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2,071,015

METHOD OF AND APPARATUS FOR DRYING MATERIAL IN SHEET OR WEB FORM

Filed Dec. 12, 1934

2 Sheets-Sheet 1

Fig. 1.

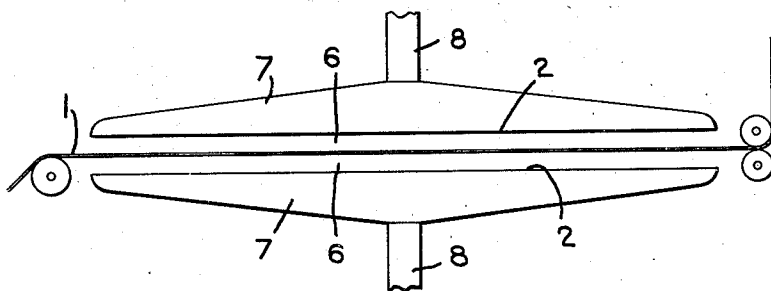


Fig. 2.

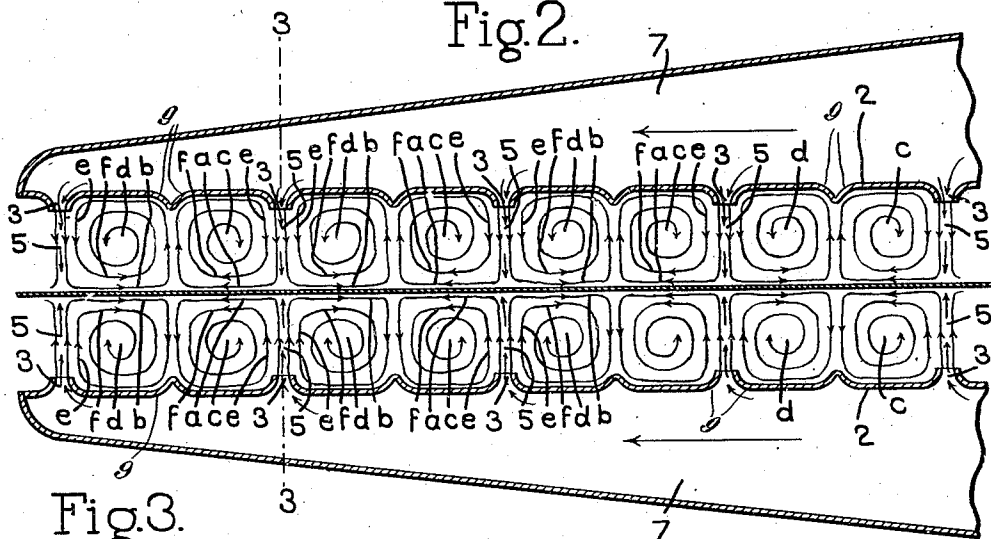


Fig. 3.

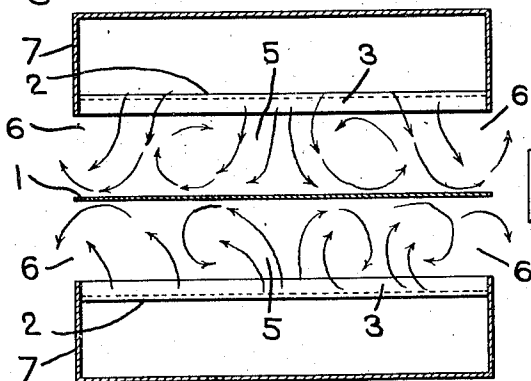
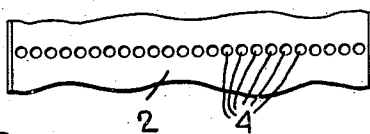


Fig. 4.



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2 Sheets-Sheet 2

Fig.5.

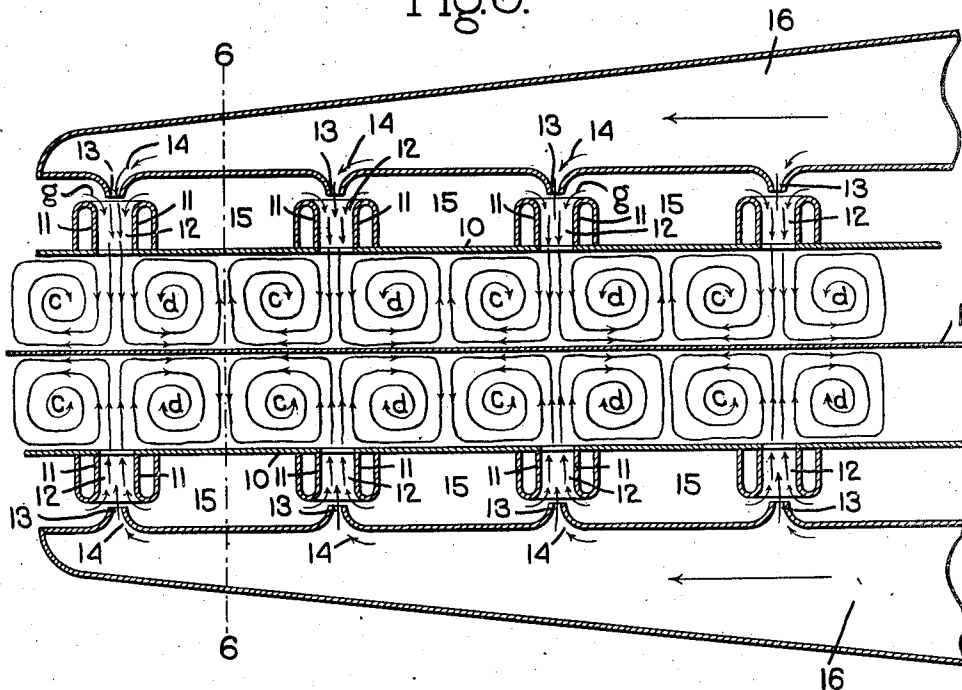
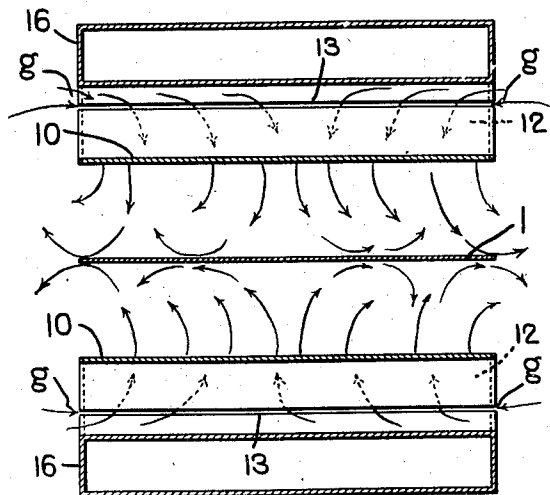


Fig.6.



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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR DRYING
MATERIAL IN SHEET OR WEB FORM

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6 Claims. (Cl. 34-48)

This invention relates to a method of and apparatus for treating material constructed with or disposed so as to have a substantially flat surface for the purpose of conditioning the material either by varying the moisture content or by varying the temperature thereof or otherwise changing the condition of said material, and the invention relates particularly to an improved method and apparatus by which the conditioning effect is produced by delivering jets or currents of gaseous conditioning medium against and over the surface of the material to be conditioned.

One of the objects of the invention is to provide an improved method by which an increased conditioning effect will be produced in the material by directing thereagainst a given volume of gaseous conditioning medium having given characteristics.

Another object of the invention is to provide an improved apparatus by which these results may be secured.

In practising my invention a plurality of streams, each preferably in the form of a sheet, of gaseous conditioning material are directed against the substantially flat surface of the material to be conditioned in a direction normal or at right angles to such surface through discharge openings in a wall extending substantially parallel to said surface. Under such conditions the streams of conditioning medium which flow through said discharge openings (which, for convenience, will be referred to as the "main" streams), and the resulting streams which flow along the surface of the material resolve the latter streams into cyclonic or whirling currents operating in the space bounded by the wall, the material being dried and the two adjacent main streams.

According to one way in which my invention may be practised the main streams are directed against the material in such a way that as each main stream engages the material it will be divided into two streams flowing in opposite directions along the surface of the material (which oppositely-flowing streams will, for convenience, be referred to as "branch" streams) and where the invention is practised in this way there will exist two oppositely-rotating cyclonic or whirling currents in each space bounded by the material, the wall, and two adjacent main streams.

The presence of these rotating cyclonic or whirling currents facilitates the conditioning operation partly by maintaining the conditioning characteristic of each main stream in its travel from

the discharge opening to the material, and also of each stream flowing along the surface of the material, by preventing loss of conditioning characteristics which would otherwise occur due to the dilution of said streams by surrounding air or other medium.

My invention is applicable for conditioning material by increasing or decreasing the moisture content thereof, or by increasing or decreasing the temperature thereof or by changing some other characteristic of the material. For illustrative purposes and for convenience in describing it, I have shown the invention as it might be used in conditioning sheet or web material by changing the moisture content thereof, but I wish to make it clear that the invention is not limited to the conditioning of web or sheet material but may be used for conditioning other material which is constructed or disposed with a relatively flat face and also may be used for conditioning material by varying the temperature or some other characteristic thereof.

Where the invention is used for conditioning material by drying it, the conditioning medium used will be a drying medium and the rotating cyclonic or whirling currents assist in maintaining the drying characteristic of each main stream during its flow from the orifice to the material, thereby preventing loss of such characteristics by dilution of the stream or surrounding medium; and such whirling or cyclonic currents also assist in maintaining the drying characteristic of the stream flowing along the surface of the material by preventing dilution of such stream with the surrounding medium.

In the drawings;

Fig. 1 is a general view of an apparatus embodying my invention and by which my improved method may be carried out.

Fig. 2 is an enlarged sectional view showing the improved method and the manner in which the device operates.

Fig. 3 is a section on the line 3-3 Fig. 2.

Fig. 4 is a fragmentary view showing an ejection opening for the main stream having a different construction from that shown in Fig. 3.

Fig. 5 is a fragmentary sectional view showing a device by which the method can be carried out, but which is somewhat different in construction from that shown in Fig. 2.

Fig. 6 is a section on the line 6-6 Fig. 5.

For convenience in describing the invention I will refer to its use for conditioning by drying material constructed or disposed to present a flat surface such, for instance, as sheet material or

web material, but the invention is by no means limited to drying material (which is conditioning it by decreasing its moisture content) and is equally adaptable for conditioning material by increasing its moisture content or changing some other characteristic thereof such, for instance, as its temperature.

In the drawings, 1 indicates the material which is to be dried and which is shown as sheet material in the form of an elongated web. This material may be cloth, paper or any other sheet material.

2 indicates a wall or plate which is situated adjacent the sheet material 1 and preferably substantially parallel thereto. This wall or plate is provided with a plurality of ejection or discharge openings, each of which may be in the form of a slot 3 as shown in Figs. 2 and 3, or in the form of a row of apertures 4 as shown in Fig. 4.

These ejection openings, whether in the form of the slots 3 or in the form of the rows of small apertures 4, are spaced from each other, and if the device is used for conditioning sheet material in web form these ejection openings will preferably extend transversely to the web and be suitably spaced from each other in the direction of the length of the web.

Means are provided for delivering a stream or current 5 of conditioning medium through each ejection opening in a direction normal or at right angles to the web or sheet 1, and if the conditioning operation being carried out is in the nature of decreasing the moisture content of the material, then the conditioning medium will be a drying medium and will preferably be forced through these ejection openings under a pressure and at a temperature which is suitable for drying the material of which the web is comprised. When these streams or currents 5 of drying medium are thus delivered through the ejection openings in a direction at right angles to the web, each stream will, upon striking the web, become divided into two streams which flow along the surface of the web in opposite directions as indicated by the arrows *a* and *b*.

As stated above I will, for convenience, refer to the streams 5 which flow through the ejection opening 3 or 4 as the "main" streams and will refer to the two parts *a* and *b* into which each main stream is divided and which flow in opposite directions as the "branch" streams. In practicing the invention as shown in Figs. 1 and 2, there will, therefore, be two streams of drying medium indicated at *a* and *b* flowing in opposite directions over the surface of the web 1 between any two adjacent main streams 5. The main streams 5 and the oppositely-flowing streams or currents *a* and *b* produce two oppositely-rotating cyclonic or whirling currents in the space bounded by the web 1, the plate 2 and the two adjacent main streams 5, such cyclonic or whirling currents being indicated at *c* and *d*. These whirling currents *c* and *d* tend to maintain the drying characteristic of the main streams 5 during their flow from the discharge openings 3 to the web 1 by preventing dilution of said streams with surrounding medium entrained thereby, and said whirling currents *c* and *d* also tend to maintain the drying characteristics of the branch streams *a* and *b* as they flow over the surface of the material being dried by preventing dilution of said branch streams with surrounding medium entrained thereby. As a result the web or material to be dried is being acted on by dry-

ing medium having substantially the same characteristics as it had when it left the discharge openings 3.

Upon referring to Fig. 2 it will be observed that the portions of the whirling or cyclonic currents *c* and *d* indicated by the arrows *e* form auxiliary currents traveling parallel to, in the same direction as and in contact with the sides of the streams 5. The presence of these auxiliary currents on each side of any main stream 5 indicated by the arrows *e* prevent the main stream from spreading and prevent it also from becoming diluted with entrained surrounding medium, these auxiliary currents *e* forming, as it were, confining walls between which the main current 5 flows to the web. This results in each main current 5 reaching the web with its drying characteristics such as temperature, velocity, etc., substantially unimpaired.

In the same way the portions of the whirling currents indicated by the arrows *f* which are traveling in the same direction and in contact with the branch streams *a*, *b* prevent dilution of said branch streams and thus assist in maintaining the drying characteristics of said branch streams.

These whirling currents, therefore, function to help maintain the velocity of the main streams 5 and the branch streams *a* and *b*, thereby increasing the drying effect of these streams, it being understood that the drying effect of a stream of drying medium flowing over the surface of material is proportionate to the surface velocity of said stream over the material. If the temperature of the drying medium is also an important factor in drying operations then the presence of these whirling currents assist in preventing loss of temperature in the main currents 5 and the branch currents *a* and *b* due to their becoming diluted with entrained surrounding medium.

I have found that excellent results are secured if the apparatus is so constructed that the space between adjacent discharge openings 3 is about twice that of the distance between the wall 2 and the web, these proportions being especially advantageous in the production of the whirling or cyclonic currents *c* and *d*. I wish to state, however, that these proportions may be varied considerably without in any way departing from or losing the advantages of the invention.

The space between the wall 2 and the sheet or web 1 is preferably open at the edges of the web as shown at 6 in Fig. 3 and the result is that the whirling, cyclonic currents *c*, *d* have not only the whirling motion indicated diagrammatically by the arrows in Fig. 2, but each current or stream 5 also has a progressive spiral outward movement from the center of the web toward each edge as indicated in Fig. 3.

If both sides of the sheet or web are to be dried, then I propose to employ a wall 2 having the ejection apertures 3 on each side of the web and to deliver through the apertures in both walls the currents of drying medium as shown in Fig. 2.

Various constructions may be adopted by which these streams 5 of drying or conditioning medium may be forced through the ejection apertures in a direction perpendicular to the web. In the construction shown in Figs. 1 and 2, the plate or wall 2 forms one wall of a duct 7 through which the drying medium may be forced under pressure at the desired temperature, and as shown in Fig. 1 this medium is delivered to the duct 7 centrally thereof through a supply pipe 8. The

wall 2 may be a flat wall or it may be deformed to present the curved sections 9 which have the advantage that they assist in the production of the cyclonic or whirling currents c and d.

In Fig. 5 I have shown a slightly different construction by which the invention may be practiced. In this device the plate in which the openings 3 are formed and which is indicated at 10, is provided on its inlet side with walls 11 forming passages 12 leading to the openings 3, and a nozzle 13 is provided for delivering drying medium under pressure into each passage 12. These nozzles and passages operate on the injector principle. The streams of drying medium 14 issuing from the nozzles 13 produce a suction at the inlet ends of the passages 12 by which gaseous medium from the spaces 15 is drawn into the passages and delivered through the openings 3 along with the medium delivered through the nozzles 13. The nozzles 13 may be supplied with drying medium under pressure and at the desired temperature in any improved way, and as shown said nozzles are formed on the bottom of a duct 16 into which drying medium under pressure is forced. The spaces 15 are open at the sides as shown in Fig. 6 so that room air will be drawn into said spaces as indicated by the arrows g, such air being forced through the openings 3 by the injector effect of the nozzles 13 along with the drying medium which is delivered from the duct 16.

The action of the currents of drying medium which are delivered through the openings 3 is, however, the same as that above-described, the stream issuing through each ejection opening 3 being directed against the web 1 in a direction perpendicular thereto, and upon impacting with the web becoming divided into two streams a and b which flow in opposite directions over the surface of the web. The two oppositely-flowing branch streams a and b between any two adjacent main streams meet and are resolved into the cyclonic or whirling currents c and d as above-described.

While I have described the invention above as it might be used in conditioning web material by drying it, yet I wish it understood that the invention is equally applicable for conditioning web material in other ways than by drying it, such as by increasing the moisture content thereof or varying the temperature thereof or subjecting it to some conditioning treatment through the medium of the conditioning currents. It will be understood, of course, that the character of the conditioning medium used will correspond to the conditioning effect which it is desired to produce.

I also wish to state that while the invention is shown as applied in conditioning material in web form, yet it is equally applicable for conditioning other material than sheet material or web material provided such material is constructed or disposed so as to present a substantially flat face against which the streams 5 of conditioning medium may be directed as above set forth.

I claim:

1. An apparatus for conditioning material which has a substantially flat face, said apparatus comprising a wall extending substantially parallel to said face and having openings spaced from each other, means to deliver a stream of gaseous conditioning medium under pressure through each opening toward said flat face, each opening having a shape to give the stream of gaseous conditioning medium issuing therefrom a sheet-like form and to direct said stream toward the

flat face at substantially right angles thereto, said openings being parallel and being spaced from the flat face a distance which is approximately one-half that between adjacent openings, whereby there is set up in each space bounded by said wall, the flat face of the material to be dried and any two adjacent sheet-like streams two oppositely-rotating whirling currents, each of which has a portion that contacts with and moves in the same direction as one of the sheet-like streams, said whirling currents serving to assist in maintaining the velocity of the said streams between the openings and the said flat face.

2. An apparatus for treating sheet material comprising means for supporting the sheet material to be dried, a wall extending substantially parallel to the sheet material and having spaced openings, there being an open space between the edges of said sheet material and the wall, and means to deliver a main stream of gaseous medium through each opening at high velocity and toward the sheet material, each opening having a shape to give the stream of gaseous medium issuing therefrom a sheet-like formation which flows toward the sheet material at substantially right angles thereto, the impact of each sheet-like stream against the sheet material dividing said stream into two oppositely-flowing branch streams, said openings being parallel and the spacing of the wall from the sheet material being less than that between adjacent openings, whereby the two oppositely-flowing branch streams between any two adjacent sheet-like streams meet each other and are developed into two oppositely-rotating whirling currents which rotate in the space bounded by said wall, the sheet material and two adjacent sheet-like streams, which whirling currents have portions contacting with and moving in the same direction as said main sheet-like streams and thereby assisting in maintaining the velocity thereof.

3. The method of conditioning material in web form which consists in directing a main sheet-like stream of gaseous conditioning medium against the web in a direction at right angles to the face thereof, said stream, by its impact against the web, being divided into two branch streams, each having a sheet-like formation, which branch streams flow over the face of the web away from each other, and converting the branch streams into two whirling cyclonic currents situated on opposite sides of the main stream and each having a portion which contacts with and moves in the same direction as said main sheet-like stream, whereby said cyclonic currents restrain said main sheet-like stream from expanding and thus assist in maintaining its velocity.

4. The method of conditioning material in web form which consists in directing a main sheet-like stream of gaseous conditioning medium against the web at right angles to the face thereof and at a relatively high velocity, said stream, by its impact against the web, being divided into two branch streams, each having a sheet-like formation, which branch streams flow over the face of the web in opposite directions away from the main stream, and converting the branch streams into two whirling cyclonic currents, one situated on each side of the main sheet-like stream, and each having a portion which contacts with the branch stream from which it originated throughout the length thereof and which moves in the same direction as said branch stream, whereby

said cyclonic currents restrain said branch streams from spreading and thus assist to maintain their velocity.

- 5 The method of conditioning material in web form which consists in directing a main sheet-like stream of gaseous medium against the web at right angles to the face thereof and at a relatively high velocity, said stream, by its impact with the web, being divided into two branch streams, each having a sheet-like formation, which branch streams flow over the face of the web in opposite directions away from the main stream, and converting each branch stream into a whirling cyclonic current having portions which
10 contact with and move in the same direction as both the main stream and the branch stream from
15

which said cyclonic current originated, whereby said cyclonic currents restrain both the main stream and branch streams from spreading and thus assist to maintain their velocities.

6. The method of conditioning material in web form which consists in directing a main sheet-like stream of gaseous conditioning material against the web at an angle to cause a part, at least, of said stream to be diverted by the impact of the stream against the web into a sheet-like stream flowing over the surface of the web, and converting said latter stream into a whirling cyclonic current having a portion in contact with and moving in the same direction as the main sheet-like stream.
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