Feb. 26, 1963 A. MARK 3,078,588

PNEUMATIC DRIERS

Filed Feb. 16, 1959 2 Sheets-Sheet 1

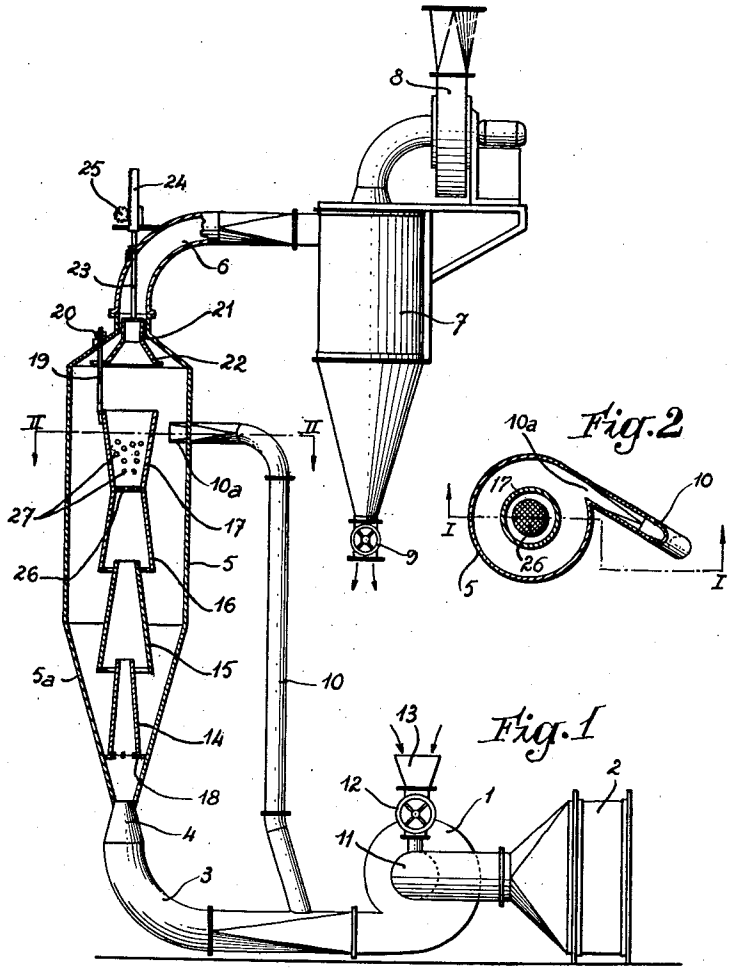


Fig. 1

Fig. 2

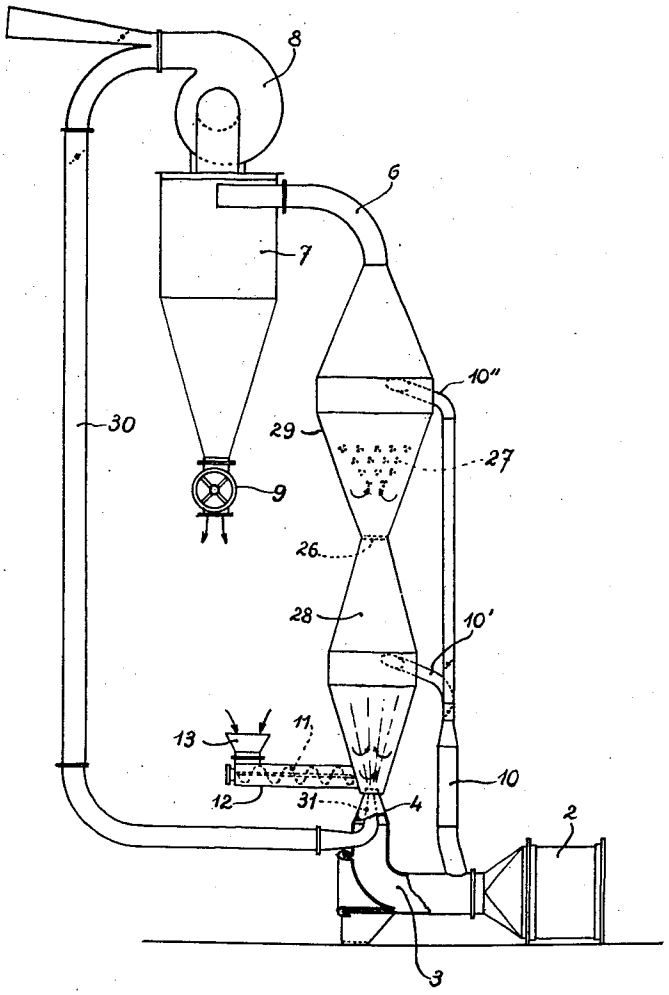
INVENTOR.
André Mark
BY

Feb. 26, 1963 A. MARK 3,078,588

PNEUMATIC DRIERS

Filed Feb. 16, 1959 2 Sheets-Sheet 2

Fig. 3



INVENTOR.
André Mark
BY
Alexander Wall
attorneys

United States Patent Office

3,078,588

Patented Feb. 26, 1963

3,078,588

PNEUMATIC DRIERS

André Mark, 24 Cours Lafayette, Lyon, France

Filed Feb. 16, 1959, Ser. No. 793,479
Claims priority, application France Feb. 20, 1958
7 Claims. (Cl. 34—57)

The present invention relates to pneumatic drying methods of the kind wherein a divided material to be dried is suspended in and conveyed by a drying gas stream through a conduit at the outlet of which it is separated within an appropriate separator from the drying gas which may be partly returned to the inlet of the said conduit after having been re-heated and/or mixed with hot gas. The disadvantage of these drying methods is the considerable length which is to be given to the drying conduit for obtaining a dry product at the outlet thereof. This may be obviated by re-cycling a portion of the material from the outlet of the conduit in such a manner that an average particle of the material may have effected a plurality of passages through the conduit before leaving the drier.

The re-cycling of the drying gas causes a marked increase of the gas flow through the drying conduit, whereby the latter should be given a relatively large diameter. The drying apparatus becomes cumbersome and the superficial heat losses are high. In the case of sticky substances which have a tendency to adhere onto the walls the drier has to be cleaned at frequent intervals, and this is quite a difficult operation in the case of the drying conduit.

It is also difficult to re-cycle preferentially the still wet particles at the end of the drying conduits and therefore the residual moisture content of the treated material extracted from the separator is far from uniform. Finally the known pneumatic driers operate as homo-current apparatus, viz. with the drying and the treated material flowing in the same direction, which is not a favourable condition for satisfactory thermic exchanges.

It is an object of the present invention to provide a drying method which will avoid the above disadvantages. In accordance with this invention the drying gas stream in which the divided material to be treated is suspended passes upwardly through a re-cycling chamber in such a manner as to cause the formation within the said chamber of re-cycling gas whirls comprising an ascending axial path and descending peripheral paths which carry with them some of the particles of material suspended in the gas which enters the chamber, while the gas which leaves the upper portion of the said re-cycling chamber preferentially carries along the dried particles towards a separator.

In accordance with another feature of this invention the gas whirls within the re-cycling chamber are further imparted an angular motion about the vertical axis of the chamber by a substantially tangential admission into the said chamber of an additional quantity of drying gas in such a manner that the gas which flows downwardly along the walls of the re-cycling chamber with particles of material in suspension therein is caused to follow a spiral path which increases the time of contact between the gas and the particles and gives rise to centrifugal forces which act on the still moist and heaviest particles to prevent the same from being carried axially by the gas which leaves the re-cycling chamber.

The re-cycling chamber may conveniently comprise an axial injector unit, preferably formed of a plurality of elements, and through which the drying gas stream is caused to pass. The upper element of this injector unit is preferably flaring upwardly in order to realize a progressive decrease of the velocity of the axially ascending gas stream whereby the heavy particles (in practice those

which still contain a substantial percentage of moisture) are prevented from being carried along upwardly by the gas which leaves the re-cycling chamber. The selection between the heavy and the light particles may be adjusted by varying the distance between the upper end of the injector unit and the outlet of the re-cycling chamber.

Calibrated balls may be disposed in the re-cycling chamber where they are maintained in suspension in the air flow without being carried along by the air which leaves the said chamber. These balls stop and break the particles of the treated material, they improve the transmission of heat between the hot air and the material and they further prevent the heaviest particles from being carried outwardly under the action of their kinetic energy.

The invention further concerns an apparatus for the carrying into practice of the above mentioned drying process.

In the annexed drawings:

FIG. 1 is a vertical section of a first embodiment of this invention, comprising a single re-cycling chamber with a multiple injector unit.

FIG. 2 is a cross-section thereof taken along line II—II of FIG. 1.

FIG. 3 is a vertical section of another embodiment comprising two re-cycling chambers disposed in series.

The pneumatic drier for divided material as illustrated in FIG. 1 comprises a main blower 1 which draws drying air from a hot air generator 2 and forces this air into a main conduit 3. This conduit 3 is connected through an upwardly directed axial nozzle 4 with the lower end of the conical lower portion 5*a* of a re-cycling chamber 5. The re-cycling chamber 5 is in turn connected by an exhaust conduit 6 with a conventional centrifugal separator 7. As illustrated, conduit 6 opens axially in the upper end of chamber 5 and it is of course tangent with respect to separator 7. The air outlet of separator 7 is connected with an exhaust blower 8, while the separated solid material is withdrawn by means of a conventional air-lock 9. A branch pipe 10 extends between the main air conduit 3 and a tangential air inlet 10*a* provided in the upper portion of the re-cycling chamber 5, as shown in FIG. 2. The air inlet of the main blower 1 supports an air-lock 12 on which is mounted a feed-hopper 13 adapted to receive the material to be treated.

The re-cycling chamber 5 comprises an inner axial multiple injector unit formed of a number of successive downwardly flaring frusto-conical elements 14, 15 and 16 with the smaller end of each element engaged into the lower end of the next one and connected with the latter by means of appropriate radial arms. The third element 16 is in one with an upwardly flaring upper element 17 and the unit thus formed rests on lower hooks 18 which support the larger end of the lower element 14, while the upper element 17 of the said unit is maintained by means of a lateral vertical rod 19 which is passed through the upper end of chamber 5 and is adjustably retained by nuts 20.

A sleeve 21 is slidably disposed within the inlet end of the exhaust conduit 6, the lower end of the said sleeve carrying a downwardly flaring member 22. This sleeve 21 is suspended by means of appropriate inner arms to a vertically slidable rod 23 which is passed through the curved wall of conduit 6 and which is itself attached to a vertical rack 24, the latter being in mesh with and adjusting pinion 25.

A grid 26 is disposed in the restricted passage situated between the injector elements 16 and 17, and the grid normally supports balls 27 (which have been illustrated in FIG. 1 as lifted by the ascending air stream).

The operation is as follows:

Neglecting the branch pipe 10 and supposing the inlet

airlock 12 is at standstill, it will be appreciated that the main blower 1 forces hot air from the hot air generator 2 through the main conduit 3, the re-cycling chamber 5, the exhaust conduit 6, the centrifugal separator 7 and the exhaust blower 8, the air flow being uniform along this path. It may therefore be said that conduits 3 and 6 form a single pneumatic conveyor line whereon chamber 5 is inserted.

The air jet which issues vertically from nozzle 4 passes axially through the injector elements 14, 15, 16 and 17 of the multiple injector unit. Under the action of this air jet, this injector unit draws air from the periphery of chamber 5 and the air flow at the outlet of element 17 is much greater than at the outlet of nozzle 4 or through conduit 3. Since the air flow through conduit 6 is equal to the flow through conduit 3, a substantial portion of the air issuing from element 17 is compelled to flow downwardly in the annular or peripheral space between the outer wall of chamber 5 and the axial multiple injector unit. In other words the air whirls within chamber 5 upwardly in the central portion and downwardly along the periphery thereof.

Owing to the relatively small cross-section of the branch pipe 10, the additional air flow which enters the re-cycling chamber 5 through the lateral opening 10*a* does not substantially modify the above-described operation. But this tangential air admission causes the air to rotate in the annular space of chamber 5 about the multiple injector unit 14–17 and therefore the air flows in a spiral path from the upper end of the upper element 17 towards the lower end of any one of the lower elements 14, 15 and 16, where it re-enters the injector unit under the sucking action of the latter. The said branch pipe 10 also supplies additional hot and dry air into the re-cycling chamber. Under the action of the ascending air flow, the balls 27 are lifted from their supporting grid 26. Since the velocity of the air stream decreases along the upwardly flaring element 17 owing to the increase of the cross-sectional area thereof, these balls remain at a given level above grid 26, where they form a kind of more or less vibrating screen.

If now the inlet air-lock 12 is started, the divided material fails into the inlet 11 of the main blower 1 and it is carried along by the air which flows from the hot air generator 2. It is thus conveyed in the form of a suspension from the said blower 1 into the injector unit. In the upper element 17 the particles of material meet the substantially stationary screen formed by the balls 27 which stop and break the large particles, and prevent in any case these particles from issuing at a too high speed from the upper element 17.

The particles of material are submitted to a selective action in the upper portion of the upper element 17. The heaviest particles, i.e. those with a very high moisture content, remain at the level where the balls 27 are suspended in the ascending air stream until they are partially dried. The partially dried particles reach the outlet of the upper element 17 at a very low speed and are carried along by the air stream which returns downwardly in the annular space between the injector unit and the wall of the re-cycling chamber. They follow a spiral path owing to the rotational movement of the air and they are re-cycled into the larger end of one of the lower elements 16, 15 or 14, it being noted that here again the re-cycling action is selective, the heaviest particles being maintained against the chamber wall by centrifugal action and being therefore preferentially recycled into the lowermost element 14. The lightest particles which rise axially with the air stream through the upper element 17 are for the most part directly carried along by the outgoing air through the exhaust conduit 6 and into the centirfugal separator 7 to be collected through the outlet air-lock 9.

It is to be noted that in actual practice the air which flows through the branch conduit 10 only contains a very small amount of material, since this conduit opens almost at 90° near the outlet of the main blower, i.e. in a zone in which the still moist and heavy particles pass at a relatively high speed and are not readily deviated laterally in front of the opening of the said conduit.

The invention finally realizes the following advantages:

(1) The drying air is re-cycled within the re-cycling chamber 5 wherein the volume of whirling air may be considerable without the main blower 1, the main conduit 3, the exhaust conduit 6 and the centrifugal separator 7 having to be designed for such a volume, as in the known constructions.

(2) The re-cycling of the material to be dried is selective and therefore the dried product is uniform as to its residual moisture content which may be quite low, the proportion of undried particles collected in the centrifugal separator 7 being practically negligible.

(3) The moist material is almost entirely located within the re-cycling chamber 5 which may be easily cleaned in the case of sticky substances. As to the main conduit 3, it may be as short as desired, in such a manner that a single opening may permit an easy access to its inner surface.

(4) The successive accelerations and decelerations imparted to the particles improve heat-exchange between the drying air and the material under treatment and enhance the drying effect.

The adjustment of the sleeve 21 by means of the adjusting pinion 25 acts on the selection of the particles at the outlet of the upper element 17. Owing to its particular mounting the injector unit 14, 15, 16 and 17 is free to vibrate to a certain degree under the action of the air stream, which prevents the particles from sticking on the walls of the successive elements.

It will be not that the material under treatment is always suspended in the drying air.

The number of elements of the multiple injector unit may vary. With divided materials in the form of lumps the main blower 1 may be used as a grinder, its outlet being vertically disposed directly below nozzle 4 in order that the bits of material of too large dimensions may return into the blower under the action of their weight. On the contrary in the case of substances which could be damaged by impact against the vanes of the blower, or which could damage the said vanes, the material to be dried may be introduced between the blower and the recycling chamber, either into the main conduit 3, or preferably into the lower end of the recycling chamber 5 immediately above nozzle 4, as for instance by means of an endless screw as indicated in broken lines in FIG. 1. It will be noted that with this latter disposition the material under treatment does no more pass through conduit 3 or branch pipe 10, which may be of advantage in the case of particularly sticky products.

The exhaust blower 8 may be suppressed or, conversely, it may be so provided as to ensure by itself the air flow through the apparatus, blower 1 then being dispensed with.

The embodiment of FIG. 3 is more particularly adapted for very sticky substances which require to reduce to a minimum the surfaces with which the material under treatment may come into contact. For this purpose the multiple injector unit of the embodiment of FIG. 1 has been suppressed, the re-cycling whirling movement of the drying air and of the particles suspended therein being only ensured by the action of the axial air jet which passes upwardly through the re-cycling chamber, and in order to obtain a sufficient total re-cycling in spite of the absence of any kind of injector, the apparatus has been provided with two re-cycling chambers 28 and 29 disposed in vertical succession. These chambers are of biconical shape. The balls 27 are disposed within the upper chamber 29 and their retaining grid 26 is situated at the restricted point of junction of chambers 28 and 29. The branch pipe 10 is divided into two portions 10′ and 10″

which open respectively into chambers 28 and 29, their outlet being somewhat directed upwardly, as shown. The exhaust blower 8 is powerful enough for ensuring the air flow through the apparatus, which dispenses with the main blower 1 of the embodiment of FIG. 1. The dryer of FIG. 3 further comprises an additional re-cycling air pipe 30 which connects the outlet of the exhaust blower 8 with an additional nozzle 31 disposed within the main nozzle 4 and co-axially with respect to the latter.

When the exhaust blower 8 is in operation, the drying air is drawn through the main nozzle 4 under the combined action of the negative pressure created by the blower and of the injector effect of the additional inner nozzle 31 which receives air under pressure.

The air jet which rises through both chambers causes the formation in each one of a whirling motion of the air contained therein, this air rising axially with the axial jet and returning downwardly along the wall of each chamber. The additional tangential air inlets 10' and 10'' determine general rotational movement of the whirling air about the vertical axis of the drier.

In each chamber the particles are submitted to the action of gravity (taking into account their vertical velocity at the point under consideration), to the action of the air flow and to centrifugal force. The lightest particles, i.e. those which are relatively dry, are carried along from the chamber by the outgoing air, while the other ones whirl within the chamber until they have lost their moisture content. The upper chamber 29 being larger in diameter, the selective effect due to centrifugal force is more marked and therefore the centrifugal separator 7 only receives dry or practically dry particles. The balls 27 whirl with the air within the upper chamber 29 but owing to their weight they are not liable to be carried along into the exhaust conduit 6 and they remain in the lower portion of the chamber. As in the preceding embodiment they stop and break the particles and prevent them from rising through the chamber at a too high velocity.

It will be appreciated that the embodiment of FIG. 3 could comprise a main blower as in the case of FIG. 1, also that the additional re-cycling air pipe 30, the main role of which is to supply air under pressure to the inner nozzle 31 in order to increase the velocity of the air jet through chambers 28 and 29, could be dispensed with, more particularly when such a main blower is provided between the main nozzle 4 and the heat generator 2.

I claim:

1. A pneumatic drier comprising means to form a stream of relatively hot and dry drying gas; means to introduce into said stream a divided material to be dried in the form of substantially discrete particles; a substantially vertical cylindrical chamber having a lower end and an upper end and a lateral wall; outlet means connected with the upper end of said chamber substantially axially thereto; a nozzle opening axially into the lower end of said chamber said nozzle receiving said stream with said divided material introduced thereinto to produce in said chamber an ascending jet of drying gas with said particles in suspension therein; a convergent-divergent injector unit of the Venturi type disposed substantially axially within said chamber and spaced from the lateral wall of said chamber to determine a substantially annular intermediate space between said injector unit and said lateral wall; said injector unit having a convergent lower element situated above said nozzle, but vertically spaced therefrom, and a divergent upper element situated below said outlet means to receive said gas jet, to cause same to draw gas from the peripheral zone of said chamber and thus to determine a downward recycling flow of gas and particles in said substantially annular intermediate space, and means to separate the dried particles from the gas issuing from said outlet means.

2. In a pneumatic drier as claimed in claim 1, an additional gas inlet tangentially disposed in the upper portion of said chamber; and means to supply to said additional inlet hot and dry drying gas substantially free from suspended particles to cause whirling motion of the downward recycling flow of gas and particles issuing from the divergent upper element of said convergent-divergent injector unit and to enhance drying of the particles in said downward flow.

3. In a pneumatic drier as claimed in claim 1, means to vary the distance between the divergent upper element of said convergent-divergent injector unit and said outlet means.

4. In a pneumatic drier as claimed in claim 1, said outlet means being in the form of a conduit having a substantially vertical inlet portion opening in the upper end of said chamber; a sleeve slidable in said inlet portion of said outlet means; and means to vary the vertical distance between the lower end of said sleeve and the divergent upper end element of said convergent-divergent injector unit.

5. In a drier as claimed in claim 1, means to loosely support said convergent-divergent injector unit within said re-cycling chamber to permit same to vibrate under the action of the drying gas.

6. In a drier as claimed in claim 1, said convergent-divergent injector unit comprising a plurality of successive nested convergent elements disposed above each other with intermediate annular gas passages, each element having a lower inlet end and an upper outlet end of smaller diameter than said inlet end and the diameter of the outlet end of said successive convergent elements increasing from the lowermost to the uppermost one; and an upper divergent element having a lower inlet end and an upper outlet end of larger diameter than said last-named inlet end, said divergent element having its inlet end directly connected with the outlet end of the uppermost of said convergent elements to form therewith a Venturi.

7. In a drier as claimed in claim 1, said upper divergent element of said convergent divergent injector unit having a lower inlet end and an upper outlet end of larger diameter than said inlet end, a grid at the lower end of said upper divergent element; and balls supported at rest by said grid to be floatingly lifted at a given level within said divergent element under the action of the ascending flow of drying gas through said element.

References Cited in the file of this patent

UNITED STATES PATENTS

1,550,992	Trump	Aug. 25, 1925
2,054,441	Peebles	Sept. 15, 1936
2,316,207	Winter	Apr. 13, 1943
2,363,281	Arnold	Nov. 21, 1944
2,435,927	Manning et al.	Feb. 10, 1948
2,492,349	Beck et al.	Dec. 27, 1949
2,538,833	De Rycke	Jan. 23, 1951
2,550,722	Rollman	May 1, 1951
2,581,134	Odell	Jan. 1, 1952
2,702,949	Parker	Mar. 1, 1955
2,874,410	Todd	Feb. 24, 1959