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[54] **METHOD OF AND A DEVICE FOR CONTROLLING THE PROCESS TEMPERATURE IN AN AIR STREAM DRYING SYSTEM**

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[52] **U.S. Cl.** ..... **34/10**, 34/13, 34/26, 34/31, 34/46, 34/57 R

[51] **Int. Cl.** **F26b 3/10**

[58] **Field of Search** ..... 34/10, 13, 20, 31, 46, 34/47, 57 R, 57 B; 263/21 A; 432/15, 58

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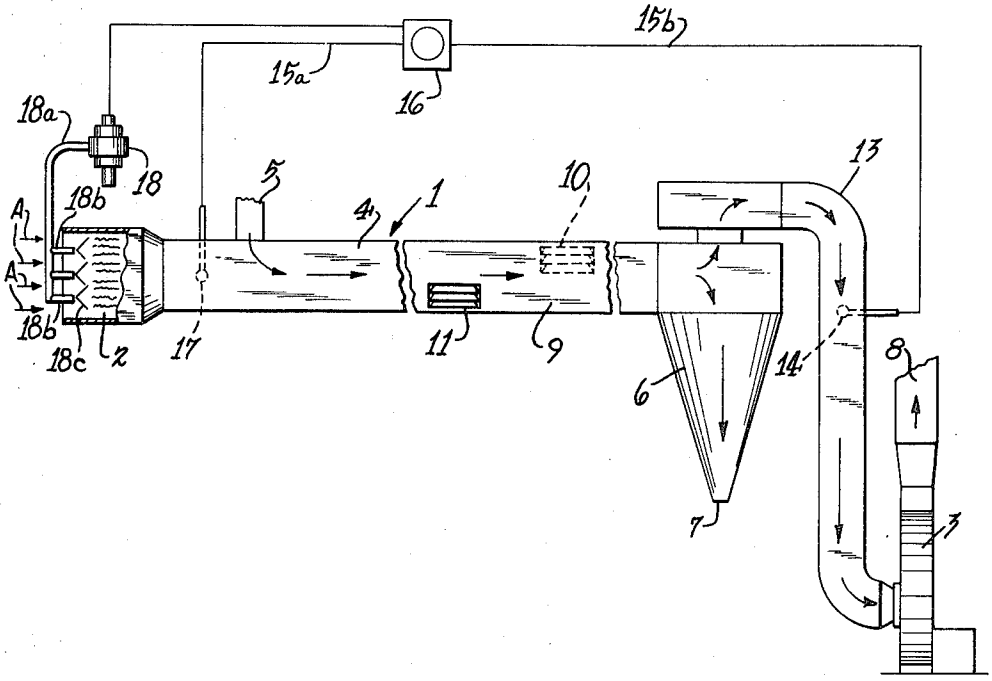
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Primary Examiner—William F. O'Dea
Assistant Examiner—W. C. Anderson
Attorney, Agent, or Firm—Ernest F. Marmorek

[57] **ABSTRACT**

A method of maintaining a high intake temperature and a low outlet temperature in a gas stream conveying suspended particles to be dried including the step of introducing a controlled amount of ambient cooler into an intermediate portion of the drying gas stream. The device comprises preferably two ambient air intake openings provided with controllable louvers.

7 Claims, 5 Drawing Figures



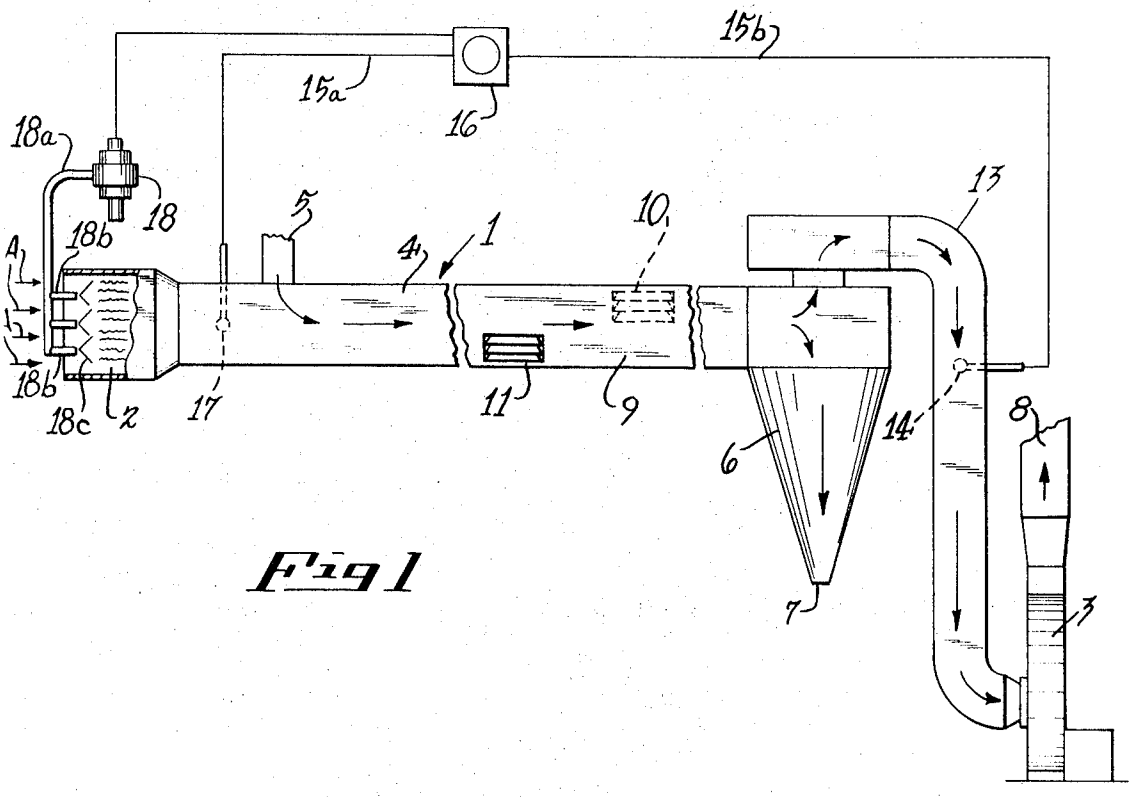

15b
15a
16
18a
18
18b
5
4
1
10
13
A
18b
18c
2
17
11
9
14
8
6
7
3

Fig 1

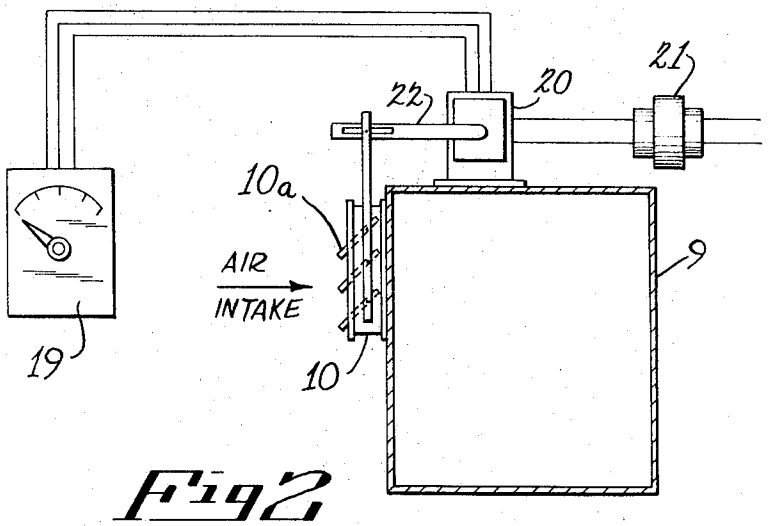

21
22
20
10a
AIR
INTAKE
9
19
10

Fig 2

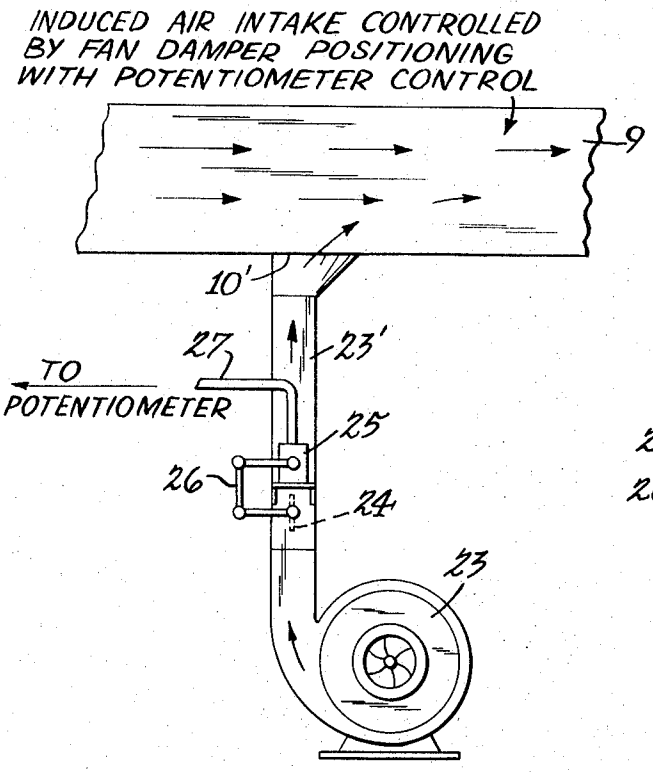


Fig 3

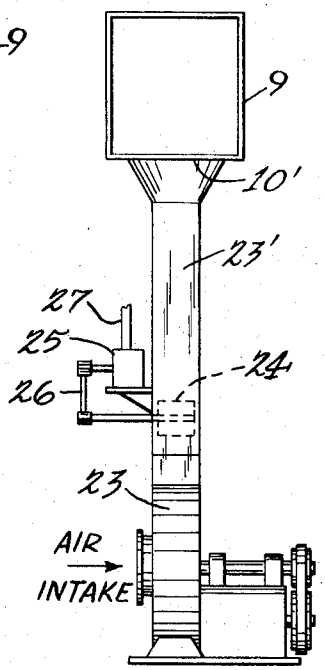


Fig 4

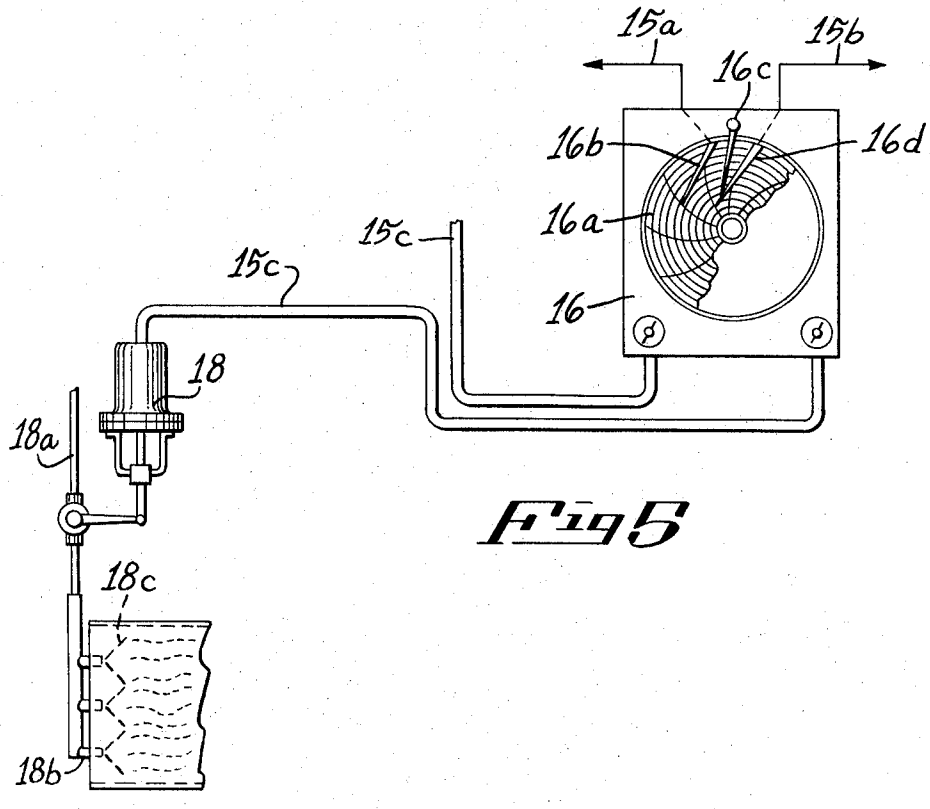


Fig 5

METHOD OF AND A DEVICE FOR CONTROLLING THE PROCESS TEMPERATURE IN AN AIR STREAM DRYING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a method of and a device for drying high volume organic or inorganic particles suspended and conveyed in a high velocity and high temperature air stream. More particularly, this invention relates to a drying method and device where the air stream is contained in an enclosed column or duct. The configuration and length of such a column corresponds to the quantity of moisture to be removed from the particles. The drying industry is well versed in the design of such enclosures which may be of infinite variations so that intermittent retention time exposure of the particles suspended and conveyed in the hot air stream may be obtained.

It is also known that the temperature of the air stream passing through the dryer or column must be sufficient to compensate the following heat losses: (a) radiation from the column walls, (b) heat required to raise the temperature of the material to be dried, including the contained moisture, (c) heat required to evaporate the moisture removed from the air and particles. Also, sufficient quantity of air must be supplied to act as a heat carrier and maintain particle suspension in the air stream.

Since heated high velocity air is used as the drying medium, time of exposure of the particles in the heated air stream becomes an important factor. The desired exposure time may be attained by designing a proportionally long configuration of the drying column which measure, of course, is economically not practical; or by adjusting temperature of the air stream to a sufficient magnitude. The temperature, however, must be below the limit that would have a deleterious affect on the particles.

Particles requiring the removal of water may be quite different in character and this would determine the rate of drying. Thus, if the particles to be dried are impervious to water, such as metal, and contain traces of water on their surface only, evaporation will take place rapidly. On the other hand, some particles are porous and the diffusion of moisture to the surface may be very slow. Therefore, the rate of drying will be governed by this factor instead of surface evaporation, and the ultimate time of drying will be governed by the rate of both evaporation and diffusion.

Now then, since the exposure time in a high velocity heated air stream type of dryer is limited, it is necessary to elevate the inlet air temperature to within the limits of the endurance of particles as heretofore described. The moisture evaporation process starts immediately as the particles to be dried enter the hot air stream and provided the temperature of the air is at the required value.

The moisture, being diffused from the particles, humidifies the hot conveying air and causes a lowering of the air temperature as the moisture evaporates.

It is known in the art how to provide a temperature sensing bulb at the heated air inlet part of the drying column, a temperature sensing bulb at the air outlet, and a capillary, thermocouple, or some equivalent means of signalling to a temperature controlling device; the outlet temperature sensing bulb being the control sensor. Now then, when moisture is being diffused and vaporized from particles, the outlet sensing bulb senses the lower air temperature and signals the controller, which in turn causes an increase in temperature for the amount of moisture being evaporated.

The problem that exists is the temperature drop -between the heated inlet air and outlet air. When a high -inlet temperature is required (to heat the air, the particles, to start the moisture evaporation process, provide for radiation heat losses from the enclosure walls, etc.), the disadvantage of prior art dryers resides in that the temperature drop at the exit end could be slight and, therefore, result in delivery of the particles in a high temperature condition. Some product requirements are only to reduce the moisture content to a specified amount.

Numerous additional problems develop with delivery of particles at too high a temperature: namely, the after drying during storage results in uncontrolled retention of moisture, possible fire hazards with organic particles, fumes being driven off detrimental to storage containers, conveying ducts, and the like.

The ideal condition would be to obtain the high inlet temperature needed to start the evaporation process, and at the same time have a low outlet temperature, or a high temperature differential between the inlet and outlet. However, the industry today experiences only a slight temperature differential which varies more or less, depending on the quantity of water being evaporated. If the quantity is small, the differential will be small. If the quantity is large, the differential will be large. But in neither case is the differential as large as is desirous under the ideal condition.

It has also been industry practice to introduce a fine water spray into the air and particle stream to increase the evaporation quantity in order to cool down the exiting air and particles. This method is not too successful in all cases and tends to create more problems than it solves.

Accordingly, it is an object of this invention to provide a drying system having a controllable high inlet air temperature while maintaining a constant low outlet air temperature, resulting in the ultimate objective of dried product delivery at a low temperature.

Another object of this invention is to provide means insuring that the high inlet temperature be accurately adjustable to the minimum temperature requirements of any specific product to start the evaporation process.

Still another object of this invention is to enable increases in the inlet temperature to a controlled higher value without increasing the outlet temperature irrespective of evaporation of moisture and without increasing the outlet temperature setting.

A further object of this invention is to provide means for attaining a controlled large temperature differential between inlet and outlet air and thereby greater reduction of delivered product temperature.

A still further object of this invention is to increase the accuracy of control of the inlet and outlet temperatures according to the minimum temperature required to start the evaporation process for a specific organic product, thereby reducing the fire potential.

Another object of this invention is to secure a more economical operation of the drying system.

Still another object of this invention is to provide a method of temperature control which has no deleterious effect on the product.

Moreover, an object of this invention is to prevent deterioration of storage bins and conveying ducts due to hot fumes emanating from the hot particles of product.

A still further object of this invention is to reduce high maintenance activity to the delivery mechanisms, fans, motors, and the like, and the maintenance requirements to subsequent process equipment that product passes through prior to storage.

Furthermore, an object of this invention is to prevent continued drying that results in loss of controlled moisture content specifications.

SUMMARY OF THE INVENTION

According to this invention, the above objects are attained by introducing a controlled amount of ambient cooler air into an intermediate portion of the drying gas stream. The device for introducing this cooler ambient gas comprises preferably ambient air inlet openings including a control member for adjusting the amount of the introduced ambient cooler air. The openings are located in an intermediate duct provided between the drying column and the particle separator and collector. The total opening area is to be a minimum of 25 percent of the clearance of the intermediate duct.

The ambient air entering the duct mixes with the hot air stream conveying the product, thus having a cooling effect on both the particles and the air. The relatively lower temperature of the separated air at the outlet of the particle collector and separator will influence the outlet sensing bulb which will signal the temperature controlling device to increase the temperature at the inlet end of the drying column. A constant wide temperature differential (for a given ambient air opening) between the inlet and outlet of the drying channel is thereby obtained while the outlet temperature of discharged particles is maintained low irrespective of the high temperature value of the feeding end of the drying channel.

If it is desired for example to maintain a constant outlet temperature of say 250°F and the temperature set pointer on the process temperature controller is positioned on the controller chart at 250°F, when the cooler outlet air reaches the outlet sensing bulb, a rise in inlet temperature will occur which, when mixed with the volume of entering ambient air, will result in maintaining a temperature of 250°F at the outlet sensing probe. The preset 250°F (or any other desired setting) will remain as a constant; the inlet temperature can be adjusted to any temperature increase by the amount of ambient air admission through the adjustable openings and thus provide an instant and fully controlled method of creating a large or small air temperature differential between the inlet and outlet ends of the system.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be best understood by reference to the following detailed description and claims and the illustrations in the accompanying drawing, in which

FIG. 1 is a schematical, partly in section and partly cut away elevational view of an air drying system of this invention;

FIG. 2 is a sectional side view of the outlet temperature control device in the system of FIG. 1;

FIG. 3 is a sectional elevational view of a modification of the outlet temperature control device of this invention;

FIG. 4 is a side view of the device of FIG. 3; and

FIG. 5 is a schematical, partly cut away elevational view of a modification of the inlet temperature control device in the system of this invention.

DETAILED DESCRIPTION

Referring now to FIG. 1, the air drying system of this invention comprises a drying channel 1 which at the intake end thereof is connected to a furnace section 2 into which a high velocity air stream is drawn in the direction as marked by arrows A past a controllable heat source 18c. The high velocity air stream is drawn into the furnace section 2 by a fan 3. The heated air stream enters into a drying column 4. The particles to be dried enter the drying column 4 at a feed opening 5 which is situated near the furnace section 2. The particles, such as tobacco particles for example are air conveyed in the hot air stream at a velocity that will maintain particle suspension through the drying channel 1 until delivery into a collector 6 where the particles are separated from the hot air flow. The particles are then delivered to a collector discharge opening 7.

After exposure of the particles to a high inlet temperature in the drying column 4 and consequently after the moisture evaporates to the degree required, the particles, still being hot air conveyed, are delivered through an intermediate drying duct 9 to collector and separator 6.

According to this invention two controllable, preferably louvered openings 10, 11 operable for introducing cooler ambient air into the high velocity and high temperature drying air stream, are located in the delivery duct 9. To prevent stratification of the ambient air entering into the hot air and particle stream, the openings 10 and 11 are located on opposite sides of the duct 9 and are staggered from each other both in the directional axis and the elevated plane.

When the ambient cooler air enters duct 9 through one of the louvered openings 10, 11 or both, a mixing of the ambient air with the hot air stream occurs, resulting in immediate lowering of the air stream temperature. The particles being air conveyed are therefore cooled to a lower temperature.

After the completion of the air and particle separation in collector 6, the separated air entering exit duct 13 comes in contact with temperature sensing member 14 in the form of a thermocouple or the like and signals the outlet temperature to a temperature controlling device 16 which in turn transmits a signal to control fuel valve 18 for injection of more or less fuel into nozzles 18*b* in the fuel conduit 18*a* of the heat source 18*c*. The temperature controlling device 16 is of any suitable conventional design such as to be capable to control the fuel injection in response to a temperature difference between a preset value of the outlet temperature and the actual outlet temperature detected by sensor 14.

The controllable openings 10 and 11 of the invention, therefore, provide a predictable means of a low temperature product delivery and an accurate control

of existing outlet air temperature. Such a control is of great importance in drying systems where moisture is evaporated from the particle surface or by diffusion from porous particles. The drying of the porous particles by diffusion requires a substantially longer time than that by surface evaporation. As previously stated, the exposure time in a drying channel using a high velocity air stream to maintain particle suspension is limited. Therefore, a maximum inlet air temperature below the limit of particle degradation is necessary for starting the evaporation process as soon as the entering particles come into contact with the hot air stream.

A modification of the temperature controlling device **16** is illustrated in greater detail in FIG. **5**. The controlling device **16** is preferably coupled with a recording chart **16***a*. A set pointer **16***c* is positioned to a desired outlet temperature and a signal from the outlet temperature sensing member **14** is recorded by pointer **15***b*. At the same time the device **16** transmits an operating signal to fuel flow control valve **18** in such a manner as to maintain the outlet temperature on the preset value. As seen in FIG. **1**, the air stream intake portion of the drying column **4** between the particle feed opening **5** and the furnace **2** is provided with an inlet temperature sensing member **17** which is also operatively connected through the temperature controlling device **16**.

As mentioned above, the heat source **2** is increased until the high velocity inlet air temperature as detected by the sensing member **17** and recorded by the pointer **16***b*, reaches a value slightly higher than the position of the temperature set pointer **16***c*. The temperature differential, resulting between the inlet and outlet sections of the drying channel **1** is due to radiation losses in the walls of the channel **1** and due to the cooling effect of the moisture evaporation process. In conventional hot air drying systems, the need for a high inlet temperature to start immediate evaporation, however, results in a high temperature of the delivered product. By contrast, with the admission of ambient cooler air through the controllable openings **10** and **11** onto the hot air and particle stream downstream of the drying column **4**, a greater temperature differential is created between the inlet and outlet air temperatures. As more volume of ambient air is admitted, the greater the differential will result, and since the outer temperature sensing member **14** affects the inlet air temperature, the air temperature at the outlet will remain constant to whatever desired temperature the set pointer **16***c* is positioned to. In this manner it will be the inlet air temperature that will increase or decrease by the admission of more or less ambient air through the openings **10** and **11**, thereby providing full control of high inlet temperatures without increasing the desired low outlet temperature.

Assume that the maximum inlet air temperature for reducing moisture content of a product being introduced into drying column **4** at inlet feed **5** is to be 600°F., and the outlet air temperature is desired at 300°F. so that delivered product temperature is 300°F. or less.

The tabulation below shows the advantages of the ambient air intake control and the large Δ T resulting as compared to no ambient air intake:

TABULATION 1

Amb. air intake, percent	Amb. air inlet in cu. ft./min.	Instrument index pointer setting	Outlet temp. in ° F.	Inlet temp. in ° F.	Temp. diff. (ΔT)
0	0	300	300	340	40
0	0	325	325	400	75
0	0	350	350	450	100
0	0	375	375	500	125
0	0	400	400	550	150
0	0	425	425	600	175

TABULATION 2

24.6	6624	300	300	395	95
26.1	7029	300	300	450	150
30.1	8096	300	300	480	180
32.8	8832	300	300	520	220
33.4	8980	300	300	600	30

Under Tabulation **1**, the maximum inlet temperature available with outlet temperature set at 300°F. is only 340°F. or a Δ T of only 40°F. In order to obtain the 600°F. inlet temperature required for moisture reduction of a specific product, a 425°F. outlet temperature setting would be required. This would also be the product temperature and creates the problems as heretofore described.

Under Tabulation **2** with the admission of ambient air, the outlet temperature remains constant and the inlet temperature rises as the volume of ambient air is increased, thereby obtaining a wide ΔT without increasing the outlet temperature. The product thereby is delivered at an acceptable temperature; namely, 300°F. versus 425°F. or 125° cooler.

In FIG. **2** there is shown schematically a preferred embodiment of the louvered ambient air intake opening **10** provided in the intermediate delivery duct **9** of the drying channel **1**. The adjustable blades of the louver **10***a* are coupled through linkage **22** with the shaft of a modutrol motor **20** which is energized by transformer **21** and controlled via an adjustable potentiometer **19**.

Another modification of the process temperature control means of this invention is illustrated in FIGS. **3** and **4**. Instead of a louvered opening **10**, there is provided preferably at the bottom of the duct **9** an opening **10'** for cooler ambient air drawn through conduit **23'** by the aid of a fan **23**. The amount of the cooler ambient air is controlled by damping valve **24** located within the conduit **23'** and coupled through linkage **26** with the shaft of motor **25**, the position of which is adjustable by a setting potentiometer in the same manner as shown in FIG. **2**.

Referring to FIG. **5** there is shown an embodiment with a pneumatical output of the temperature controlling device **16** which regulates through air supply conduits **15c** the fuel control valve **18**.

We wish it to be understood that we do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

Having thus described the invention, what we claim as new and desire to be secured by Letters Patent is as follows:

1. In a drying process hwerein particles are suspended and conveyed in a high velocity and high temperature gas stream and thereupon, after drying, are separated from the gas stream, the improvement of

controlling the temperature of the gas stream comprising,

introducing, by suction, after the drying and before the separation of the particles, a controlled amount of an ambient gas into said gas stream at opposite sides of said gas stream in staggered relationship both as to the vertical and horizontal directions of said gas stream, thereby restraining stratification of the entering gas.

2. In a process according to claim **1,** the step of adjusting the inlet temperature of said gas stream in response to specific temperature requirements of the particles.

3. In a process according to claim **2,** further comprising the step of adjusting the amount of said ambient gas fed into said stream, in response to a desired outlet temperature of said particles.

4. In an air drying system for particles suspended and conveyed in a high velocity and high temperature air stream passing through a channel, including a drying portion, an intermediate portion and an end portion thereafter,

process temperature control means comprising two adjustable ambient air inlet openings located on opposite sides in the intermediate portion of said drying channel and being staggered from each other in both the horizontal direction and the vertical direction,

means operable for introducing a controlled amount of ambient air through said inlet openings, thereby controlling the process and outlet temperatures of said particles.

5. In an air drying system according to claim **4** wherein each of said ambient air inlet openings includes adjustable louvers.

6. In an air drying system according to claim **4,** further comprising inlet temperature control means including an adjustable heat source disposed at the intake section of said drying channel portion, inlet temperature sensing means disposed in said drying channel portion and outlet temperature sensing means disposed in said end channel portion, heat source control member operatively associated with said inlet and outlet temperature sensing means and being operable for adjusting said heat source and thereby the inlet temperature of said air stream according to specific temperature requirements of processed particles.

7. In an air drying system for particles suspended and conveyed in a high velocity and high temperature air stream passing through a channel, including a drying portion, an intermediate portion and an end portion thereafter,

process temperature control means comprising at least one ambient air inlet opening located in the intermediate portion of said drying channel,

means operable for introducing a controlled amount of ambient air through said inlet opening thereby controlling the process and outlet temperatures of said particles, said process temperature control means further including a cool air blower, ambient air duct connected between said air blower and said ambient air inlet opening, and a controllable damping member disposed in said ambient air duct, and further comprising inlet temperature control means including an adjustable heat source disposed at the intake section of said drying channel portion, inlet temperature sensing means disposed in said drying channel portion and outlet temperature sensing means disposed in said end channel portion, heat source control member operatively associated with said inlet and outlet temperature sensing means and being operable for adjusting said heat source and thereby the inlet temperature of said air stream according to specific temperature requirements of processed particles.

* * * * *