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(54) **METHOD FOR INHIBITING CONTAMINATION OF A WORKPIECE**

VERFAHREN ZUR VERHINDERUNG DER VERUNREINIGUNG EINES WERKSTÜCKS

PROCÉDÉ PERMETTANT D'INHIBER LA CONTAMINATION D'UNE PIÈCE À TRAVAILLER

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to method for inhibiting contamination of a workpiece according to the preamble of patent claim 1 and the preamble of patent claim 19, respectively.

[0002] Such a method and such a device can be used to inhibit contamination in various types of heat treatment of different products and components, yet for exemplifying but by no means limiting purposes a description will here follow of how the method and the invention can be applied so as to inhibit one or more components from being contaminated when joined together by soldering in an oven.

BACKGROUND OF THE INVENTION

[0003] There is a need within the aviation industry, for example, to heat-treat various types of workpieces. When various components, such as, for example, plates, are joined together by soldering, the components are heated in an evacuated oven. The oven is evacuated in order to create a vacuum in the oven and thereby lower the partial pressure for the unwanted chemical compounds which would otherwise react with the workpiece and cause contamination of the workpiece. Despite the fact that many vacuum ovens can have low pressures, they often have leaks in the construction which cause air to filter into the oven. For many sorts of materials, the pressure in the oven is nevertheless sufficiently low for the oven to be able to be used to perform the heat treatment with the desired result. This means, however, that any oven leaks often remain undetected and unsealed, since it is not profitable to try thereby to obtain a better vacuum.

[0004] Workpieces made of highly contamination-sensitive materials, such as various titanium alloys, cannot, however, be heat-treated in such "leaky" and hence contaminated ovens. The properties of these materials are impaired even at relatively low partial pressures of certain contaminants, such as, for example, oxygen. Apart from the measures to increase pump capacity for evacuation of the oven or to make the oven as leak-tight as possible, an inert gas can be used to avoid contamination of the workpiece.

[0005] A method according to the prior art which utilizes a protective gas of this kind is described in DE-A-24 48 714. In this method, the partial pressures of unwanted gases are controlled by a flow of protective gas, such as argon, streaming continuously through the oven. The method does, however, have drawbacks. One drawback is that the purity of the oven atmosphere is determined by the purity of the protective gas. There are always contamination products present in a protective gas and these will be fed continuously to the oven together with the other gas. The oven is also required to be suitable for use of a protective gas, which means, in turn, that an existing oven may need to be modified, i.e. it is not possible to use just any vacuum oven, but rather the oven is required, for example, to have necessary gas connections. Moreover, a continuous flushing of the oven using a highly pure gas, i.e. a high gas consumption, involves substantial costs associated with the method.

OBJECT OF THE INVENTION AND SUMMARY OF THE INVENTION

[0006] One object of the present invention is to provide a method of the type defined in the introduction, in which method at least some of the above-mentioned drawbacks of previously known such methods have been substantially reduced, i.e. to provide a method by which contamination of a workpiece can be inhibited even when the workpiece is heated in a relatively impure oven.

[0007] The object is achieved by the provision of a method according to patent claim 1.

[0008] The fact that, in a first step, the first container is flushed and filled with a protective gas and, in a second step, the second container, preferably an oven, and hence the first container, is evacuated to create a vacuum inside the first and second container, so as, during the first and second step, to reduce the partial pressure for the contaminant in the first container before the workpiece is heated, means that the likelihood of substantial contamination of the workpiece is diminished. The initial concentration of a contaminant in the first container can be considerably reduced by such a method. This method should not be confused with methods according to the prior art in which continuous flushing of the oven is required throughout the heating process in order to inhibit contamination of the oven and of the workpiece being heated. According to the method according to the invention, the first container can be flushed and filled with a protective gas, for example argon, as a one-off measure, and placed in the second container, whereafter necessary evacuation is performed.

[0009] In the subsequent heating of the workpiece, either a duct, preferably a duct of relatively large volume which can act as a buffer in case of pressure fluctuations in the second container, and/or a valve system can be used to establish an atmospheric connection between the first and second container while contamination of the workpiece is inhibited. The difference in partial pressure between the contaminant in the second container and the contaminant in the first container, which difference can arise during heating as a result of leaks from the environment into the second container, tends to be equalized by the transport of such contaminant from the second container in the direction of the first container. The use of a duct which has a cross section possessing at least one dimension with an extent in the same order of magnitude as the mean free path, and preferably less than the mean free path, which the contaminant has in the atmosphere prevailing in the duct as the workpiece

is heated increases the likelihood of such a contaminant reacting with the limit face of the duct, whereby the transport of such a contaminant to the first container is inhibited.

[0010] What is meant here, of course, is the use of a duct whereof said one cross-sectional extent is substantially larger than the cracks which might be present in the first container and might be identified visually or with a microscope. It is generally the case that the better the vacuum which can be obtained, the larger is the permitted cross-sectional dimension of the duct. In many applications, the mean free path for the molecules of the contaminant is in the order of magnitude of a few millimeters.

[0011] By means of a duct, the extent of which in the longitudinal direction is many times larger than the extent of said at least one cross-sectional dimension of the duct, the likelihood of a contaminant being able to reach the first container can be further diminished by exposing the contaminant in the duct to a relatively large surface area in relation to the path over which the contaminant has to be transported in order to make its way inside the first container and the workpiece. The likelihood of the contaminant reacting with the limit face of the duct is thereby, in turn, substantially increased.

[0012] The use of a valve system instead of, or in combination with a duct requires a slightly more advanced first container, but has the advantage that transport of contaminant from the second container to the first container during the heating phase can be very effectively inhibited. In the evacuation of the first and the second container, a valve in the first container is opened to establish an atmospheric connection between the first container and the second container, which valve is closed following completed evacuation. In the heating of the workpiece, a valve in the first container is opened at a total pressure in the second container exceeding a predetermined value or at a pressure difference between the first and second container exceeding a predetermined value. In order to inhibit contaminant from being transported to the first container, the pressure at which the valve will open should be higher than pressure fluctuations arising in the second container, but lower than the pressure required to compress the first container at the temperature in question, in order to avoid damage to the first container.

[0013] A further object of the present invention is to provide a device of the type defined in the introduction, which device is suitable for use in implementation of the method according to the invention.

[0014] A major advantage of the invention is that the method according to the invention can be used for various types of pre-existing vacuum ovens. The device is portable and, if so desired, can be reused and moved between different ovens without the ovens having to be specially modified. A cost-effective method for heating workpieces while inhibiting contamination of the workpiece, and a method which is applicable in most vacuum ovens, are therefore obtained.

[0015] Other advantages of the method according to the invention can be gleaned from the following detailed description and other contingent patent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Preferred embodiments of the invention will be described below by way of example, with reference to the appended drawings, in which:

Fig. 1 is a diagrammatic view illustrating a device according to the invention,

Fig. 2 is a cross-sectional view of the device according to Fig. 1,

Fig. 3 is a diagrammatic view illustrating a variant of the device according to the invention,

Fig. 4 is a diagrammatic view illustrating a further variant of the device according to the invention,

Fig. 5 is a diagrammatic view illustrating another variant of the device according to the invention, and

Fig. 6 is a diagrammatic view illustrating yet another variant of the device according to the invention, utilizing valves instead of a duct.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0017] In Figs. 1 and 2, an inventive device suitable for use in the implementation of the method according to the invention is illustrated diagrammatically. The device comprises a first container 1 for accommodating a workpiece 2, which first container 1 is intended for placement in a second container 3 as the workpiece 2 is heated. The second container 3 can be any arbitrary oven which is provided with a pump so that a vacuum can be created in the oven during heat-treatment of workpieces 2 in the oven. The invention can be applied at different vacuum levels and total pressure in the oven in the order of magnitude of 10^{-2} mbar has proved to be appropriate. The first container 1 further comprises a first means 4 for introduction of a protective gas and a second means 5 for establishment of an atmospheric connection between the first container 1 and the second container 3. In the example illustrated in Fig. 1, the first means is a valve 4, with associated connections, disposed in the first container 1 and the second means is a duct 5 connecting the first container 1 to the environment, i.e. to the second container 3 when the first container 1 is placed in the second container 3. The first container has at least one such duct, but, in another embodiment, could have two or more ducts.

[0018] Although the duct 5 can be produced in a variety of ways within the scope of the invention, the device in

the embodiment illustrated in Fig. 1, which has a first container 1 consisting of two parts 6, 7, in the form of a box 6 and a lid 7 for the box, for accommodating the workpiece 2 and, at the same time, creating the duct 5, has the advantage that no special means is required to open and close the first container 1 when a workpiece 2 is to be placed in or taken out of this. The lid 7 can quite simply be removed from the box 6, after which access is gained to the interior of the box.

[0019] The lid 7 is disposed in the first container 1 such that the duct 5 is formed between the lid 7 and the box 6. The cross section 8 of the duct 5 is therefore, in this case, annular. In order to produce the duct 5, one or more fixed or loose distancing elements (not shown) disposed between the upper edge 9 of the box and the lid 7 can be used to position the lid 7 and the box 6 in relation to each other so that a desired gap is obtained between the lid and the box. The duct 5 expediently has a cross section 8 possessing at least one dimension 10, here the gap width 10 between the lid and the box in the horizontal direction, with an extent in the same order of magnitude as the mean free path which the contaminant has in the atmosphere prevailing in the duct 5 as the workpiece 2 is heated, and the duct 5 preferably has a cross section possessing at least one dimension with an extent which is less than the mean free path which the contaminant has in the atmosphere prevailing in the duct 5 as the workpiece 2 is heated.

[0020] Advantageously, the duct 5 has an extent in the longitudinal direction 11 which is many times greater than the extent of at least one cross-sectional dimension 10 of the duct 5 and, preferably, the duct 5 has an extent in the longitudinal direction 11 which is more than 10 times greater than the extent of at least one cross-sectional dimension of the duct 5. In certain cases, an extent of the duct which is 50 times, and preferably 100 times greater than the extent of at least one cross-sectional dimension of the duct is more advantageous. It is desirable if the volume of the duct 5 is relatively large. This means that the duct 5 expediently has a second sizeable cross-sectional dimension and, as described earlier, a large extent in the longitudinal direction.

[0021] In the embodiment illustrated in Figs. 1 and 2, a cross-sectional dimension 12 of the duct 5 extends along the whole of the circumference of the first container 1, which means that, despite the relatively small extent of the gap 10 between the box 6 and the lid 7, the duct 5 has a relatively large cross-sectional area 8. The volume of the duct 5, i.e. the length of the duct x the cross-sectional area of the duct, in this case the duct length x the gap width x the box circumference, is expediently tailored to the volume of the first container so that the volume relationship V_1/V_k between the volume V_1 of the first container and the volume V_k of the duct is less than 20, preferably less than 15 and, more preferably, less than 10. There is also a possibility of further reducing the contamination of the workpiece 2 through the use of piece goods 13, in the form of chips, for example, for providing surfaces for the capture of said contaminant by dint of a reaction between the contaminant and the surfaces of the piece goods 13. It should be emphasized that, although the term "chips" 13, i.e. material separated in the machine-working of a workpiece, is used frequently below, it is also possible to use other piece goods which are thread-like or particular in form, such as, for example, a powder or the like, and which have surfaces suitable for capturing a contaminant.

[0022] The device according to the embodiment in Figures 1 and 2 comprises a means 14, for example a dividing plate, for dividing the first container 1 into a first chamber 15 and a second chamber 16. The dividing plate 14 is tailored to the shape and size of the first container 1 so that a gap 17 is formed between the outer edge 18 of the dividing plate 14 and the inner limit face 19 of the first container 1. Chips 13 with high affinity for one or more contaminants can hence be disposed in the first chamber 15, so that, while the first and the second chamber 15, 16 of the first container 1 are in mutual atmospheric connection, the chips 13 are separated from the workpiece 2 present in the second chamber 16.

[0023] Along its periphery, the dividing plate could have flanges, such as plates, which are essentially parallel with the inner limit face of the first container, so that the gap 17 acquires a larger extent in the longitudinal direction (in the vertical direction in Fig. 1), which means that a second duct is formed between the flanges and the internal limit face of the first container. The second duct, which therefore, in this case, connects the first and the second chamber, can be dimensioned so that it acquires essentially identical properties to the abovementioned duct situated between the box and the lid.

[0024] The chips 13 can be made of titanium, for example, and can advantageously be made of the same material as the workpiece 2 to be heat-treated or soldered. A material with high affinity for the contaminant can also be utilized in the production and/or preparation of the first container 1. For example, the internal face 20 of the duct and/or the inner side 19 of the first container can be lined with such a material in order further to reduce the risk of contamination of the workpiece. Through a choice of dimensions of the device and/or materials of the device and/or the chips, the method and the device according to the invention can be tailored to the specific contaminant against which it is wished to protect the workpiece.

[0025] A number of variants of the device according to the invention will be described below for exemplifying purposes. It should be pointed out, however, that those features will primarily be described which differ from the previously described embodiments of the device according to the invention, whereas a description of common, aforementioned features and properties is omitted. The second container, with which the first container is intended to interact, is also omitted in all cases. Furthermore, the same reference notations are used for identical or corresponding components of the different variants.

[0026] In Fig. 3, a variant of the device according to the invention is illustrated diagrammatically, in which the duct 5 is configured as an elongated, serpentine loop to inhibit the contaminant from reaching the workpiece. A long duct 5 can thereby be obtained in a space-saving manner. In order to be able to introduce and withdraw the workpieces into/from the first container 1, the latter is provided with a tight-shutting door 22 or lid or the like, so that the container 1 can be opened and closed according to requirement.

[0027] In Fig. 4, a further variant of the device according to the invention is illustrated diagrammatically, in which the duct 5 is configured as an elongated column. The column has a first portion 23, of larger cross-sectional area, disposed next to the first container 1, and which portion contains chips 13 with high affinity for a contaminant, and a second portion 25, of smaller cross-sectional area, disposed next to the environment-facing mouth 24 of the duct 5. In this case, the outer portion 25 of the duct 5 can have a cross-sectional dimension in the order of magnitude described earlier in this application, whereas the inner portion 23, in certain cases, can be permitted to have larger cross-sectional dimensions which allow chips 13 to be placed in a practical manner in the column. The column and a lid 22 which shuts tight against the container can be made integrated in a detachable part to enable the first container 1 to be opened and closed.

[0028] In Figure 5, a further variant of the device according to the invention is illustrated diagrammatically, in which the first container 1 is provided with a plurality of chambers 15 for the accommodation of chips 13 at different levels in the first container 1. A dividing plate 14 is disposed between each set of two mutually adjoining chambers, so that a gap 17 is formed between the outer edge of the dividing plate and the internal limit face of the first container. As regards different embodiments of the dividing plates, reference is made to the description provided in connection with Figs. 1 and 2.

[0029] In Figure 6, a further variant of the device according to the invention is illustrated diagrammatically, utilizing valves instead of a duct to establish the necessary connection with the environment, i.e. with the second container when the first container 1 is placed in the second container. Although the first container is provided with three valves 4, 26, 27 in the example illustrated in Fig. 6, it is possible, at least in certain cases, to utilize a lesser number of valves by making it/them multifunctional. In the example in question, the first valve 4 constitutes a means for introducing protective gas into the first container. By means of a second valve 26, a connection between the first container 1 and the second container can be provided when the containers are evacuated before the workpiece is heated. A third valve 27 is designed, during heating of the workpiece, to equalize any pressure differences between the first 1 and second container 3 should a difference in total pressure arise between the first and second container, which difference risks damaging the first container 1.

[0030] Experiments have been conducted with various embodiments of the device according to the invention. For example, successful trials have been conducted with the following dimensions of the device:

Trial 1

[0031] The volume of the first container, V_1=1.75 dm^3, the length of the duct, L=100 mm, and the cross-sectional dimensions of the duct, B x t=500 x 5 mm, which gives a relationship between the duct length and gap width, L/t=20, and a volume relationship between the first container and the duct volume, V_1/N_k=1 4.

Trial 2

[0032] The volume of the first container, V_1=15 dm^3, the length of the duct, L=250 mm, and the cross-sectional dimensions of the duct, B x t=1000 x 5 mm, which gives a relationship between the duct length and gap width, L/t=50, and a volume relationship between the first container and the duct volume, V_1/V_k=12.

[0033] In the implementation of the method according to the invention, a workpiece which is required to be heated, for example for the execution of a soldering, is placed in a first container. In a first step, the first container is flushed and filled with a protective gas. The duration of the flushing is tailored to the geometric complexity of the workpiece and can range from a few minutes to a number of hours. Flushing of the container with a protective gas, such as, for example, argon, results in partial pressure for the contaminant being lowered. The first container filled with protective gas is then placed in a second container, preferably an oven and, in a second step, the partial pressure of the contaminant in the first container is further lowered by the evacuation of the second container, and hence the first container, to create a vacuum inside the first and second container. The air is thus pumped out of the oven and the protective gas and remaining contaminants flow out of the first container to the second container and onward out from the second container to the environment.

[0034] In this way, the total pressure, on the one hand, and the oxygen partial pressure, for example, on the other hand, is lowered. Oxygen is an agent which, when workpieces made of certain materials are heated, should as far as possible be minimized in the atmosphere surrounding the workpiece, since the oxygen can otherwise react with the material and form compounds and/or phases which produce undesirable properties of the material. Other examples of contaminants are various nitrogen compounds and gaseous carbon compounds. Following creation of a vacuum in the first container, the first container and the workpiece placed therein can be heated in the oven in order to perform a desired heat treatment and/or joining together of different components of the workpiece.

[0035] In the trials, a volume V_2=0.5-1 m^3 for the second container has been used. The invention is not, of course, limited to the volume of the second container, but a relatively small oven is advantageous. A larger-volume oven, which tends to equalize the oxygen partial pressure inside the first container, will contaminate the first container to a greater extent than a smaller-volume oven.

[0036] Although, as stated above, it may be advantageous first to flush and fill the first container with protective gas and then place this in the second container, it should be stressed that the first container could very well be placed in the second container first and then flushed and filled with protective gas.

[0037] The invention is not, of course, limited to the embodiments of the invention described herein, but is only limited by the following patent claims. For example, in one embodiment of the invention, a valve system could be used in combination with a duct and these components could interact so that, when the valve is opened at a certain total pressure in the second container, contamination of the workpiece can still be inhibited by the fact that the contaminant, after having passed through the valve, must pass through the duct in order to get into the first container.

Claims

1. A method for, in the heating of a workpiece (2), inhibiting contamination of the workpiece by a contaminant, which method involves the workpiece being placed in a first container (1), **characterized in that**, in a first step, the first container (1) is flushed and filled with a protective gas, **in that** the first container (1) is placed in a second container (3), wherein a connecting means (5) is used to establish an atmospheric connection between the first container and the second container, and **in that**, in a second step, the second container (3), and hence the first container (1), is evacuated to create a vacuum inside the first and second container, so as, during the first and second step, to reduce the partial pressure for said contaminant in the first container (1) before the workpiece (2) is heated.

2. The method as claimed in claim 1, **characterized in that**, in the heating of the workpiece (2), transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through a duct (5) in order to get into the first container.

3. The method as claimed in claim 2, **characterized in that**, in the heating of the workpiece (2), transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through said duct (5) in order to reach the first container, which duct has a cross section possessing at least one dimension (10) with an extent in the same order of magnitude as the mean free path which the contaminant has in the atmosphere prevailing in the duct (5) as the workpiece (2) is heated.

4. The method as claimed in claim 2, **characterized in that**, in the heating of the workpiece (2), transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through said duct (5) in order to reach the first container (1), which duct has a cross section possessing at least one dimension (10) with an extent which is less than the mean free path which the contaminant has in the atmosphere prevailing in the duct (5) as the workpiece (2) is heated.

5. The method as claimed in claims 2-4, **characterized in that**, in the heating of the workpiece (2), transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through said duct (5) in order to reach the first container, the extent of which duct in the longitudinal direction (11) is many times greater than the extent of at least one cross-sectional dimension (10) of the duct (5).

6. The method as claimed in claim 5, **characterized in that** the contaminant has to pass through said duct (5) in order to reach the first container (1), the extent of which duct in the longitudinal direction (11) is more than 10 times greater than the extent of at least one cross-sectional dimension (10) of the duct (5).

7. The method as claimed in claim 5, **characterized in that** the contaminant has to pass through said duct (5) in order to reach the first container (1), the extent of which duct in the longitudinal direction (11) is more than 50 times greater than the extent of at least one cross-sectional dimension (10) of the duct (5).

8. The method as claimed in claim 5, **characterized in that** the contaminant has to pass through said duct (5) in order to reach the first container (1), the extent of which duct in the longitudinal direction (11) is more than 100 times greater than the extent of at least one cross-sectional dimension (10) of the duct (5).

9. The method as claimed in any one of claims 2-8, **characterized in that**, in the heating of the workpiece (2), transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through said duct (5) in order to reach the first container, the volume

of which duct is tailored to the volume of the first container so that the volume relationship (V_1/V_k) between the volume (V_1) of the first container and the volume (V_k) of the duct is less than 20.

10. The method as claimed in any one of claims 2-8, **characterized in that**, in the heating of the workpiece, transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through said duct (5) in order to reach the first container, the volume of which duct is tailored to the volume of the first container so that the volume relationship (V_1/V_k) between the volume (V_1) of the first container and the volume (V_k) of the duct is less than 15.

11. The method as claimed in any one of claims 2-8, **characterized in that**, in the heating of the workpiece (2), transport of said contaminant from the second container (3) to the first container (1) is inhibited by the contaminant having to pass through said duct (5) in order to reach the first container, the volume of which duct is tailored to the volume of the first container so that the volume relationship (V_1/V_k) between the volume (V_1) of the first container and the volume (V_k) of the duct is less than 10.

12. The method as claimed in claim 1, **characterized in that**, in the evacuation of the first and the second container (1. 3), a valve (26) of the first container (1) is opened to establish an atmospheric connection between the first container and the second container, which valve (26) is closed following completed evacuation.

13. The method as claimed in claim 1 or 12, **characterized in that**, in the heating of the workpiece (2), a valve (27) of the first container (1) is opened at a total pressure in the second container (3) exceeding a predetermined value or at a pressure difference between the first and second container exceeding a predetermined value, so as to inhibit compression of the first container (1).

14. The method as claimed in any one of the preceding claims, **characterized in that** the first container (1) is filled with the protective gas before it is placed in the second container (3).

15. The method as claimed in any one of the preceding claims, **characterized in that** piece goods (13) are placed in the first container (1) in order to provide surfaces for the capture of said contaminant by dint of a reaction between the contaminant and the surfaces of the piece goods (13).

16. The method as claimed in claim 15, **characterized in that** such piece goods (13) are placed in a first chamber (15) of the first container (1) so that these piece goods (13) are separated from the workpiece (2) present in a second chamber (16) of the first container (1), the first chamber (15) and the second chamber (16) of the first container being in mutual atmospheric connection.

17. The method as claimed in any one of claims 2-11 or 15-16, **characterized in that** piece goods (13) are placed in the duct (5) in order to create surfaces for the capture of said contaminant by dint of a reaction between the contaminant and the surfaces of the piece goods (13).

18. The method as claimed in any one of the preceding claims, **characterized in that** the workpiece (2) is heated for soldering of the workpiece.

Patentansprüche

1. Verfahren zum Hemmen der Verunreinigung eines Werkstücks (2) durch eine Verunreinigungssubstanz bei der Erwärmung des Werkstücks, wobei das Verfahren beinhaltet, dass das Werkstück in einem ersten Behälter (1) platziert wird, **dadurch gekennzeichnet, dass**
bei einem ersten Schritt der erste Behälter (1) gespült und mit einem Schutzgas gefüllt wird, dass der erste Behälter (1) in einem zweiten Behälter (3) platziert wird, wobei eine Verbindungseinrichtung (5) zur Herstellung einer atmosphärischen Verbindung zwischen dem ersten Behälter und dem zweiten Behälter verwendet wird, und dass bei einem zweiten Schritt der zweite Behälter (3), und somit der erste Behälter (1), evakuiert wird, um ein Vakuum innen in dem ersten und zweiten Behälter zu erzeugen, um während des ersten und zweiten Schritts den Partialdruck für die Verunreinigungssubstanz in dem ersten Behälter (1) zu verringern, bevor das Werkstück (2) erwärmt wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch einen Kanal (5) hindurchgehen muss, um in den ersten Behälter zu gelangen.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter zu erreichen, wobei der Kanal einen Querschnitt hat, der wenigstens eine Ab-

messung (10) mit einer Ausdehnung in der gleichen Größenordnung wie die mittlere freie Weglänge besitzt, die die Verunreinigungssubstanz in der in dem Kanal (5) vorherrschenden Atmosphäre hat, wenn das Werkstück (2) erwärmt wird.

4. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter (1) zu erreichen, wobei der Kanal einen Querschnitt hat, der wenigstens eine Abmessung (10) mit einer geringeren Ausdehnung als die mittlere freie Weglänge besitzt, die die Verunreinigungssubstanz in der in dem Kanal (5) vorherrschenden Atmosphäre hat, wenn das Werkstück (2) erwärmt wird.

5. Verfahren nach den Ansprüchen 2 bis 4, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter zu erreichen, wobei die Ausdehnung des Kanals in Längsrichtung (11) um ein Vielfaches größer als die Ausdehnung von mindestens einer Querschnittsabmessung (10) des Kanals (5) ist.

6. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter (1) zu erreichen, wobei die Ausdehnung des Kanals in Längsrichtung (11) mehr als 10-mal so groß wie die Ausdehnung von wenigstens einer Querschnittsabmessung (10) des Kanals (5) ist.

7. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter (1) zu erreichen, wobei die Ausdehnung des Kanals in Längsrichtung (11) mehr als 50-mal so groß wie die Ausdehnung von wenigstens einer Querschnittsabmessung (10) des Kanals (5) ist.

8. Verfahren nach Anspruch 5, **dadurch gekennzeichnet, dass** die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter (1) zu erreichen, wobei die Ausdehnung des Kanals in Längsrichtung (11) mehr als 100-mal so groß wie die Ausdehnung von wenigstens einer Querschnittsabmessung (10) des Kanals (5) ist.

9. Verfahren nach einem der Ansprüche 2 bis 8, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter zu erreichen, wobei das Volumen des Kanals auf das Volumen des ersten Behälters so zugeschnitten ist, dass das Volumenverhältnis (V_1/V_k) zwischen dem Volumen (V_1) des ersten Behälters und dem Volumen (V_k) des Kanals weniger als 20 beträgt.

10. Verfahren nach einem der Ansprüche 2 bis 8, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter zu erreichen, wobei das Volumen des Kanals auf das Volumen des ersten Behälters so zugeschnitten ist, dass das Volumenverhältnis (V_1/V_k) zwischen dem Volumen (V_1) des ersten Behälters und dem Volumen (V_k) des Kanals weniger als 15 beträgt.

11. Verfahren nach einem der Ansprüche 2 bis 8, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) der Transport der Verunreinigungssubstanz von dem zweiten Behälter (3) zu dem ersten Behälter (1) **dadurch** gehemmt wird, dass die Verunreinigungssubstanz durch den Kanal (5) hindurchgehen muss, um den ersten Behälter zu erreichen, wobei das Volumen des Kanals auf das Volumen des ersten Behälters so zugeschnitten ist, dass das Volumenverhältnis (V_1/N_k) zwischen dem Volumen (V_1) des ersten Behälters und dem Volumen (V_k) des Kanals weniger als 10 beträgt.

12. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** bei der Evakuierung des ersten und des zweiten Behälters (1, 3) ein Ventil (26) des ersten Behälters (1) geöffnet wird, um eine atmosphärische Verbindung zwischen dem ersten Behälter und dem zweiten Behälters herzustellen, wobei das Ventil (26) nach vollendeter Evakuierung geschlossen wird.

13. Verfahren nach Anspruch 1 oder 12, **dadurch gekennzeichnet, dass** bei der Erwärmung des Werkstücks (2) ein Ventil (27) des ersten Behälters (1) bei einem einen vorher bestimmten Wert überschreitenden Gesamtdruck in dem zweiten Behälter (3) oder bei einem einen vorher bestimmten Wert überschreitenden Druckunterschied zwischen dem ersten und zweiten Behälter geöffnet wird, um die Komprimierung des ersten Behälters (1) zu hemmen.

14. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der erste Be-

hälter (1) mit dem Schutzgas gefüllt wird, bevor er in dem zweiten Behälter (3) platziert wird.

15. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** Stückware (13) in dem ersten Behälter (1) platziert wird, um Oberflächen für das Einfangen der Verunreinigungssubstanz mittels einer Reaktion zwischen der Verunreinigungssubstanz und den Oberflächen der Stückware (13) bereitzustellen.

16. Verfahren nach Anspruch 15, **dadurch gekennzeichnet, dass** derartige Stückware (13) in einer ersten Kammer (15) des ersten Behälters (1) so platziert wird, dass diese Stückware (13) von dem in einer zweiten Kammer (16) des ersten Behälters vorhandenen Werkstück (2) getrennt ist, wobei die erste Kammer (15) und die zweite Kammer (16) des ersten Behälters in gegenseitiger atmosphärischer Verbindung stehen.

17. Verfahren nach einem der Ansprüche 2 bis 11 oder 15 bis 16, **dadurch gekennzeichnet, dass** Stückware (13) in dem Kanal (5) platziert wird, um Oberflächen für das Einfangen der Verunreinigungssubstanz mittels einer Reaktion zwischen der Verunreinigungssubstanz und den Oberflächen der Stückware (13) zu schaffen.

18. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Werkstück (2) zum Löten des Werkstücks erwärmt wird.

Revendications

1. Procédé pour, lors du chauffage d'une pièce à usiner (2), empêcher une contamination de la pièce à usiner par un contaminant, lequel procédé implique que la pièce soit placée dans un premier conteneur (1), **caractérisé en ce que**
dans une première étape, le premier conteneur (1) est rincé et rempli d'un gaz protecteur, **en ce que** le premier conteneur (1) est placé dans un second conteneur (3), dans lequel des moyens de liaison (5) sont utilisés pour établir une liaison atmosphérique entre le premier conteneur et le second conteneur, et **en ce que**, dans une deuxième étape, le second conteneur (3) et donc le premier conteneur (1) sont évacués pour créer un vide à l'intérieur des premier et second conteneurs de manière à, pendant les première et seconde étapes, réduire la pression partielle pour ledit contaminant dans le premier conteneur (1) avant que la pièce à usiner (2) ne soit chauffée.

2. Procédé selon la revendication 1, **caractérisé en ce que** lors du chauffage de la pièce à usiner (2), un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (1) est empêché par le contaminant devant passer à travers un conduit (5) pour aller jusque dans le premier conteneur.

3. Procédé selon la revendication 2, **caractérisé en ce que** durant le chauffage de la pièce à usiner (2), un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (1) est empêché par le contaminant devant passer à travers ledit conduit (5) pour atteindre le premier conteneur, lequel conduit a une coupe transversale possédant au moins une dimension (10) avec une étendue du même ordre de grandeur que le trajet libre moyen du contaminant dans l'atmosphère dominant dans le conduit (5) lorsque la pièce à usiner (2) est chauffée.

4. Procédé selon la revendication 2, **caractérisé en ce que** durant le chauffage de la pièce à usiner (2), un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (1) est empêché par le contaminant devant passer à travers ledit conduit (5) pour atteindre le premier conteneur (1), lequel conduit a une coupe transversale possédant au moins une dimension (10) avec une étendue qui est inférieure au trajet libre moyen du contaminant dans l'atmosphère dominant dans le conduit (5) lorsque la pièce à usiner (2) est chauffée.

5. Procédé selon l'une quelconque des revendications 2 à 4, **caractérisé en ce que** durant le chauffage de la pièce à usiner (2), un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (11) est empêché par le contaminant devant passer à travers ledit conduit (5) pour atteindre le premier conteneur, conduit dont l'étendue dans la direction longitudinale (11) est de nombreuses fois supérieures à l'étendue de la au moins une dimension de coupe transversale (10) du conduit (5).

6. Procédé selon la revendication 5, **caractérisé en ce que** le contaminant doit passer à travers ledit conduit (5) pour atteindre le premier conteneur (1), conduit dont l'étendue dans la direction longitudinale (11) est plus de 10 fois supérieure à l'étendue d'au moins une dimension de coupe transversale (10) du conduit (5).

7. Procédé selon la revendication 5, **caractérisé en ce que** le contaminant doit passer à travers ledit conduit (5) pour atteindre le premier conteneur (1), conduit dont l'étendue dans la direction longitudinale (11) est plus de 50 fois supérieure à l'étendue d'au moins une dimension de coupe transversale (10) du conduit (5).

8. Procédé selon la revendication 5, **caractérisé en ce que** le contaminant doit passer à travers ledit conduit (5) pour atteindre le premier conteneur (1), con-

duit dont l'étendue dans la direction longitudinale (11) est plus de 100 fois supérieure à l'étendue d'au moins une dimension de coupe transversale (10) du conduit (5).

9. Procédé selon l'une quelconque des revendications 2 à 8, **caractérisé en ce que** durant le chauffage de la pièce à usiner (2), un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (1) est empêché par le contaminant devant passer à travers ledit conduit (5) pour atteindre le premier conteneur, conduit dont le volume est ajusté par rapport au volume du premier conteneur, de sorte que la relation de volume (V_1/N_k) entre le volume (V_1) du premier conteneur et le volume (V_k) du conduit est inférieure à 20.

10. Procédé selon l'une quelconque des revendications 2 à 8, **caractérisé en ce que** durant le chauffage de la pièce à usiner, un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (1) est empêché par le contaminant devant passer à travers ledit conduit (5) pour atteindre le premier conteneur, conduit dont le volume est ajusté par rapport au volume du premier conteneur, de sorte que la relation de volumes (V_1/V_k) entre le volume (V_1) du premier conteneur et le volume (V_k) du conduit est inférieure à 15.

11. Procédé selon l'une quelconque des revendications 2 à 8, **caractérisé en ce que** durant le chauffage de la pièce à usiner (2), un transport dudit contaminant depuis le second conteneur (3) vers le premier conteneur (1) est empêché par le contaminant devant passer à travers ledit conduit (5) pour atteindre le premier conteneur, conduit dont le volume est ajusté par rapport au volume du premier conteneur de sorte que la relation de volumes (V_1/V_k) entre le volume (V_1) du premier conteneur et le volume (V_k) du conduit est inférieure à 10.

12. Procédé selon la revendication 1, **caractérisé en ce que** durant l'évacuation des premier et second conteneurs (1, 3), une vanne (26) du premier conteneur (1) est ouverte pour établir une liaison atmosphérique entre le premier conteneur et le second conteneur, laquelle vanne (26) est fermée à la suite d'une évacuation complète.

13. Procédé selon la revendication 1 ou 12, **caractérisé en ce que** durant le chauffage de la pièce à usiner (2), une vanne (27) du premier conteneur (1) est ouverte à une pression totale dans le second conteneur (3) dépassant une valeur prédéterminée ou à une différence de pressions entre les premier et second conteneurs dépassant une valeur prédéterminée, de manière à empêcher une compression du premier conteneur (1).

14. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le premier conteneur (1) est rempli du gaz protecteur avant qu'il ne soit placé dans le second conteneur (3).

15. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** des articles (13) sont placés dans le premier conteneur (1) pour fournir des surfaces pour la capture dudit contaminant par déclenchement d'une réaction entre le contaminant et les surfaces des articles (13).

16. Procédé selon la revendication 15, **caractérisé en ce que** de tels articles (13) sont placés dans une première chambre (15) du premier conteneur (1), de sorte que ces articles (13) sont séparés de la pièce à usiner (2) présente dans une seconde chambre (16) du premier conteneur (1), la première chambre (15) et la seconde chambre (16) du premier conteneur étant dans une liaison atmosphérique mutuelle.

17. Procédé selon l'une quelconque des revendications 2 à 11 ou 15 et 16, **caractérisé en ce que** des articles (13) sont placés dans le conduit (5) pour créer des surfaces pour la capture dudit contaminant par déclenchement d'une réaction entre le contaminant et les surfaces des articles (13).

18. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la pièce à usiner (2) est chauffée pour brasage de la pièce à usiner.

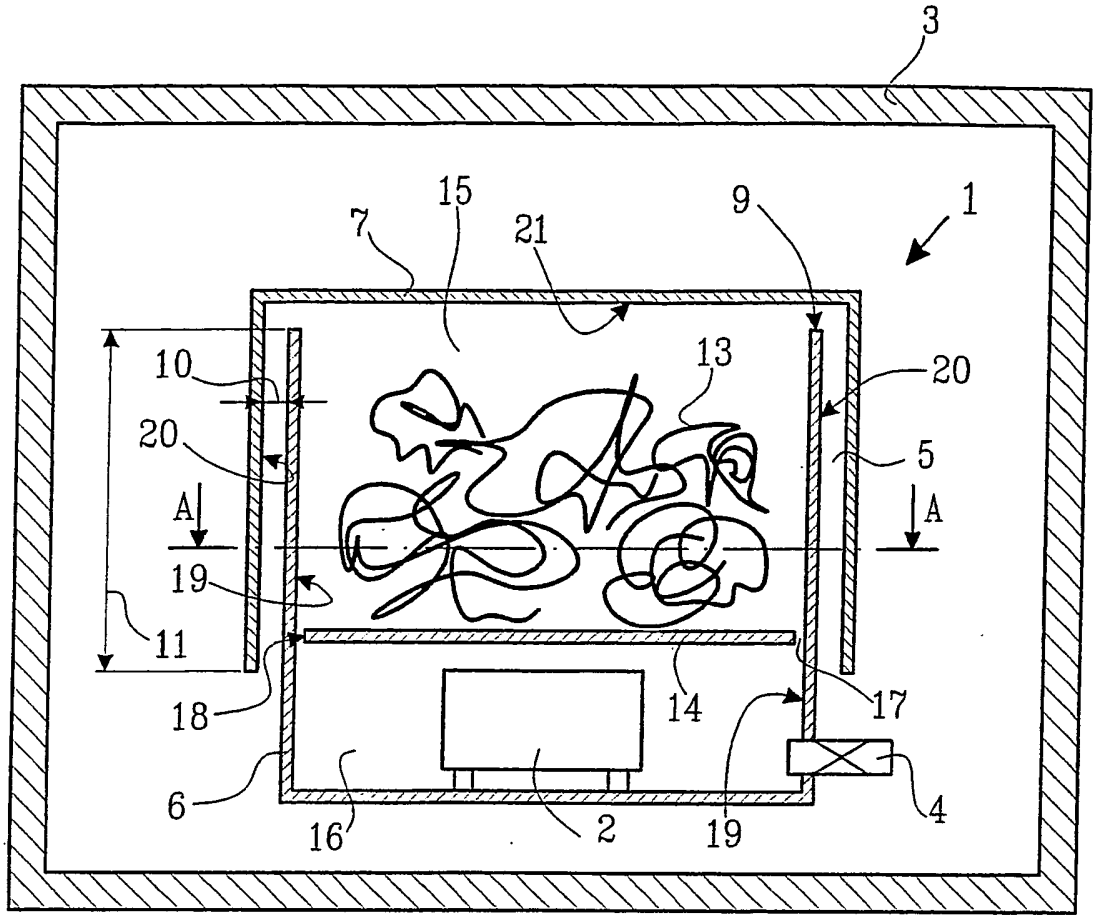

FIG. 1

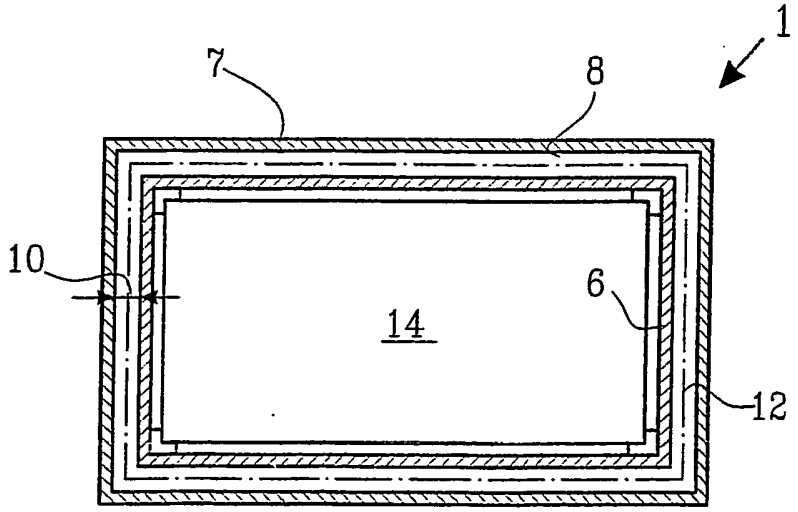

FIG. 2

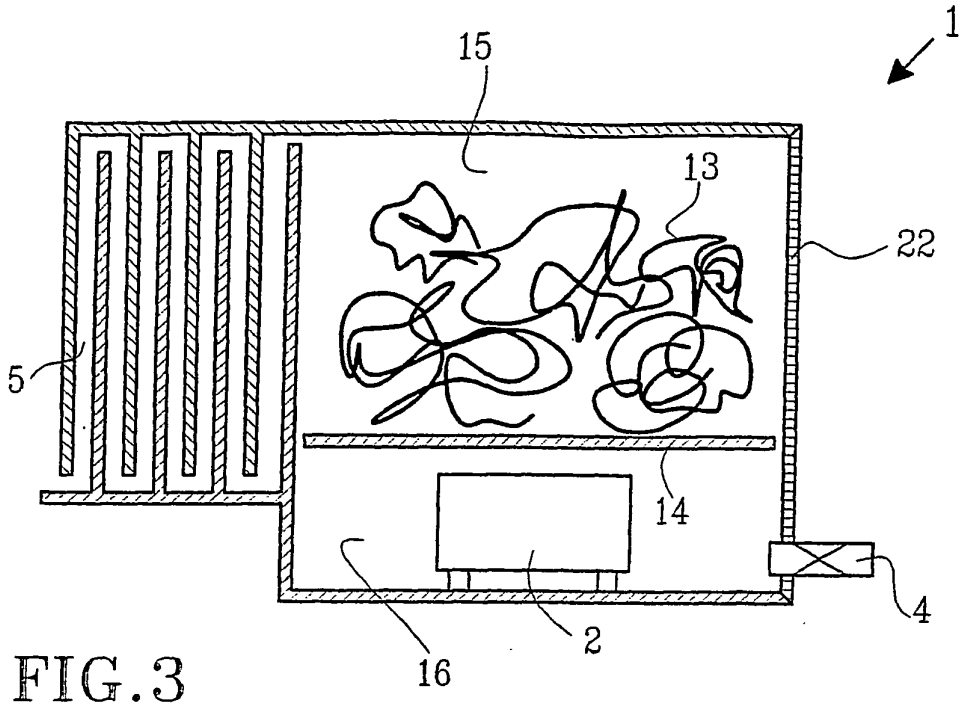

FIG.3

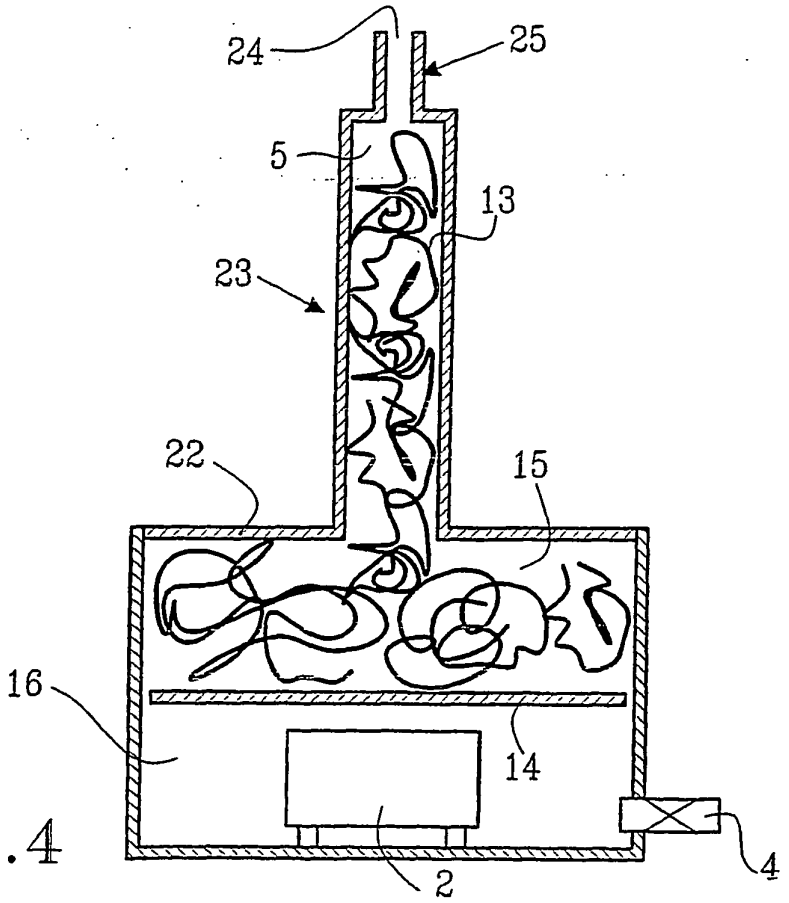

FIG.4

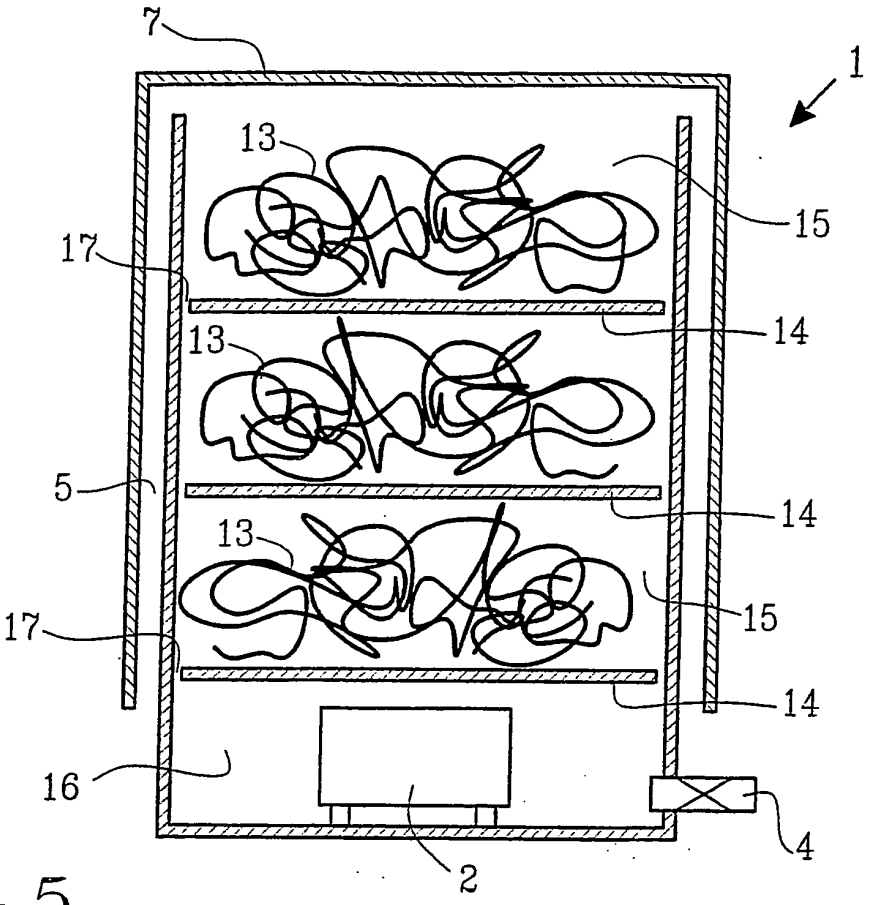

FIG.5

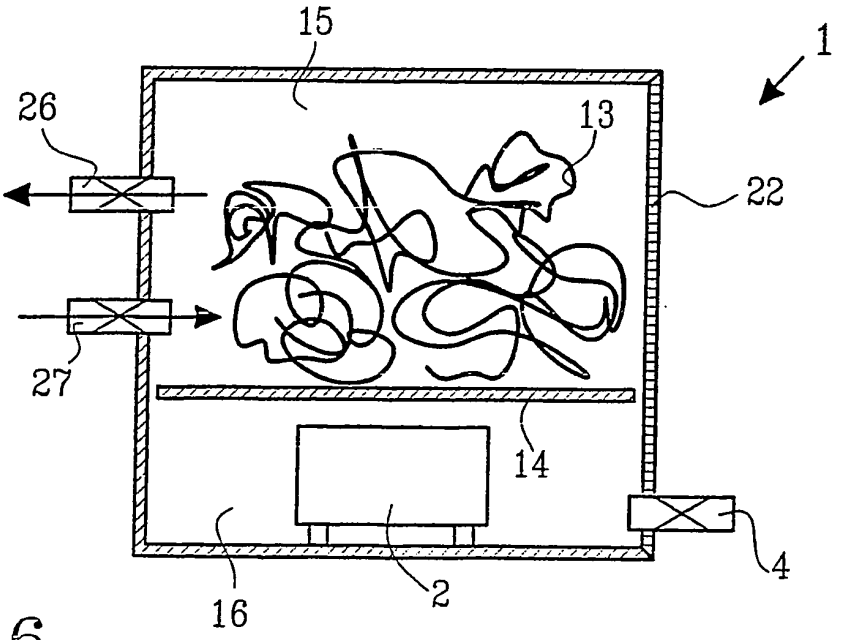

FIG.6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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