

Method for freeze-drying a product and freeze-drying apparatus for carrying out the method

Field of the invention

- 5 The present invention relates to a method for freeze-drying a product using a freeze-drying apparatus, and to a freeze-drying apparatus for carrying out said method.

Background of the invention

- 10 In the field of freeze-drying it is generally known and preferred to use freeze-dryers comprising a vacuum-chamber in which product receptacles comprising a solid bottom and an open top and containing a product to be freeze-dried are placed between heating elements upon insertion. Such a freeze-dryer is known from e.g. US 3382586.

- 15 The product receptacles, traditionally being trays, are used to avoid product loss when moving the product during the freeze-drying process. To save space and freeze-dry larger quantities of product simultaneously, the product receptacles are traditionally stacked in the freeze-drying apparatus in such a way that a heating element is situated
20 between each two trays.

- Upon insertion of the product containing product receptacles the vacuum chamber is sealed off and evacuated to a pressure well below 6.1 mbar, being the pressure coordinate of the triple-point of water. Subsequently the heating elements are brought to emit heat. In the
25 above-mentioned US reference, the trays are placed directly on the heating elements and the heat will be transferred to the product to be freeze-dried by radiation and conduction. In further developments of such an apparatus, the trays are suspended at a distance from the heating elements, and the heat is transferred to the product solely by
30 radiation as no convection occurs due to the low pressure. The heating by radiation in combination with the low pressure ensures that water is removed from the product by sublimation only and substantially without any melting of the water.

 A freeze drying process may be performed in a batch appa-

tus/process or in a continuous apparatus/process. In a batch process trays are loaded into a chamber, vacuum is established, drying takes place, normal pressure is established, and trays are finally being removed. In a continuous process trays or product are loaded suc-
5 cessively through an airlock into the evacuated chamber, transported through drying zones, and removed through an outlet airlock. In a continuous apparatus, the receptacles may be trays or a conveyer belt.

In the prior art freeze-drying systems each heating element is traditionally brought to radiate heat upwards and downwards to freeze-
10 dry a product placed in a product receptacle located above and below, respectively, the heating element. This is particularly advantageous in combination with the mentioned stacking of the product receptacles, in which the same heating element therefore emits heat radiation to the top of one product receptacle and to the bottom of another product
15 receptacle. This configuration is also preferred since radiating heat from both above and below accelerates sublimation because the speed of sublimation is dependent on how fast the heat energy may be transferred to the product.

However, the product pieces situated near the solid bottom of a
20 product receptacle are taking longer to be freeze-dried as the heat transfer through the solid bottom of the product receptacle is comparatively smaller than the heat transfer by direct radiation. This is believed to be due to the solid bottom of the product receptacles having an insulating effect. Consequently, the product dries faster from the top,
25 where the maximum allowable product temperature is reached relatively fast. As the maximum allowable product temperature is reached it is necessary to reduce the temperature of the heating elements and thus the initial energy of the heat radiation to stabilize the product temperature at said maximum. This has to be done without exceeding said
30 maximum temperature at any time, as excessive heating of the product will cause qualitative deterioration of the product. Hence, the need for keeping the temperature at the top below the maximum temperature necessitates a longer time for carrying out complete freeze-drying of a product.

Summary of the invention

The object of the present invention is thus to provide a method for freeze-drying a product whereby the time needed for completing the freeze-drying process may be shortened while preserving the quality of the product.

A further object of the present invention is to provide a freeze-drying apparatus adapted to carry out a method according to the invention, thus achieving a freeze-dried end product in a shorter time than possible hitherto.

In a first aspect of the invention this object is achieved by providing a method for freeze-drying a product using a freeze-drying apparatus, the method comprising the steps of providing a freeze-drying apparatus, providing said freeze-drying apparatus with a plurality of product receptacles comprising a solid bottom and an open top, and with a plurality of heating elements comprising a bottom surface and a top surface, providing a product to be freeze-dried in each of said product receptacles, placing said product receptacles and said heating elements above one another such that at least one heating element is placed between each two product receptacles, and providing heat radiation from said heating elements to said product, wherein the energy of said heat radiation is dependent on whether the heat is transferred directly to said product or through the bottom of said product receptacle to said product.

Such a method provides for an optimization of the heat transfer to the product to be freeze-dried, whereby the product may be freeze-dried in significantly shorter time than with methods of the prior art. Adapting the energy of the heat radiation in dependence of whether the heating elements provide the heat directly to the product or through the product receptacle bottom, which to some extent absorbs the radiated heat, makes it possible to attain a more uniform temperature throughout the product contained in the product receptacle.

In one development of the method the step of providing heat radiation comprises providing said heat radiation with a larger initial

energy when the heat is transferred through the bottom of a product receptacle to a product than when the heat is transferred directly to a product.

In this way it is made possible to optimize the heat transfer to all segments of the product by taking heat absorbed in the bottom of a product receptacle into account. The initial energy emitted from a heating element positioned below a product receptacle is larger than the initial energy emitted from a heating element positioned above the corresponding product receptacle.

10 In a particularly preferred development the method comprises the additional step of providing a shielding between said product to be freeze-dried and a heating element adapted to transfer heat directly to said product, whereby the amount of heat transferred to the product from a given heating element and thus from a given direction may be
15 modified. This makes it possible to utilize one and the same heating element for providing the heat to the product receptacles positioned above and below the heating element.

If the shielding is for instance placed to shield the product from a part of the heat radiated directly onto said product such shielding may
20 be used to absorb an amount of heat similar to that absorbed by the bottom of a product receptacle, hence providing for the desired heat transfer optimization.

In a further particularly preferred development of the method only one heating element is placed between each two product receptacles, and the method comprises the further step of providing each
25 heating element with a difference in surface temperature between its top surface and its bottom surface, thus varying the initial heat energy emitted from the heating element. This development enables the desired heat transfer optimization to be provided without having to provide for
30 additional shielding means, thus being even simpler than the embodiment mentioned previously.

In a preferred development the step of providing a difference in surface temperature comprises modification of the geometrical shape of said heating elements and/or the combination of materials constituting

said heating elements.

According to further developments of the method a modification of the geometrical shape of a heating element comprises modifying the shape of one or more surfaces of said heating element and a modification of the combination of materials constituting a heating element comprises providing one or more surfaces of said heating element with a coating and/or providing said heating element with a plurality of layers of varying materials. Such modifications provide for different patterns and/or magnitudes of heat radiation, hence providing the desired heat transfer modification.

A further particularly preferred development of the method comprises the further step of providing means for individually controlling the surface temperature or temperatures of each heating element, whereby the heat transfer may be controlled according to the requirements of a specific product and/or specific circumstances. Such control may be performed prior to the initiation of a freeze-drying process, or even in real time during a freeze-drying process.

In another particularly preferred development of the method the step of providing said plurality of heating elements comprises arranging the heating elements to form at least two separate heating zones, and the further optional step of providing means for transporting said product into and out of said heating zones. In this way the method according to the invention provides for the possibility of sub-dividing a freeze-drying process into several independent steps, during each of which the temperature and time used may be varied, thus further improving both processing speed and quality of the freeze-drying process according to the invention.

In a second aspect of the invention a freeze-drying apparatus for freeze-drying a product is provided, said apparatus being adapted to carry out a method according to the invention.

The invention is relevant for both batch and continuous freeze dryers and the receptacles may be of any suitable embodiment, such as trays or a conveyer.

Brief description of the drawings

The invention will now be described in further detail based on a non-limiting exemplary embodiment, and with reference to the drawings. In the drawings,

5 Fig. 1 shows a sectional view of a freeze-drying apparatus according to the present invention comprising a plurality of heating zones,

 Fig. 2 shows a cross-sectional view of an embodiment of the freeze-drying apparatus according to the invention taken through a heating zone,

10 Fig. 3 is a schematic view of a detail of an embodiment of the freeze-drying apparatus, shown as a section of a heating zone according to Fig. 2,

 Fig. 4 shows a view corresponding to Fig. 3 of an embodiment of the freeze-drying apparatus according to the invention featuring a
15 shielding,

 Fig. 5 is a schematic view of another embodiment of a freeze-drying apparatus according to the invention, shown as a section of a heating zone corresponding to Fig. 3 but featuring two heating plates, and

20 Fig. 6 is a schematic view of another embodiment of a freeze-drying apparatus corresponding to the invention, shown as a section of a heating zone according to Fig. 5 featuring a shielding.

Detailed description of the invention and of preferred embodiments

25 With reference to Fig. 1 a longitudinal cross-section of an embodiment of a continuous freeze-drying apparatus 1 is shown. The freeze-drying apparatus shown comprises a body 9 having an opening 5 at a first end 6 and an opening 7 at a second end 8, respectively. The openings 5, 7 serve maintenance purposes, and are normally sealed in
30 an airtight manner by closing and locking the first and second ends 6, 8 respectively. Loading/unloading airlocks (now shown) and elevators 3, 4 are placed in each end of the apparatus, the function of which will be described in further detail below. The apparatus 1 further comprises one or more heating zones, in the embodiment shown in Fig. 1 eight zones

2a, 2b...2h, for drying a product (not shown) which is successively transported through the zones. An inlet and an outlet for respectively feeding a heating medium, e.g. hot water, to and discharging the heating medium from heating elements in the body 9 are provided in a manner known *per se*. It is generally known in the field of freeze-drying that the interior space of the body 9 of the apparatus 1 should be capable of being evacuated to and kept at a pressure sufficiently low to ensure that a product will be freeze-dried substantially by heat radiation only.

Such air locks are known in the art and are adapted to transfer the product receptacles from the outside and into the freeze-drying apparatus 1 and vice versa. The product receptacles are introduced successively through the air lock at the first end 6 to the elevator 3. When one product receptacle has been moved into the elevator 3, the elevator 3 is moved upwards to make room for the following product receptacle. When the elevator 3 has been filled with the appropriate number of product receptacles, all of the product receptacles in the elevator are moved into the heating zone closest to the first end 6, i.e. heating zone 2a in the shown embodiment of the freeze-drying apparatus 1. In case a corresponding number of product receptacles was already present in the first heating zone 2a, these product receptacles are moved into the next heating zone 2b during this operation. Correspondingly, product receptacles present in the remaining heating zones 2b...2g are moved to the respective following heating zone 2c...2h, whereas the product receptacles located in the heating zone 2h closest to the second end 8 of the freeze-drying apparatus 1 are moved into the elevator 4. Here, the product receptacles are unloaded successively from the freeze-drying apparatus through the airlock at the second end 8 to an unloading device (not shown). The operation thus entails that one product receptacle is loaded into the apparatus 1 at the first end 6 and one product receptacle is simultaneously unloaded from the apparatus at the second end 8. The operation may for instance be carried out as a fully automatic process.

Fig. 2 illustrates a transverse cross-section through the first

heating zone 2a of the freeze-drying apparatus 1. The heating zone 2a comprises a plurality of heating elements 10 between which a plurality of product receptacles 11 may be placed to form an array of heating elements 10 and product receptacles 11. The product receptacles 11
5 have prior to entering the apparatus 1 through the airlocks been filled with a product (not shown) to be freeze-dried. Fig. 2 illustrates an example of an embodiment according to the invention of an apparatus incorporating such an array. However, it is obvious to a person skilled in the art that other configurations according to the invention are possible,
10 e.g. including a different number of heating elements 10 and product receptacles 11.

When the product receptacles 11 containing the product to be freeze-dried have been placed in the heating zone 2a the heating elements 10 are brought to radiate heat whereby heat is transferred to
15 the product that is thus freeze-dried. Heating of the heating elements 10 may be provided in any suitable manner. For instance, the heating elements 10 may, as shown, be connected to conduit 3a supplied from the not-shown inlet for conducting a heating medium, e.g. hot water, through the heating elements 10 to thereby provide the heating. The
20 spent heating medium is discharged through conduit 4a leading to the outlet (not shown either). Other heat sources may be utilized as well, e.g. electrical heating of the heating elements 10. The array of product receptacles 11 are moved successively from one heating zone 2a to the next heating zone 2b, until the array reaches the second end 8 of the
25 body 9. The finished product is eventually removed from the freeze-drying apparatus 1 through the airlock at the second end.

Although not shown in the drawings, the invention is equally applicable to a batch freeze dryer. In such a freeze dryer, the product receptacles are placed in a chamber constituting a single heating zone
30 when the access door or gate has been opened. This loading may e.g. be carried out manually or by means of an automated lifting device. Subsequently, the access door or gate is closed, vacuum is established and the drying takes place, following which normal pressure is established and the product receptacles, e.g. in the form of trays, are

removed, either manually or by means of the lifting device. Instead of moving the product receptacles through the heating zones providing individually set temperatures as described in the above, the temperature of the heating elements in the single heating zone is varied over time.

5 Generally, a product receptacle 11 comprises an open top 13 and a solid bottom 14, and a heating element 10 comprises a top surface 15 and a bottom surface 16, as can be seen from e.g. Fig. 3 showing a segment of a heating zone 2a having a structure similar to the one shown in Fig. 2.

10 According to the invention the heat radiation originating from the surfaces 15, 16 of the heating elements 10 is provided with an initial energy that is dependent on whether the heat is transferred directly to the product or through an intermediate element to the product.

 The receptacles are advantageously optimized to receive prod-
15 uct and/or are optimized to receive heat energy. To this end, the receptacles may include fins and/or the outer surface of the tray bottom may be optimized to receive heat. This applies to receptacles both of the tray and of the conveyor kind.

 In a first embodiment of an apparatus for carrying out the
20 method according to the invention this may be achieved with a configuration as shown in Fig. 3 by providing the top surface 15 and the bottom surface 16 of the heating element 10 with different surface temperatures. In this way it is possible to take into account that part of the heat radiation emitted from the top surface 15 in the configuration
25 according to Fig. 3 will be absorbed in the solid bottom 14 of the upper product receptacle 11 by raising the surface temperature of the top surface 15.

 According to the invention the difference in surface temperature may be obtained by manipulating the shape and/or material composition
30 of the heating element 10. For example the shape of one or both of the surfaces 15, 16 of a heating element 10 may be modified, e.g. to be concave or convex or a combination thereof, and/or the heating element 10 may for instance have a sandwich structure consisting of a plurality of materials or mixtures of materials with different properties regarding

heat, and/or a part of or all of one or both of the surfaces 15, 16 of the heating element 10 may be provided with a coating layer or other surface treatment, for instance having heat absorbing properties.

In another particularly preferred embodiment of an apparatus
5 for carrying out the method according to the invention a shielding 12 is inserted between the heating element 10 and the lower product receptacle 11 as shown in Fig. 4. With this configuration part of the heat radiation transferred from the bottom surface 16 of the heating element to the product through the open top 13 of the lower product receptacle
10 11 may be absorbed in the shielding 12. This allows for a generally higher surface temperature of the heating element 10, thus taking into account the part of the heat radiation emitted from the top surface 15 that will be absorbed in the solid bottom 14 of the upper product receptacle 11. To this end the shielding 12 is preferably made of a heat
15 absorbing and/or insulating material.

In yet other embodiments of the invention exemplified by Figs 5 and 6 both featuring two heating elements 10 there may be more than one heating element 10 between two neighbouring product receptacles 11.

20 With a configuration of the type shown in Fig. 5 the difference in surface temperature may now be obtained by manipulating the shape and/or material composition of one or more of the heating elements 10 as described in detail above.

With reference to Fig. 6 a shielding 12 may be introduced. The
25 shielding may for instance as shown in Fig. 6 be placed between the heating elements 10. In this way it is possible to prevent downwardly directed heat radiation from the upper heating element and/or upwardly directed heat radiation from the lower heating element from passing the inserted shielding. Consequently it is now possible to obtain the desired
30 difference in surface temperature by simply inducing different surface temperatures on each of the heating elements. The shielding 12 may however in principle also be placed in any other desired position between the upper and lower product receptacle 11.

EXAMPLE

In the following a practical example will be given in order to further illustrate the method according to the invention, and in particular highlight the advantages of the present invention.

5 A series of test runs using a small-scale freeze-dryer designed for test work was conducted using trays as product receptacles. The freeze-dryer used is a batch dryer comprising a heating zone having heating elements in the form of plates, and is suitable to successively simulate the principle configuration of the dryer shown in Fig. 1.

10 Furthermore the freeze-dryer used for the test runs has a maximum evaporative capacity of approximately 2 kg/h and the amount of product feed required is between 0 and 6 kg – typically 1.5 to 2 kg. The freeze-dryer used has a tray system with 4 trays, each having an area of 0.19 m², and a weighing device for accurate control of the process. The
15 freeze dryer can operate at a pressure as low as 0.2 mbar.

The process was continuously monitored and controlled by the selection of drying parameters such as vacuum, heating plate temperatures and maximum product temperature.

The test runs were conducted to test the capacity with higher
20 heat input from the bottom than from the top of the tray and to produce a freeze-dried product for evaluation of the effects of higher heat input from the bottom of the tray.

The results of the test runs are displayed in table 1 below.

In the table the test run displayed in the column marked SUB
25 1.7 represents a test run using the standard according to the state of the art, that is without increased heat input from a heating element to the bottom of a product receptacle situated above it. Hence this trial represents a reference used for comparison.

The subsequent test runs – displayed in the columns denoted
30 SUB 2.0, SUB 2.2 and SUB 2.4 respectively – all serve to illustrate the effect of using a method according to the invention, thus ensuring an increased heat input from the bottom of the product receptacles. In the first of these (SUB 2.0) only three of the heating zones were operated according to the method of the invention, whereas all ten zones in the

last two (SUB 2.2 and SUB 2.4) were operated according to the method of the invention, albeit with different heating plate temperatures.

TABLE 1: Results from test run using a method according to
5 the invention

	SUB 1.7	SUB 2.0	SUB 2.2	SUB 2.4
Tray Load	12.5 kg/m²	12.6 kg/m ²	12.5 kg/m ²	12.8 kg/m ²
Pressure	0.4 mbar	0.4 mbar	0.4 mbar	0.4 mbar
Zone 1	80 °C	120 °C	120 / 143 °C	120 / 143 °C
Zone 2	130 °C	140 °C	140 / 143 °C	140 / 143 °C
Zone 3	135 °C	140 °C	140 / 143 °C	140 / 143 °C
Zone 4	135 °C	140 °C	140 / 143 °C	140 / 143 °C
Zone 5	135 °C	140 °C	140 / 143 °C	140 / 143 °C
Zone 6	120 °C	140 °C	140 / 143 °C	140 / 143 °C
Zone 7	105 °C	120/140 °C	125/140 °C	125/143 °C
Zone 8	85 °C	100/130 °C	100/130 °C	100/143 °C
Zone 9	65 °C	75/85 °C	75/85 °C	75/95 °C
Zone 10	55 °C	60 °C	60/70 °C	60/75 °C
Max. product temperature	55 °C	55 °C	55 °C	55 °C
Drying time	250 min.	210 min.	190 min.	180 min.
Sublimation	1.7 kg/m²h	2.0 kg/m ² h	2.2 kg/m ² h	2.4 kg/m ² h

For each of the test runs table 1 displays the heating plate temperature used in each heating zone. Where appropriate the temperatures are displayed in the form "bottom surface temperature/top surface temperature". That is, for e.g. zone 2 of the test run SUB 2.4 the heating elements had a bottom surface temperature of 120°C and a top surface temperature of 143°C.

As can be seen from the table, increasing the temperature of the top side of the heating elements and thus the heat input to the bottom of the product receptacle causes sublimation to increase from

1.7 kg/m²h in the reference test run (SUB 1.7) to 2.4 kg/m²h when operating with the highest difference in heat input (SUB 2.4).

Hence, the test runs verify that by increasing the heat input to the bottom of the product receptacle the drying time may be lowered
5 from 250 minutes (SUB 1.7) to as little as 180 minutes (SUB 2.4), corresponding to increasing the capacity by as much as 41%, without increasing the product temperature during the drying.

Furthermore it can be seen that in all the tests the maximum temperature of the product is 55 °C and even with the higher heat input
10 to the bottom than to the top of the product receptacle the highest product temperatures are still measured at the top of the product layer.

Finally it should be noted that all the tests were made without any melting of the granules.

The small-scale freeze-dryer utilized in the test run was limited
15 to a maximum temperature of 143°C. In practice, the process would be optimized according to the field of application. For instance, it may be an aim to have the same temperature difference between the heat input from the top and the bottom, respectively, of the product receptacles. As an example, the temperature differences of the test run values 120 / 143
20 °C; 140 / 143 °C could be modified into the temperature differences 120 / 140 °C; 140 / 160 °C and so on. The condition underlying the optimization is, of course, that the maximum allowable temperature of the product is not exceeded.

Obviously the above description of preferred embodiments
25 merely serve as an example, and the skilled person would know that numerous variations and combinations are possible without departing from the scope of the claims.

P A T E N T C L A I M S

1. A method for freeze-drying a product using a freeze-drying apparatus, said method comprising the steps of:
 - providing a freeze-drying apparatus,
 - 5 - providing said freeze-drying apparatus with a plurality of product receptacles comprising a solid bottom and an open top, and with a plurality of heating elements comprising a bottom surface and a top surface,
 - 10 - providing a product to be freeze-dried in each of said product receptacles,
 - placing said product receptacles and said heating elements above one another such that at least one heating element is placed between each two product receptacles, and
 - providing heat radiation from said heating element to said product, wherein the energy of said heat radiation is dependent on whether the heat is transferred directly to said product or through the bottom of said product receptacle to said product.
 - 15 2. The method of claim 1, wherein the step of providing heat radiation comprises providing said heat radiation with a larger initial energy when the heat is transferred through the bottom of a product receptacle to a product than when the heat is transferred directly to a product.
 - 20 3. The method of claim 1 or 2, comprising the additional step of providing a shielding between said product to be freeze-dried and a heating element adapted to transfer heat directly to said product.
 - 25 4. The method of any one of the preceding claims, where only one heating element is placed between each two product receptacles, and comprising the further step of providing each heating element with a difference in surface temperature between its top surface and its bottom surface.
 - 30 5. The method of claim 4, wherein the step of providing a difference in surface temperature comprises modification of the geometrical shape of said heating element and/or the combination of materials constituting said heating element.

6. The method of claim 5, wherein said modification of the geometrical shape of a heating element comprises modifying the shape of one or more surfaces of said heating element.

5 7. The method of claim 5, wherein said modification of the combination of materials constituting a heating element comprises providing one or more surfaces of said heating element with a coating or surface treatment and/or providing said heat element with a plurality of layers of varying materials.

10 8. The method of any one of the preceding claims comprising the further step of providing means for individually controlling the surface temperature or temperatures of each heating element.

9. The method of any one of the preceding claims, wherein the heat radiation from said heating element to said product is varied over time.

15 10. The method of any one of the preceding claims, wherein the step of providing said plurality of heating elements comprises arranging the heating elements to form at least one separate heating zone, and comprising the further optional step of providing means for transporting said product into and out of said heating zone or zones.

20 11. The method of claim 10, whereby 4 to 12, preferably 6 to 10, most preferred 8 heating zones are provided.

12. A freeze-drying apparatus for freeze-drying a product, comprising a plurality of product receptacles, a plurality of heating elements, said plurality of heating elements being arranged to form one or more
25 heating zones, wherein said apparatus is adapted to carry out the method according to any one of claims 1 to 11.

13. An apparatus as claimed in claim 12, wherein said receptacles are trays.

14. An apparatus as claimed in claim 12, wherein said receptacles are integrated in a conveyor belt or constituted by a conveyor belt.
30

15. An apparatus as claimed in any one of claims 12 to 14, wherein said receptacles are optimized to receive product and/or are optimized to receive heat energy.

16. An apparatus as claimed in claim 12 or 13, wherein means

for transporting said product into and/or out of said heating zone or zones is provided, said means for transporting said product into and out of said heating zone or zones being an automated receptacle moving system.

5 17. An apparatus as claimed in claim 12 or 14, wherein means for transporting said product into and/or out of said heating zone or zones is provided, said means for transporting said product into and out of said heating zone or zones being a conveyor belt.

10 18. An apparatus as claimed in any one of claims 12 to 17, wherein a shielding is provided between said product to be freeze-dried and a heating element, particularly a heating element situated above the product receptacle to transfer heat directly to said product.

15 19. An apparatus as claimed in any one of claims 12 to 18, comprising only one heating element between each two product receptacles, wherein each heating element comprises a difference in surface temperature between its top surface and its bottom surface.

20 20. An apparatus as claimed in any one of claims 12 to 19, wherein said difference in surface temperature is obtained by modification of the geometrical shape of said heating element and/or the combination of materials constituting said heating elements.

21. An apparatus as claimed in claim 20, wherein said geometrical shape modification comprises modifying the shape of one or more surfaces of a heating element.

25 22. An apparatus as claimed in claim 20 or 21, wherein said modification of the combination of materials comprises providing one or more heating elements with a sandwich structure comprising one or more or a mixture of materials with different properties and/or providing a part of or all of one or more surfaces of said heating elements with a coating.

30 23. An apparatus as claimed in any one of claims 12 to 22, further comprising means for individually controlling the surface temperature or temperatures of each heating element.

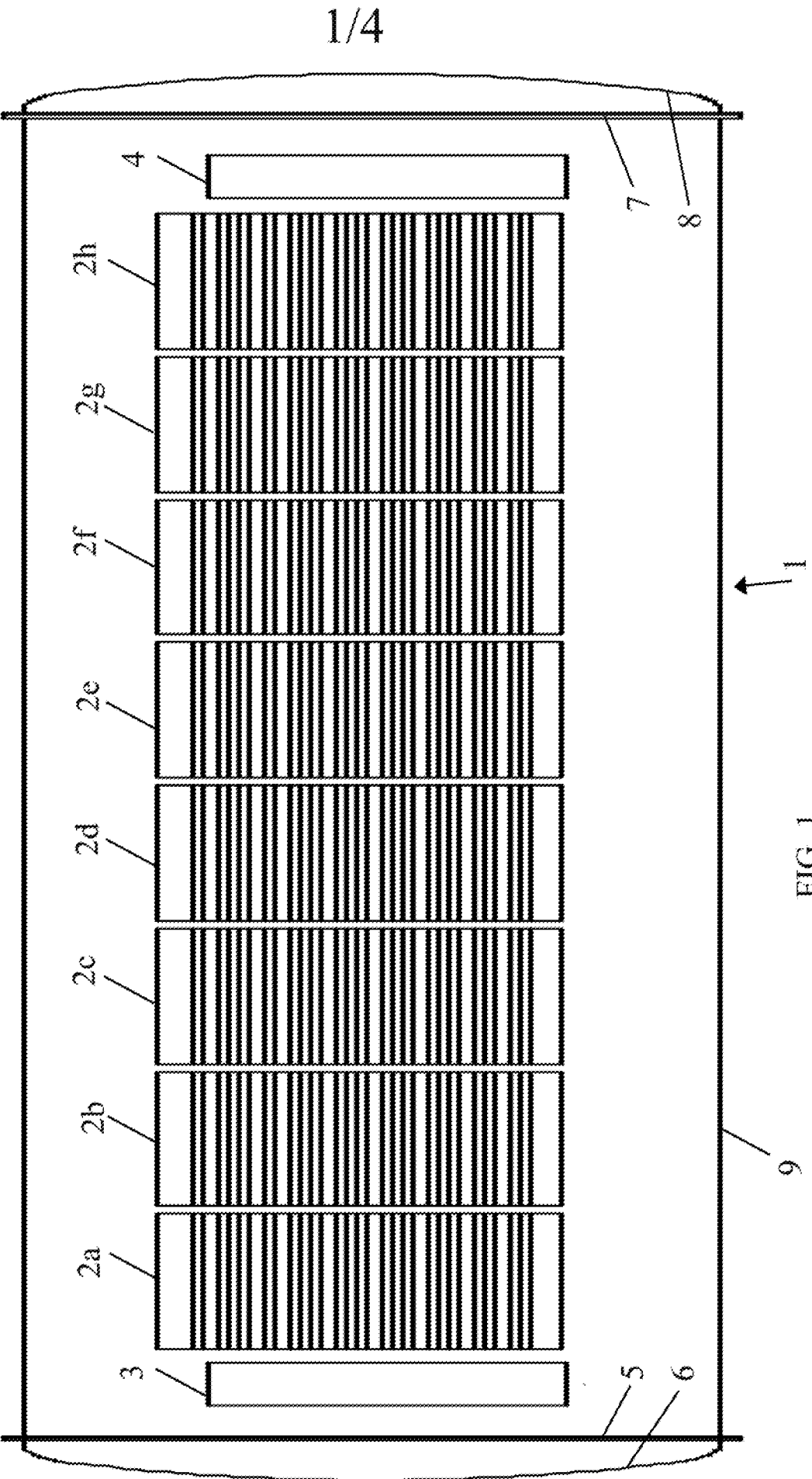


FIG. 1

2/4

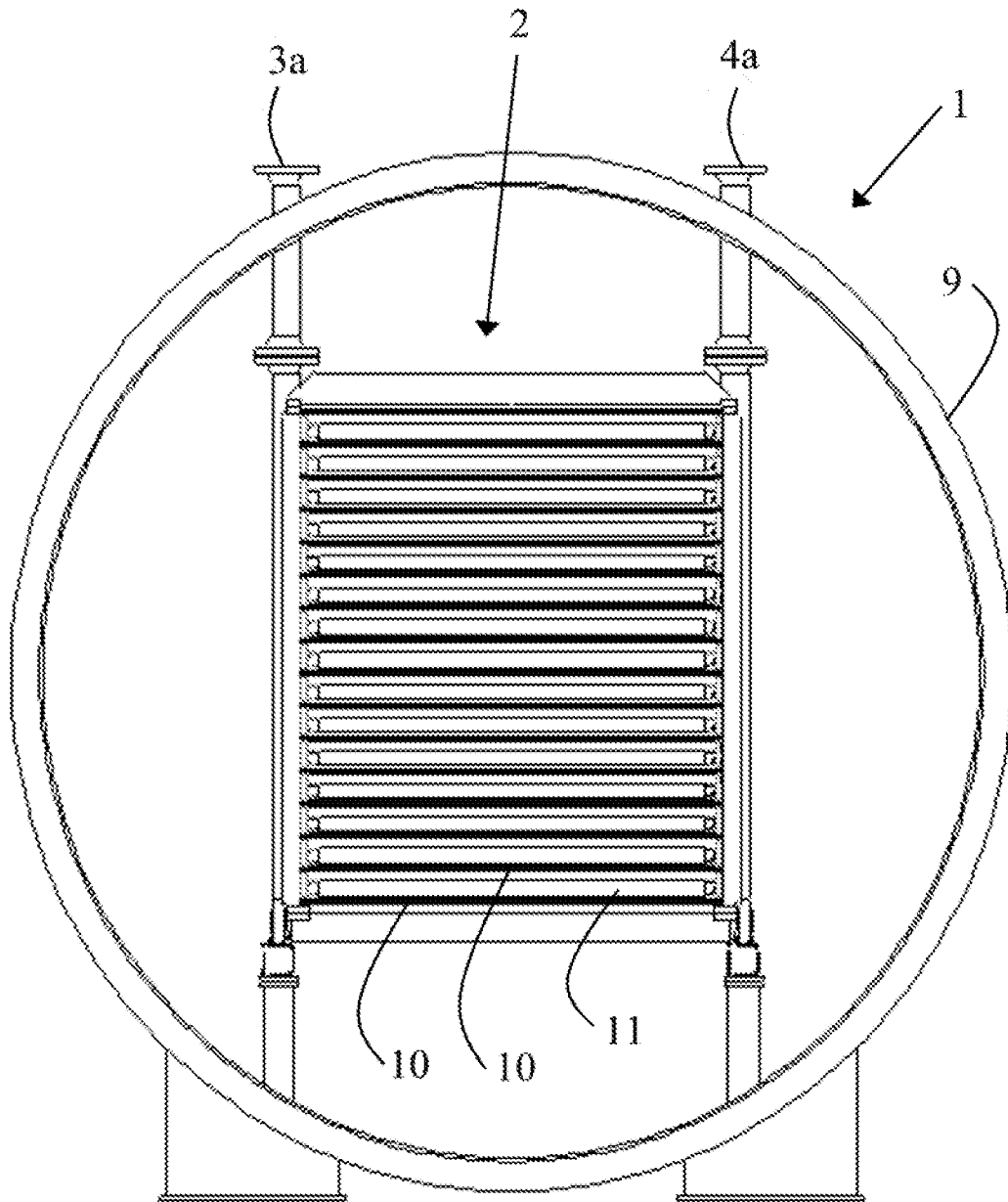
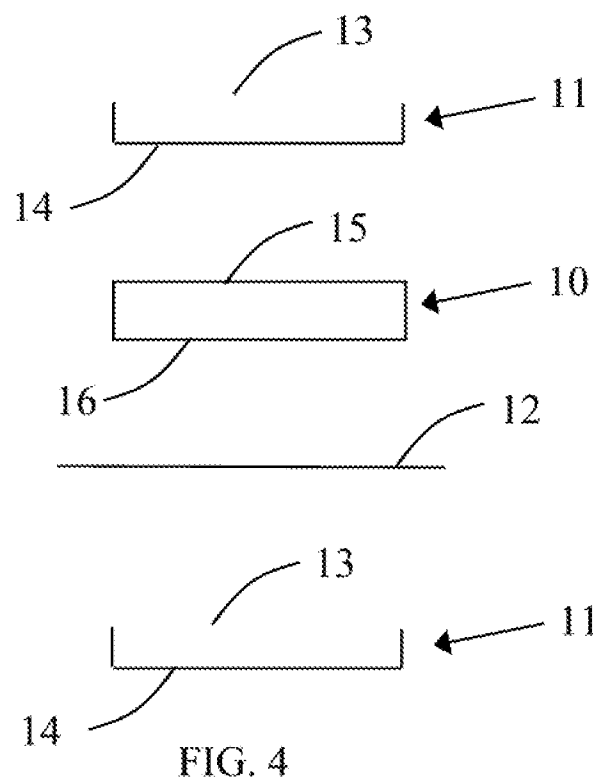
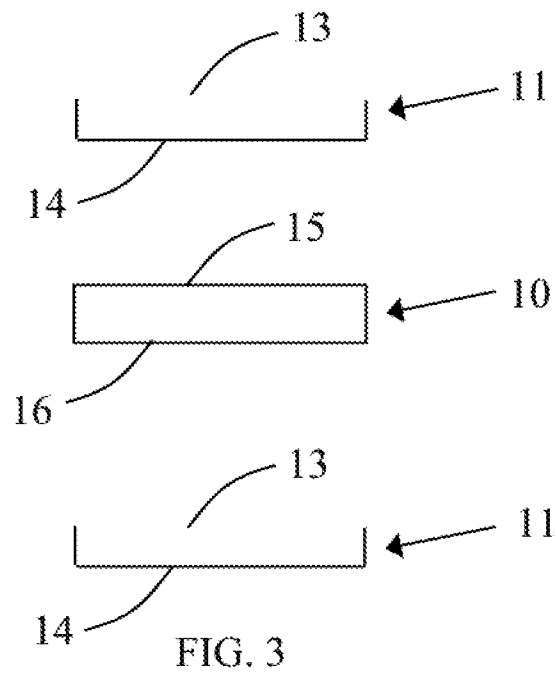


FIG. 2

3/4



4/4

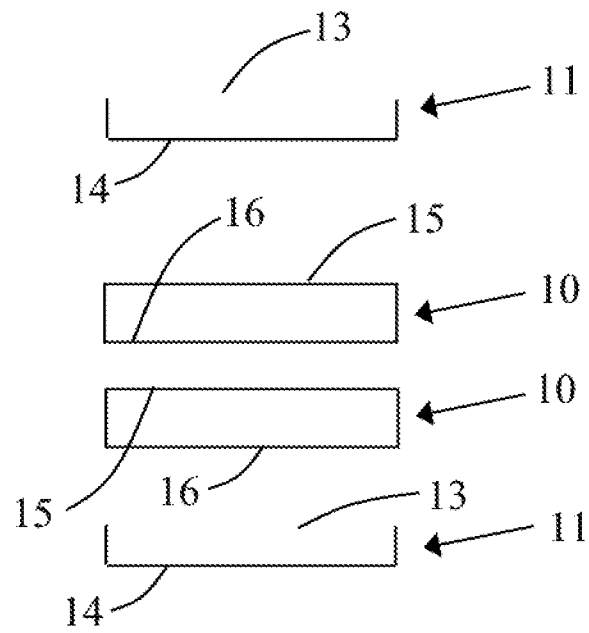


FIG. 5

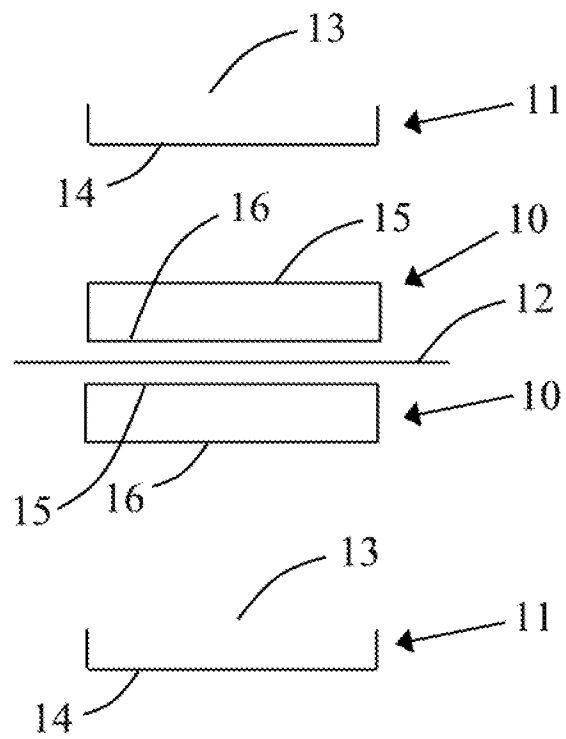


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2007/050089

A. CLASSIFICATION OF SUBJECT MATTER

INV. F26B5/06

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 practical, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 58 074103 A (YAMANOUCHI PHARMA CO LTD) 4 May 1983 (1983-05-04)	1,4,8, 10,12,19
Y	abstract; figure	7,20,22
Y	----- US 3 135 589 A (EVANS STOKES DAVID) 2 June 1964 (1964-06-02)	7,20,22
A	the whole document	1,12,13
X	----- US 3 318 012 A (PERCY THOMPSON HUGH) 9 May 1967 (1967-05-09)	1,2,9, 10,12,13
Y	the whole document	10,11, 14-17
Y	----- US 3 769 717 A (CARLSEN C ET AL) 6 November 1973 (1973-11-06)	10,11,16
A	the whole document	1,12,13
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

3 June 2008

Date of mailing of the international search report

13/06/2008

Name and mailing address of the ISA/

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Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Silvis, Henk

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International application No

PCT/DK2007/050089

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