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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **Vapour phase drying apparatus**

(57) The present invention relates to a vapour phase drying apparatus (1), comprising: a drying chamber (3) configured to receive an article (4) to be dried by means of the apparatus; a vacuum pump (12) arranged for lowering the pressure within the drying chamber; an evaporator (2) arranged for fluid connection with the drying chamber and for evaporating a volatile fluid such that the volatile fluid in vapour form can enter the drying chamber by means of the fluid connection; a pressurised gas source (9); and piping (7,10) connected to the evaporator and to the pressurised gas source, and arranged for transporting the volatile fluid in liquid form to said evaporator by means of a pressure provided by said pressurised gas source. The invention also relates to a method of transporting a volatile fluid to an evaporator of a vapour phase drying apparatus.

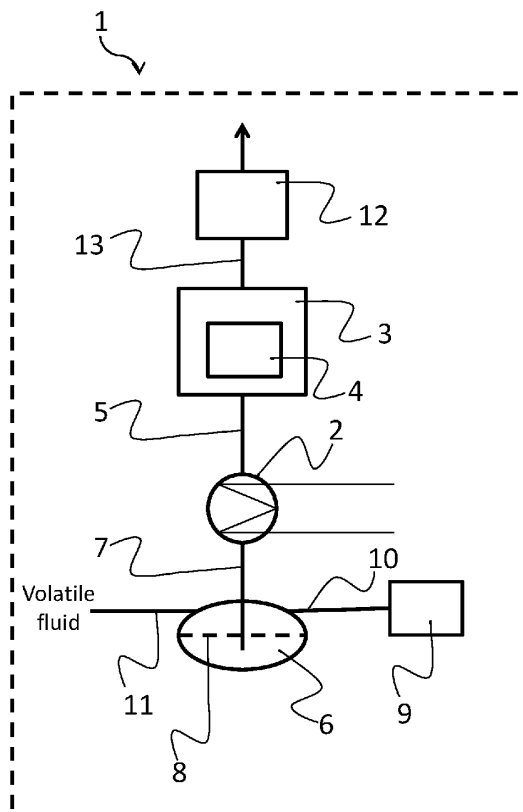


Fig 1

Description

TECHNICAL FIELD

[0001] The invention relates to a vapour phase drying apparatus as well as to a method of transporting a volatile fluid to an evaporator of a vapour phase drying apparatus.

BACKGROUND

[0002] Vapour phase drying (VPD) may be used to dry, i.e. remove water moisture, from parts. It may be suitable for drying active parts of super voltage and high-capacity transformers, instrument transformers and such. The transformer to be dried is put in an autoclave, which is then evacuated. Kerosene is evaporated by an evaporator and the gaseous kerosene is contacted with the transformer in the autoclave, where it is condensed on transformer surfaces thereby heating the transformer. Condensed kerosene is collected at the bottom of the autoclave and is returned to the evaporator for reuse. The kerosene is collected and pumped by a circulation pump back to the evaporator in a vacuum or low pressure environment since the kerosene collector and evaporator are evacuated together with the autoclave. Pumping the kerosene at low pressure and elevated temperature is difficult due to the risk of cavitation. A net positive suction head is required. This is achieved by the use of a pump pit to create a static pressure of the kerosene being pumped. When the transformer has reached the desired temperature, the addition of kerosene vapour to the autoclave is stopped and the pressure is reduced by a vacuum pump to remove water and kerosene vapour. The heating in combination with the reduced pressure dries the transformer. An important point is that the saturation pressure of kerosene is lower than the saturation pressure of water, but higher than the saturation pressure of transformer oil. A vapour phase drying apparatus for drying transformers is disclosed in US 4,292,744.

SUMMARY

[0003] According to an aspect of the present invention, there is provided a vapour phase drying apparatus, comprising: a drying chamber configured to receive an article to be dried by means of the apparatus; a vacuum pump arranged for lowering the pressure within the drying chamber; an evaporator arranged for fluid connection with the drying chamber and for evaporating a volatile fluid such that the volatile fluid in vapour form can enter the drying chamber by means of the fluid connection; a pressurised gas source; and piping connected to the evaporator and to the pressurised gas source, and arranged for transporting the volatile fluid in liquid form to said evaporator by means of a pressure provided by said pressurised gas source.

[0004] According to another aspect of the present invention, there is provided a vapour phase drying appa-

ratus, comprising: means for receiving an article to be dried by means of the apparatus; means for lowering the pressure within the means for receiving an article; means arranged for fluid connection with the drying chamber and for evaporating a volatile fluid such that the volatile fluid in vapour form can enter the means for receiving an article by means of the fluid connection; means for providing a pressurised gas; and means for transporting the volatile fluid in liquid form to said means for evaporating, by means of a pressure provided by said pressurised gas. The means for receiving an article may e.g. be a drying chamber as mentioned above. The means for lowering the pressure may e.g. be a vacuum pump as mentioned above. The means for evaporating may e.g. be an evaporator as mentioned above. The means for providing a pressurised gas may e.g. be a pressurised gas source as mentioned above. The means for transporting may e.g. be the piping mentioned above. However, alternative embodiments of the means may be apparent to the person skilled in the art in view of the present disclosure.

[0005] According to another aspect of the present invention, there is provided a method of transporting a volatile fluid to an evaporator of a vapour phase drying apparatus, the method comprising pressing the volatile fluid in liquid form into the evaporator by means of a pressurised gas source.

[0006] According to another aspect of the present invention, there is provided a use of a pressurised gas source for pressing a volatile fluid into an evaporator of a vapour phase drying apparatus.

[0007] By using a pressurised gas source for pressing the liquid volatile fluid into the evaporator, the circulation pump(s) and pump pit of the prior art may no longer be needed, or the need is at least reduced. This pumping equipment including surrounding equipment and redundancies may thus be dispensed with. The vapour phase drying apparatus is thus made simpler and more cheaper to construct and maintain. Specifically, the foundation of a vapour phase drying plant in accordance with the present invention may be prepared more cheaply, easily and faster since fewer concrete pour steps may be needed. The hydraulic situation in the ground may be of less importance with the invention. The present invention may also be suitable for retrofitting old plants.

[0008] The discussions above and below in respect of any of the aspects of the invention is also in applicable parts relevant to any other aspect of the present invention.

[0009] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig 1 is a schematic diagram of an embodiment of an apparatus of the present invention.

Fig 2 is a schematic diagram of another embodiment of an apparatus of the present invention.

Fig 3 is a schematic flow chart of an embodiment of a method of the present invention.

DETAILED DESCRIPTION

[0011] The invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout the description.

[0012] The term "volatile fluid" should be interpreted broadly. Any fluid which may be evaporated and used for heating an article to be dried in vapour phase drying is included by the term. Preferably, the volatile fluid is more volatile than water. Conveniently, the volatile fluid is a petroleum fraction, such as kerosene.

[0013] The term "piping" and the like is herein used broadly and is not limited to a certain material or design. The term encompasses any type of piping, tubing, conduit or the like. Also, the term encompasses not only regular pipes for transporting a fluid from one place to another, but also tanks, valves, couplings etc. as needed.

[0014] The pressurised gas source and the pressurised gas of the present invention, is pressurised in the sense that it has an over pressure when compared with the interior pressure of the evaporator, thus allowing it to press the volatile fluid into the evaporator. If e.g. the evaporator, as well as the drying chamber, is evacuated e.g. by means of a vacuum pump, the pressurised gas source and the pressurised gas may very well have a pressure below atmospheric pressure, since it may still have a pressure above the pressure of the evaporator.

[0015] The drying chamber may be any chamber able to receive an article to be dried at reduced pressure, such as an autoclave. The drying chamber may have any size, depending on the article it is designed to receive. The drying chamber does not have to be completely air tight, just tight enough to allow a reduction of a pressure therein by means of a vacuum pump, or the like, while the vacuum pump is in use for lowering the pressure in the drying

chamber.

[0016] The article may be any article that may be dried by vapour phase drying. Conveniently, the article may be an electrical article, such as a transformer.

[0017] The vacuum pump may be any means able to lower the pressure in the drying chamber, such as a regular vacuum pump arranged to pump a gas phase out from the drying chamber through piping/tubing/conduit putting the vacuum pump in fluid connection with the drying chamber. The gas phase may be released to the atmosphere or may be at least partly condensed for recovering and recycling.

[0018] The evaporator may be any means able to evaporate the volatile fluid. The evaporator is arranged for fluid connection with the drying chamber. Thus, the evaporator, when operating may be connected, via piping/tubing/conduit, to the drying chamber such that a fluid, e.g. the volatile fluid in gas/vapour phase, may pass from the evaporator to the drying chamber and enter the same. The evaporator may be at a reduced pressure, just as the drying chamber, and connected to the vacuum pump, either directly or via the connection to the drying chamber.

[0019] The pressurised gas source, may be any such source, such as a gas tube, a container for intermediate storing of gas, and/or a gas production unit. Conveniently, the pressurised gas source is a pressurised gas container arranged to allow the pressurised gas to be provided to the piping from the gas container. The container may e.g. be provided with a valve which when it is opened allows pressurised gas access to the piping. This access to the piping may be such that the pressurised gas enters into the piping, and/or it may be such that the pressure of the pressurised gas presses on fluid already present in the piping such that the pressure provided by the pressurised gas propagates through the piping towards the evaporator.

[0020] The piping is connected to both the evaporator and to the pressurised gas source. The piping may thus allow the pressure of the gas source to be used for pushing or pressing the volatile fluid into the evaporator. The piping may thus be configured such that the evaporator is in fluid connection with the pressurised gas source such that a fluid pressure of the gas source may propagate via the piping to the evaporator.

[0021] The pressurised gas may be any gas, such as air. However, it may be convenient to use an inert gas. Thus, the pressurised gas container according to an embodiment of the present invention may contain an inert gas. An advantage with using an inert gas is that the risk of fire is reduced, especially if the volatile fluid is combustible, which is the case with e.g. kerosene and other petroleum products. It may thus be preferred to use an inert gas which protects the volatile fluid from oxidising agents such as oxygen. Another advantage with an inert gas is that corrosion, of piping and other parts of the apparatus which the pressurised gas may come into contact with, may be reduced. It may be convenient to use

nitrogen gas as the pressurised gas. Nitrogen is readily available and inert at regular operating conditions of the apparatus.

[0022] The nitrogen may be provided e.g. by obtaining an externally prepared and filled gas tube containing nitrogen. Another way of obtaining nitrogen gas is to integrate the apparatus with an air separation unit configured to separate nitrogen from e.g. atmospheric air or from compressed air available in close vicinity of the inventive apparatus. The apparatus may thus also comprise an air separation unit connected to the gas container and arranged to supply the pressurised nitrogen to said gas container after having separated said nitrogen from air. The air separation unit may be regarded as the gas production unit mentioned above. For large scale vapour phase drying, this may be preferred to buying gas tubes since it may be cheaper and the apparatus may become more self sufficient. On the other hand, it may in some cases be convenient to use an externally filled nitrogen gas tube or other externally produced pressurised nitrogen, if e.g. a gas tube is already available at a plant comprising the apparatus, since not much pressurised nitrogen may be needed to provide the pressure needed to press the volatile fluid into the evaporator (the nitrogen itself may not be consumed, only provide pressure). The air separation unit may operate in any way to separate nitrogen from air, e.g. by cryogenic separation, or by using a filter or membrane. It may be convenient to use a filter/membrane since only the nitrogen is of interest and not the other gas compounds of air (oxygen, argon etc.). The air separation unit may thus conveniently comprise a membrane for separating the nitrogen from air. Since many industrial plants have compressed air available for different uses, it may be convenient to use such compressed air (air having a pressure above atmospheric pressure) as the source of air for the air separation unit.

[0023] In accordance with the present invention, the volatile fluid may be pressed into the evaporator by creating an over pressure upstream of the evaporator by means of the pressurised gas source, which over pressure is in relation to the pressure in the evaporator as well as downstream of the evaporator. A pressure gradient over the evaporator may thus be created. The volatile fluid may accordingly be pressed into the evaporator, evaporated, and further pressed into the drying chamber as vapour. If the pressure of the drying chamber is atmospheric, the pressurised gas source of the inventive method has a pressure above atmospheric pressure. However, a vacuum pump or the like may be used to lower the pressure in the drying chamber and downstream of the evaporator, increasing the pressure gradient over the evaporator and/or reducing the required pressure of the pressurised gas source. Additionally or alternatively, the pressure gradient may be increased or created by placing the evaporator below, i.e. at a lower altitude than, the drying chamber, thereby taking advantage of the action of gravity.

[0024] The pressurised gas may engage or contact the

volatile fluid such that the fluid is pressed into the vapouriser. However, it may not be convenient to allow the pressurised gas, or at least not much of it, to enter the evaporator, since this would consume pressurised gas, reduce any reduced pressure downstream of the evaporator, put more strain on a vacuum pump etc. The piping of the apparatus may thus be designed such that the pressurised gas is allowed to contact a liquid surface of the volatile fluid in liquid form. The contacting may e.g. take place in an intermediate storage tank for the volatile fluid. The pressure applied to the liquid surface may then press the volatile fluid through a pipe or such and through an inlet of the evaporator, without allowing the pressurised gas to enter the evaporator via the pipe and inlet. This may function in a similar way as when the atmospheric pressure presses liquid through a drinking straw when in use.

[0025] Above it has been described how the pressurised gas source may be used to press the volatile fluid into the evaporator. However, the pressurised gas source may be used also elsewhere in the apparatus for transporting the volatile fluid or any other fluid, such as water and/or oil evaporated and pumped from the drying chamber. The pressurised gas source may e.g. be used to press the volatile fluid from a storage tank to the apparatus or vice versa, or to press the volatile fluid after condensation at the bottom of the drying chamber from the intermediate tank (which intermediate tank is supplying fluid to the evaporator and is discussed above) to the evaporator or to the fluid storage tank.

[0026] With reference to figure 1, an embodiment of a vapour phase drying apparatus 1 according to the present invention is schematically shown. The apparatus 1 comprises an evaporator 2 e.g. in the form of a heat exchanger. The evaporator is arranged to evaporate a volatile fluid by heat exchanging with a heating medium in the evaporator 2. The evaporator 2 is connected to the drying chamber 3 containing the article 4 to be dried by means of the apparatus 1. The evaporator 2 is connected to the drying chamber 3 by means of the fluid connection or conduit 5 arranged to allow evaporated fluid to travel from the evaporator 2 to the drying chamber 3. The evaporator 2 is also connected to the fluid container 6 via the fluid connection or conduit 7 arranged to allow liquid fluid to travel from the fluid container 6 to the evaporator 2 via the conduit 7. The fluid container 6 is configured to hold the volatile fluid such that a liquid surface 8 is formed in the fluid container (the surface 8 is illustrated by the dashed line within the container 6 in figure 1). The liquid surface 8 may alternatively be defined as a gas-liquid interface. The conduit 7 is arranged extending into the container 6 such that it can extend below the liquid surface 8 so as not to transport any of the gas above the liquid interface 8 to the evaporator 2. The container 6 is connected to a pressurised gas source 9 via the fluid connection or conduit 10. The conduit 10, when open such that the pressurised gas of the gas source 9 contacts the volatile fluid at the liquid surface 8, allows the

gas source to provide an over pressure to the volatile fluid such that the volatile fluid is pressed into the evaporator 2 via the conduit 7. It may be convenient to connect the container 6 via the conduit 10 above the liquid surface 8 to avoid foaming of, or bubbles in, the volatile fluid. The container 6 is also connected with a fluid connection or conduit 11 for supplying the liquid volatile fluid to the container 6. In an alternative embodiment of the present apparatus 1, the liquid surface 8 may be in the conduit 10 instead of in the container 6, whereby the conduit 7 may not have to extend into the container 6 and the container 6 may be reduced, possibly to a three-way joint of the three conduits 7, 10 and 11. The drying chamber 3 is connected to a vacuum pump 12 via the fluid connection or conduit 13, allowing the vacuum pump 12 to reduce the pressure of the chamber 3 to below atmospheric and possibly to essentially vacuum. Since the vacuum pump 12 may be in fluid connection with the chamber 3 via the conduit 13, and the chamber 3 is in fluid connection with the evaporator 2 via the conduit 5, the vacuum pump 12 may also reduce the pressure of the evaporator 2. Thus, a pressure gradient may be formed over the evaporator 2 by means of the over pressure provided by the gas source 9 upstream of the evaporator 2 and the vacuum pump downstream of the evaporator 2, able to press and suck, respectively, the volatile fluid downstream from the container 6 to the chamber 3 via the conduits 7 and 5.

[0027] Figure 2 schematically shows an embodiment of an apparatus 1 of the present invention in more detail. When applicable, the same reference numerals are used as in figure 1 for corresponding parts of the apparatus 1. As in figure 1, the drying chamber 3 is connected to three vacuum pumps 12 via the conduit 13 and connected with the chamber 6 via the conduit 5 and the evaporator 2. The container 6 is connected to the pressurised gas source 9 (nitrogen, N₂, in figure 2) via the conduit 10, and the conduit 11 is connected to the container 6 for supplying the evaporator 2 with liquid volatile fluid. As shown in figure 2, the volatile fluid may be supplied from a storage tank 21. The drying chamber 3 is also provided with a liquid outlet 22 at the bottom of the drying chamber 3. The outlet 22 is arranged to allow condensed volatile fluid to leave the drying chamber 3. The condensed volatile fluid may then either be returned to the storage tank 21 or be recycled to the evaporator 2 via the conduit 11. Since the condensed volatile fluid may be regarded as dirty, it may be convenient not to allow it to return to the storage tank, but to rather pass a filter and be recycled. The article, such as a transformer, may contain oil, whereby the drying of the article may also include washing of the article, this oil may be removed from the article and exit the drying chamber 3 via the outlet 22 together with the volatile fluid and be recycled with the fluid via the conduit 11 to the evaporator 2, where the oil may be separated by not being evaporated with the fluid and removed via an outlet at the bottom of the container 6 via the conduit 14. The oil is generally heavier than the volatile fluid (e.g. kerosene). The waste

oil of conduit 14 may be used to pre-heat the volatile fluid before it enters the container 15. The conduit 13 is arranged to allow the pumps 12 to remove any gases from the chamber 3. The gases will be water vapour, uncondensed volatile fluid and possibly some nitrogen that has leaked in from the pressurised gas source 9. The removed gases pass a condenser 16 where the water and volatile fluid condenses and are transported to the container 17. Any nitrogen is pumped passed the vacuum pumps 12 and may either be released to the atmosphere or be compressed by the compressor 20 and returned to the air separation unit 18 for recycling to the conduit 10 or the gas source 9. Compressed air may be fed to the air separation unit 18 from a compressed air source 19. The air separation unit 18 comprises a membrane which separates the nitrogen from the other air constituents (mainly oxygen, O₂). The nitrogen may then be transported to the conduit 10 or the gas source 9, whereas the oxygen may be released to the atmosphere or used elsewhere. The container 17 is arranged to receive the condensate from the condenser 16 and to separate the water, which may be released to a drain, and the volatile fluid, which may be returned to the evaporator 2 or the containers 15 or 6, via the conduit 11, or to the storage tank 21. Since the volatile fluid vapour from the chamber 3 is clean, or at least cleaner than the condensed fluid in container 15, the volatile fluid in container 17 may conveniently be returned to the storage tank 21. According to figure 2, the vacuum pumps 12 may act via conduits on the chamber 3 as well as on the containers 6, 15 and 17, thus able to reduce the pressure of different parts of the apparatus 1 as needed to transport the volatile fluid within the apparatus 1. Similarly, the pressurised gas source 9 may also act on the containers 6, 15 and/or 17 to raise the pressure of different parts of the apparatus 1 as needed to transport the volatile fluid within the apparatus 1. Thus, pressure gradients may be created and controlled at different parts in the apparatus 1 by means of the vacuum pumps 12 and the pressurised gas source 9 such that the volatile fluid may be transported within the apparatus 1 without the need of pumping the volatile fluid. In figure 2, the words "N₂", "Fluid" and "Vacuum" have been associated with different conduits of the apparatus 1 in order to make it easier to see where, i.e. via which conduits, the pressurised gas source 9 may act, the volatile fluid may flow and the vacuum pumps 12 may act, respectively. Also, valves are marked on the different conduits of the apparatus 1, by conventional marking. It should be noted, that this is a simplified illustration of an apparatus 1 of the present invention why additional components, such as conventional components associated with the components shown in figure 2, may very well be included in the apparatus 1.

[0028] It is noted, with reference to figure 2 and the embodiment illustrated therein, that for the fluid condensed in the chamber 3 and recycled to the evaporator 2, the container 15 may have the function of the container 6 in figure 1, i.e. the fluid is pressed by means of gas

pressure in the container 15 from said container 15 into the evaporator 2 without passing the container 6. Then the valve towards the chamber 3 and the valve towards the container 6 may be closed and the valve towards the evaporator 2 is open. Similarly, the container 17 may have the function of the container 6 in figure 1 for pressing the condensed fluid vapour from the container 17 into the evaporator 2 without passing the container 6. Additionally, or alternatively, the container 6 may be used for intermediate storage or as buffer of volatile fluid for the evaporator 2 from the container 15 (condensed fluid from the drying chamber 3) and/or from the chamber 17 (condensed vapour from the chamber 17).

[0029] With reference to figure 3, an embodiment of a method 100 according to the present invention is schematically illustrated. By means of the over pressure provided by the pressurised gas source 9 upstream of the evaporator 2 (i.e. at the side of the evaporator 2 where the conduit 7 is provided for transportation of liquid volatile fluid to the evaporator 2) and the reduced pressure provided by the vacuum pump 12 downstream of the evaporator 2 (i.e. at the side of the evaporator 2 where the conduit 5 is provided for transportation of vaporised volatile fluid from the evaporator 2), a pressure gradient is obtained (step 101) over the evaporator 2. This obtained 101 pressure gradient act to press/suck the volatile fluid downstream through the evaporator such that the volatile fluid is transported (step 102) to the evaporator 2 via the conduit 7 by means of the pressurised gas source 9. The volatile fluid is evaporated in the evaporator 2 and the evaporated volatile fluid in gas form is further transported 102 to the chamber 3 via the conduit 5.

[0030] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. A vapour phase drying apparatus (1), comprising:

a drying chamber (3) configured to receive an article (4) to be dried by means of the apparatus (1);
a vacuum pump (12) arranged for lowering the pressure within the drying chamber (3);
an evaporator (2) arranged for fluid connection with the drying chamber (3) and for evaporating a volatile fluid such that the volatile fluid in vapour form can enter the drying chamber (3) by means of the fluid connection;
a pressurised gas source (9); and
piping (7,10) connected to the evaporator (2) and to the pressurised gas source (9), and arranged for transporting the volatile fluid in liquid

form to said evaporator (2) by means of a pressure provided by said pressurised gas source (9).

2. The apparatus of claim 1, further comprising a volatile fluid container (6;15;17) arranged for fluid connection with the evaporator (2) and the pressurised gas source (9), and arranged for, in the volatile fluid container (6;15;17), allowing pressurised gas from the pressurised gas source (9) to contact and press on a liquid surface of the liquid volatile fluid such that the liquid fluid is pressed into the evaporator (2) without the pressurised gas entering the evaporator (2).
3. The apparatus of claim 1 or 2, wherein the pressurised gas source (9) is a pressurised gas container arranged to allow the pressurised gas to be provided to the piping (10) from said gas container.
4. The apparatus of claim 3, wherein the gas container (9) contains a pressurised inert gas.
5. The apparatus of claim 4, wherein the gas is nitrogen.
6. The apparatus of claim 5, further comprising an air separation unit (18) connected to the gas container (9) and arranged to supply the pressurised nitrogen to said gas container (9) after having separated said nitrogen from air.
7. The apparatus of claim 6, wherein the air separation unit (18) comprises a membrane for separating the nitrogen from air.
8. The apparatus of claim 6 or 7, wherein the air is compressed air having a pressure above atmospheric pressure.
9. The apparatus of any preceding claim, wherein the evaporator (2) is arranged at a lower altitude than the drying chamber (3), such as below a bottom wall of the drying chamber (3).
10. A method (100) of transporting a volatile fluid to an evaporator (2) of a vapour phase drying apparatus (1), the method comprising pressing (102) the volatile fluid in liquid form into the evaporator (2) by means of a pressurised gas source (9).
11. The method of claim 10, wherein the pressing (102) of the volatile fluid is achieved by obtaining (101) a pressure gradient over the evaporator (2), with a pressure provided by the pressurised gas source (9) upstream of the evaporator (2) and a reduced pressure provided by means of a vacuum pump (12) downstream of the evaporator (2), such that the volatile fluid is pressed downstream through the evaporator (2).

12. The method of claim 10 or 11, wherein the pressurised gas contacts and presses on a liquid surface of the liquid volatile fluid such that the liquid fluid is pressed into the evaporator (2) without the pressurised gas entering the evaporator (2). 5
13. The method of any one of claims 10-12, wherein the pressurised gas is an inert gas, such as nitrogen.
14. Use of a pressurised gas source (9) for pressing (101) a volatile fluid into an evaporator (2) of a vapour phase drying apparatus (1). 10

Amended claims in accordance with Rule 137(2) EPC. 15

1. A vapour phase drying apparatus (1), comprising:
- a drying chamber (3) configured to receive an article (4) to be dried by means of the apparatus (1); 20
 - a vacuum pump (12) arranged for lowering the pressure within the drying chamber (3);
 - an evaporator (2) arranged for fluid connection with the drying chamber (3) and for evaporating a volatile fluid such that the volatile fluid in vapour form can enter the drying chamber (3) by means of the fluid connection; 25
 - a pressurised gas source (9); 30
 - pipings (7,10) connected to the evaporator (2) and to the pressurised gas source (9), and arranged for transporting the volatile fluid in liquid form to said evaporator (2) by means of a pressure provided by said pressurised gas source (9); and 35
 - pipings (11) arranged for recycling liquid volatile fluid to the evaporator (2) from the drying chamber (3). 40
2. The apparatus of claim 1, further comprising a volatile fluid container (6;15;17) arranged for fluid connection with the evaporator (2) and the pressurised gas source (9), and arranged for, in the volatile fluid container (6;15;17), allowing pressurised gas from the pressurised gas source (9) to contact and press on a liquid surface of the liquid volatile fluid such that the liquid fluid is pressed into the evaporator (2) without the pressurised gas entering the evaporator (2). 45
3. The apparatus of claim 1 or 2, wherein the pressurised gas source (9) is a pressurised gas container arranged to allow the pressurised gas to be provided to the pipings (10) from said gas container. 50
4. The apparatus of claim 3, wherein the gas container (9) contains a pressurised inert gas. 55

5. The apparatus of claim 4, wherein the gas is nitrogen.

6. The apparatus of claim 5, further comprising an air separation unit (18) connected to the gas container (9) and arranged to supply the pressurised nitrogen to said gas container (9) after having separated said nitrogen from air.

7. The apparatus of claim 6, wherein the air separation unit (18) comprises a membrane for separating the nitrogen from air.

8. The apparatus of claim 6 or 7, wherein the air is compressed air having a pressure above atmospheric pressure.

9. The apparatus of any preceding claim, wherein the evaporator (2) is arranged at a lower altitude than the drying chamber (3), such as below a bottom wall of the drying chamber (3).

10. A method (100) of transporting a volatile fluid to an evaporator (2) of a vapour phase drying apparatus (1), the method comprising;

- pressing (102) the volatile fluid in liquid form into the evaporator (2) by means of a pressurised gas source (9);
- evaporating the volatile fluid in the evaporator (2) such that the volatile fluid in vapour form enters a drying chamber (3) of the apparatus by means of a reduced pressure of the drying chamber;
- condensing the volatile fluid in the drying chamber (3) to heat the article (4) therein; and recycling the liquid volatile fluid from the drying chamber (3) to the evaporator (2).

11. The method of claim 10, wherein the pressing (102) of the volatile fluid is achieved by obtaining (101) a pressure gradient over the evaporator (2), with a pressure provided by the pressurised gas source (9) upstream of the evaporator (2) and a reduced pressure provided by means of a vacuum pump (12) downstream of the evaporator (2), such that the volatile fluid is pressed downstream through the evaporator (2).

12. The method of claim 10 or 11, wherein the pressurised gas contacts and presses on a liquid surface of the liquid volatile fluid such that the liquid fluid is pressed into the evaporator (2) without the pressurised gas entering the evaporator (2).

13. The method of any one of claims 10-12, wherein the pressurised gas is an inert gas, such as nitrogen.

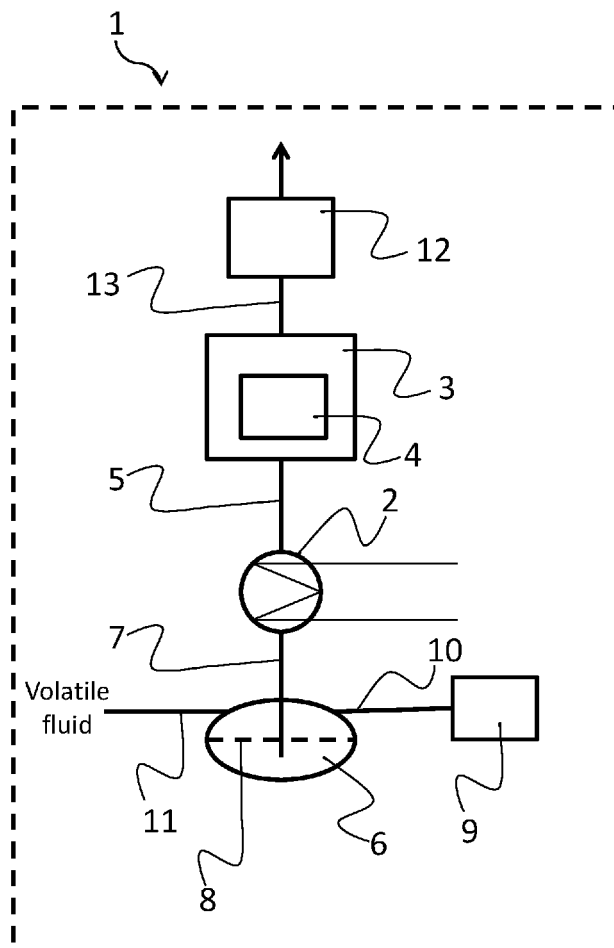


Fig 1

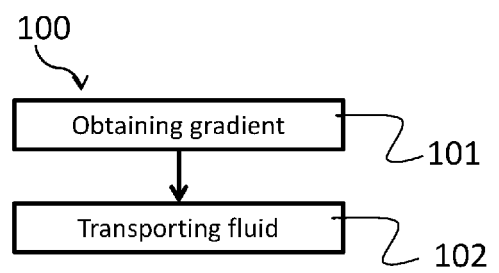
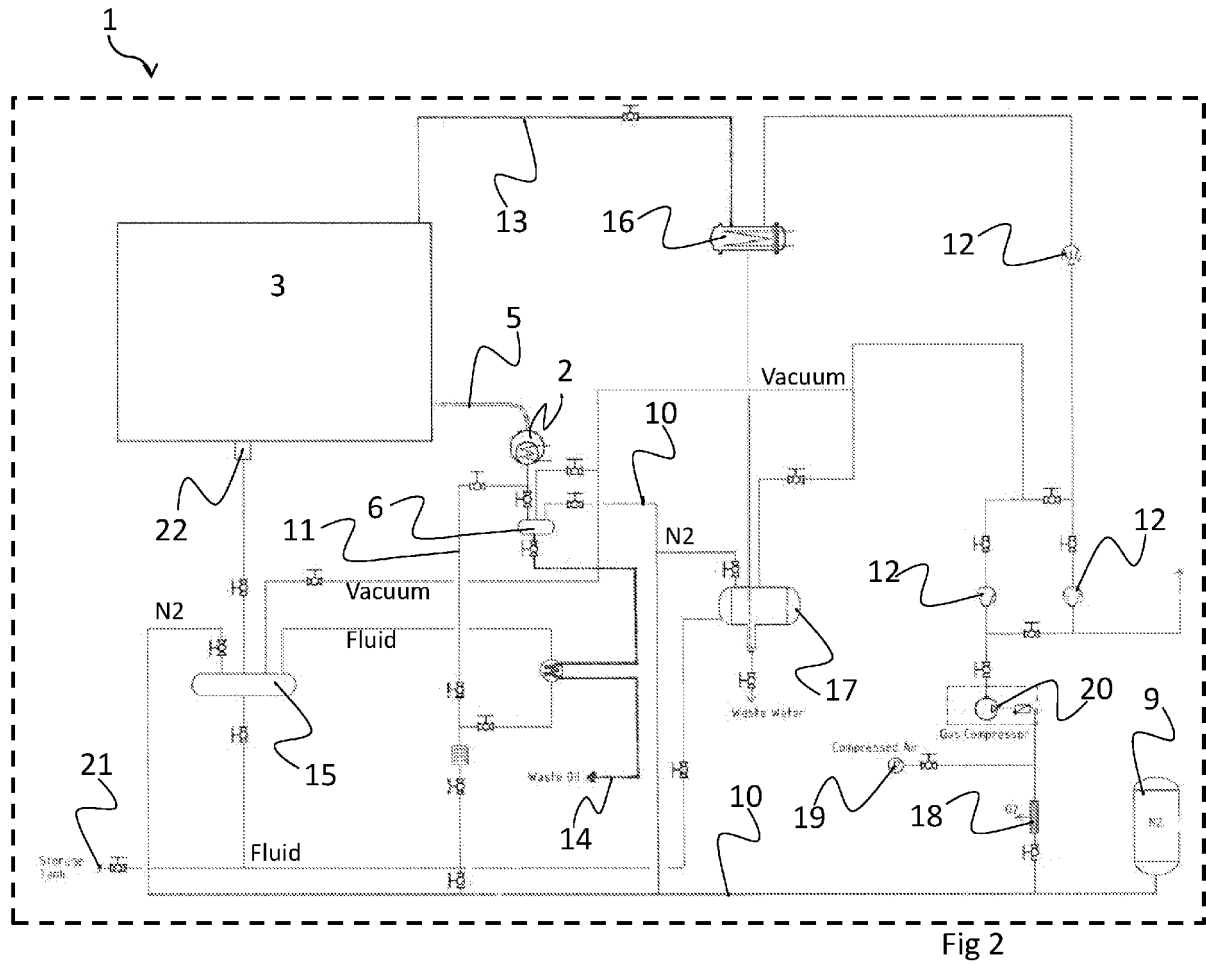


Fig 3





EUROPEAN SEARCH REPORT

Application Number
EP 11 18 0920

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A	DE 22 26 440 A1 (LEYBOLD HERAEUS GMBH & CO KG) 6 December 1973 (1973-12-06) * the whole document * -----	9	
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 14 February 2012	Examiner Hauck, Gunther
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

2
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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The members are as contained in the European Patent Office EDP file on
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