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(54) **Method for drying animal feed and drying system suited to implement said method**

(57) The invention concerns a drying method particularly suited to be used for treating animal feed, comprising the following operations: introducing the food to be dried into a sealed container; depressurizing the container by sucking the gases contained therein; taking from the container the water vapour released by the food due to the effect of depressurization; condensing the vapour outside the container; unloading the dried food from the container.

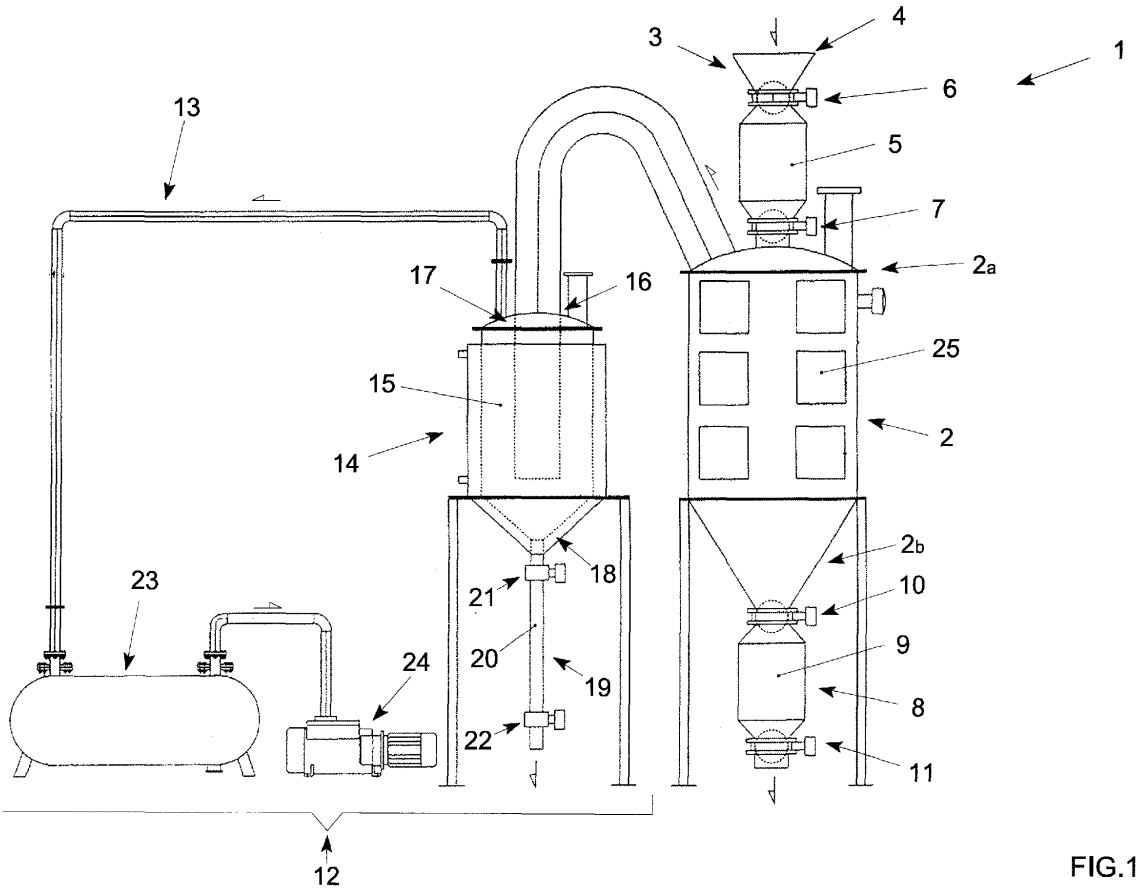

FIG.1

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Description

[0001] The present invention concerns a method for drying animal feed, particularly suitable for flours and products in pieces like, for example, fodder, biscuits, croquettes and the like.

[0002] The invention furthermore concerns a drying system implementing said method.

[0003] As is known, animal feed in pieces is obtained from a compound, generally through a forming process achieved by extrusion or compression in briquetting presses or similar machines.

[0004] To be able to amalgamate the compound, it is necessary to heat it before forming, an operation that is generally carried out via the injection of water vapour.

[0005] After the forming process, the temperature of the product is high and therefore it must be cooled before the successive packaging stage.

[0006] Furthermore, since during heating the compound absorbs a considerable quantity of water vapour, it is also necessary to dry the product, in order to prevent the rapid growth of mildew that would make it unusable.

[0007] Similar requirements apply also to flour products that in fact must be subjected to a so-called "sanitation" process, according to which they are heated through water vapour to a temperature in the order of 130 - 140°C.

[0008] The sanitation of the products makes it possible to eliminate some pathogenic microorganisms like, for example, the salmonella bacterium, but it must be followed by a successive product cooling and drying process.

[0009] According to the known art, the cooling and drying processes of the food are carried out in drying tunnels, where the product is exposed to an air current under forced ventilation that is successively discharged in the environment.

[0010] A first drawback of the known method described above lies in that the air flowing out of the drying tunnel must undergo a filtering treatment before being able to be discharged into the external environment.

[0011] In fact, while flowing through the drying tunnel, the air removes from the product and fills with powders that are potentially harmful to the environment.

[0012] The air filtering process poses the drawback that it requires particularly large, complex and costly filters.

[0013] A further drawback posed by the known technique lies in that the above mentioned filters require a routine maintenance procedure that, due to the complexity of the filters themselves, is quite complicated and thus involves high maintenance costs.

[0014] According to a known construction variant, instead of the above mentioned filters water depurators are used that, however, require high quantities of water for treating the drying air.

[0015] Furthermore, the water used for the depuration process must in turn be treated, since it contains the above mentioned powders deriving from the drying process, with a further inconvenience lying in that the system requires an additional depuration stage.

[0016] Another drawback posed by the drying methods described above lies in that a considerable quantity of air is required in order to guarantee drying to a sufficient degree, so that it becomes necessary to use drying tunnels and corresponding ducts having large dimensions compared to the volume of product to be dried.

[0017] For this reason, the drying systems of known type are rather bulky and costly.

[0018] A further drawback posed by the known art lies in that to generate the air current necessary for the drying process powerful fans are needed, which involve high system running costs.

[0019] The object of the present invention is to overcome all the drawbacks described above.

[0020] In particular, it is a first object of the invention to implement a method for drying and cooling animal feed that does not require the use of air.

[0021] It is a further object of the invention to develop a drying system whose energy consumption is lower than that of the systems of known type, though guaranteeing the same drying capacity.

[0022] It is a further object of the invention to develop a drying system that requires less maintenance than equivalent systems of known type, with a consequent cost reduction.

[0023] It is another, yet not the least object of the invention, to develop a drying method and system that, while absorbing the same power as the known methods and systems described above, make it possible to obtain food with a lower degree of humidity and, consequently, longer duration.

[0024] The objects described above are achieved by a drying method carried out according to the main claim, as well as by a drying system carried out according to claim 4.

[0025] Other details of the method and system that are the subjects of the invention are described in the corresponding dependent claims.

[0026] Advantageously, since the system subject of the invention does not use air, it does not require any filters to treat the air, thus avoiding all the related maintenance costs.

[0027] Still advantageously, the system subject of the invention has smaller overall dimensions than an equivalent system of known type since, besides avoiding the use of the above mentioned filters, it does not require ducts with large section for the circulation of the drying air.

[0028] Consequently, to advantage, the system of the invention can be installed in sites where reduced spaces are available.

[0029] On the other hand, advantageously, the invention makes it possible to develop systems with higher drying capacity than the known systems, but with lower costs and smaller overall dimensions.

[0030] The objects and advantages described above,

and others described below, will be highlighted in greater detail in the description of a preferred embodiment of the invention that is provided as an indicative, non-limiting example with reference to the enclosed table, wherein Figure 1 illustrates an embodiment of the system that is the subject of the invention.

[0031] The drying method proposed by the invention is particularly suitable for treating animal feed, to which reference is made below.

[0032] It is evident, however, that in other embodiments it can be used to treat other materials that need drying like, for example, fertilizers.

[0033] According to the invention, the method comprises a first stage at which the food to be dried is introduced into a sealed container.

[0034] The method further includes an operation that consists in depressurizing the container by sucking all the gases present therein.

[0035] The above mentioned depressurization favours the evaporation of the water contained in the food, as a consequence of the well-known principle of physics according to which a liquid substance evaporates until the pressure of the vapour reaches a balance level corresponding to the so-called "vapour tension" that, for a given temperature, is typical of that substance.

[0036] Therefore, owing to the depressurization generated in the container, the water present in the food in the liquid state changes into vapour until when the pressure in the container is equal to the above mentioned vapour tension.

[0037] Furthermore, advantageously, since evaporation is an endothermic change, it extracts vapour from the food that thus cools down.

[0038] The method of the invention further includes an operation that consists in taking the evaporated air from the container, preferably through the same gas sucking operation described above.

[0039] The extraction of vapour from the container prevents said vapour from reaching the thermodynamic balance with the liquid present in the food, which therefore keeps evaporating.

[0040] Preferably, the depressurization in the container will be as near vacuum as possible.

[0041] This advantageously favours the evaporation of the liquid since, as known, evaporation speed increases as pressure in the container decreases.

[0042] It can be understood that, since evaporation is obtained exclusively through depressurization, and therefore without using air, a first object of the invention has thus been achieved.

[0043] Advantageously, the drying speed ensured by considerable depressurization allows drying times to be highly reduced compared to the methods of known type.

[0044] Still advantageously, the food is not struck by a constant flow of drying air and therefore does not release any powder.

[0045] Consequently, to advantage, the vapour extracted from the container does not contain substances that are harmful to the environment and does not require special depuration procedures.

[0046] Furthermore, to advantage, depressurization in the container limits the proliferation of some types of microorganisms like for example salmonella.

[0047] According to the method, furthermore, the vapour extracted from the container is condensed outside it and can thus return into the environment.

[0048] Finally, the dried and cooled food is unloaded from the container and goes on to the successive stages in the production process.

[0049] Preferably, the operations for loading/unloading the food into/from the container take place intermittently, in order to advantageously ensure the continuous operation of the system, as explained below.

[0050] Preferably, the method also includes an operation that consists in heating the inside walls of the container, at least during the extraction of vapour.

[0051] Advantageously, this operation prevents the condensation of vapour when it comes into contact with the cold walls of the container, which would hinder its extraction.

[0052] The method of the invention described above is particularly suited to be implemented on a drying system as represented in Figure 1 and therein indicated as a whole by **1.**

[0053] According to the invention, the system **1** comprises:

- a sealed container **2** for the food to be dried;
- means **3** for loading the food to be dried into the container **2;**
- means **8** for unloading the dried food from the container **2;**
- means **12** for sucking the gases present in the container **2.**

[0054] The container **2** may clearly have any shape and size, chosen by the manufacturer according to the overall dimensions and the required capacity of the system **1.**

[0055] The loading means **3** comprise a first sealed chamber **5,** operatively connected to means **4** for feeding the food to be dried through a first inlet valve **6** and communicating with the container **2** through a first outlet valve **7.**

[0056] Preferably, the above mentioned feeding means **4** comprise a hopper suited to convey the food coming from the production line.

[0057] The unloading means **8** comprise a second sealed chamber **9,** communicating with the container via a second inlet valve **10** and operatively connected to means for collecting the dried food, not illustrated herein, through a second outlet valve **11.**

[0058] The collection means are preferably containers but in other embodiments of the invention they may comprise conveyor belts for transferring the dried product to the successive processing stages.

[0059] Furthermore, the loading means **3** are preferably arranged at the top **2a** of the container **2** and the unloading means **8** at the bottom **2b** of the same.

[0060] This configuration advantageously makes it possible to exploit gravity in order to induce both the transit of the food between the loading means **3** and the unloading means **8,** and the loading and unloading operations themselves.

[0061] It is clear, however, that in construction variants of the invention and should there be particular needs, the loading means **3** and the unloading means **8** can be arranged differently than described above, for example horizontally, provided that the container **2** is equipped with a system for transporting the food from the loading means **3** to the unloading means **8.**

[0062] The suction means **12** comprise a vacuum pump **24,** operatively connected to the container **2** via a suction circuit **13.**

[0063] The suction circuit **13** comprises a condenser **14** provided with a condensation chamber **15** in which it is possible to identify one inlet mouth **16** for the gases sucked from the container **2,** operatively connected to it, one outlet mouth **17** for the non-condensable gases, operatively connected to a vacuum pump **24,** and a mouth **18** for conveying the condensation, associated with conveyance means **19.**

[0064] In particular, the above mentioned non-condensable gases are substantially constituted by air that, due to the depressurization of the system **1,** can penetrate inside the system **1** through the valves and/or because of sealing failures.

[0065] The above mentioned condensation chamber **15** is preferably, but not necessarily cooled by means of a refrigerating system associated with the condenser **14,** not illustrated herein.

[0066] This advantageously allows a high refrigerating capacity to be obtained, particularly in the hot season, thus limiting the size of the condenser **14.**

[0067] The means **19** for conveying the condensation comprise a third sealed chamber **20** communicating with the condensation chamber **15** via a third inlet valve **21** and operatively connected to means for collecting the condensation, not illustrated herein, through a third outlet valve **22.**

[0068] Advantageously, the sealed chambers **5, 9, 20** with which the above mentioned loading means **3,** unloading means **8** and conveyance means **19** are provided make it possible to maintain the system **1** depressurized during the transit of the food or condensation, by operating the corresponding valves **6, 7, 10, 11, 21, 22** alternatively, so that when one of them is open, the other is closed.

[0069] The suction circuit **12** preferably comprises a filter **23** for the non-condensable gases, interposed between the condenser **14** and the vacuum pump **24.**

[0070] Advantageously, the above mentioned filter **23** makes it possible to block any impurities brought along by the non-condensable gases before releasing them into the atmosphere, in such a way as to guarantee the total absence of powders.

[0071] It is also evident that, since the non-condensable gases are present in a limited quantity, as they are essentially constituted by the air that enters the container **2** during the food loading/unloading operations, the filter **23** will be much smaller than the filters used in the equivalent systems of known type.

[0072] Therefore, the invention achieves the object to carry out a drying system **1** that requires less maintenance than the equivalent systems of known type, given that the filter **23** used is much less complex and much smaller than the filters normally used in the systems of known type.

[0073] The system **1** preferably comprises also means **25** for heating the inner surface of the container **2** that, as already explained, advantageously allow the condensation of vapour in the container **2** to be avoided.

[0074] The above mentioned heating means **25** comprise a circuit for the circulation of a hot fluid that is preferably water.

[0075] It is obvious, however, that in construction variants of the invention, not illustrated herein, the circulation fluid can use a hot fluid different from water.

[0076] Analogously, in further construction variants of the invention, the heating means **25** may comprise, instead of a circulation circuit, any type of heating device, provided that it is suitable for heating the inner surface of the container **2,** like for example a set of electric resistances or other similar devices of known type.

[0077] It is thus clear that the system **1** of the invention absorbs much less power than the equivalent systems of known type, since it does not require the generation of considerable air flows by means of correspondingly powerful fans.

[0078] Furthermore, due to the limited quantity of gas that flows along the system **1,** the volume of its parts is considerably smaller compared to the equivalent systems of known type, and the diameter of the ducts used is smaller, too.

[0079] Consequently, to advantage, the system **1** of the invention has much smaller overall dimensions than a system of known type equivalent to it in terms of drying capacity.

[0080] For this reason, the invention also makes it possible to carry out a drying system that is more effective than systems of known type comparable to it in terms of costs and dimensions, and therefore achieves another of its objects.

[0081] In practice, the vacuum pump **24** provides for sucking the air present in the container **2,** thus depressurizing it.

[0082] The food coming from the production cycle, which is characterized by high temperature and humidity, is introduced in the container **2** through the loading means **3.**

[0083] As mentioned above, the food is introduced intermittently: at first the inlet valve **6** is opened to fill the

sealed chamber **5,** after which the inlet valve **6** is closed and at the same time the outlet valve **7** is opened, so that the contents of the sealed chamber **5** are emptied into the container **2.**

[0084] The intermittent introduction described above prevents air from entering the container **2** during the introduction of food, thus advantageously making it possible to maintain the system **1** depressurized and allowing it to operate continuously.

[0085] The introduction of food continues until the container **2** is filled to a predetermined level.

[0086] Inside the container **2,** depressurization favours the evaporation of the water contained in the food, which is consequently dried and cooled.

[0087] The vapour developed in this way flows into the condensation chamber **15** of the condenser **14** through its inlet mouth **16,** due to the sucking action of the vacuum pump **24.**

[0088] The liquid that condenses flows towards the conveyance means **19** through the conveyance mouth **18,** to be then unloaded into the external environment by the operation of the two valves **21, 22,** in a manner analogous to that described above for the loading means **3,** in such a way as to maintain the system **1** depressurized.

[0089] The non-condensable gases, on the other hand, flow through the outlet mouth **17** of the condensation chamber **15,** drawn by the vacuum pump **24,** and are finally unloaded into the atmosphere, after passing through the filter **23.**

[0090] The food remains in the container **2** for a time sufficient to achieve the desired degree of drying, after which they are unloaded by gravity through the unloading means **8,** whose operation is analogous to that of the loading means **3** described above.

[0091] Advantageously, the food can be loaded and unloaded at the same time, since the loading means **3** and the unloading means **8** are independent of each other.

[0092] Furthermore, since loading means **3** and the unloading means **8** are situated on opposite sides of the container **2,** the last food loaded will also be the last to be unloaded.

[0093] This ensures a given transit time of the food in the container **2,** advantageously making it possible to carry out the drying process in a continuous cycle.

[0094] The above clearly shows that the invention achieves all the set objects.

[0095] In particular, the depressurization of the container allows the food to be dried with no need to use air currents.

[0096] Therefore, since very powerful fans are not required, the energy consumption of the drying system of the invention is lower than that of the equivalent drying systems of known type.

[0097] Furthermore, the system of the invention requires neither the use of filters nor the use of depuration systems, whose maintenance is expensive.

[0098] Thanks to the advantages achieved by the system of the invention and described above, it is also possible to construct systems that are more effective compared to the systems of known type, though having the same cost and/or dimensions.

[0099] On implementation, the method and the system that are the subjects of the invention may undergo changes that, though not illustrated or described herein, shall nonetheless be covered by the present patent, provided that they come within the scope of the claims that follow.

[0100] Where technical features mentioned in any claim are followed by reference signs, those reference sings have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. Drying method particularly suitable for treating animal feed, **characterized in that** it comprises the following operations:

- introducing said food to be dried into a sealed container;
- depressurizing said container by sucking the gases present inside it;
- taking from said container the water vapour released by said food due to the effect of said depressurization;
- condensing said vapour outside said container;
- unloading said dried food from said container.

2. Drying method according to claim 1), **characterized in that** said operations for loading/unloading said food into/from said container are carried out intermittently.

3. Drying method according to any of the preceding claims, **characterized in that** it comprises a heating operation intended to heat the inside walls of said container at least during said extraction of said vapour.

4. Drying system (1) particularly suitable for treating animal feed, **characterized in that** it comprises:

- a sealed container (2) for said food to be dried;
- means (3) for loading said food to be dried into said container (2);
- means (8) for unloading the dried food from said container (2);
- means (12) for sucking the gases present in said container (2).

5. System (1) according to claim 4), **characterized in that** said loading means (3) comprise at least one

first sealed chamber (5), operatively connected to means (4) for feeding said food to be dried through a first inlet valve (6) and communicating with said container (2) through a first outlet valve (7).

6. System (1) according to any of the claims 4) or 5), **characterized in that** said unloading means (8) comprise at least one second sealed chamber (9), communicating with said container (2) through a second inlet valve (10) and operatively connected to means for collecting said dried food through a second outlet valve (11).

7. System (1) according to any of the claims from 4) to 6), **characterized in that** said loading means (3) are associated with the top (2a) of said container (2) and said unloading means (8) are associated with the bottom (2b) of said container (2).

8. System (1) according to any of the claims from 4) to 7), **characterized in that** said suction means (12) comprise a vacuum pump (24) operatively connected to said container (2) through a suction circuit (13).

9. System (1) according to claim 8), **characterized in that** said suction circuit (13) comprises at least one condenser (14) equipped with a condensation chamber (15) provided with at least one inlet mouth (16) for said sucked gases, operatively connected to said container (2), one outlet mouth (17) for the non-condensable gases, operatively connected to said vacuum pump (24), and a mouth (18) for conveying the condensation, associated with conveyance means (19).

10. System (1) according to claim 9), **characterized in that** said condenser (14) is associated with a refrigerating system for cooling said condensation chamber (15).

11. System (1) according to any of the claims 9) or 10), **characterized in that** said conveyance means (19) comprise at least one third sealed chamber (20), communicating with said condensation chamber (15) through a third inlet valve (21) and operatively connected to means for collecting said condensation through a third outlet valve (22).

12. System (1) according to any of the claims from 9) to 11), **characterized in that** said suction circuit (13) comprises a filter (23) for said non-condensable gases, interposed between said condenser (14) and said vacuum pump (24).

13. System (1) according to any of the claims from 4) to 12), **characterized in that** it comprises heating means (25) suited to heat the inner surface of said container (2).

14. System (1) according to claim 13), **characterized in that** said heating means (25) comprise a circuit for the circulation of a hot fluid.

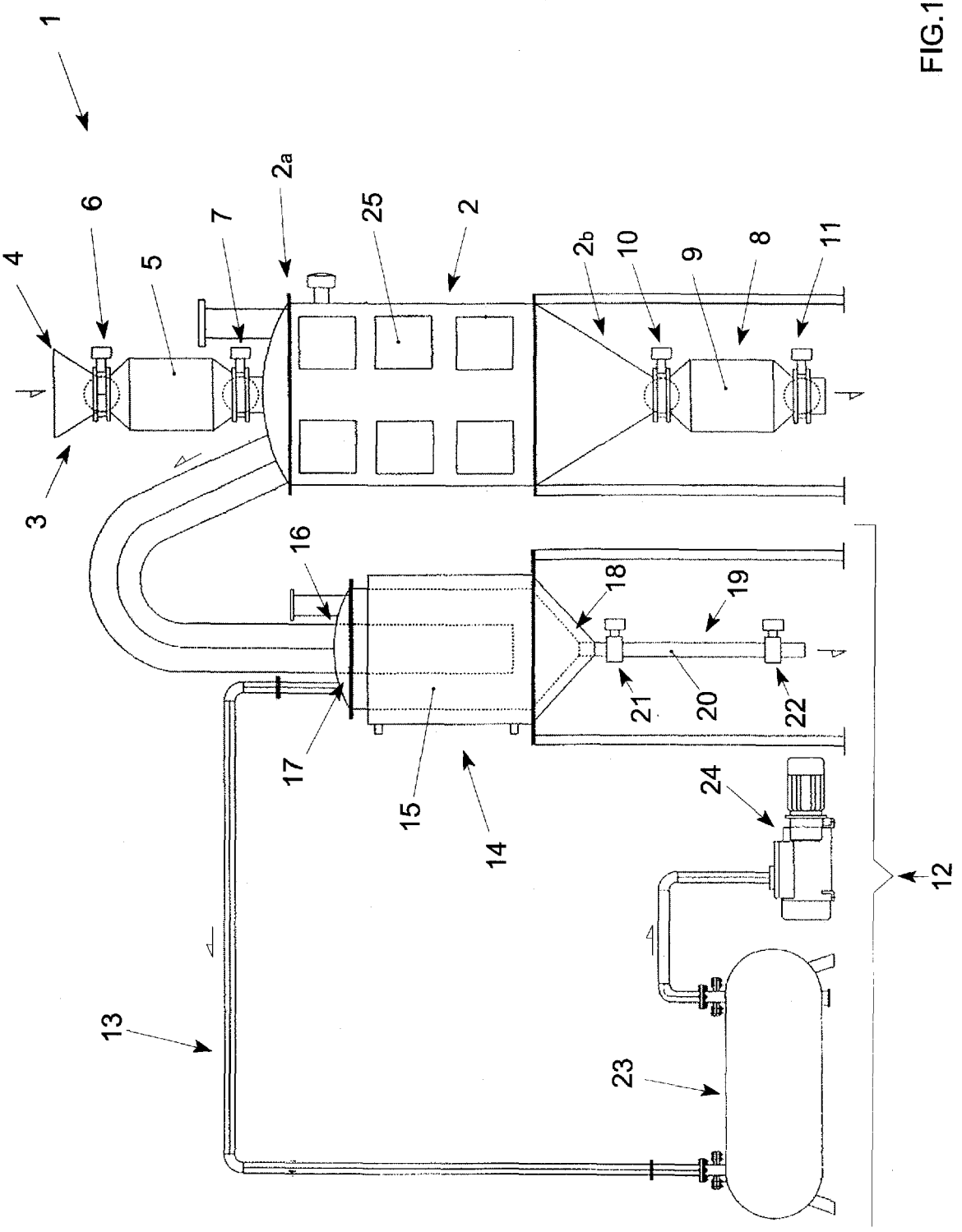

FIG.1