded in the cell (1).

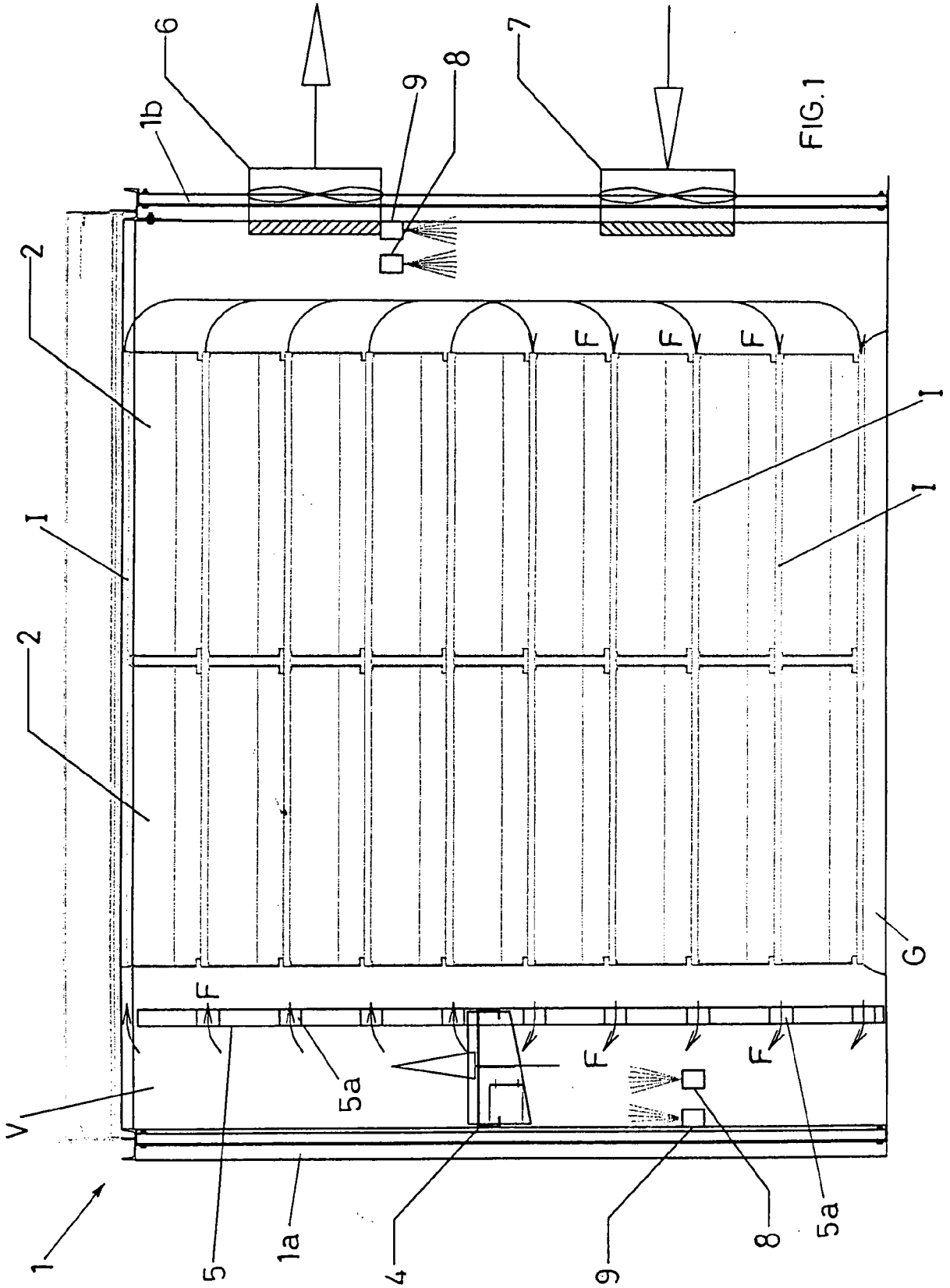



FIG.1

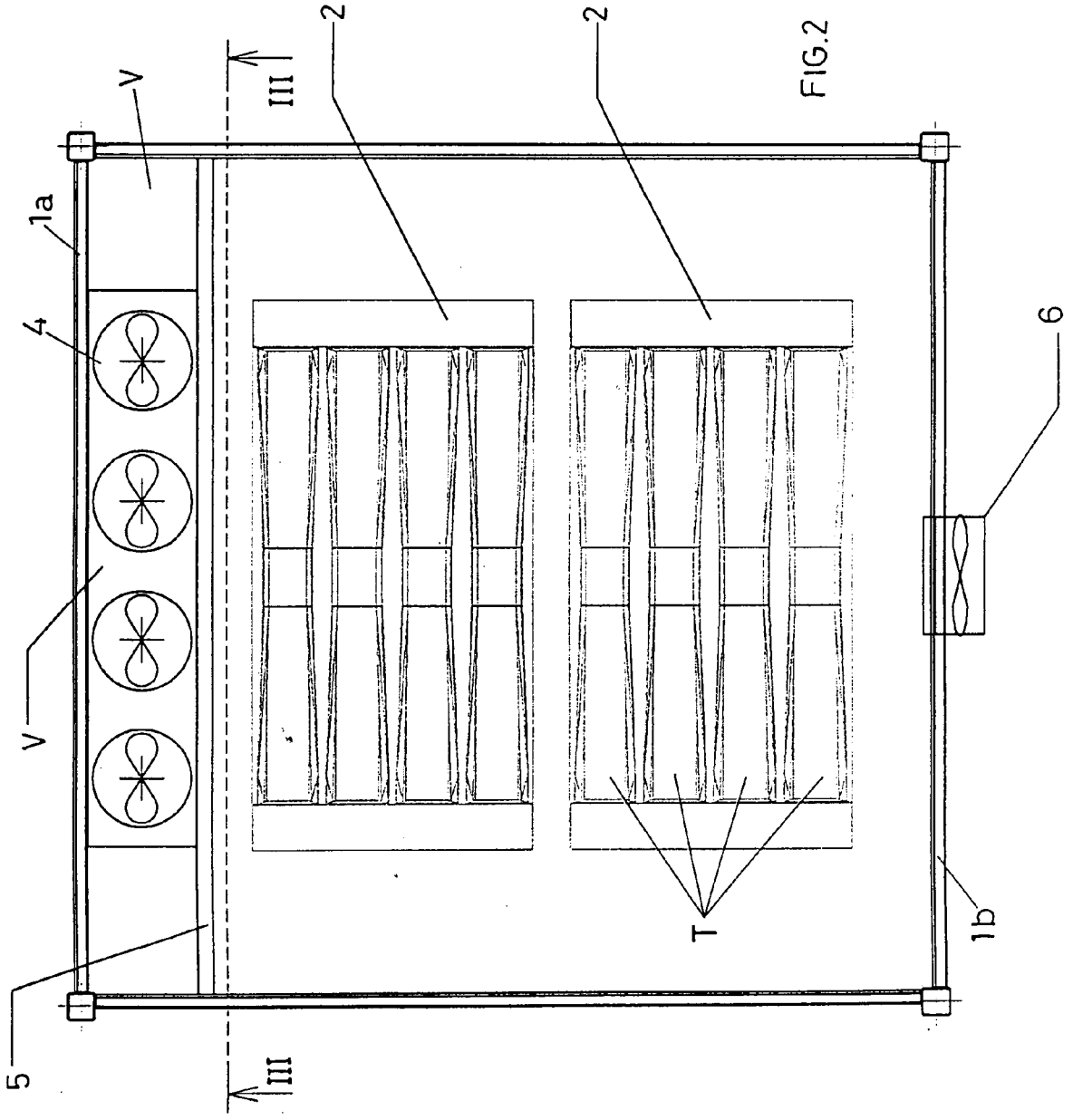



FIG.2

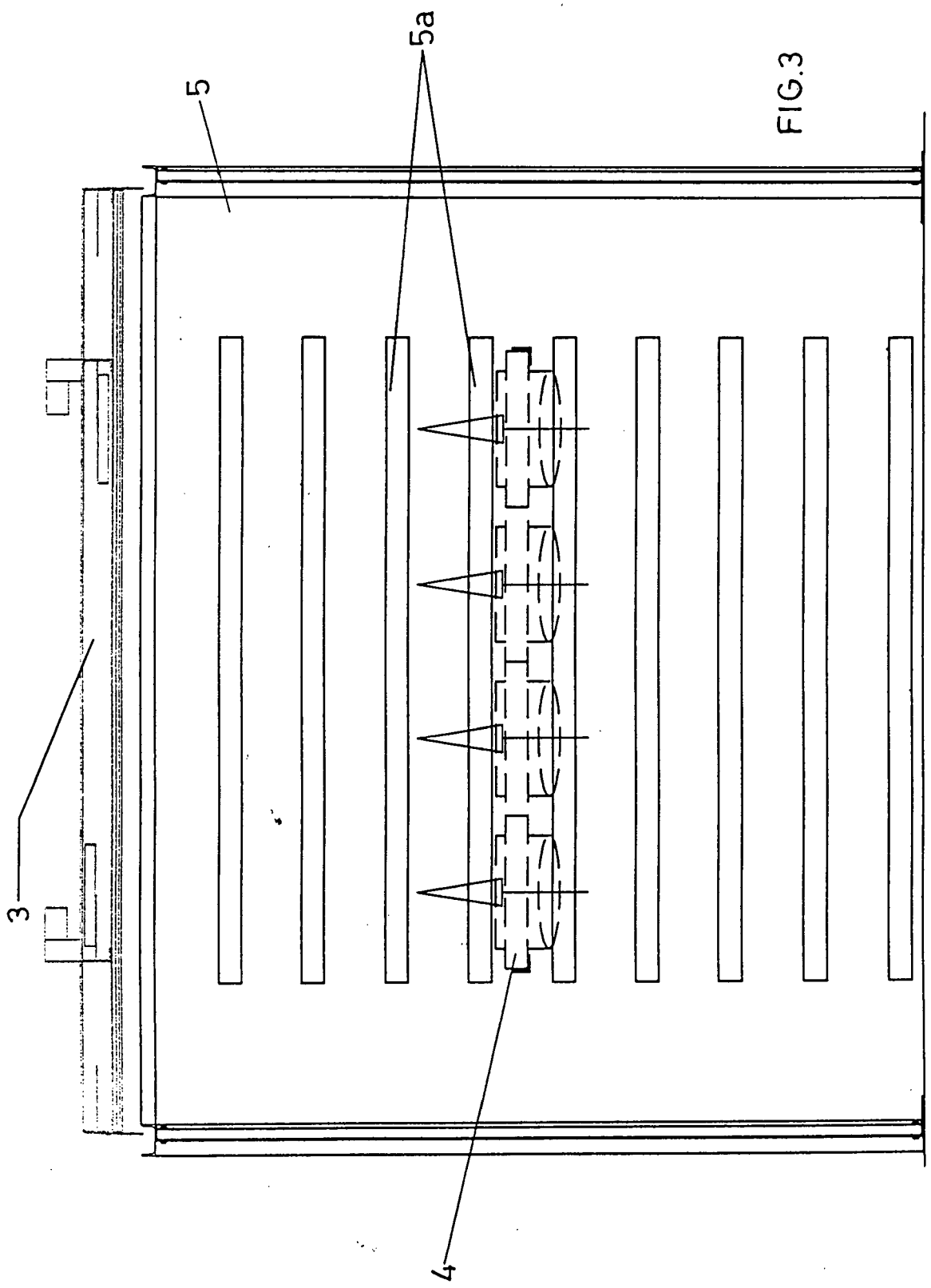



FIG.3

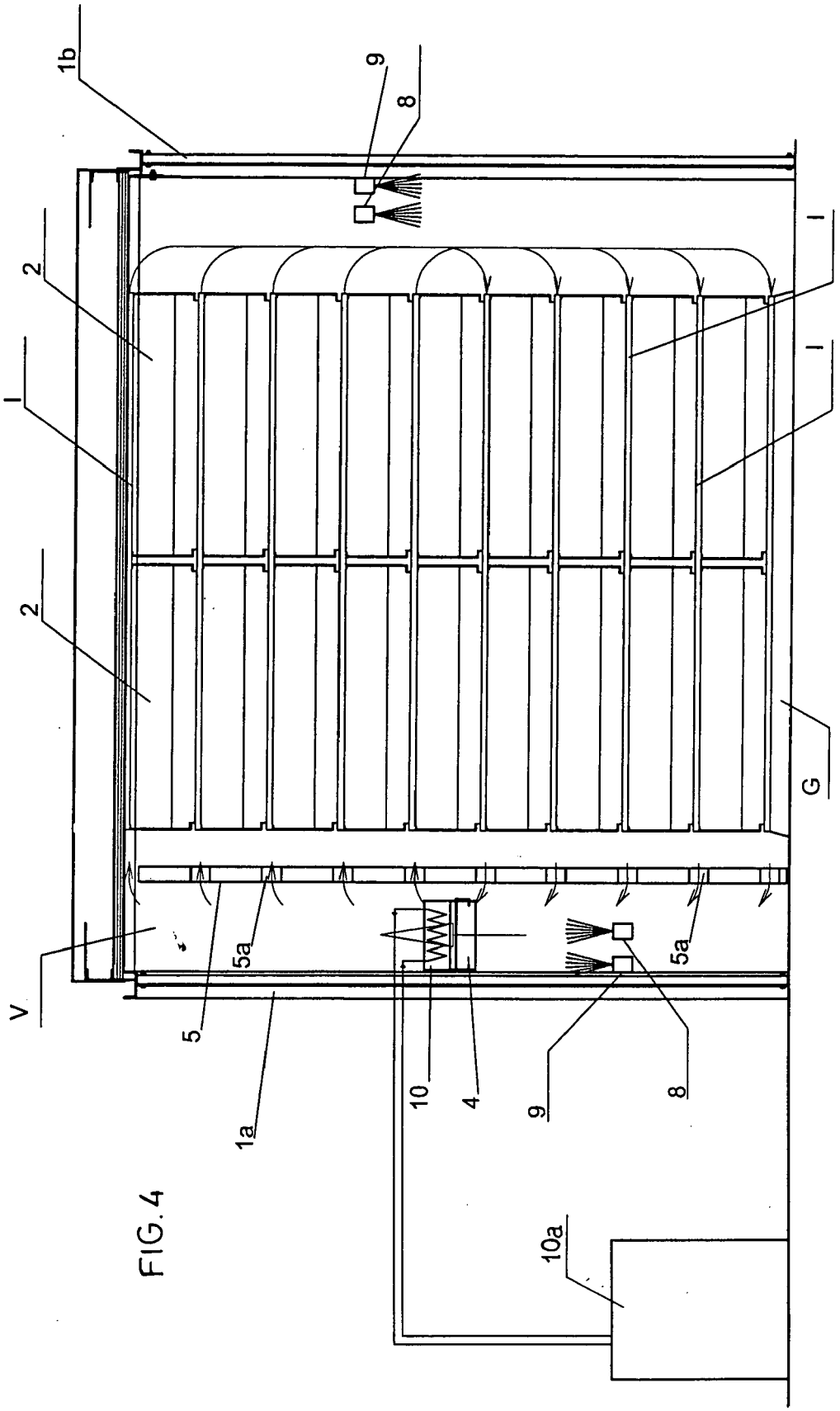



FIG. 4

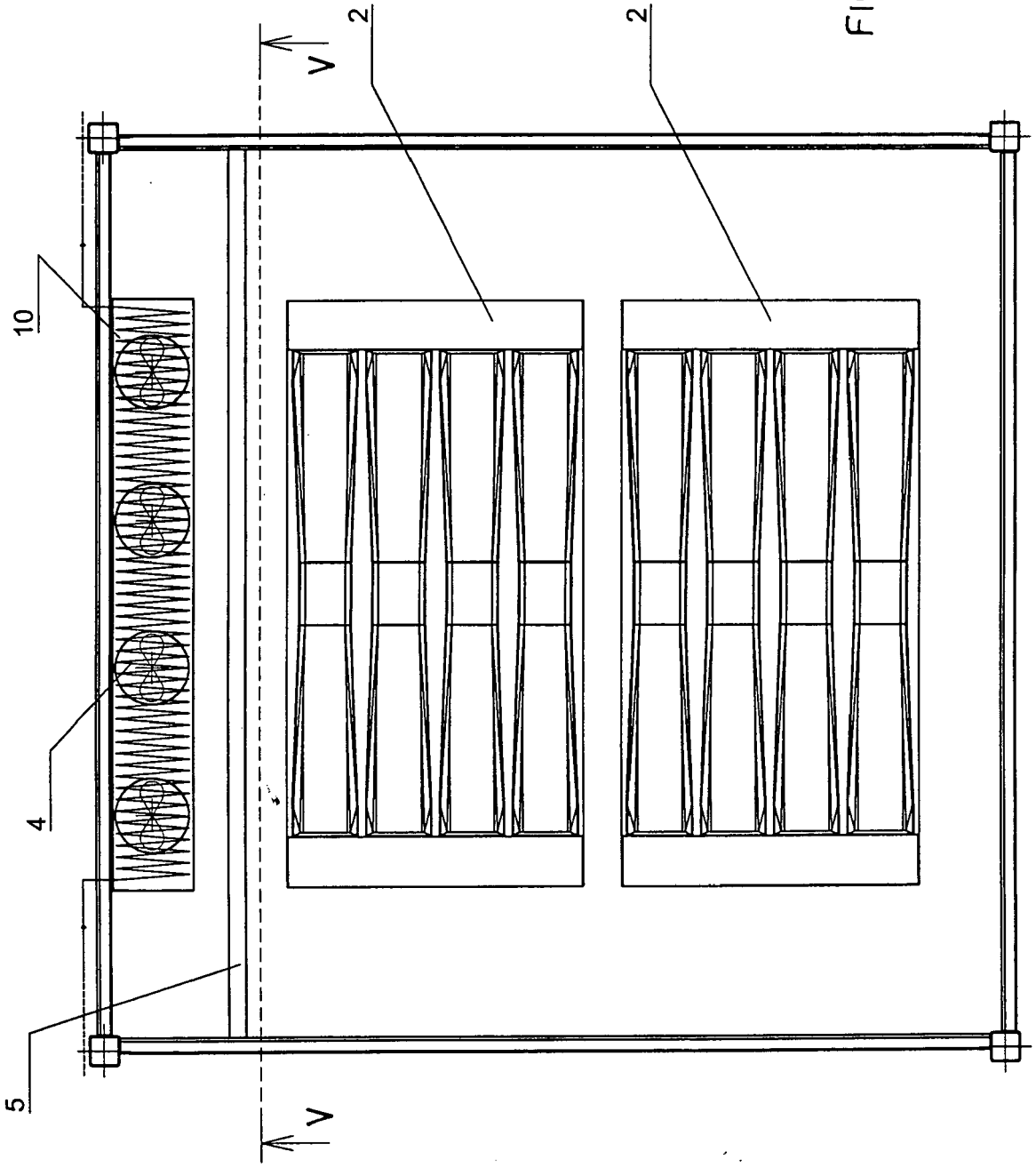
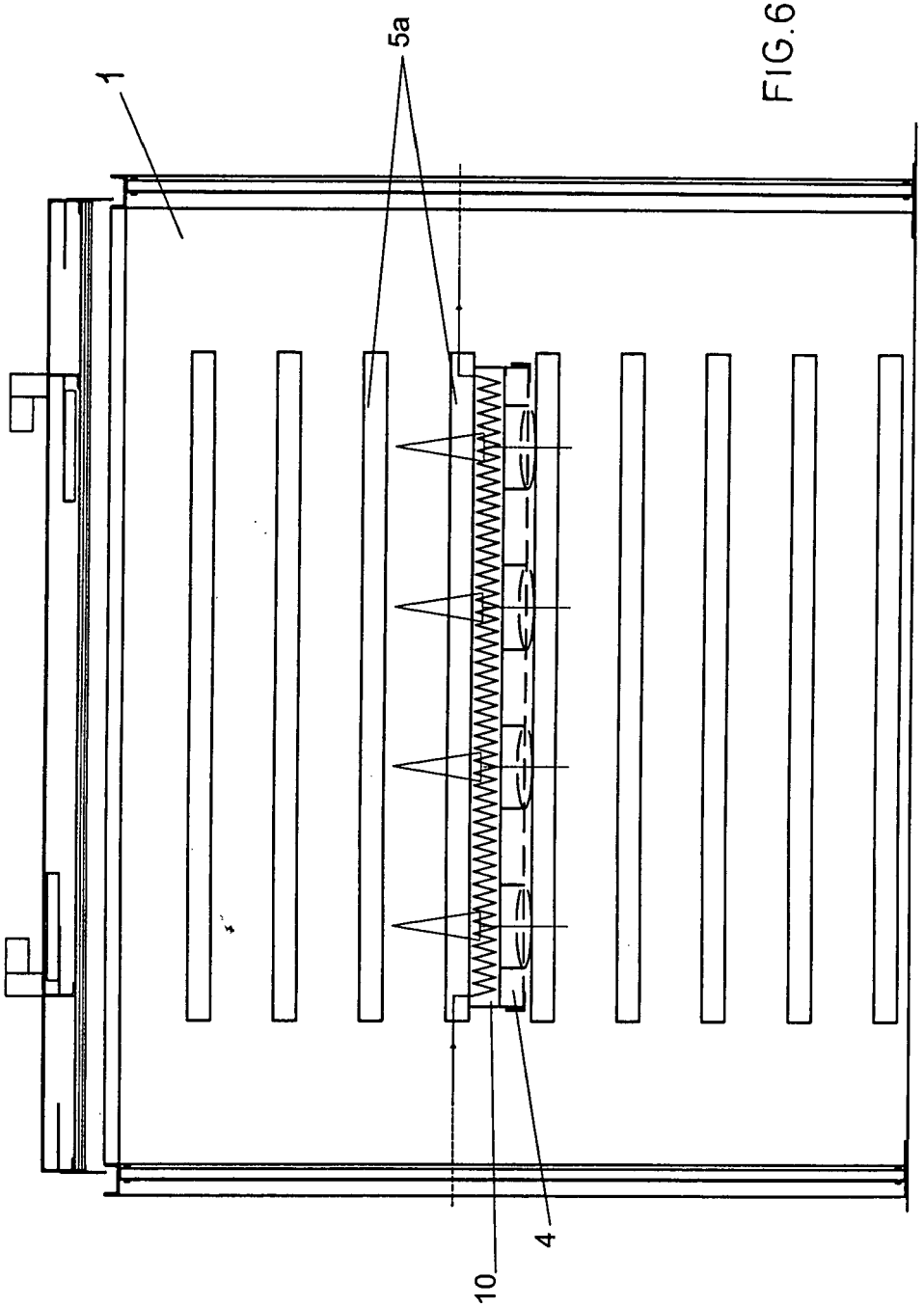



FIG.5

FIG.6



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# EUROPEAN SEARCH REPORT

Application Number
EP 05 42 5017

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
|---|---|---|---|
| X | DE 195 41 866 A1 (YTONG AG, 80797 MUENCHEN, DE; YTONG AG) 15 May 1997 (1997-05-15) | 1,3 | B28B11/24 F26B21/08 C04B40/02 |
| A | * column 4, line 26 - column 5, line 13 * * column 7, line 2 - column 8, line 2; claims 19-30; figure 1 * | 4,5 | |
| Y | US 4 531 304 A (WAUHOP, JR. ET AL) 30 July 1985 (1985-07-30) * column 2, line 67 - column 3, line 64; figure 1 * | 5,6 | |
| A | * column 4, line 28 - line 49 * | 1,3,4 | |
| Y | US 4 772 439 A (TREVINO-GONZALEZ ET AL) 20 September 1988 (1988-09-20) | 5,6 | |
| A | * column 2, line 16 - column 3, line 10 * * column 3, line 30 - column 4, line 68; claim 1; figure * | 1,2,7 | |
| A | US 3 614 074 A (WALKER L. WELLFORD JR) 19 October 1971 (1971-10-19) * column 3, line 51 - column 4, line 68; figures * | 4 | TECHNICAL FIELDS SEARCHED (Int.Cl.7) B28B C04B F26B |
| A | FR 946 126 A (ANTON PISCHINGER) 24 May 1949 (1949-05-24) * the whole document * | 5 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 26 July 2005 | Orij, J |

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 42 5017

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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26-07-2005

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| DE 19541866 A1 | 15-05-1997 | AT 182086 T | 15-07-1999 |
| | | AU 7622196 A | 29-05-1997 |
| | | BA 98310 A | 02-08-1999 |
| | | BG 63037 B1 | 28-02-2001 |
| | | BG 102422 A | 30-11-1998 |
| | | CN 1201402 A | 09-12-1998 |
| | | CZ 9801284 A3 | 17-03-1999 |
| | | DE 59602460 D1 | 19-08-1999 |
| | | WO 9717131 A1 | 15-05-1997 |
| | | EP 0873181 A1 | 28-10-1998 |
| | | GR 3031449 T3 | 31-01-2000 |
| | | HU 9900732 A2 | 28-07-1999 |
| | | IL 123862 A | 06-12-2000 |
| | | JP 2000501020 T | 02-02-2000 |
| | | PL 326492 A1 | 28-09-1998 |
| | | SI 9620118 A | 31-12-1998 |
| | | SK 56898 A3 | 11-02-1999 |
| | | TR 9800791 T2 | 21-07-1998 |
| US 4531304 A | 30-07-1985 | AU 544296 B2 | 23-05-1985 |
| | | AU 6994681 A | 19-11-1981 |
| | | CA 1168031 A1 | 29-05-1984 |
| | | DE 3118046 A1 | 08-04-1982 |
| | | JP 57047784 A | 18-03-1982 |
| | | NZ 197078 A | 05-12-1986 |
| US 4772439 A | 20-09-1988 | NONE | |
| US 3614074 A | 19-10-1971 | DE 2055390 A1 | 19-05-1971 |
| | | FR 2067288 A5 | 20-08-1971 |
| | | GB 1326575 A | 15-08-1973 |
| | | JP 50024736 B | 18-08-1975 |
| FR 946126 A | 24-05-1949 | NONE | |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82