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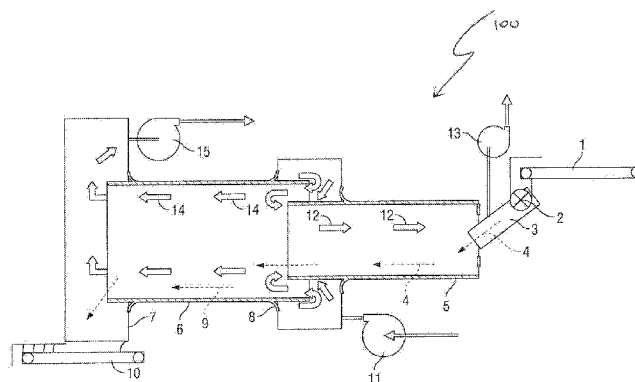


FIG. 1

(57) **Abstract:** A rotary drying apparatus for drying a fibrous granular material is described. The apparatus provides a first substantially cylindrical drum having a first drum inlet for introducing fibrous or granular material into the drum and a first drum outlet, a second substantially cylindrical drum having a second drum inlet and a second drum outlet through which process gas and dried fibrous or granular material is discharged after passing through the first drum and then the second drum, the first drum and the second drum each having an axis of rotation at an angle to the horizontal and each being arranged to rotate about their respective axes. There is provided a plenum located between the first and second cylindrical drums and arranged in fluid communication with the first drum outlet and the second drum inlet, the plenum having an air inlet fan located at a plenum inlet and arranged to urge process gas from the plenum into the first and second cylindrical drums. The process gas is urged through the first cylindrical drum in a direction counter to the direction of the process product flow and process gas is urged through the second cylindrical drum in a direction co current with the direction of the process product flow. An efficient drying apparatus and operation is achieved.



DRYING APPARATUS

The present invention relates to drying apparatus and a method for drying a fibrous or granular material, particularly, but not exclusively to a drying apparatus and a method of drying a fibrous material such as tobacco leaves or portions of tobacco leaves.

Tobacco leaves are processed for cigarette manufacture in a primary tobacco process. Laminate portions of tobacco leaves are compressed and then cut in a cutting machine to provide tobacco particles suitable for cigarette manufacture. Moisture is removed from the fibrous tobacco material typically to improve the handling and filling properties of the tobacco material.

For drying of tobacco in particular, and of other products in general, cascading rotary cylinder dryers are known, an example of such a dryer is described in US 3785765. The dryer usually consists of a hollow rotating cylinder through which the product to be dried is conveyed along the cylinder by the action of lifting flights or paddles which may be combined with the declination of the cylinder from an input or infeed portion to a discharge end. A horizontal cylinder is also known whereby the product is conveyed by flights or paddles which are helical in shape, and therefore convey the product in a similar manner to an Archimedian screw. The repeated lifting and dropping of the product enables it to be alternatively heated when in contact with a heated surface or area, and cooled when not.

It is known to heat, for example, the cylinder to dry the tobacco. The heat for drying the product within the cylinder may be applied by heating the drying air or other gas before it enters the cylinder, by heating the walls of the cylinder or by a combination of both means. A significant portion of this drying apparatus could require heating which would be expensive to run.

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The heat necessary for the drying process may typically be achieved by generating and then using heat from various sources, such as a steam boiler or thermal fluid heater, by direct or indirect heat from a gas or other fuel burner, or by heat from an electric source. Where steam or other fluid heating is employed, the cylinder and its lifting flights are constructed so that the heating fluid passes through heating jackets or ducts which are in intimate contact with the internal surfaces of the cylinder, thus transferring heat to the product as it passes through the cylinder. The heating fluid is typically supplied and removed from the rotating cylinder by means of rotary joints or unions which contain the fluid flow whilst allowing the cylinder to rotate.

The heating uniformity can be variable and the effect of product temperature on the smoking characteristics of the tobacco can, in turn, be variable.

In accordance with a first aspect of the present invention, there is provided a rotary drying apparatus for drying a fibrous or granular material comprising; a first substantially cylindrical drum having a first drum inlet for introducing fibrous or granular material into the drum and a first drum outlet, a second substantially cylindrical drum having a second drum inlet and a second drum outlet through which process gas and dried fibrous or granular material is discharged after passing through the first drum and then the second drum, the first drum and the second drum each having an axis of rotation at an angle to the horizontal and each being arranged to rotate about their respective axes, a mechanical seal apparatus arranged to minimise leakage of air into or out from the dryer, a plenum located between the first and second cylindrical drums and arranged in fluid communication with the first drum outlet and the second drum inlet, the plenum having an air inlet fan located at a plenum inlet and arranged to urge process gas from the plenum into the first and second cylindrical drums, wherein process gas is urged through the first cylindrical drum in a direction counter to the direction of the process product flow and process gas is urged

through the second cylindrical drum in a direction co current with the direction of the process product flow.

There is also described a rotary drying apparatus for drying a fibrous or granular material comprising; a first substantially cylindrical drum having a first drum inlet
5 for introducing fibrous or granular material into the drum and a first drum outlet, a second substantially cylindrical drum having a second drum inlet and a second drum outlet through which process gas and dried fibrous or granular material is discharged after passing through the first drum and then the second drum, the first drum and the second drum each having an axis of rotation at an
10 angle to the horizontal and each being arranged to rotate about their respective axes, a plenum located between the first and second cylindrical drums and arranged in fluid communication with the first drum outlet and the second drum inlet, the plenum having an air inlet fan located at a plenum inlet and arranged to urge process gas from the plenum into the first and second cylindrical drums,
15 wherein process gas is urged through the first cylindrical drum in a direction counter to the direction of the process product flow and process gas is urged through the second cylindrical drum in a direction co current with the direction of the process product flow.

20 The product in granular or fibrous form, in this case granular or fibrous tobacco, is dried in the prior art by passing air or other gases along a drum or cylinder, either in the same direction as the product flow (co-current) or in a direction opposed to the product flow (counter-current).

The invention addresses the limitations of the prior art, as for certain products,
25 particularly tobaccos, the physical and chemical properties of the product are affected by the time and temperature regimes to which the product is subjected during processing.

For example, is tobacco dried with co-current air flow, unless a suitable pre-treatment or conditioning is employed, results in a final product that can be brittle, dusty and will exhibit poor characteristics (known as filling value) which is relevant to the manufacture of cigarettes. On the other hand, if contra airflow is employed such that the humidity of the air leaving the dryer at the infeed end is saturated, the physical characteristics of the tobacco can be more resilient, less dusty, and the filling power is significantly better than for the co-current situation described above.

Also of interest is the effect of product temperature on the smoking characteristics and so called taste of the tobacco. For certain products high temperatures are required in order to develop a toasting effect, whereas for other products it is desirable to restrict the process temperature to preserve certain flavours or prevent the generation of undesirable tastes due to chemical changes in the tobacco constituents.

The present invention seeks to resolve the flow and taste conflict by allowing a dryer to be operated in a combined mode, such that product entering the dryer is first subjected to contra-airflow, and after passing some distance along the dryer it is then subjected to co-current airflow. By arranging the dryer in this way, there is considerable flexibility in selection of operating temperatures and air flows to achieve the desired taste and product physical characteristics.

In an embodiment the first drum and the second drum have a common axis of rotation. In an embodiment the axis of rotation is declined from the horizontal at an angle in the range from 0 degrees to 15 degrees to the horizontal, 0 degrees to 10 degrees to the horizontal and, in an embodiment is in the range of 2 to 8 degrees to the horizontal. This slope makes for ease of transfer and movement of the tobacco product along the first and second drum.

The actual temperature of the tobacco is affected both by the temperature of the heated surfaces with which it comes into contact, and also by the temperature and humidity of the process air. In the case of a co-current air flow, the tobacco and air temperatures are very close to each other, and as the tobacco exits the dryer its temperature and moisture are in equilibrium with the air. If the air flow is reduced, the tobacco temperature rises in order to maintain this equilibrium at the desired exit moisture. If lower tobacco temperatures are required, the air flow must be increased, to enable the air to carry the necessary moisture loading at the lower temperature. Similarly with a contra-airflow mode, the tobacco temperature at the dryer exit is reduced for increased airflows, but so is the humidity of the air leaving the infeed end of the dryer. In terms of fill value, it is desirable to ensure high humidity or saturated air conditions at the infeed of the dryer, which implies minimising the process air flow. Thus there is a conflict between the desire to maintain low tobacco temperature on the one hand, and improved physical product characteristics such as good fill value and minimum dust generation on the other.

In the preferred embodiment the first and the second drum are arranged to rotate with a respective first and second speed of rotation. The first and the second speed of rotation are equal in an embodiment and wherein the first drum and the second drum rotate together. In an embodiment the first and the second speed of rotation are different. The speed of rotation can be chosen to match the specific system and type of tobacco product being processed.

In a further embodiment the first drum comprises a first diameter and the second drum comprises a second diameter, wherein the first diameter is less than the second diameter. In an embodiment, a portion of the first drum is accommodated within the second drum. This takes account of the fact that for co-current operation the required air volume flow is generally higher than for counter-current operation, thus a larger diameter drum is preferable for co-current operation in order to ensure that the airflow is not so high as to unduly

hasten the transit of the product along the drum. Accommodating a portion of the first drum within the second drum can lead to a compact dryer and the portion accommodated can vary with space and operational requirements.

A rotary drying apparatus is described having control apparatus arranged to
5 control one of the range of (i) the speed of air flow volume through the first drum, (ii) the temperature of the wall of the first drum and (iii) the pressure difference or differential between the interior of the first drum and the exterior of the apparatus. The monitoring and management of the parameters of the first drum are used to set and maintain the quality of tobacco product output.
10 Similarly, in an embodiment a rotary drying apparatus is arranged further comprising control apparatus arranged to control one of the range of (i) the speed of air flow volume through the second drum, (ii) the temperature of the wall of the second drum and (iii) the pressure difference between the interior of the second drum and the exterior of the apparatus. The monitoring and
15 management of the parameters of the second drum are used to set and maintain the quality of tobacco product output.

The apparatus further includes a mechanical seal apparatus arranged to minimise leakage of air into or out from the dryer. This aids the efficiency of heat generation and maintenance of heat in the system. Also in an embodiment
20 there is a mechanical seal apparatus at the first drum inlet wherein the mechanical seal apparatus comprises one of the range of rotary air lock, labyrinth seal and metering tube seal. The options available all provide air lock and air seal functions and provide the designer and user of the system with options for the construction and arrangement of the dryer. In an embodiment a
25 seal apparatus may be located between the first drum outlet and the second drum outlet. This seal can maintain an air tight arrangement for product and air flow.

In accordance with the present invention as seen from a second aspect, there is provided a method of drying a fibrous product using the apparatus of the present invention.

Further preferred features of the invention are defined in the accompanying claims and include a rotary dryer consisting of two cylinders rotating on a common axis with the first cylinder projecting into the second, and arranged so that drying air can be introduced at the junction between the cylinders so that it passes through the first cylinder in a direction contrary to the product flow, and passes through the second cylinder in the same direction as the product flow. The air and product flow are known as co- and counter current in this device. Also included are a rotary drying apparatus wherein the air volumes flowing through the first and second parts of the cylinder are separately controlled.

A rotary dryer of an embodiment includes the feature of the wall temperatures of the first and second parts being separately controlled.

Embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of the drying apparatus of the present invention;

Figure 2 is a schematic view of a part of the drying apparatus of Figure 1 including a first seal system;

Figure 3 is a schematic view of a part of the drying apparatus of Figure 1 including a second seal system.

Referring to figure 1 of the drawings there is shown a drying apparatus according to an embodiment of the present invention having a co current and counter current flow and with process duct 3 and a rotary air lock 2.

The dryer consists of two hollow cylinders or drums, the first drum 5 being of smaller diameter than the second drum 6. The drums are in this embodiment supported from a common axis and in can be supported by spokes (not shown) from a common axis which is in turn supported by fixed bearings (not shown).

- 5 In the alternative, the drums 5, 6, may be supported by track rings (not shown) on support rollers (not shown). The drums 5, 6, may be rigidly joined together or separated. The drums 5, 6 share a common axis of rotation which may be declined or horizontal depending on the method chosen to convey product along and through the dryer 100. Figure 1 depicts a horizontal configuration.]
- 10 In use and operation product is fed to the dryer 100 by means of a suitable conveying system 1, which may typically comprise belt, vibratory or screw conveyors. The product passes into the dryer 100 through a seal which minimises the amount of air leakage from the environment into the dryer, or vice versa. This seal is typically a rotary airlock 2, but other means may be
- 15 employed such as the labyrinth seal (illustrated in Figure 2) or metering tube seal (illustrated in Figure 3). The seal should be able to withstand and adapt to slight changes in temperature and underpressure readings from one zone to another. The labyrinth seal consists of a series of flexible fabric curtains 20 suspended from a conveyor discharge hood (such that they lightly contact the
- 20 surface of the band conveyor), allowing product 22 to pass freely to the dryer feed chute 3 but minimising the free area through which air can pass either in or out of the chute.

The seal provides a sealing function and allows and ensures that the desired process airflow passes along both drum 5 and drum 6, in the desired correct

25 proportions.

In the metering tube seal shown in Figure 3, the product level 26 is allowed to build up within the metering tube 25 and rests on the dryer feed conveyor 1 whose discharge hood 21 is sealed to the dryer infeed chute 3 through which

the product passes into the drying cylinder. Air leakage into or from the dryer is prevented or minimised due to the fact the leakage path is blocked by product.

The drying drums comprise two parts, 5 and 6, of the apparatus as a whole such that the product exiting from the first part 5 then enters the second part 6.

- 5 The drums or cylinder parts 5, 6, are generally coupled together and may be fixed. In the embodiment illustrated, in use, the drums 5, 6 are driven so that they rotate together. If the drums 5, 6 are connected but allowed separate movement then, this allows for them to be rotated at different speeds.

- 10 The general product flow direction of product in use in the drying system 100 is shown by broken line arrows, (numbered 4 and 9). After passing through the second drum part 5, the product is discharged into a hood 7, and thence into a further system of conveyors 10. It is preferable for the hood 7 to be sealed to the take off conveyor 10 to prevent unwanted airflows from entering or leaving the dryer at this point. The sealing methods may typically be those already
15 described for the infeed end of the drying apparatus.

Drying air enters a central hood or plenum 8 from an air inlet fan 11, such that the air may pass from the hood or plenum into the drying cylinder drum parts 5 and 6 through the circumferential gap formed between the two parts 5 and 6.

- 20 The inlet plenum 8 is provided with seals between its static part and the rotating surfaces of the drum. A proportion of this air 12 is drawn through the first drum part 5 in a contra flow direction by a variable-speed exhaust fan 13. Exhaust fan 13 is located near the first drum inlet and is in communication with the first drum inlet. The remainder of the process air 14 is drawn through the second drum
25 part 6 in a co-current direction by an independently controlled variable-speed exhaust fan 15. Exhaust fan 15 is located near the hood 7 and in communication with the second drum outlet. The relative proportion of the counter current to the co-current airflow is determined primarily by the speeds of the exhaust fans 13 and 15. The sum of the counter current and co-current

airflows is determined by the speed of the air inlet fan 11. The fans 11, 13 and 15 may include some filtering function as well.

Further refinements can be applied to this system, in particular instrumentation to measure the volume of air flow passing through the fans 11, 13 and 15, and also the humidity of the exhaust air from the fans 13 and 15. Data from this instrumentation may be used to compute the amount of evaporation taking place in the first and second drum parts of the dryer, 5 and 6.

It is also possible to arrange independent temperature control of the two parts of the dryer, so that the heat transfer to the product in these two parts may be varied according to the requirements of the process. In this way a multi-zone arrangement of temperature control can be provided.

Examples of the speed of flow and air velocity useful for the drying apparatus and separation function are; 0.2 to 0.3 m/s in the first drum, 5, and 0.3 to 0.6 m/s in the larger drum, 6. Other flow rates may be used or required for particular product. The temperature of the drum walls may be 100 to 200 degrees C, and may be from 50 to 250 degrees C.

Various modifications may be made to the described embodiments without departing from the scope of the present invention. The mechanical seal may not be present. There may be a different number of drying stages or heating means. The material to be dried may be fibrous or granular and may comprise organic material. The ducts here are shown as circular. Other shapes or sizes of duct may be used, they may be of any convenient section, e.g. round or rectangular.

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CLAIMS

1. A rotary drying apparatus for drying a fibrous or granular material comprising;
- 5 a first substantially cylindrical drum having a first drum inlet for introducing fibrous or granular material into the drum and a first drum outlet,
- a second substantially cylindrical drum having a second drum inlet and a second drum outlet through which process gas and dried fibrous or granular material is discharged after passing through the first drum and then the second drum,
- 10 the first drum and the second drum each having an axis of rotation at an angle to the horizontal and each being arranged to rotate about their respective axes,
- a mechanical seal apparatus arranged to minimise leakage of air into or out from the dryer,
- 15 a plenum located between the first and second cylindrical drums and arranged in fluid communication with the first drum outlet and the second drum inlet, the plenum having an air inlet fan located at a plenum inlet and arranged to urge process gas from the plenum into the first and second cylindrical drums,
- wherein process gas is urged through the first cylindrical drum in a direction counter to the direction of the process product flow and process gas is urged through the second cylindrical drum in a direction co current with the direction of the process product flow.
- 20
2. A rotary drying apparatus according to claim 1, wherein the first drum and the second drum have a common axis of rotation.
- 25
3. A rotary drying apparatus according to claim 1 or claim 2, wherein the axis of rotation is declined from the horizontal at an angle in the range from 0 degrees to 15 degrees to the horizontal.

4. A rotary drying apparatus according to claim 3, wherein the axis of rotation is declined from the horizontal at an angle in the range from 0 degrees to 10 degrees to the horizontal.
5. A rotary drying apparatus according to claim 3 or claim 4, wherein the axis of rotation is declined from the horizontal at an angle in the range from 2 degrees to 8 degrees to the horizontal.
6. A rotary drying apparatus according to any preceding claim, wherein the first drum and the second drum are arranged to rotate with a respective first and second speed of rotation.
- 10 7. A rotary drying apparatus according to claim 6, wherein the first and the second speed of rotation are equal and wherein the first drum and the second drum rotate together.
8. A rotary drying apparatus according to claim 6, wherein the first and the second speed of rotation are different.
- 15 9. A rotary drying apparatus according to any preceding claim, the first drum having a first diameter and the second drum having a second diameter, wherein the first diameter is less than the second diameter.
10. A rotary drying apparatus according to any preceding claim, wherein a portion of the first drum is accommodated within the second drum.
- 20 11. A rotary drying apparatus according to any preceding claim, further comprising control apparatus arranged to control one of the range of (i) the speed of air flow volume through the first drum, (ii) the temperature of the wall of the first drum and (iii) the pressure difference between the interior of the first drum and the exterior of the apparatus.
- 25 12. A rotary drying apparatus according to any preceding claim, further comprising control apparatus arranged to control one of the range of (i) the

speed of air flow volume through the second drum, (ii) the temperature of the wall of the second drum and (iii) the pressure difference between the interior of the second drum and the exterior of the apparatus

13. A rotary drying apparatus according to claim 1, wherein the mechanical seal apparatus is located at the first drum inlet.

14. A rotary drying apparatus according to claim 13 wherein the mechanical seal apparatus comprises one of the range of rotary air lock, labyrinth seal and metering tube seal.

15. A rotary drying apparatus according to claim 13 or claim 14, further comprising a seal apparatus located between the first drum outlet and the second drum outlet.

16. A rotary dryer according to any preceding claim consisting of two cylinders rotating on a common axis with the first cylinder projecting into the second, and arranged so that drying air can be introduced at the junction between the cylinders so that it passes through the first cylinder in a direction contrary to the product flow, and passes through the second cylinder in the same direction as the product flow.

17. A rotary dryer as in claim 16 in which the air volume flows through the first and second parts of the cylinder are separately controlled.

18. A rotary dryer as in claim 17 in which the air volume flows through the first and second parts of the cylinder are separately controlled by variable-speed exhaust fans located at opposing ends of the rotary dryer.

19. A rotary dryer as in claims 16 in which the wall temperatures of the first and second parts are separately controlled.

20. A method of drying a fibrous or granular material using the apparatus according to any preceding claim.

21. A drying apparatus substantially as herein described with reference to the accompanying drawings.

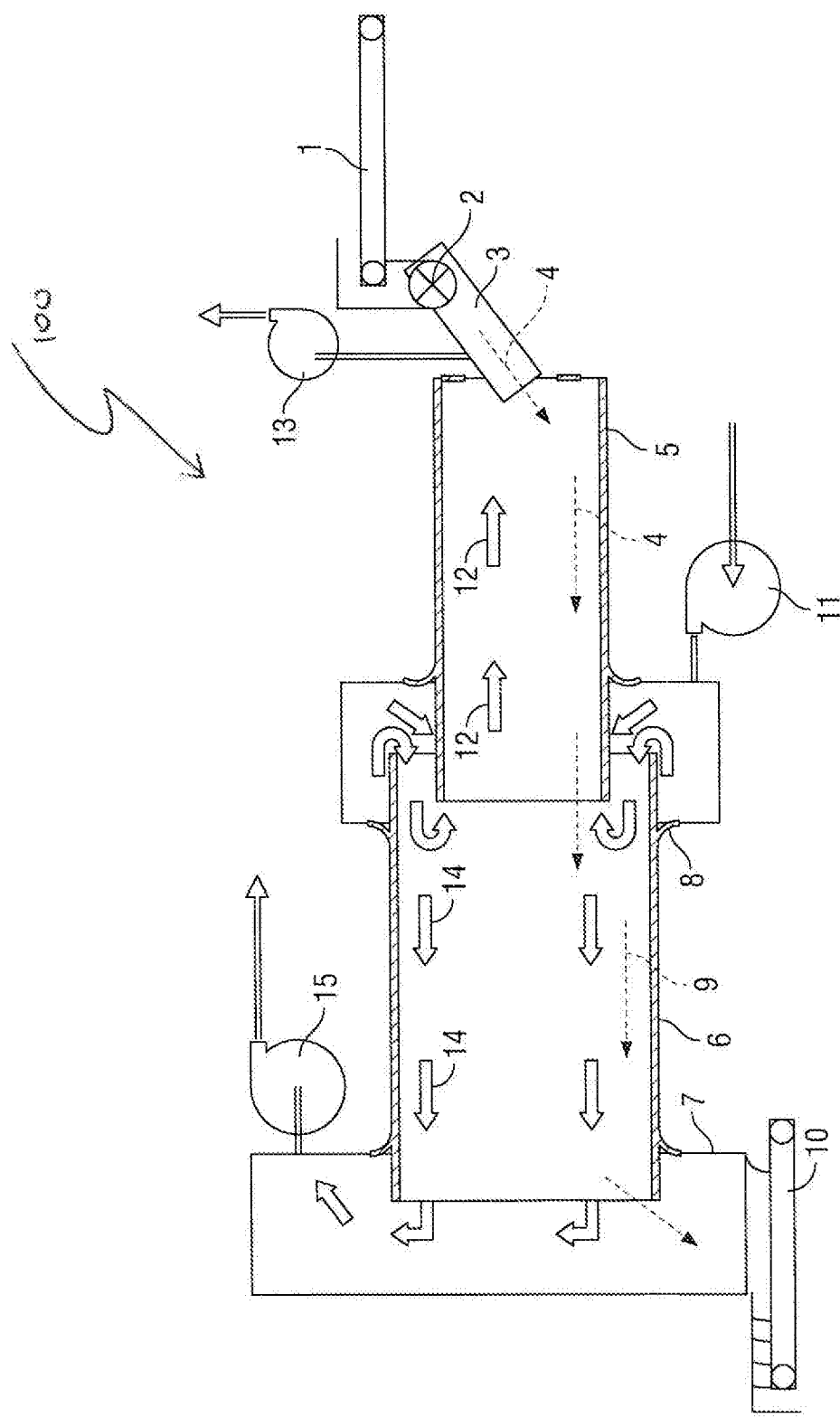


FIG. 1

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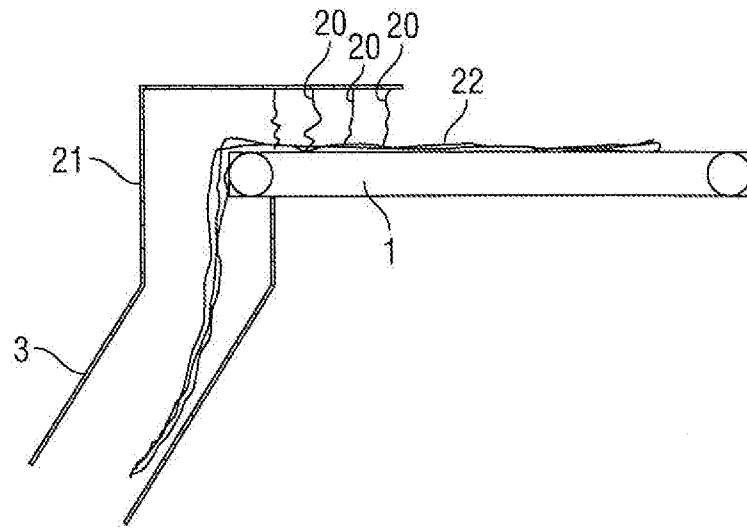


FIG. 2

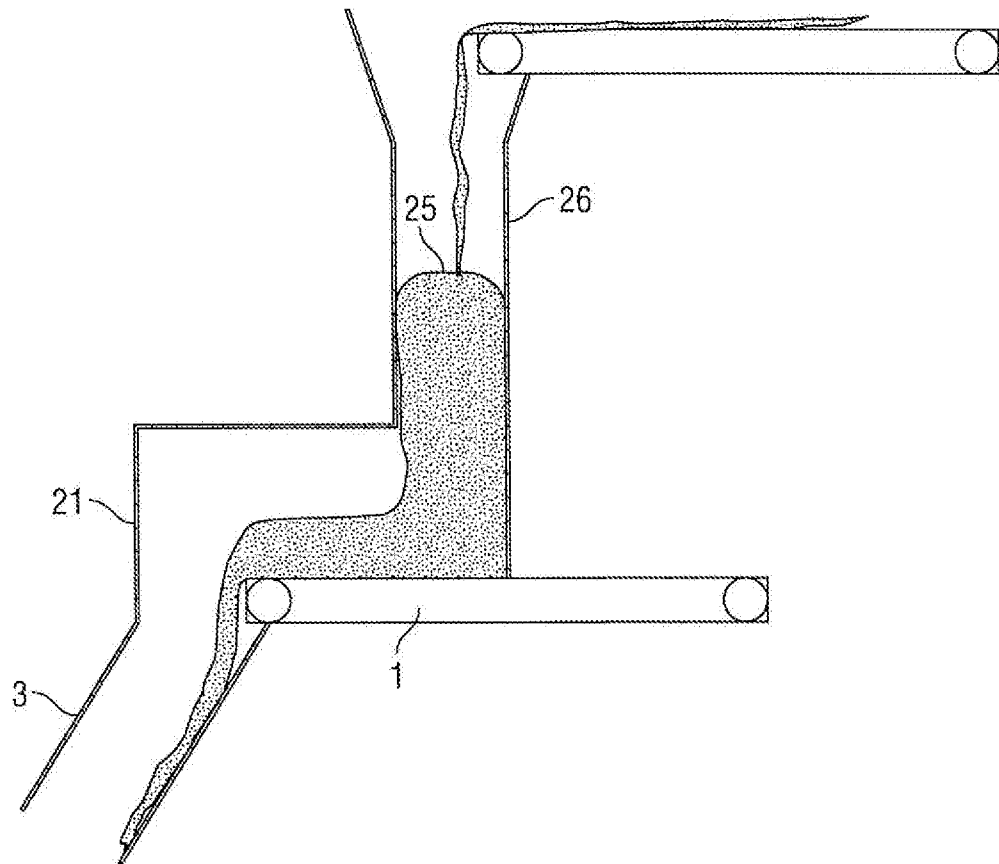


FIG. 3