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(54) **Method and apparatus for expanding a starch containing product**

(57) The present invention relates to a method for expanding a starch containing product comprising the following steps: heating the product to a first temperature which is higher than the boiling point of water; increasing the pressure around the product to a first pressure above ambient pressure; and rapidly lowering the pressure to a second pressure to expand the product. The invention further relates to an apparatus for expanding a starch containing product and a tobacco product.

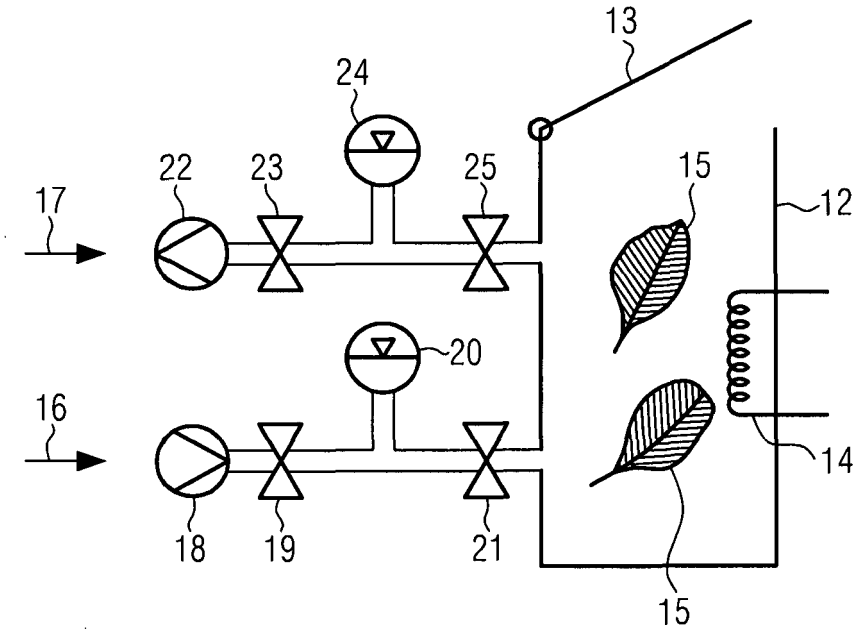

FIG. 2

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Description

[0001] The present invention relates to a method and an apparatus for expanding a starch containing product, in particular tobacco. The invention further relates to a tobacco product processed by the method or apparatus.

[0002] In the prior art, it is known to expand cut tobacco lamina, tobacco ribs, and cut tobacco stems for the purpose of improving their filling properties. The mechanism of expansion is explained by the phase change of an expansion medium in the tobacco from solid or liquid to vapor. Currently used methods often require additional expansion agents, such as carbon dioxide, isopentane, or nitrogen which is impregnated into the tobacco prior to the expansion process. While the use of expansion agents increases costs, their use allows processing of the tobacco at higher temperatures, which can otherwise have an undesired impact on the taste and quality of the tobacco. During the expansion process, the starch contained in the tobacco is expanded by means of evaporating the fluid comprised therein, which changes the structure of the starch into a crispy foam. Although starch is initially comprised in tobacco, starch may also be added, in particular by infusion.

[0003] Further starch containing products which can be expanded include food products, for example corn or rice, which can be transformed by means of expansion into popcorn or puffed rice, respectively.

[0004] It is the object of the invention to provide a method and apparatus for expanding a starch containing product, which allows an efficient expansion while avoiding undesired effects on the taste and quality of the product.

[0005] This is enabled by providing a method for expanding a starch containing product comprising the following steps: first heating the product to a first temperature that is higher than the boiling point of water; increasing the pressure around the product to a first pressure above ambient pressure; and subsequently rapidly lowering the pressure to a second pressure to expand the product.

[0006] One of the benefits of the invention is that as a product is first heated, and subsequently the pressure is increased, a higher maximum temperature can be obtained without evaporating the fluid comprised in the product. In particular, the subsequent increase in pressure can be conducted relatively quickly. By increasing the pressure quickly, and in contrast to heating the product and gas surrounding the product, the product will not be subjected to a high temperature longer than necessary. Furthermore, a controlled increase of the pressure avoids crushing or degrading the product, which may occur if the pressure is increased too rapidly. Thus, the invention avoids product degradation that could negatively impact the qualities of the product, including the structure or taste of the product.

[0007] In particular, the heating of the product to a first temperature is carried out at a constant initial pressure. The initial pressure may be ambient pressure.

[0008] Preferably, the pressure is rapidly lowered to a second pressure below ambient pressure. Rapidly lowering the pressure may relate to instantly lowering the pressure. Preferably rapidly lowering the pressure involves a pressure reduction rate of at least several bar per second, in particular in between about 500 millibar per second and about 10 bar per second, more preferably in between 5 bar per second and 10 bar per second. When subjecting tobacco to the method according to the invention, the tobacco is in particular expanded such that it comprises blisters on its surface.

[0009] During the rapid lowering of the pressure the fluid comprised in the product evaporates, changing the structure of the starch in the product. The fluid comprised in the product is usually water. The blisters are sized between 1mm and 50mm, preferably between 7mm and 13mm. The cellular make-up is epidermal cells. In particular, the blisters are formed by epidermal cells affected by the method. The surface of the blister includes pleats or wrinkles and is slightly lighter in color.

[0010] The method according to the invention can, in particular, be applied to tobacco leaves, and also cut tobacco. The tobacco may comprise lamina, rib, and stem parts or pieces. In particular, the expansion of stem parts enables to obtain a product with high filling power but low nicotine content.

[0011] Preferably, the starch containing product is tobacco, more specifically cut tobacco, tobacco lamina, tobacco ribs, tobacco stems or whole leaves. In other applications the product may also be corn or rice, which can be expanded as well, as these are all starch containing products.

[0012] Preferably, the first temperature is above the gelatinization temperature of starch. In particular, the first temperature is above 120 degrees Celsius. Note that for some types of starch, the gelatinization temperature may be as low as 55 degrees Celsius or 85 degrees Celsius. Preferably, the first temperature is around 130 degrees Celsius. These temperatures enable that after pressurization and the rapid lowering of the pressure, an effective expansion process can be carried out. Preferably, the first temperature is less than 180 degrees Celsius. Thus, degradation of the starch containing product, in particular tobacco, can be avoided.

[0013] In one embodiment, the first pressure is more than 10 bar. Preferably the first pressure is around 12 bar. This has the benefit that by means of the pressure increase, the temperature can be further increased while evaporation of the fluid comprised in the starch containing product can still be largely avoided. In particular, water is comprised in the starch containing product as a fluid. The evaporation mainly occurs during the subsequent rapid lowering of pressure.

[0014] Preferably, the first pressure is less than 14 bar. This pressure is sufficiently high for avoiding effective expansion of the starch containing product.

[0015] In particular, the pressure is increased from an initial pressure to a first pressure in less than 90 seconds.

A relatively rapid increase of the pressure to the first pressure allows that the total time that the product is subjected to high pressure and temperature can be reduced. Thus, the product can be expanded, avoiding degradation of the product. Nevertheless, the pressure is sufficient to enable a sufficiently high temperature, and, therefore, an effective expansion.

[0016] In particular, the temperature increases together with the pressure to more than 135 degrees Celsius. The temperature increase mainly occurs according to the second law of Gay-Lussac, as preferably, the volume surrounding the product may be kept constant, but the temperature or the pressure may change.

[0017] In one embodiment, the first pressure is maintained at least 300 seconds. More preferably, the first pressure is maintained at least 400 seconds, in particular around 420 seconds. The fact that the product is subjected to a high pressure for the aforementioned time allows that expansion medium, such as vapor, is absorbed by the product and that, thus, the expansion is more effective. In particular, the expansion medium may be saturated steam, super heated steam, or a mixture of steam and air. In particular, the steam is on the basis of water. Even if no expansion medium is absorbed by the product, the aforementioned time, at high pressure enables that the whole product is heated to a high temperature, such that the following lowering of the pressure has a thorough expansion effect on the product, as all the fluid comprised in the product will evaporate rapidly.

[0018] In particular, the second pressure is less than 0.1 bar. More preferably, the second pressure is around 50 millibar. The low pressure facilitates the expansion of the product, as it supports the evaporating of fluid in the product.

[0019] Preferably, water contained in the product is in its liquid state while the product is subjected to the first pressure and first temperature. Thus, as the water only evaporates during the rapid lowering of pressure, an efficient expansion of the starch containing product can be obtained.

[0020] In particular, the method is free of the use of an expansion agent. Expansion agents are, for example, carbon dioxide, nitrogen, or isopentane. These expansion agents allow higher temperatures without the degradation of the product, but are costly. As an expansion medium, vapor may be injected in some embodiments of the invention. The gas surrounding the product may be air. However, the gas surrounding the product may also be saturated steam, super heated steam, or a mix of steam and air.

[0021] Preferably, starch is added to the product for expansion, wherein the adding of starch involves subjecting the product to a starch containing fluid, such that the starch containing fluid is absorbed by the product. In particular, the fluid containing the starch is a liquid. The increase of the starch content of the product improves its expansion properties, as the starch is the main component that is expanded. Furthermore, for products that do not comprise any starch, the whole starch content can be added before expansion.

[0022] The invention further provides an apparatus for expanding a starch containing product comprising a heating means adapted to heat the product to a first temperature, a pressure increasing means adapted to increase the pressure to a first pressure after the product has been heated, and a pressure reducing means that is adapted to quickly reduce the pressure. In particular, the product is arranged in a hermetically sealable chamber. The heating means may be an electric heater or fan applying hot air, vapor or steam. The pressure increasing means may, in particular, be a pump, which is adapted to pump additional air, vapor or steam into the chamber. The pressure reducing means is, in particular, a valve that can be opened to release the pressure rapidly from the sealable chamber. Quickly reducing the pressure relates in particular to a pressure reduction rate of several bar per second, preferably in between 0.5 bar per second and 10 bar per second, more preferably in between 5 bar per second and 10 bar per second.

[0023] Preferably, the pressure reducing means is adapted to apply a vacuum to the product. Thus, the pressure reducing means may particularly comprise in addition to a valve releasing the pressure from the chamber, a vacuum pump, which can reduce the pressure in the chamber to a pressure lower than ambient pressure. Vacuum is defined in the context of the present application as a pressure lower than ambient pressure. Between the vacuum pump and the hermetically sealable chamber, a vacuum tank may be provided, which is evacuated before the valve is opened, such that a more rapid lowering of the pressure in the chamber can be obtained.

[0024] The invention further relates to a tobacco product comprising tobacco material processed by the method or apparatus according to embodiments of the invention as decribed beforehands. In particular, 70 percent to 90 percent of the cells in the tobacco material affected by the process are epidermal cells. More in particular, 75 percent to 85 percent, in one embodiment about 80 percent, of the cells in the tobacco material affected by the process are epidermal cells.

[0025] The remaining affected cells are in particular mainly palisade cells, which account for 30 percent to 10 percent, more in particular 25 percent to 15 percent, in one embodiment about 20 percent of the cells in the tobacco material affected by the process.

[0026] In particular, spongy-layer cells are not significantly affected by the process. Furthermore, the process does not significantly affect long-stalked trichomes and broader short-stalked trichomes.

[0027] In tobacco material processed by a preferred method or apparatus according to an embodiment of the invention, out of the epidermal cells 90 percent to 95 percent of the affected cells are pavement cells and out of the epidermal cells the remaining 10 percent to 5 percent of the affected cells are stomatal guard cells.

[0028] The above-indicated percentages of cells relate

to the cell count.

[0029] Affected cells are in particular cells, whose cell envelope or cell wall has been modified by the process such that the volume of the cell has been increased. In some processes carried out by embodiments of the method or apparatus, the volume of the affected cells has been increased by at least 20 percent, at least 50 percent, or at least 100 percent. The volume increase of the affected cells is in particular due to a weakened or at least partially broken down cell envelope or cell wall. The tobacco product may be tobacco leaves, cut tobacco leaves, tobacco lamina, tobacco ribs, tobacco stems or cut filler tobacco, but may also be a final product, such as smoking articles, in particular cigarettes, cigars, roll your own tobacco, make your own tobacco, or volume tobacco. Cut filler tobacco comprises mainly cut-up strands of tobacco material of various length and color due to blending. However, the presence of blisters in the areas of the affected cells can be observed under the microscope or magnifying glass. Furthermore, the tobacco product may also be a tobacco containing product for a smoking device, which only heats, but not burns the tobacco. In particular, the tobacco product differs from expanded tobacco products in the prior art by having a higher expansion level.

[0030] The invention will now be further described with reference to exemplary embodiments as shown in the Figures.

Figure 1 shows a temperature and pressure chart over time according to an embodiment of the method of the invention.

Figure 2 shows an apparatus according to an embodiment of the invention.

[0031] In Figure 1, an embodiment of the method according to the invention for expanding a starch containing product, in particular tobacco, is illustrated by means of a temperature chart T and pressure chart p over time t. The upper line in the chart shows the temperature T to which the starch containing product is subjected, while the lower line relates to the pressure p surrounding the product. At the beginning of the method according to the invention, the product is heated to a first temperature 1, which is higher than the boiling point of water. In particular, the temperature around the product may be kept substantially constant at the first temperature 1 during a pre-heating phase 2. At the end of the pre-heating phase 2 the whole product has substantially the first temperature 1. During the pre-heating phase 2, the pressure surrounding the product is substantially ambient pressure 3. The pre-heating phase may last from at least about 30 seconds to about 15 minutes.

[0032] After the pre-heating phase 2, the pressure around the product is increased to a first pressure 4 in a pressurization phase 5.

[0033] The pressure increase in the pressurization phase 5 is carried out in less than 90 seconds, preferably in about one minute. After the pressurization phase 5, the first pressure 4 of about 11 bar is attained. During the pressurization phase, the temperature of the product increases together with the pressure to a second temperature 6 of more than 130 degrees Celsius, preferably around 135 degrees Celsius. This is due to the law of Gay-Lussac, as in this embodiment, the volume of the chamber comprising the product is kept constant, while the pressure is increased, which leads to an increase in the temperature as well.

[0034] The gas surrounding the product is then maintained substantially constant at the first pressure 4 and second temperature 6 during a high pressure phase 7. The high pressure phase 7 lasts preferably around 7 minutes.

[0035] During the high pressure phase 7 the temperature of the product is at a level which is high enough to allow boiling of water at an atmospheric pressure, but low enough to maintain water in its liquid state at the first pressure 4. The starch comprised in the product gelatinizes during the high pressure phase 7.

[0036] Thus, during a subsequent pressure release phase 8, the product expands, when the water and/or expansion agent comprised within the starch rapidly evaporates and therefore changes the structure of the starch to a crispy foam. The pressure is lowered during the pressure release phase 8 from the first pressure 4 to a second pressure 9. The second pressure 9 is lower than the first pressure 4, and may for example be ambient pressure. However, in the present embodiment, the second pressure 9 is less than 100 millibar, preferably around 50 millibar. Thus, when a product, for example in the form of a tobacco leaf, is subjected to the method according to the embodiment of the invention, it is first pressurized up to 12 bar, then quickly depressurized to a vacuum of about 50 millibar while heat is applied at a temperature of around 130 degrees Celsius. Thus, the tobacco leaf is expanded, which is recognizable by the fact that it has big blisters on its surface.

[0037] In particular, during the rapidly lowering of the pressure to the second pressure 9, the temperature is lowered to a third temperature 10, which is preferably around the first temperature 1 or slightly lower. The lowering of the temperature to the third temperature 10 occurs according to the law of Gay-Lussac due to the lowering of the pressure while maintaining the volume. The product is maintained for a certain time during a low pressure phase 11 at the second pressure 9 and third temperature 10, until the expansion is finished. Subsequently, the pressure around the product is again set to ambient pressure such that the chamber comprising the product can be opened, for example by connecting the chamber to the environment.

[0038] A key component of method according to the invention is the presence of starch in the product, which can be naturally present in the product or added to the product, as the starch is the component in the product which enhances expansion, such as it happens for ex-

ample in corn or rice during the manufacture of popcorn or puffed rice.

[0039] During the expansion process, an expansion agent such as carbon dioxide, isopentane or nitrogen, can be applied. This may prevent negative impact on the taste or appearance of the product due to too high temperatures. However, a main benefit of the method according to the invention is that the use of such expansion agents is not necessary, as the method according to the invention enables a gentle processing of the product. Preferably, saturated steam or super heated steam or a mixture of steam and air can be applied to the gas surrounding the product. This may improve the expansion process due to a better heat transfer in between the gas surrounding the product and the product, and due to the higher moisture content which leads to a better expansion.

[0040] In Figure 2, an apparatus according an embodiment of the invention is shown. The apparatus comprises a hermetically sealable chamber 12, which can be closed by means of a lid 13. In the chamber 12, a heating means 14 is provided, which is adapted to heat the gas around a product 15, which is in particular in the form of tobacco leaves. Furthermore, a pressure increasing means 16 and a pressure reducing means 17 are connected to the chamber 12. The pressure increasing means 16 comprises a pump 18, which is adapted to pump additional air, vapor or steam into the chamber 12. In between the pump 18 and the chamber 12, a first valve 19, a pressure tank 20 for storing pressurized gas and a second valve 21 are provided. The pump 18 is at the upstream end of the pressure increasing means 16, followed by the first valve 19, the tank 20 and the second valve 21 in the downstream direction towards the chamber 12. The pressure increasing means 16 comprising these components is sometimes referred to as a pressure booster. Initially the first valve 19 is opened while the pump operates to fill the pressure tank 20 with pressurized gas, while the second valve 21 is closed. Then, the first valve 19 is closed, such that the tank 20 stores the pressurized gas therein, while the pump 18 may stop operation. When the product 15 is heated to the first temperature 9 in the chamber 12, the second valve 21 is opened, while the lid 13 of the chamber 12 is in its closed state. Thus, the pressure around the product 15 is increased to the first pressure 4 above ambient pressure. In another mode of operation, the first valve 19 may remain open while the pump 18 continuously operates when the second valve 21 is opened, such that pressurized gas from both the pump 18 and the pressure tank 20 is provided to the chamber 12, increasing the pressure around the product 15 to the first pressure 4.

[0041] The pressure reducing means 17 comprises a pump 22, a third valve 23, a vacuum tank 24 and a fourth valve 25. The fourth valve 25 is at the most upstream position next to the chamber 4, followed by the vacuum tank 24, the third valve 23 and the pump 22 in the downstream direction.

[0042] The pressure reduction means 17 is operated in the following manner. During the pressurization of the chamber 12, the fourth valve 25 is closed. The third valve 23 is open during the operation of the pump 22 such that the vacuum tank 24 is evacuated to a low pressure. Then, the third valve 23 may be closed while the operation of the pump 22 is stopped. For the rapid lowering of the pressure to the second pressure 9, the fourth valve 25 is opened. Thus, the pressure from the chamber 12 flows into the vacuum tank 24, such that the chamber 12 is evacuated to the second pressure 9. During this operation the third valve 23 may be closed. However, in other embodiments, the third valve 23 may be open during the rapidly lowering of the pressure in the chamber 12, while the pump 22 is in operation, such that the chamber is evacuated by means of the vacuum tank 24 and the operation of the pump 22.

[0043] In some embodiments, the chamber 12 may comprise an opening for inserting the product and one opening for removing the product. The respective openings may be closed by lids or other closing means, such that the chamber 12 is hermetically sealable. Furthermore, the chamber 12 may be provided on a revolving member, wherein in particular several sealable chambers are provided on the revolving member. Thus, the product may be provided in one of the chambers, which is in a loading position, then the revolving member may be rotated while the product is maintained in one of the chambers at the first pressure 4. Then the pressure in the chamber may be lowered to the second pressure 9 and the product may be discharged from the chamber, when the chamber is in a discharging position. The revolving member may significantly increase the throughput of product in the apparatus.

[0044] In particular, the vacuum tank 24 or the pressure tank 20 or the pressure tank 20 and vacuum tank 24 may be large with respect to the volume of the chamber 12, such that the pressure in the chamber can be rapidly changed, in particular that it can be rapidly lowered. In particular, the volume of the vacuum tank 24 or the pressure tank 20 may be larger than the volume of the chamber 12. Furthermore, the pipes connecting the chamber 12 and the vacuum tank 24 or the pressure tank 20 may have a high diameter, which facilitates the rapidly changing of the pressure in the chamber 12.

[0045] The volume of the vacuum tank 24 is 500 to 10000 litres, preferably 1000 to 5000 litres, more preferably 3000 to 5000 liters. The volume of the pressure tank 20 is 20 to 100 litres, preferably 40 to 80 litres, more preferably 40 to 60 liters. The volume of the product chamber 12 is 1 to 5 litres, more preferably 1 to 4 litres. The pipe diameter used for the vacuum tank is 50mm (DN50) and the pipe diameter for the pressure tank is 40mm (DN40).

Claims

1. Method for expanding a starch containing product comprising the following steps:

   - heating the product to a first temperature which is higher than the boiling point of water;
   - increasing the pressure around the product to a first pressure above ambient pressure; and
   - rapidly lowering the pressure to a second pressure to expand the product.

2. Method according to claim 1, wherein the first temperature is above the gelatinization temperature of starch, preferably more than 120 degrees Celsius.

3. Method according to claim 1 or 2, wherein the first temperature is less than 135 degrees Celsius.

4. Method according to any one of the preceding claims, wherein the first pressure is more than 10 bar, and preferably less than 14 bar.

5. Method according to any one of the preceding claims, wherein the pressure is increased from an initial pressure to the first pressure in less than 90 seconds.

6. Method according to any one of the preceding claims, wherein the temperature increases together with the pressure to more than 135 degrees Celsius.

7. Method according to any one of the preceding claims, wherein the first pressure is held at least 300 seconds.

8. Method according to any one of the preceding claims, wherein the second pressure is less than 0.1 bar.

9. Method according to any one of the preceding claims, wherein water contained in the product is in its liquid state while the product is subjected to the first pressure and first temperature.

10. Method according to any one of the preceding claims, wherein the method is free of the use of expansion agent.

11. Method according to any one of the preceding claims, wherein starch is added to the product before the expansion, wherein the adding of starch involves subjecting the product to a starch containing fluid, and the starch from the fluid is absorbed by the product.

12. Apparatus for expanding a starch containing product comprising
    a heating means, which is adapted to heat the product to a first temperature,
    a pressure increasing means, which is adapted to increase the pressure surrounding the product to a first pressure, after the product has been heated, and
    a pressure reducing means, which is adapted to quickly reduce the pressure surrounding the product.

13. Apparatus according to claim 12, wherein the pressure reducing means is adapted to apply a vacuum to the product.

14. Tobacco product comprising tobacco material processed by the method or apparatus according to any one of the preceding claims.

15. Tobacco product according to claim 14, wherein 70% to 90% of the cells in the tobacco material affected by the process are epidermal cells, and wherein out of the epidermal cells 90% to 95% of the affected cells are pavement cells and 10% to 5% of the affected cells are stomatal guard cells.

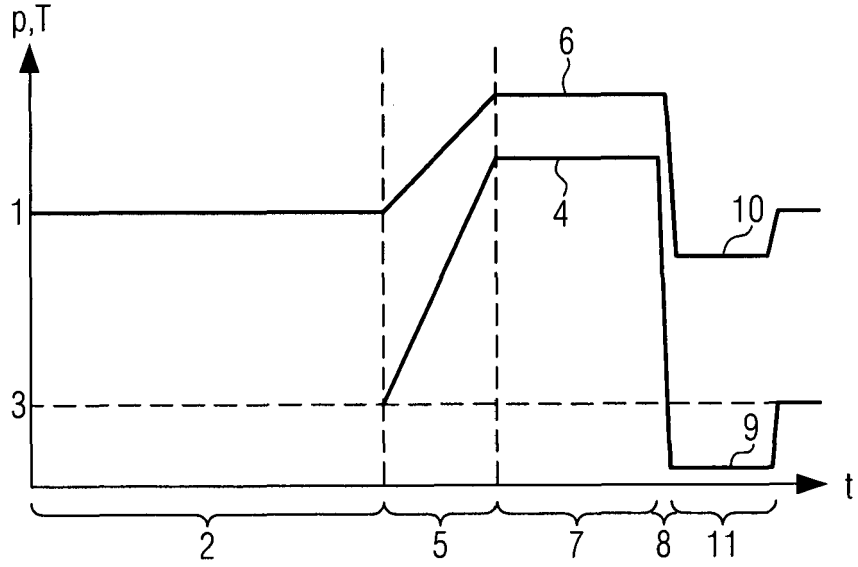

FIG. 1

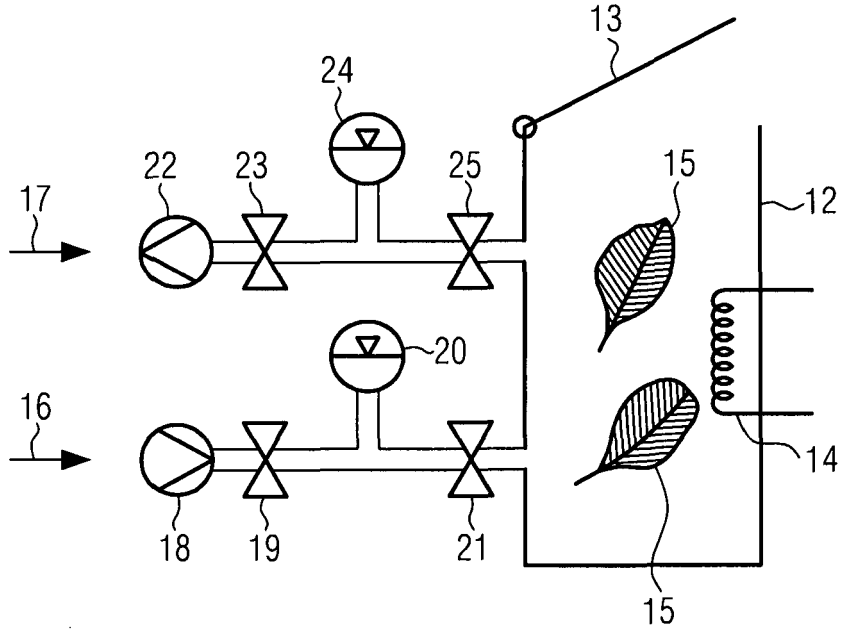

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
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A24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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