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(54) Device for treatment of biological waste

(57) This invention relates to a device for drying of biological waste, in particular food waste. The device comprises a chamber (2) for receiving the waste and at least one radiation-generating source (14) which is arranged for radiation of the waste in said chamber (2). The device comprises a closed circuit (2, 16), which extends through the chamber (2) and through which air is adapted to circulate.

The invention also concerns a method for drying of biological waste and a system for treating and drying of biological waste.

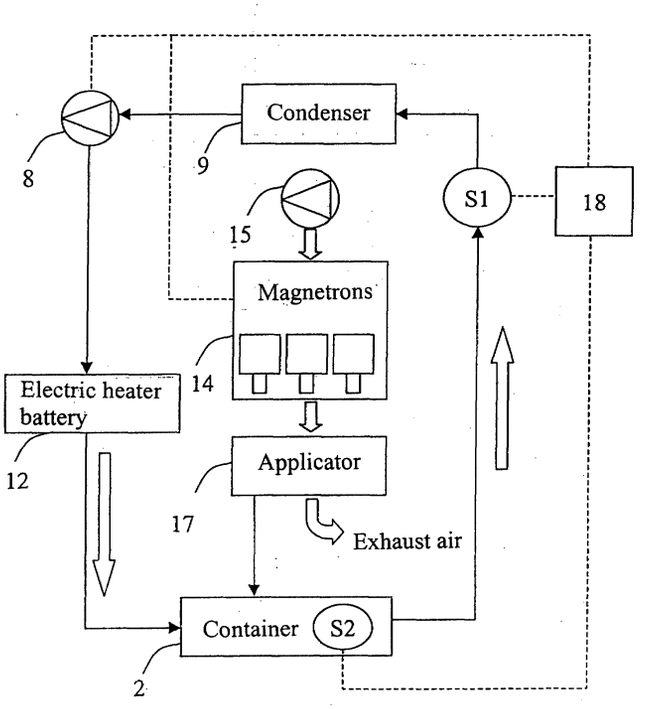

Fig. 1

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Description

Field of the Invention

[0001] This invention relates to a device for drying biological waste, in particular food waste. The device comprises a chamber for receiving the waste and at least one radiation-generating source which is adapted to radiate the waste in said chamber. Moreover the invention concerns a method for drying biological waste and a system for treating and drying biological waste.

Background Art

[0002] In, for instance, food shops, restaurants and large-scale kitchens large amounts of biological waste are produced every day, e.g. remainders of various animal and vegetable products, such as fruit, vegetables, meat and fish. This waste begins to rot and develop an unpleasant smell if stored at room temperature for long periods. This means that the waste must be collected frequently, or be stored in cooled waste chambers, which can be very expensive. Moreover this waste is bulky, heavy, unpleasant and costly to handle and may also contain large amounts of bacteria.

[0003] New laws and stipulations require that in future the biological waste be handled in a recycling system. From 2005 there will be a ban on placing organic waste (also comprising biological waste) on landfill sites. Experiments have been made to take care of the biological fraction by advanced methods, such as grinding and adding of water in order to obtain a wet sludge which can be stored in tanks and transported in special sludge suction vehicles.

[0004] The public cleansing departments strive to be able to handle the biological fraction using the transport and handling systems that are available today.

[0005] Moreover, society strives to recover and reuse, within the scope of recycling systems in connection with various activities, the energy and nutritional values and the valuable minerals which are present in the biological waste, and recirculate them in the system in the form of e.g. sludge to arable land or as raw material in the production of fodder.

[0006] A way of circumventing the problems described above is microwave drying of the waste. There are presently a number of different devices of this type. However they suffer from several problems. For instance, there is a risk of fire owing to the risk of overheating in radiation of the waste with high-energy microwaves. Furthermore, unpleasant smells may form and undesirable substances, such as mould spores, can be spread in connection with the drying of the waste, and these can spread in the building, and it is also difficult to achieve efficient drying.

Objects of the Invention

[0007] The object of the invention is thus to provide a device and a method for drying biological waste consisting of e.g. fruit, vegetables, meat and fish, which obviate the above problems of prior-art technique. One more object of the invention is to provide a device and a method/system for drying the waste and thus making it stable in storage so that existing transport and handling systems can be used without additional investments. A further object of the invention is to provide a method in connection with the treatment of the biological waste which is advantageous in terms of economy and handling, while at the same time the goal of society as regards recycling can be reached.

Summary of the Invention

[0008] According to the invention, the above-mentioned objects are achieved by a device which is characterised in that the device comprises a closed circuit which extends through said chamber and through which air is adapted to circulate. This means that any evil-smelling gases forming in the drying chamber do not diffuse in the atmosphere but remain in the closed system, which means that the device can be located, for instance, in a food shop with no risk of nasty smell or spreading of bacteria.

[0009] A dehumidifying unit is also suitably arranged in the closed circuit for the purpose of dehumidifying the air which leaves the chamber. The air is dehumidified in the closed system and can thus be recirculated into the chamber for new absorption of moisture. The air can thus be reused and need not be exchanged in the closed system. Suitably a closed container is sealingly connected to said dehumidifying unit for receiving and storing of emitted liquid. As a result, also the emitted liquid does not come into direct contact with the atmosphere and thus does not emit any nasty smell, bacteria or the like to the atmosphere.

[0010] Moreover a heating unit is suitably arranged in said circuit for the purpose of heating the gas before its entering the chamber, to obtain more efficient liquid absorption. This allows in turn the waste in the chamber to be heated to an appropriate temperature.

[0011] Conveniently a stirring means is arranged in the chamber for stirring of the waste. This allows more uniform heating and drying of the waste, which prevents hot zones from forming in the waste, thereby reducing the risk of overheating.

[0012] Furthermore a sensor is suitably arranged in the closed circuit before the dehumidifying unit in the direction of flow, the sensor being connected with a control unit for controlling the radiation power of said radiation-generating source in relation to the moisture content of the air flow in that position, for the purpose of achieving equilibrium between the moisture released in radiation and the moisture which the flow of air can re-

move. The device can thus be optimised in such manner that exactly the amount of moisture is generated in the chamber which the air in the closed circuit is capable of removing. Further the radiation, such as by means of microwaves, can be interrupted on a suitable occasion, as a function of the sensor output signal.

[0013] Moreover the above objects are achieved by a method for drying biological waste, comprising the steps of placing the waste in a sealed chamber, injecting hot air into the chamber for heating of the waste, radiating the waste in the chamber for drying of the waste, removing emitted moisture from the chamber by way of an outgoing flow of air, and recirculating the air via a closed circuit in order to reinject the air into the chamber. This method causes drying of the waste while at the same time the moisture which is generated is removed from the chamber. The closed circuit also prevents evil-smelling and contaminated gases from diffusing to the atmosphere.

[0014] The method suitably also comprises the step of conveying via the closed circuit the outgoing flow of air to a dehumidifying unit for cooling and dehumidifying the air, and subsequently to a heating unit, to obtain hot air, and subsequently reinjecting the hot air into the chamber, the air being circulated in the closed circuit. The heating of the air before the chamber results in the air having an increased tendency to removing moisture, thus increasing the efficiency of the device. Furthermore the air is dehumidified in the dehumidifying unit in conventional manner and can thus be recirculated to the chamber to absorb additional moisture.

[0015] Suitably the emitted liquid forming in the dehumidifying unit is via a closed system passed on to a closed storage chamber. This means that also the liquid does not come into direct contact with the atmosphere and consequently does not emit any nasty smell or bacteria to the atmosphere.

[0016] Moreover the step of radiating the waste in the chamber for drying the waste further comprises the step of radiating the waste by uniform radiation power until the moisture content of the outgoing flow of air falls below a predetermined value. This results in rapid and efficient drying until the waste has reached a predetermined degree of dryness. The step of radiating the waste in the chamber for drying the waste suitably also comprises the step of reducing, after said uniform radiation the radiation, the radiation power gradually/continuously and, below a certain degree of power, pulsating the source of radiation to a predetermined moisture content of the outgoing flow of air and subsequently ceasing the radiation. This pulsation allows the waste to cool somewhat between the pulses, which helps to prevent overheating of the material and thus also reduces the risk of fire breaking out in the material. Furthermore the step of radiating the waste in the chamber preferably using microwaves for drying the waste also comprises the step of initially increasing the radiation power gradually, while monitoring the temperature in the chamber so that this does not exceed a predetermined value. This results in a smooth temperature gradient at the beginning of the heating process.

[0017] Finally, the above-mentioned objects are achieved by a system for treating and drying of biological waste, which system comprises a device of the type described above. Preferably the system also comprises a dividing device for finely dividing the waste before drying, which contributes to a more uniform drying result. Further the system suitably comprises an exhausting device for exhausting dried waste from the chamber in the drying device to a storage unit. Also a packing device can be included in the system, in which case the dried waste is conveyed thereto for direct packing in bags or the like. This results in a fully automatic method of handling biological waste, in the vicinity of the place where the waste is produced.

Brief Description of the Drawings

[0018] The invention will now be described further by way of example with reference to the accompanying drawings.

[0019] Fig. 1 is a schematic view of a device according to the invention.

[0020] Fig. 2 is a perspective view of a drying device according to an embodiment of the invention.

[0021] Fig. 3 is a schematic view of a system comprising a drying device according to the invention.

Description of Preferred Embodiments

[0022] The drying device 1 according to Figs 1 and 2 comprises a cylindrical drying chamber 2, which is made of a material that does not absorb microwaves, such as plastic. The drying chamber 2 is surrounded, except at its top face, by a radiation-shielding metal cover (not shown). A number of, in this case two, air nozzles lead into the bottom of the chamber 2, and three microwave applicators/waveguides 17 lead into the side wall of the metal cover, said microwave applicators being connected to radiation-generating sources, in this case microwave-generating magnetrons 14 which are cooled by a cooling fan 15. These jointly form a microwave unit 13. The microwave applicators are uniformly distributed in the vertical direction of the chamber. The air nozzles 5 eject air at an angle, preferably about 30°, to the horizontal plane in mutually different directions, to cause cyclic rotation of the air. This results in a large contact surface between waste and air. In this case, the nozzles consist of plates covering the openings and have inclined (about 30°) through openings. In the chamber a stirring means 4 is also arranged, which comprises a centrally rotationally arranged arm. The stirring means is connected to a motor and can be caused to rotate in the chamber at a speed of e.g. 10-20 revolutions per minute. The chamber is upwardly open but is closed with a lid 3, which also comprises a metal plate, to supple-

ment the shielding metal cover. This plate, together with the above-mentioned metal cover, surrounds the drying chamber 2 completely when the lid is closed, to provide complete shielding. In the top portion of the chamber there is an opening 6 which is covered with a perforated sheet 7 round the upper part of the drying chamber and through which the air leaves. From this top opening 6 extends a duct 16 leading to a condenser 9. After that the duct 16 extends via a fan 8 to an electric heater battery 12 and then finally leads to the above-described air nozzle 5 to form a closed circuit. The condenser 9 is further sealingly connected to a container 10 for condensate. This container can be emptied via a valve 11. A number of sensors S1, S2 are also arranged in the device. These can be located in different positions in the device, but in the case shown a first moisture sensor S1 is arranged before the condenser for the purpose of checking the moisture content of the outgoing flow of air. Moreover a second condenser is positioned before the nozzles at the chamber, for measuring the air temperature in the chamber. The sensors are connected to a control unit 18. The above-described units jointly form a closed circuit, or circulating system, in which the air can be circulated without coming into contact with the atmosphere during drying. As an example, the air in the system can have a speed of circulation of about 100 m^3/h during drying.

[0023] When drying biological waste, such as remainders of fruit, fish, vegetables and meat, the waste is placed in the chamber 2, after which the lid 3 is closed and the chamber 2 is sealed. Conveniently the waste has been finely divided into pieces of uniform size before it was placed in the chamber 2. This can take place by means of a dividing device I which is located in connection with the drying device. This is schematically illustrated in Fig. 3. The dividing device also comprises an integrated screening table for screening the waste. Optionally, a dividing device can be arranged for this purpose in the chamber. Subsequently the fan 16 is set into operation, and air begins to circulate in the system. In this connection, the electric heater battery 12 is set into operation, which heats the air to a selected temperature, and later the air emits this heat to the waste in the chamber. The air is heated by the battery to a temperature of between about 50° and 150°C, preferably between 75° and 100°C, suitably about 80°C. The heating of the air results in an increase in its capacity of absorbing moisture. Thanks to the injection of hot air, waste in the chamber is thus heated. When the waste has reached a predetermined temperature, the magnetrons 14 are started at a relatively low effect, which gradually increases as the evaporation of moisture from the waste increases. Subsequently the magnetron effect is kept at an even level until the moisture sensor S1 which is located before the condenser 9 indicates that the moisture content of the outgoing air decreases, after which the magnetron effect is gradually lowered until it reaches below a predetermined value, below which the magnetrons 14 are pulsed for 10-20 s/min until the moisture content of the flow of air reaches a preset value. Then the microwave radiation is interrupted while the fan 8 is allowed to operate for a further period of time, for the purpose of causing afterdrying of the waste. During the entire drying period, the above-mentioned sensors S1, S2 check the moisture content and the temperature in the different parts of the system, for the purpose of controlling the magnetron radiation and the electric heating and, thus, optimising the drying process while at the same time overheating of the system as well as the forming of liquid in the chamber are prevented. Optimally, the air removes exactly all the moisture that is generated in microwave drying of the waste. If too large an amount of moisture is removed, there is a risk of the waste overheating, with the ensuing risk of fire. Therefore the device can also, as an additional measure of precaution, be provided with means for fire protection. If too small an amount of moisture is removed, liquid forms in the drying chamber 2, which results in an impaired drying result and greater time expenditure. The moist air forming in the chamber is exhausted through the perforated sheet 7 and into the duct and on to the condenser. In the condenser 9 the air is dehumidified in conventional manner. Before the condenser, the air can have a relative humidity of 20-100%. When the air is cooled in the condenser, the relative humidity increases to 100% and water is precipitated. The condensate is conveyed to the above-described condensate container 11 to be stored. After the condenser, the air is conveyed to the electric heater battery where the air is again heated and the relative humidity decreases to 15-25%, so as to be injected once more into the drying chamber.

[0024] According to an alternative embodiment of the invention hot air is circulated through the chamber 2 in such manner that the waste in the chamber is rapidly heated and thus begins to emit vapour. In this position, the moisture content of the outgoing flow of air is monitored by means of the sensor S1 and/or S2. As the moisture content begins to decrease and, for example, falls below a predetermined value, the sensor sends a signal to the stirring means 4, and stirring of the waste takes place for a predetermined period of time, after which the circulation of hot air continues. The circulation of air may also occur during the stirring. Owing to the stirring, the emitted amount of vapour from the waste probably increases after stirring. After stirring, the circulation of air continues until the moisture content of the outgoing flow of air once more falls below said predetermined value, and then stirring is started again. This process continues until stirring of the waste does not significantly result in an increased moisture content of the outgoing air. Subsequently magnetrons are started and radiate the waste until the moisture content of the waste falls below a second predetermined value, whereby the treatment of the waste is completed. Also other modes of controlling the device are feasible within the scope of this invention.

[0025] The units described above are arranged in a closed system, which means that there is no risk of smell or the like escaping, which makes the device suitable for use in, for instance, food shops and restaurants.

[0026] The waste product from the above device forms flakes, so-called bioflakes. Owing to the drying process, in contrast to, for instance, pressing, the bioflakes retain the entire nutritional value that was present in the waste. As a result, the bioflakes are usable, for instance, as additives in e.g. fodder. Moreover, the bioflakes can be used as additives in, for example, composting, digestion or combustion. Thus, the biological waste has been converted from waste into a useful product. A further advantage of the drying is that the volume and weight of the waste decrease to a considerable extent. In connection with animal waste, the volume after drying will be about 50% of the original and, in connection with vegetable waste, the volume amounts to about 10-20% of the original. The decreases in weight in each case are equivalent. The maximum moisture content is 10% in both cases. This also results in decreased transport charges. The waste is sanitised by being heated to min. 75° for at least one hour, during which pathogenic bacteria are killed. Thus the bioflakes will have a storage life at room temperature of at least 6 months and are essentially odourless. This dried waste can be stored in an ordinary room. Conveniently the waste can be stored in vessels which are intended for transport. An exhausting device is suitably used to empty the chamber of dried waste into a storage container before new waste for drying can be supplied to the chamber. Thanks to the fact that the dried waste has a long storage life and is essentially odourless and sanitised, the dried waste can be collected using the same vehicle as delivers e.g. food, which results in changed and less expensive treatment of waste. Furthermore a conventional packing machine can be arranged in connection with the drying device for direct packing of the bioflakes in bags or the like.

[0027] It will be appreciated that many modifications of the above-described embodiment of the invention are feasible within the scope of the invention as defined by the appended claims. For instance, the above-mentioned fan can be located in different positions in the system since its only purpose is to circulate the air in the closed circuit. Also the location of the sensors can be varied, and the sensors can be, for instance, temperature or moisture measuring means, depending on the design of the control box. It has also been described above that the flow of air from the air nozzles makes an angle to the horizontal plane of about 30°. It goes without saying that this angle can be varied as regards the geometry of the chamber etc. The embodiment described above has also air nozzles for injection of air at the bottom of the chamber and air outlets at the top of the chamber. These nozzles and outlets can be located in different positions in the chamber but are suitably, like in the above example, arranged on opposite sides of the chamber to produce a flow of air through essentially the entire chamber. The radiation sources described in the embodiments are microwave sources, more specifically magnetrons, but it is also possible to use radiation sources in certain other wavelength ranges, for instance in the infrared radiation range or the HF and VHF or EHF frequency bands, to provide a drying device with the desired properties in different situations. Also use of a condenser as the humidifying unit is described above, but this can be replaced by, for example, a compressor.

[0028] Also a number of alternatives and possible modifications are described above.

Claims

1. A device for drying biological waste, in particular food waste, the device comprising a chamber (2) for receiving the waste and at least one radiation-generating source (14) which is adapted to radiate the waste in said chamber (2), **characterised in that** the device comprises a closed circuit (2, 16) which extends through said chamber (2) and through which air is adapted to circulate.

2. A device as claimed in claim 1, **characterised in that** a dehumidifying unit (9) is arranged in said circuit (2, 16) for the purpose of dehumidifying the air leaving the chamber (2).

3. A device as claimed in claim 2, **characterised in that** a closed container (10) is sealingly connected to said dehumidifying unit (3) to receive and store emitted liquid.

4. A device as claimed in claim 1, 2 or 3, **characterised in that** a heating unit (12) is arranged in said circuit for the purpose of heating the air before its entering the chamber (2).

5. A device as claimed in any one of the preceding claims, **characterised in that** a stirring means (5) for stirring the waste is arranged in the chamber (2).

6. A device as claimed in claim 2 or 3, **characterised** in that at least one sensor (S1) is arranged in the closed circuit, before the dehumidifying unit (9) in the direction of flow, the sensor (S1) being connected with a control unit (18) for controlling the radiation power of said radiation-generating source (14) in relation to the moisture content of the air flow in that position.

7. A method for drying biological waste, comprising the steps of

   placing the waste in a sealed chamber,
   injecting hot air (A) into the chamber for heating of the waste,

radiating the waste in the chamber for drying of the waste,
removing residual moisture from the chamber by way of an outgoing flow of air (B), and
recirculating via a closed circuit (2, 16) the air to be reinjected into the chamber.

8. A method as claimed in claim 7, further comprising the steps of

conveying via the closed circuit (2, 16) the outgoing flow of air (B) to a dehumidifying unit (16) for cooling and dehumidifying the air, and subsequently to a heating unit (12), to obtain hot air, and subsequently reinject the hot air (A) into the chamber, the air being circulated in the closed circuit (2, 16).

9. A method as claimed in claim 8, further comprising the step of

conveying via a closed system the emitted liquid forming in the dehumidifying unit (9) to a sealed storage chamber (10).

10. A method as claimed in any one of claims 7-9, wherein the step of radiating the waste in the chamber (2) for drying the waste further comprises the step of

radiating the waste by uniform radiation power until the moisture content of the outgoing flow of air (B) falls below a predetermined value.

11. A method as claimed in claim 10, wherein the step of radiating the waste in the chamber (2) preferably using microwaves for drying the waste further comprises the step of

reducing, after said uniform radiation, the radiation power gradually and, below a certain degree of power, pulsating the source of radiation for 10-20 s/min until the moisture content of the flow of air reaches a preset value and subsequently ceasing the radiation.

12. A method as claimed in claim 10 or 11, wherein the step of radiating the waste in the chamber (2) for drying the waste further comprises the step of

initially increasing the radiation power gradually, while monitoring the temperature of the outgoing flow of air from the chamber (2) so that this does not exceed a predetermined value.

13. A system for treating and drying biological waste, in particular food waste, **characterised in that** the system comprises a drying device (II) of the type as defined in any one of claims 1-6.

14. A system as claimed in claim 13, **characterised in that** it also comprises a dividing device (I) for finely dividing the biological waste before drying.

15. A system as claimed in claim 13 or 14, **characterised in that** it also comprises an exhausting device (III) for exhausting dried biological waste from the chamber in the drying device (II) to a storage unit.

16. A system as claimed in claim 14 or 15, **characterised in that** said devices are integrated into one unit.

17. A system as claimed in any one of claims 13-16, **characterised in that** it also comprises a packing device (IV), the dried waste being conveyed thereto for direct packing in bags or the like (V).

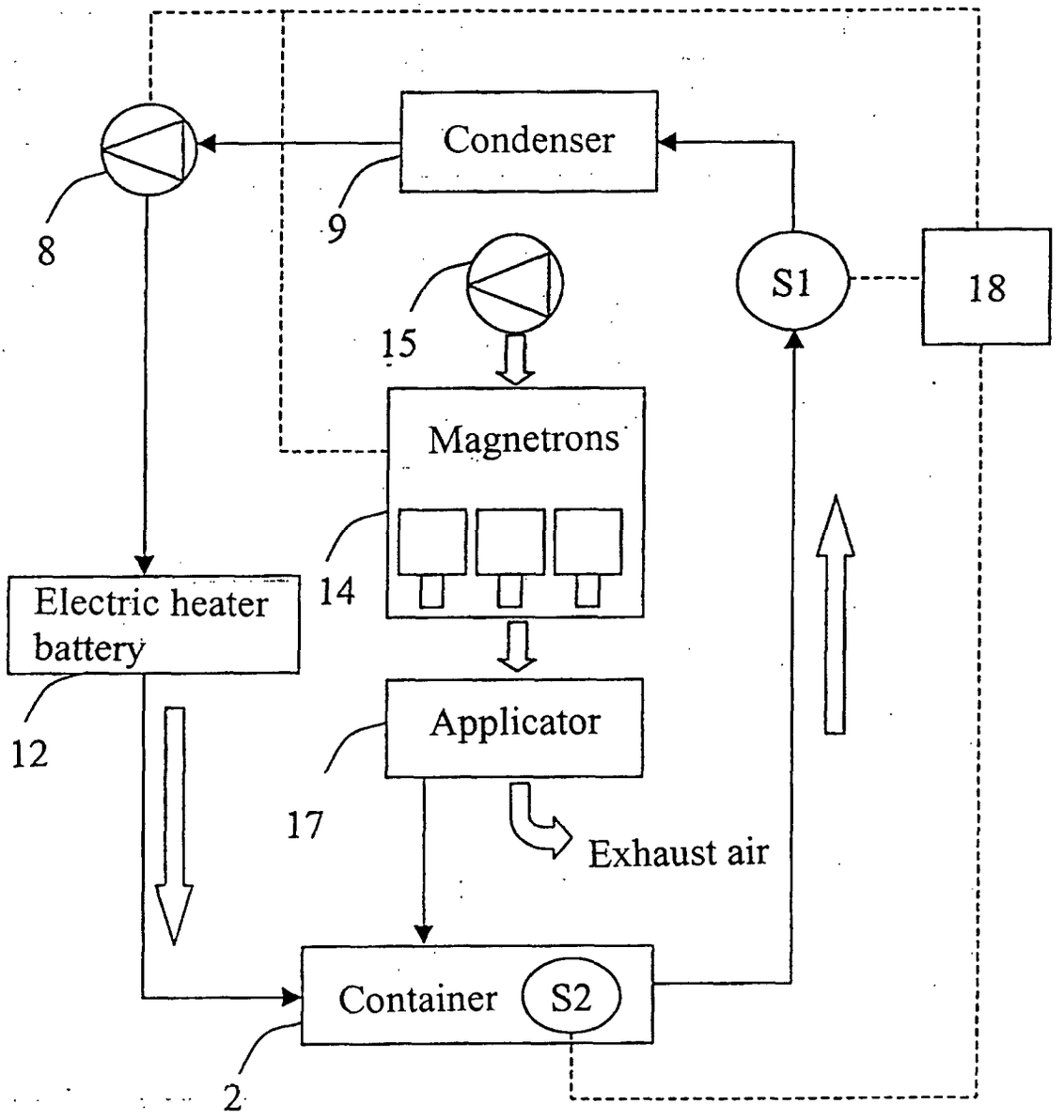
Condenser
8
9
15
S1
18
Magnetrons
14
Electric heater battery
12
Applicator
17
Exhaust air
Container
S2
2

Fig. 1

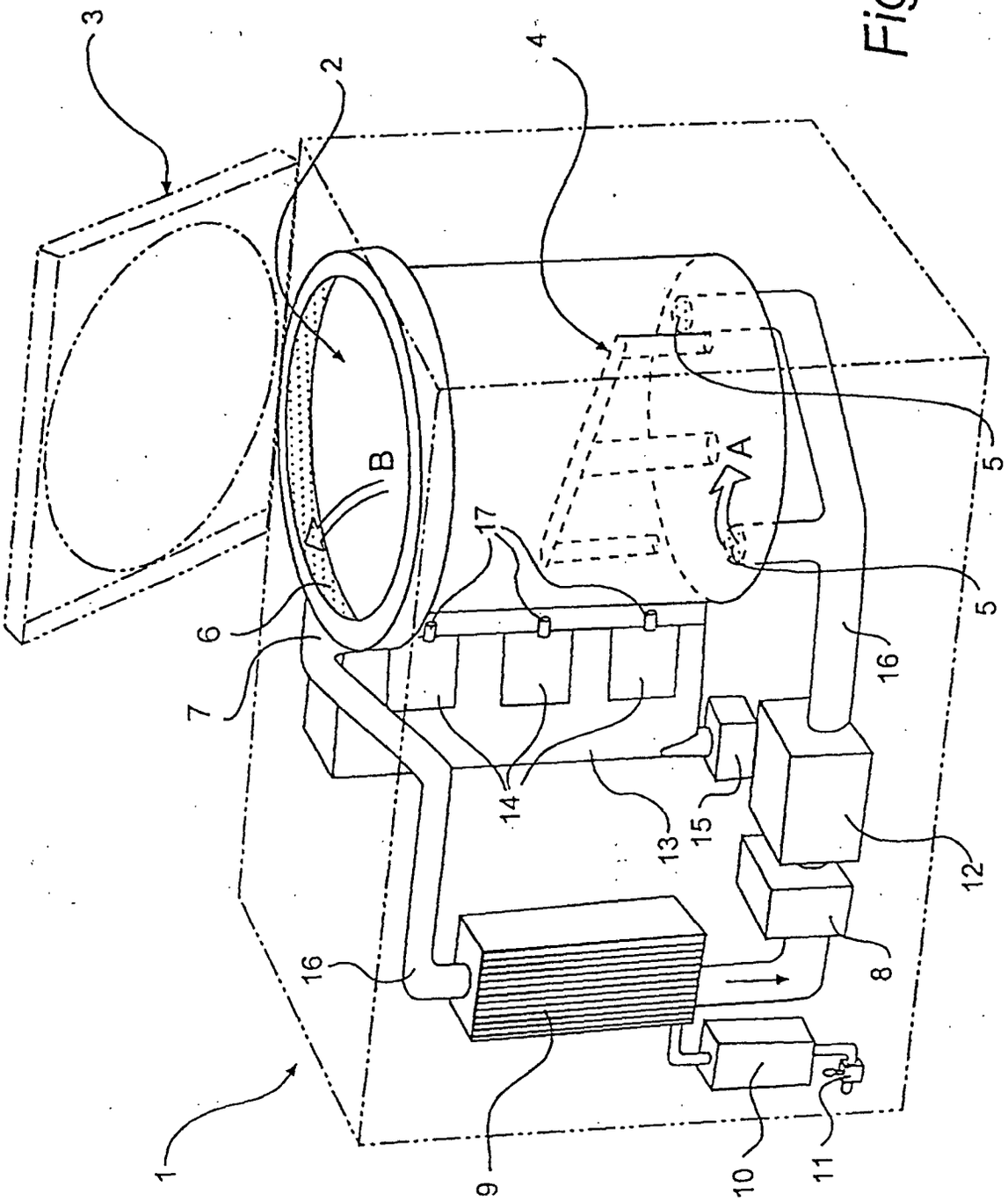

Fig. 2

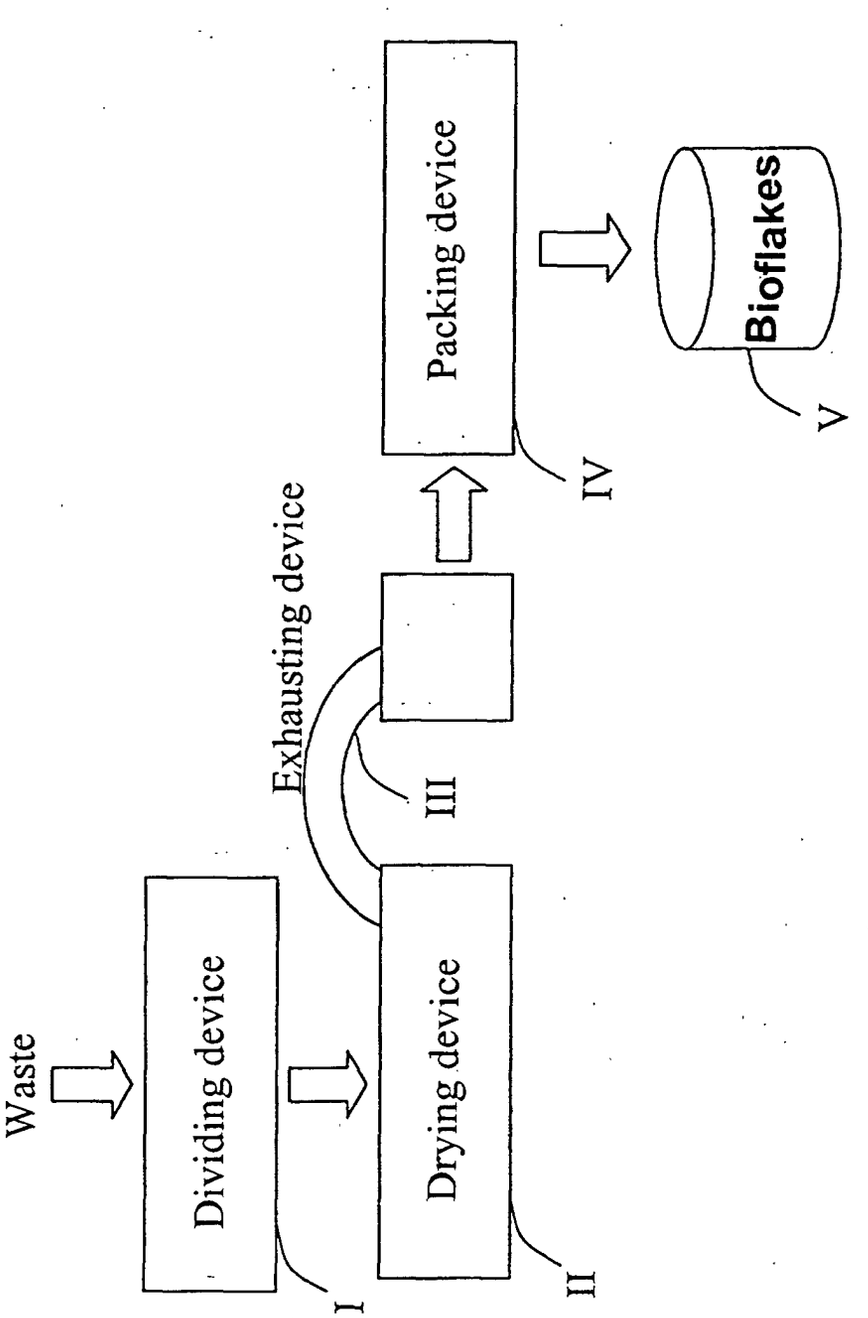
Waste
Dividing device
I
Drying device
II
Exhausting device
III
Packing device
IV
Bioflakes
V

Fig. 3