

Nov. 21, 1944.

G. D. ARNOLD

2,363,281

APPARATUS AND METHODS FOR TREATING PNEUMATICALLY BORNE MATERIAL

Filed April 4, 1941

2 Sheets-Sheet 1

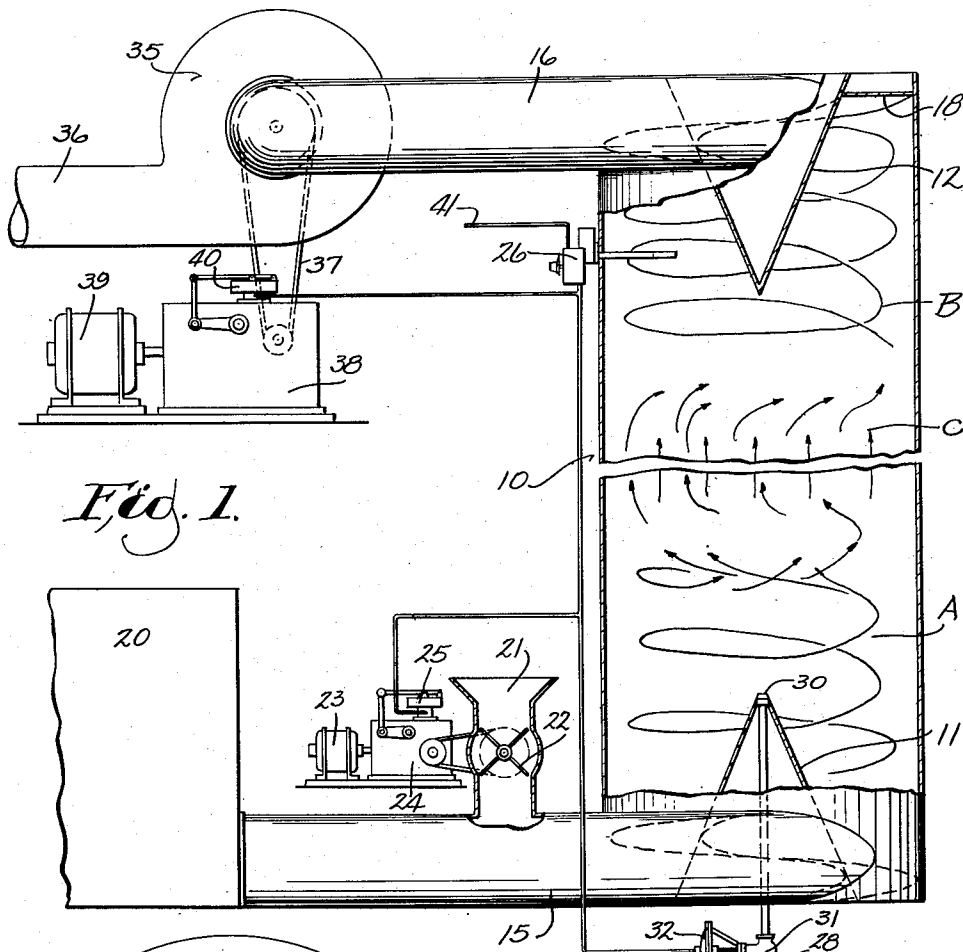


Fig. 1.

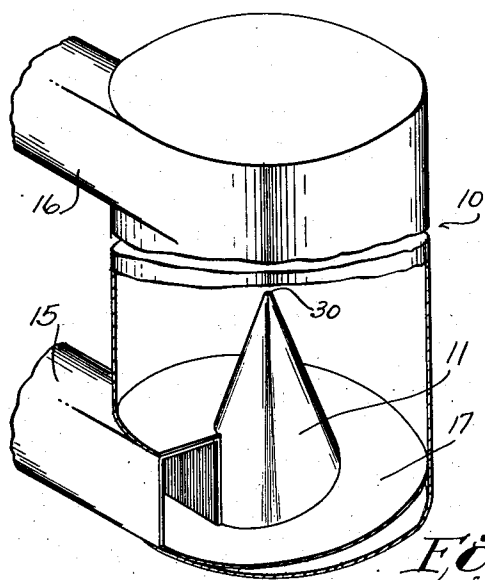


Fig. 2.

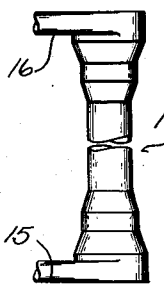


Fig. 3.

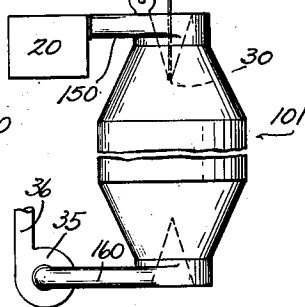


Fig. 4.

INVENTOR
GERALD D. ARNOLD

BY
Wheeler, Wheeler & Wheeler

Nov. 21, 1944.

G. D. ARNOLD

2,363,281

APPARATUS AND METHODS FOR TREATING PNEUMATICALLY BORNE MATERIAL

Filed April 4, 1941

2 Sheets-Sheet 2

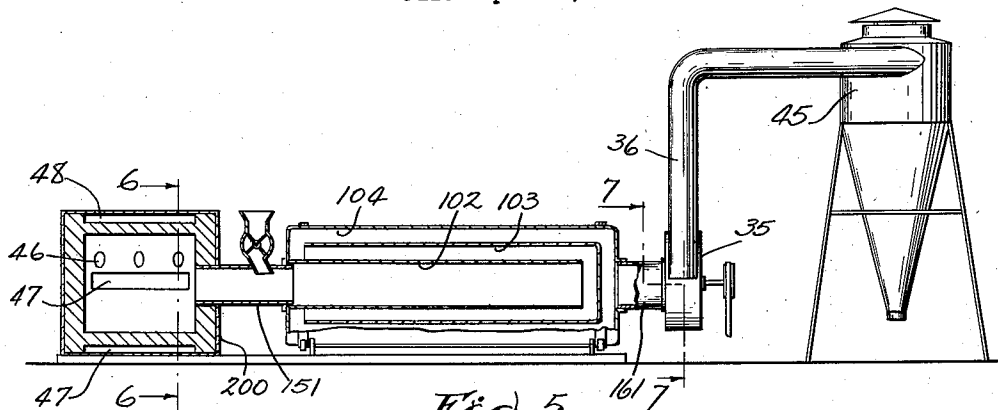


Fig. 5.

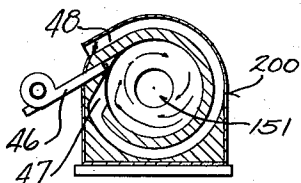


Fig. 6

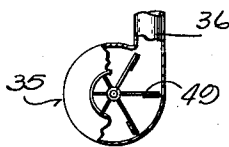


Fig. 7

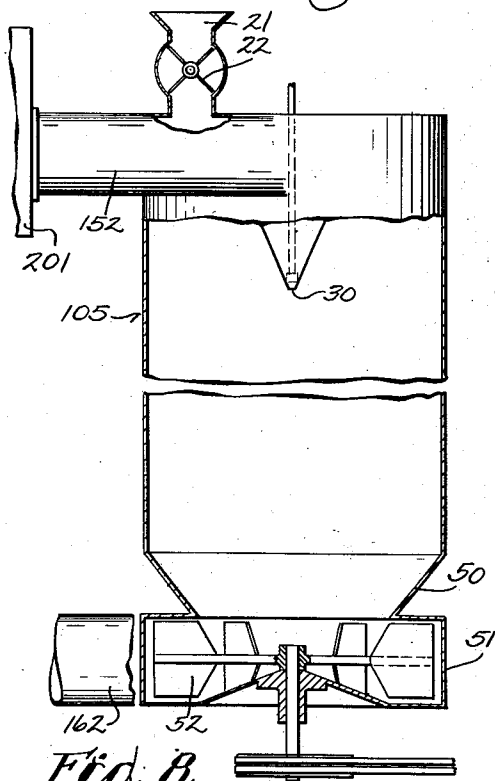


Fig. 8.

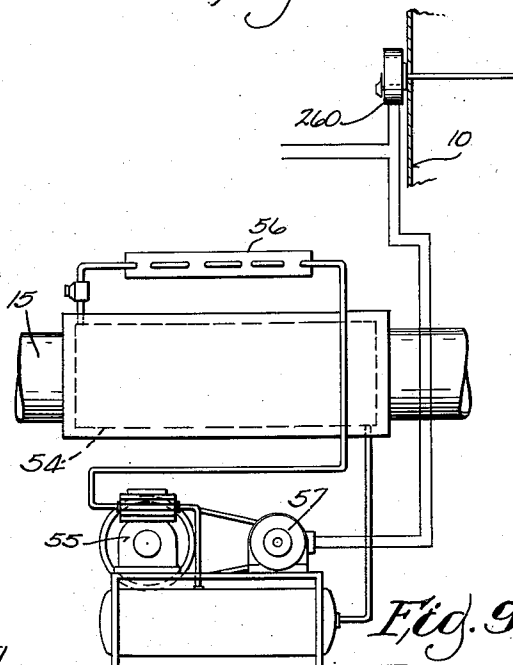


Fig. 9.

INVENTOR
GERALD D. ARNOLD
BY
Wheeler, Wheeler & Wheeler.

UNITED STATES PATENT OFFICE

2,363,281

APPARATUS AND METHOD FOR TREATING
PNEUMATICALLY BORNE MATERIAL

Gerald D. Arnold, Wauwatosa, Wis.

Application April 4, 1941, Serial No. 386,788

28 Claims. (Cl. 34—10)

This invention relates to improvements in apparatus and methods for dehydrating, heating and cooling pneumatically borne material.

It is the primary object of the invention to provide, without baffles, for rectified pneumatic flow through a dehydrating chamber for the purpose of enabling the full capacity of the cross section of the chamber to be utilized uniformly, whereby the effect of the pneumatic currents upon material to be dried may accurately be predetermined.

In the ordinary dehydrating chamber, particularly one in which either the admission ports or the delivery ports are tangential, the air currents have the nature of a vortex. The material to be dried, ordinarily heavier than air, is thrown thereby to the outside periphery of the chamber and the air itself tends to densify at the outside of the chamber and to become rarefied near the center. The capacity of such a chamber is materially less than would be the capacity of a chamber of like cross section if the air were moving uniformly through the chamber using the entire cross section thereof for rectified delivery.

Under certain circumstances it is desirable to use relatively high speed vortex currents for the support and pneumatic elevation of material heavier than air which is to be dehydrated. By introducing the relatively heavy rough material in a vortex current when it is admitted to the dehydrating chamber, and by subsequently rectifying the current, it is possible, by employing the reduced current velocity consequent upon rectification, to hold the material suspended or at least retarded in its advance by the reduced velocity of the current until it is sufficiently dehydrated to be further lifted by the pneumatic current even at such reduced velocity. However, if baffles are employed for this purpose, they rapidly become clogged and catch material which tends to burn thereon if the dehydrating current is heated.

Accordingly, I seek to provide the entire control without the use of baffles and to convert a whirling or vortex current of pneumatic propulsion air or gas into a rectified current of air or gas moving rectilinearly parallel to the axis of the chamber throughout its entire cross section without the use of baffles.

Other objects of the invention pertain to the efficient and economical accomplishment of the aforesaid purposes with various arrangements of chamber inlets and outlets and propulsion fans.

While the invention has its primary application to dehydration, it is also applicable in anal-

ogous manner to chilling apparatus or to apparatus which is used for heating without dehydration, as will hereinafter be made apparent.

A further object is generally to simplify and improve the construction, arrangement and operation for one or more of the purposes mentioned, and still other objects will be apparent from the specification.

In the drawings:

Fig. 1 is a view partially in side elevation but largely in axial section showing a device embodying the invention.

Fig. 2 is a view in perspective partially broken away to an axial section showing the treating chamber of the device of Fig. 1.

Fig. 3 and Fig. 4 are diagrammatic views on a greatly reduced scale showing in side elevation modified embodiments of the treatment chambers and associated apparatus.

Fig. 5 is a view largely in axial section but partly in side elevation showing the invention applied to a rotary drum dehydrator.

Fig. 6 is a detail view taken in section on line 6—6 of Fig. 5.

Fig. 7 is a detail view taken on line 7—7 of Fig. 5.

Fig. 8 is a view partially in side elevation but largely in axial section through a treating chamber and associated apparatus comprising a modified embodiment of the invention.

Fig. 9 is a view diagrammatically illustrating the application of cooling rather than heating means to the device of Figs. 1 and 2.

Like parts are identified by the same reference characters throughout the several views.

The treatment chamber 10 is a generally cylindrical drum of suitable height. The ends of the drum preferably comprise cones 11 and 12 about which the incoming and discharging gases take circuitous paths. The incoming gases are supplied through conduit 15 and the discharging gases leave through conduit 16. The false bottom 17 encircling the cone 11 gives the incoming gases sufficient helical pitch to clear without eddy currents the top of the delivery pipe 15. Similar provision is made by a false top 18 at the discharge end of the treating chamber.

The air or other gas supplied through the delivery pipe 15 to the treating chamber is preferably heated and may comprise a mixture of air and flue gas from the furnace 20. The material to be treated, if solid, is preferably introduced through a charging hopper 21 and a charging valve 22, the latter comprising a rotor driven from motor 23 through rate changer 24 subject

to a regulator 25 which may be operated by air pressure subject to the control of the thermostat 26 near the top of the treating chamber or otherwise exposed to the temperature of the gases leaving such chamber.

For example, the material to be treated may be comminuted kelp or green alfalfa and the objective may be dehydration. Such material, cut up in an ensilage cutter or otherwise, is delivered into the hopper 21 and discharged by valve 22 into the path of the heated currents of air and gas traversing conduit 15 enroute to chamber 10.

For the purpose of making a stock food it may be desired to enrich the comminuted vegetable growth with some such material as molasses. In that event the liquid molasses is supplied through pipe 28 to a spray nozzle at 30 which is located at the apex of cone 11 and directed upwardly in the treating chamber 10 so that the spray will become thoroughly mixed with the pneumatically borne alfalfa or the like, and be dehydrated at the same time. A valve at 31 controlling the liquid supply line 28 is provided with a regulator 32 operable synchronously with regulator 25 from the thermostatic control mechanism 26.

Alternatively, the molasses or other liquid material may be the sole material to be treated in chamber 10. Partially condensed or evaporated milk may be supplied through line 28 and sprayed at nozzle 30 into the path of the air for treatment in the chamber.

Under many conditions the air currents traversing chamber 10 may be motivated by a fan propelling the air through the admission conduit 15 but preferably the fan is applied to the air and material leaving the chamber, as this produces a partial vacuum in the chamber which assists in the dehydration of the treated material, assuming that dehydration is the objective. A large blower at 35 motivates the air currents for the purposes of the present exemplification of the invention and delivers both the air and the treated material through the discharge pipe 36. The fan is driven by belt 37 from the rate changer 38 which is operated by motor 39. A regulator 40 determines the rate of motion transmission through the fan subject to the control of the thermostatic control device 26, air pressure being transmitted through the control device from the air supply line 41 to the various regulators 40, 25 and 32. The arrangement for dehydration is preferably such that if the temperature of the gases leaving the treating chamber is increased, the control will energize the several regulators to increase the rate of material delivery through the charging valve 22 and the liquid valve 31 and at the same time to increase the rate of fan operation whereby to accelerate the flow of both gaseous and solid and liquid materials through the device. Conversely, when the temperature to which thermostat 26 is subject falls, the fan operation will be retarded to slow the air currents and concurrently the amount of liquid and solid material introduced into such air currents will be reduced.

The slightest off center location either of an inlet or outlet from a cylindrical chamber will tend to induce helical motion of gases traversing the chamber from end to end. For the purposes of the present description an off center location of inlet or outlet will be referred to as tangential even though it may not be mathematically tangential to the chamber.

Where the air currents move upon a helical path they tend to concentrate current flow at the periphery of the chamber and at relatively high velocity about the chamber even though the velocity axially of the chamber may not be high. The currents of high velocity are well adapted to propel relatively heavy material such as the undehydrated green produce or wet molasses or milk previously referred to by way of exemplification. If the helical current is continuous throughout the chamber, the heavy produce tends to be conveyed too rapidly through the chamber without adequate time for dehydration, and there is no substantial change of velocity anywhere in the chamber to produce a differential such as automatically to differentiate between the rate at which wet material will move through the chamber and the rate at which dry material will move therethrough. In other words, if the helical velocity of the air currents is substantially uniform throughout, and if such velocity is high enough to cause wet material to be elevated at the inlet end of the chamber it will likewise be high enough to cause such wet material to move with undiminished velocity through the chamber and out the discharge end or top.

Not all material is susceptible of being uniformly dried. A larger particle, or one which does not have many cut surfaces, will be relatively slow to dry and consequently will require relatively prolonged exposure to the hot dehydrating gases in order to reach a given degree of dehydration. On the other hand, a smaller particle of material or one having numerous cut surfaces, will tend to become dehydrated with rapidity. If particles of these various types are all given a uniform treatment of exposure to hot gases the relatively large and uncut particles may be inadequately dried while the relatively small and well exposed particles may become too dry or even burned.

By introducing the gases helically into one end of the chamber and removing them through a helical discharge port oppositely located at the other end of the chamber, I induce oppositely whirling helical currents at the respective ends of the chamber and thereby assure the production of a rectified and non-helical axially moving current at some intermediate point, the exact location of which will depend upon the design of the chamber and the disposition of the air circulating means and other factors.

As elsewhere exemplified by discussion of particular figures of the drawings, I contemplate that either end of a given chamber may be the inlet and either end may be the outlet, and the movement of the product may be with or against the current. Where the axis is vertical the gaseous currents may move either up or down and the product to be dehydrated may, in proper cases, move either up or down.

In stating that the tangential outlet is opposite to the tangential inlet I do not mean that it is located at the opposite side or diameter of the chamber. On the contrary, the inlet and outlet, both tangential, are located at the same side of the chamber, as clearly appears from Fig. 2 and Fig. 3. They are, however, opposite in the sense that they tend to produce opposite directions of whirling movement of the conveying gases. The interaction of the two oppositely rotating vortices of gas currents within the chamber is responsible for producing at an intermediate point within the chamber a rectified current in which all of the gas is moving

axially of the chamber substantially uniformly throughout the entire cross section thereof.

The arrows in Fig. 1 show the inlet vortex at A, the outlet vortex at B, and the intervening rectified axial current at C.

For various special conditions the drum may be reduced in diameter at the point where the current is rectified so as to compensate in part for the decrease in velocity which occurs by reason of the use of the entire cross section of the chamber. This is illustrated by the chamber 100 in Fig. 3 which is identical with the Fig. 1 arrangement except for successive reductions in diameter toward the center of the chamber. Or the chamber may be increased in diameter at its center as indicated by the chamber 101 in Fig. 4. In such a case the larger cross section at the center will so far reduce the velocity of the gases as to make it virtually impossible for the gases to lift any material to be treated. Consequently, in the Fig. 4 construction I have diagrammatically illustrated the reverse of the arrangement shown in Figs. 1 and 2, the furnace 20 supplying hot gases through the upper inlet pipe 150 equipped with a charging hopper 21 like that shown in Fig. 1. The flow of the material and the gas is downward through the chamber 101 and delivery occurs through the tangential discharge conduit 160 to the fan 35.

In all of these arrangements the flow differential is employed to vary the action of the currents upon the material to be treated. Using Fig. 1 as an example, it will be apparent that the relatively high velocity currents confined closely to the periphery of the drum at A will carry relatively heavy material upwardly upon a helical path. However, as the air assumes a more directly vertical direction and spreads out over the relatively quiescent and non-whirling current in the area C of the chamber, the velocity of the current will be inadequate to lift the heavier particles and these will tend to remain suspended while only the lighter particles are carried on out. As the air above zone C resumes helical motion and thereby throws the suspended particles again to the outside of the drum, its lifting force will be greater upon such particles and they will be rapidly expelled. The chief regulatory effect, therefore, at least for purposes of dehydration, will occur in or between zones A and C.

I have discovered that the principles here enunciated affect the operation of rotary dehydrators such as that illustrated in my Patent No. 1,988,677. This device involves a triple drum such as is shown in Fig. 5. The hot gases from the furnace 200 pass through the feed pipe 151 into an inner drum 102 and thence into an intermediate drum 103, from which the material passes through the outer drum 104 to the discharge conduit 161 leading into blower 35, the blower discharging into centrifugal separator 45.

In such a device the triple drums are rotated, and flights within the several drums lift the material and discharge it across the path of the air stream whereby the material is advanced progressively through the series of drums. However, a cylindrical furnace so arranged that the gases in the furnace rotate co-axially with the delivery pipe will induce helical currents within the drum instead of axial currents. Similarly, a fan at the outlet of the drum will induce helical currents within the drum. By opposing the direction of rotation of these currents I am able to produce without baffles a rectified current

axially of the drum in the central portions thereof intermediate its ends which will have a much higher differential effect to distinguish between the rate of advance of wet material and the rate of advance of dry material than is possible where the current is continuously helical throughout the drum.

Therefore the flights within the drum which lift the material will respond differently according to whether the air current is moving axially of the drum or is moving in such a direction as to tend to hold the material in the successive flights, or is moving with the direction of drum rotation so as to tend to deliver the material prematurely from the flights

As shown in Figs. 5, 6 and 7, the furnace 200 is cylindrical and co-axial with the delivery passage 151 and with the triple drum. Air inlet 47 is tangential to the drum. Centrally of the air inlet is the burner 48 supplied with combustion air by blower 46. In actual practice a plurality of tangential inlets will be used, thus producing high velocity vortex of gases within the furnace. The helical travel of such gases in the furnace is desirable because it gives time for fuller diffusion of the hydrocarbon in the air and for thorough combustion before the resulting flue gases are delivered into the dehydrator. In the dehydrator, however, it is desirable that the gas currents be rectified. Accordingly, at the discharge end of the drum the blower 35 has its delivery pipe 36 tangentially arranged to be opposite to the tangential air inlets 47 of the furnace in a sense as to tend to produce an opposite vortex. The rotation of the blower rotor 49 has the same effect in communicating backward into the drum a high velocity vortex which neutralizes within the dehydrator the vortex produced at the furnace end of the system, so that there is a resulting rectified current axially of the drum between its inlet and outlet ends.

Fig. 8 is an arrangement in which the material is delivered into the top of the treating chamber 105. The furnace 201 supplies hot flue gases to the inlet pipe 152 which enters chamber 105 tangentially at its top. Into such hot gases any solid material requiring dehydration will preferably be fed through a hopper 21 and charging valve 22 similar to those already described.

At the bottom of the treating chamber 105 there may be a tapering section 50, though this is not at all essential. Below this is a section 51 in which the blower fan 52 is operated to deliver the material through the usual tangential outlet 162, the direction of fan rotation and the location of outlet 162 being, of course, such as to induce at the bottom of the treating chamber a vortex opposite to that produced at the top thereof by the tangential location of the inlet passage 152.

The fan 52 is almost entirely exposed to the descending material and convection currents and the fan casing 51 is therefore virtually a part of the treating chamber. The rectification of the pneumatic currents intermediate the two ends of the treating chamber will greatly vary the rate of delivery which would otherwise be effected so far as the lighter particles are concerned. The heavier particles of pneumatically borne material will tend to continue upon their initial helical paths long after the gaseous currents have been rectified. The lighter material will readily diffuse toward the center of the chamber with the gaseous currents and will readily partake of the accelerated axial movement of the gaseous currents, thereby moving toward the outlet of the

drum more rapidly than will be the heavier particles which are continuing helically about the drum.

It will be understood that the treated material and the gaseous medium carrying it will be passed from the discharge conduit 161 into any type of separating means, whether it be the centrifugal separator 45 or any other acceptable means for diverting the treated material from such gaseous carrier.

While all of the devices thus far illustrated have been equipped with furnaces for heating or dehydration of the material treated, it will of course be understood that the invention is equally applicable to an arrangement in which cooling is the objective. Fig. 9 diagrammatically illustrates a cooling application to the structure of Fig. 1. The intake pipe 15, instead of leading from a furnace, passes through the evaporator radiator 54 of a refrigeration system, wherein 55 is a motor driven compressor and 56 a condenser. The control 260 is a thermostat said to respond to the desired degree of chill produced within the treating chamber 10, and the thermostat regulates the operation of the motor 57 which drives the compressor. This is intended to be merely representative of numerous arrangements in which the chilling of the air entering the chamber may be automatically controlled to respond to the temperature of that air which has already acted upon the product so that if the air leaving the chamber is too warm, the rate of feed of the product may be reduced, as through the mechanism shown in Fig. 1 and the rate of refrigeration increased.

Regardless of the purpose of the process and whether it is used to heat or to chill the material undergoing treatment, and regardless of the direction and movement of the pneumatic convection currents in the treatment chamber, and regardless of whether the chamber is vertical or horizontal or movable or fixed, in either case I produce opposite rotation of the pneumatic convection currents in the opposite ends of the chamber with a resulting rectification of such currents to a direction axially of the chamber in an intermediate portion thereof, thereby regulating the relative rate of delivery of large and small or heavy and light particles of material through the chamber, exposure of the product being inversely proportioned to axial velocity of the gases.

Various forms of the device may be preferred to other forms according to the material to be treated. The treatment may involve the dual objective of mixing a liquid such as molasses with a solid such as alfalfa for the production of a stock food while uniformly drying all of the material. For this and many other purposes the organization shown in Fig. 1 is preferred since, as above described, it involves the suspension of the treated material on the pneumatic convection currents in space within the chamber until drying is effected, the change in relative rate of flow of the convection currents being varied without exposing any internal baffle through the wet material.

The chambers herein disclosed are preferably, though not necessarily, round in cross section. The round cross section eliminates corners which might produce undesired and uncontrollable eddies. It also tends to prevent material from accumulating in the corners. However, irrespective of the shape of the chamber in cross section, references herein to the movement of the material axially of the chamber are intended to

mean movement longitudinally of the chamber along its general center line between its inlet and outlet ends, irrespective of the particular form of the chamber in cross section. It has already been explained that references to the disposition of the inlet and outlet conduits tangentially of the chamber are not intended to refer to a tangent in any mathematical sense but to an off center location such as to tend to produce rotation of the convection currents in the respective ends of the chamber.

I claim:

1. The combination with a treatment chamber of circular form in cross section having a tangential inlet, of a centrifugal fan casing comprising an axial extension of said chamber in communication with said chamber, a fan rotor in said fan casing, said fan casing having a peripheral outlet, means for rotating the fan rotor for the expulsion of gas from the fan casing and chamber whereby to establish in said chamber a vortex current of gas admitted through said tangential inlet, the direction of fan rotor rotation being opposite to the direction of vortex movement of the gas admitted to the chamber, whereby the fan rotor tends to establish an opposite vortex in the fan casing and the portion of the chamber adjacent thereto, together with means for introducing into the current of gas established by said rotor a material to be pneumatically carried by said current and treated by the gas in the course of its movement therewith.

2. The combination with a treatment chamber, of a fluid conduit communicating in a general tangential manner with said chamber adjacent one end thereof, and a discharge fluid conduit communicating in a general tangential manner with said chamber adjacent the opposite end thereof, the tangential connections of the inlet and discharge conduits being opposite in the sense of tending to produce opposite directions of rotation of fluid convection currents in the chamber.

3. The combination with a treatment chamber of generally cylindrical tubular form provided at one end with a tangential inlet conduit, of a central cone at said end, an end wall following a helical path about said cone from the outer side of said conduit to the inner side thereof, said chamber at its other end being provided with a tangential outlet, a central cone at said other end, and an end wall following a generally helical path of opposite pitch to the path of said first end wall about the last mentioned cone from the inner side of the outlet conduit to the outer side thereof.

4. A pneumatic convection system including inlet and outlet conduits and an intervening treatment chamber of progressively varying diameter from one end toward an intermediate point and having reverse variation in diameter thence toward the other end, said conduits comprising means for introducing gases into one end of the chamber in a predetermined direction of vortex rotation and removing gases from the other end in an opposite direction of vortex rotation, and means for introducing into said gases to be pneumatically conveyed thereby a material to be treated in said chamber for automatic control of the advance of different particles of said material in accordance with the change in current movement produced by the interaction of the vortices in the differently diametered intermediate portions of said chamber.

5. A chamber of generally circular cross section provided with a tangential inlet conduit and a tangential outlet conduit disposed in different planes normal to the axis of the chamber, said inlet and outlet conduits being oppositely disposed in the sense of tending to produce opposite vortex rotations in said chamber, and means associated with the outlet conduit for exhausting gas from said chamber whereby to produce convection current movement therethrough, means associated with the inlet conduit for varying the temperature of gas admitted therethrough to said chamber, and means associated with the inlet conduit for introducing therein material to be borne through said chamber by a convection current passing between the inlet and the outlet of said chamber.

6. The combination with a cylindrical furnace having tangentially disposed burners and air inlets, of a treatment chamber comprising a drum connected with said furnace to receive a vortex current of hot gas therefrom, means for introducing into such current material to be conveyed and treated thereby, and means for exhausting gas from said chamber in a manner to produce an opposite direction of vortex movement thereof, said exhausting means including means for removing the treated material as well as the gas exhausted from the chamber.

7. The combination with a rotatable treatment chamber comprising a series of concentric shells having communicating spaces therebetween, of means for introducing hot gases with a vortex movement into one of said shells, means for removing gases from another of said shells and including means for producing an opposite direction of vortex movement in the course of such removal, said shells communicating to provide a gaseous path of varying cross section, and means for introducing into said gaseous path material to be pneumatically conveyed and treated by gases traversing said chamber and to be affected as to its rate of progress through said chamber by the change of gaseous movement resulting from the interaction in an intermediate portion of the chamber of the vortices adjacent the inlet and outlet portions of the chamber.

8. The combination with a rotatable treatment chamber comprising a series of three concentric shells having communicating spaces providing a path of gradually increasing cross section for pneumatic convection current, of an inlet to the smallest of said shells comprising a cylindrical furnace having a tangential burner and air inlet and communicating axially with the smallest shell of said chamber, a charging valve operatively connected to deliver material for treatment into the path of hot gases delivered from the furnace to the smallest shell of said chamber, and a discharge blower having a tangential outlet so disposed as to create a vortex rotating oppositely to the vortex originally in the furnace and communicated to the smallest shell of said chamber, said blower communicating with the largest shell of said chamber to receive convection current and treated material borne thereby for delivery from said chamber, the arrangement being such that the vortex produced in the furnace and the opposite vortex produced in the blower interact at an intermediate point in said chamber to produce a rectified current therein.

9. The combination with a vertical chamber having upper and lower portions of substantially like diameter, of gaseous inlet and outlet con-

duits opening into and from the said respective chamber portions and tangentially disposed with respect to said chamber and opposite in the sense of tending to produce oppositely rotating vortices occupying the full cross section of the chamber at the top and bottom thereof, means associated with one of said conduits for inducing a convection flow of gas through said chamber, and means for introducing into the gaseous current in said chamber a material to be treated thereby.

10. The combination with a vertically disposed treatment chamber of generally circular cross section, of a tangential inlet at the bottom of said chamber, means for heating gases admitted to said inlet, means for delivering to the heated gases a material to be conveyed and treated thereby in said chamber and to partake in said chamber of the vortex movement of such gases, and a discharge conduit from the top of said chamber communicating therewith tangentially in opposition to the inlet in the sense of tending to produce an opposite direction of gaseous vortex movement at the upper discharge end of said chamber, together with means for circulating gases through the inlet, the chamber, and the discharge conduit the interaction of the inlet and discharge vortices in said chamber tending to produce intermediate the top and bottom of the chamber a substantially rectified current of reduced actual velocity but increased vertical velocity.

11. The combination with a vertically disposed chamber, of means for passing a current of treatment gas through the chamber and including tangential conduits communicating with upper and lower portions of the chamber in opposition in the sense of tending to create oppositely rotating vortices in the chamber, means for effecting a variation in the temperature of gas admitted to the chamber through one of said conduits, and means for introducing material into the path of such gas adjacent its point of admission to the chamber.

12. The device of claim 11 in which the path of gas movement through the chamber is downward, said device including a fan adjacent the bottom of the chamber to expel the gas and material treated through the tangential conduit nearest the bottom.

13. The combination with a treatment chamber having a tangential inlet conduit and a tangential outlet conduit opposed in the sense of tending to produce opposite vortices in the chamber, of means for inducing a flow of gas through the inlet conduit, the chamber, and the outlet conduit in series, means for heating such gas prior to its admission to the chamber, means for introducing a solid material to be treated into the path of the heated gas for pneumatic delivery with the gas to the chamber, and means for spraying into the path of such material and heated gas within the chamber a liquid.

14. A treatment chamber having a cone at one of its ends, a tangential inlet entering the chamber between the cone and the side of the chamber, gas discharge means adjacent the other end of the chamber comprising a tangential discharge conduit opposed to said inlet conduit in the sense of tending to produce an oppositely rotating vortex in the chamber, means for delivering a solid material into the path of gas admitted to the chamber through the inlet conduit to be pneumatically conveyed thereby into said chamber for treatment, and a spray nozzle disposed adjacent the apex of the cone and provided with con-

nections for the delivery of a liquid into said gas directly in the chamber.

15. The device of claim 13 in which such spraying means comprises a spray nozzle provided with liquid supply connections and disposed within the chamber for projection of liquid in the form of a spray into the path of such gas directly within the chamber.

16. The combination with a vertically disposed treatment chamber having a tangential lower inlet conduit and a tangential upper discharge conduit in opposition to the inlet conduit in the sense of tending to create an oppositely rotating vortex in the chamber, means for withdrawing gas through the discharge conduit, and a spray nozzle centrally disposed within the chamber and provided with liquid supply connections for spraying a liquid into the path of gas rising in said chamber.

17. The combination with a treatment chamber having inlet and outlet conduits tangentially disposed and opposed to each other in the sense of tending to create opposite vortices in said chamber, said conduits being located adjacent opposite ends of the chamber, fan means for withdrawing gas through the outlet conduit and introducing gas through the inlet conduit, means for delivering material into the gas adjacent the inlet conduit, mechanism for operating the fan means and the material delivering means, regulatory means for varying the rate of operation of the fan means and the material delivering means, and a thermostat exposed to gas leaving the chamber in operative connection with said regulatory means for varying the rate of operation of the fan and the rate of supply of material to be treated in said chamber in accordance with the temperature of such gas.

18. A method of treating material in the course of its pneumatic propulsion, such method including the creation of a pneumatic current, establishing oppositely rotating vortices at longitudinally spaced points in said current and axially exposed to each other intermediate such points, whereby to establish a zone of rectified current movement between said vortices, and the delivery of material to be treated into said current to pass through said zone.

19. The method of treating material in the course of its pneumatic delivery, such method including establishing a pneumatic current, delivering thereto the material to be treated, vortically rotating the pneumatic current and material in a predetermined direction helically with respect to the general direction of current advance, rectifying such current and material into a path of movement substantially parallel to such general direction of current advance, and subsequently rotating such current and material helically in a direction opposite to the original direction of vortical movement.

20. A method of treating material in the course of its pneumatic propulsion, such method comprising establishing a current having a generally vertical direction of advance, vortically rotating the current in opposite directions at vertically spaced points in the course of its advance, whereby to produce an intermediate zone in which the general movement of the current in vertical upon the path of such advance, and delivering into one of said vortices the material to be treated, whereby such material is obliged to traverse one of said vortices and the intermediate zone and the other of said vortices.

21. The method of treating material in the course of its pneumatic propulsions, such method comprising establishing a gaseous current having a general upward vertical component of movement, establishing vortices in said current successively rotating in opposite directions whereby to provide an intermediate rectified zone in which said current has a substantially directly upward movement, and delivering into the lower vortex of said current material to be pneumatically conveyed thereby, while maintaining the velocity of the current such as to elevate all particles of such material in the lower and the upper vortex while elevating in said intermediate zone only the lighter of such particles.

22. A method of dehydration which consists in establishing a current of dehydrating gas having a generally vertically upward movement and establishing at different levels in said current oppositely rotating vortices and an intermediate zone of rectified movement in which the gas comprising said current is moving substantially directly vertically upward, introducing into said current particles of material to be dehydrated, and maintaining gas velocity in said current sufficient to elevate all of the material in the respective vortices and to differentially elevate only the lighter particles of such material in said intermediate zone, whereby to maintain the heavier particles in the lower vortex pending dehydration thereof.

23. A method of dehydration which comprises heating gas, establishing a vertical current of heated gas, subsequently establishing axially spaced oppositely rotating vortices in the rising current of said heated gas and an intermediate rectified zone in which all of the gas is moving substantially directly vertically, introducing into the current of said heated gas particles of material to be dehydrated, and maintaining a gas velocity such as to support all of such material in the respective vortices and to differentially support the lighter particles in preference to the heavier particles in said intermediate zone.

24. The method of claim 23 in which the method includes moving the gas and the material treated both in an upward direction and atomizing liquid material to be dehydrated and delivering the atomized liquid directly into the lowermost vortex.

25. A method of dehydration which comprises heating gas, establishing a vertical current of such gas, establishing oppositely rotating vortices at vertically spaced points in the current of heated gas and an intermediate rectified zone in which said vortices interact, whereby all of the gas in the intermediate zone is moving substantially vertically, and introducing into the current of gas to pass through at least one of said vortices and said intermediate zone a finely divided material to be acted upon by said gas.

26. The combination with a treatment chamber having a tangential inlet and an outlet near its center, of a centrifugal fan including a rotor positioned to receive gas from said chamber outlet, whereby to withdraw gas from the chamber and to cause a flow of gas into the chamber through said inlet in a whirling convection current, means for rotating the fan rotor in a direction to produce a whirling current of gas at the chamber outlet which is opposite in its direction of rotation to the whirling current at the chamber inlet, whereby an interaction of the oppositely rotating whirling currents of convection gases at a point in the chamber intermediate the

inlet and outlet in the path of movement of such gases will produce a substantially rectified zone, together with means for introducing into the convection current material to be pneumatically carried by said current and treated thereby in said chamber.

27. The combination with a treatment chamber of generally circular form in cross section, such chamber having a tangential inlet adapted to deliver a pneumatic current into said chamber for vortical rotation therein, a fan chamber communicating substantially axially with said treatment chamber to receive a pneumatic current therefrom, a fan in the fan chamber rotatable approximately coaxially with the treatment chamber, means for rotating said fan in a direction opposite to the rotation of the vortex established in the treatment chamber by the tangential inlet thereto, whereby said fan tends to communicate an oppositely rotating vortex from the fan chamber into the treatment chamber, and a tangential outlet from the fan chamber opposite from the tangential inlet in the sense of tending to encourage the production of a vortex rotating oppositely from that produced by the tangential inlet, said tangential outlet being adapted directly to receive the vortex established in the fan chamber by the rotation of the fan.

28. The combination with a treatment chamber of generally circular form in cross section and a blower comprising a casing and a fan, said casing having an inlet eye communicating substantially coaxially with the treatment chamber and the fan being mounted for rotation substantially coaxially with the fan casing eye and the treatment chamber, an approximately tangential inlet conduit opening to the treatment chamber and tending to establish a vortical pneumatic current therein, an approximately tangential outlet from the fan casing tending to establish a vortical pneumatic current in the fan casing, the tangentially disposed inlet and outlet conduits aforesaid being opposite in the sense that the vortices tending to be produced thereby rotate in opposite directions, and means for operating the fan in the same casing in the direction of operation of the vortex therein whereby to deliver a pneumatic current from the fan casing directly to the outlet conduit therefrom and to encourage the propagation in said treatment chamber of a vortex current approaching said fan casing in a direction of rotation opposite to that of the vortex current caused in said treatment chamber by the tangential inlet thereto.

GERALD D. ARNOLD.