Dec. 10, 1963 CARL-LUDWIG NOTTEBOHM ETAL 3,113,349

METHODS AND APPARATUS FOR THE PRODUCTION OF PERFORATED NON-WOVEN FIBER WEBS

Filed Nov. 29, 1960

3 Sheets-Sheet 1

Fig. 1

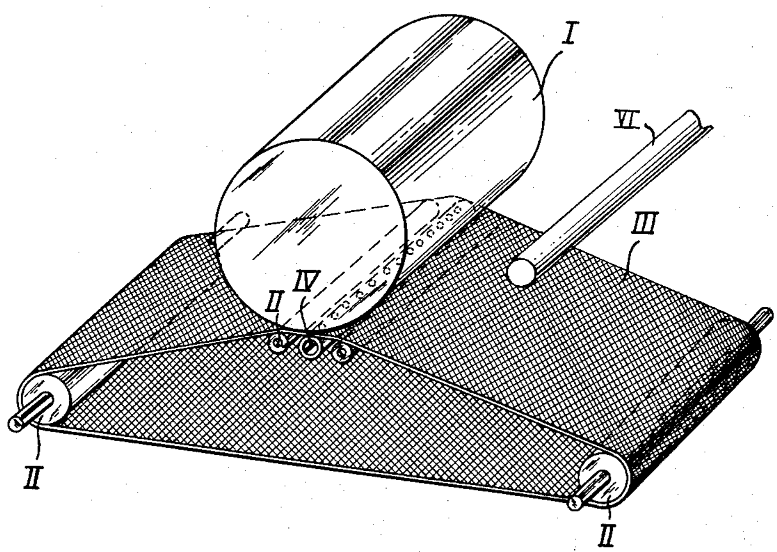
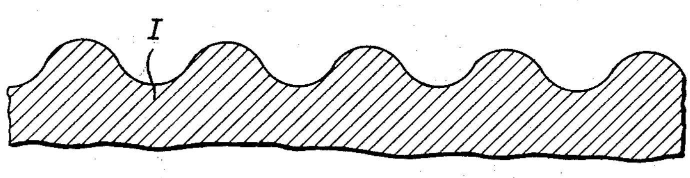


Fig. 2a



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3 Sheets-Sheet 2

FIG. 2b

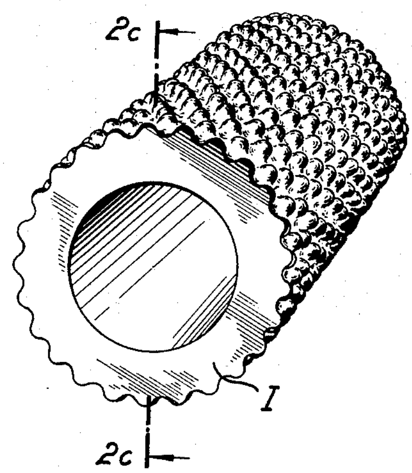
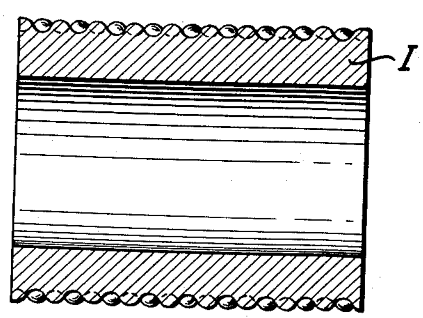


FIG. 2c



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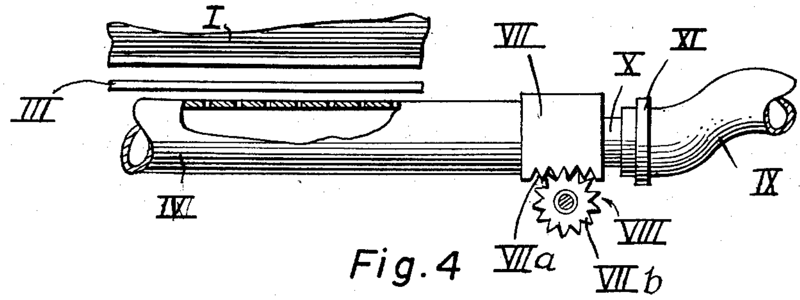


Fig. 4

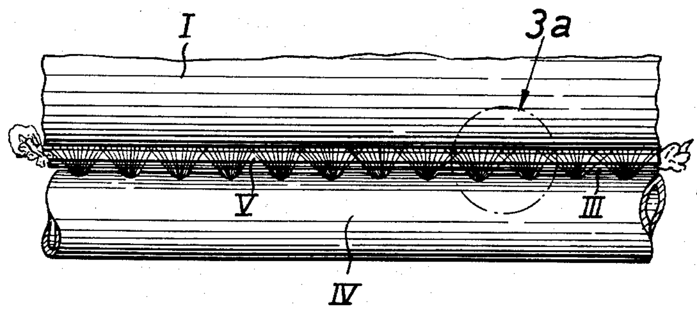
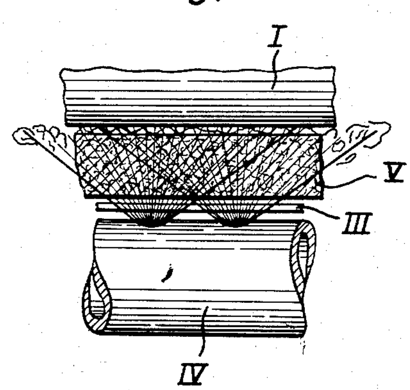


Fig. 3

Fig. 3a



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METHODS AND APPARATUS FOR THE PRODUCTION OF PERFORATED NON-WOVEN FIBER WEBS

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16 Claims. (Cl. 19—161)

This invention relates to new and useful improvements in the production of perforated non-woven fiber webs and is a continuation-in-part of our copending application Serial No. 36,686, filed June 16, 1960, now abandoned.

Sheets or webs of textile-like material, composed of cardable fibers bound together at their crossing points, are known and are, for example, described in United States Patents No. 2,719,795, No. 2,719,802, No. 2,719,-803 and 2,719,806. These non-woven textile webs are generally produced by treating a fleece of more or less randomly distributed fibers with a binding agent which is subsequently set, cementing the fibers together at their crossing points, forming a non-woven textile.

In order to produce a non-woven textile having a multiple number of apertures or perforations therethrough, as for example in a patterned configuration, it has been proposed to perforate the non-fiber woven web or fleece prior to treatment with the binding agent with fluid streams which are passed through the web while the same is supported on a perforated backing surface having apertures corresponding to the perforations to be formed in the web. The fluid streams pass through the apertures in the perforate backing, which acts as a flow guide or die for these fluid streams which displace the fibers of the web at the areas where the flow takes place through the perforations of the backing, thus correspondingly perforating the web at these areas with correspondingly shaped apertures. The web being perforated is preferably held between the perforate backing plate having the perforations corresponding to those to be formed in the web and a screen or mesh on being subjected to the fluid streams. While fluids in general have been suggested as being applicable to the above-described method, as a practical matter only liquids have proven suitable, and the use of gas streams for this purpose has not been successful. In practice, liquids, and in general water, have been used for this purpose, and the liquid stream flowing through the apertures in the perforated backing surface mechanically force the fibers aside and displace the same mechanically, as would the forcing through of a solid object with a comparable shape. A gas with pressures and velocities practical for this purpose is too low in density to accomplish this result. Even if it were practical or feasible to achieve the velocities and pressures required, the resulting turbulent flow and eddies which would be set up would prevent successful operation.

The use of liquids as the perforating fluid offers certain operational disadvantages. Thus, it is not always desirable or beneficial to wet the fiber web with the perforating liquid, and with the use of the liquid it is not possible to impregnate the web prior to the perforation, as the liquid would wash out the binder during the perforating operation.

One object of this invention is a novel method for the fluid perforation of non-woven fiber webs, which allows the use of a gas stream as the perforating fluid and overcomes the above mentioned disadvantages. This and still further objects will become apparent from the following description, read in conjunction with the drawings, in which:

FIG. 1 is a perspective view of an embodiment for

effecting gas perforation of non-woven fiber webs in accordance with the invention;

FIG. 2*a* is a diagrammatic cross-sectional view, showing a surface configuration of an embodiment the roller in FIG. 1 may have;

FIG. 2*b* is a perspective view, showing a further embodiment of a roller suitable for use in the apparatus of FIG. 1;

FIG. 2*c* is a vertical section of the roller shown in FIG. 2*b*;

FIG. 3 is a front elevation on an enlarged scale, showing further details of the gas supply device of the apparatus of FIG. 1;

FIG. 3*a* is a diagrammatic front elevation on a greater enlarged scale, showing the action of the gas stream on the non-woven fiber web passed through the apparatus of FIG. 1; and

FIG. 4 is a diagrammatic front elevation view depicting an embodiment of the apparatus of the invention wherein the gas supply tube is provided with means for oscillating it.

In accordance with the invention, a multiple number of spaced apertures are formed through a non-woven fiber web by passing a stream of gas of sufficient velocity to displace individual fibers of the web through a perforate surface and the web against an imperforate backing surface while maintaining the web between said perforate surface and said imperforate backing surface. Very surprisingly and unexpectedly, by using the imperforate backing surface in place of the perforate backing surface, as used in the prior art process described above, it becomes for the first time practical to use a gas as the perforating fluid in place of liquid.

With the use of gas, the execution of the process is greatly facilitated, and it is not necessary to wet the web, although, of course, the web may be wetted if desirable, and it becomes possible for the first time to effect a perforation of a non-woven fiber web after impregnation with a binder rather than prior to such impregnation, as was required in the prior art process. The web may thus be impregnated with the binder and perforated with the gas stream prior to a setting of the binder. The previous impregnation with the binder allows the web to achieve the necessary stability during the perforating operation, and the perforation of the impregnated web assures that the binder will not fill or clog the perforations, as could occur if the impregnation were effected after the perforation.

With the use of the gas perforation in accordance with the invention it is possible to wet the fiber batt with a liquid prior to the perforation and subject the same to the gas perforation while wet. Such a mode of operation may be preferable when the batt contains water-soluble fibers or fibers which soften in water, so that the drying of the perforated web will cause a stabilization without the addition of a binder.

The use of the gas stream as the perforating fluid, in accordance with the invention, allows a further novel embodiment to be effected in accordance with this invention. In accordance with this novel embodiment, the dry, non-woven fiber web to be perforated consists of or contains fibers of a thermoplastic material, and the gas stream used for the perforation is maintained at a temperature high enough to soften this thermoplastic material. The gas stream, as it effects the perforation, will thus soften the thermoplastic material, and as the same cools and the thermoplastic material hardens, the web will be stabilized or even bonded.

The non-woven fiber webs, which may be treated in accordance with the invention, may comprise any known or conventional webs of this type in which the fibrous elements are still free to move under the influence of the gas stream. The webs are preferably webs used in formation of non-woven textile fabrics, as for example described in United States Patents No. 2,719,795, No. 2,719,802, No. 2,719,803 and No. 2,719,806. The webs should have a weight between about 10 and 150 grams per square meter and are preferably formed from individual thin webs of fleece, formed of carded fibers, using for example conventional carding rolls, or by flocculation, using for instance conventional flocculation suction drums. These individual fleece webs are preferably superimposed, one on the other, in a laminate form and most preferably with the fibers of one web superimposed at an angle with respect to the principal direction of the fibers in an adjacent individual web, so as to obtain a multitude of cross-points between the fibers composing the aggregate web treated. This web is thus preferably composed of randomly directed, polyposed fibers. The individual webs are preferably of considerable length, being formed, for example, by the conventional continuous methods of production. The individual webs forming the aggregate web may each, for example, have a thickness between about 0.1 and 1.2 millimeters.

The individual fibers are preferably cardable fibers, including those of vegetable, animal or synthetic origin. Examples of vegetable fibers which may be used include cotton, ramie, denatured flax, hemp and jute. Examples of animal fibers which may be used include wool, goat's hair, camel hair or human hair. Examples of synthetic fibers include acetate, alginate fibers, polyacrylonitrile fibers, polyvinyl fibers, polyvinylidene fibers, superpolyamides, polyesters, and the like.

The loose fleece web may be subjected to the perforating gas stream as such, may be wetted with any desired liquid prior to this perforation, may be pre-stabilized by applying a binder material in a liquid carrier to at least one surface in order to provide a light surface cohesion without an appreciable reduction in the porosity of the fleece prior to the perforation or may be impregnated with the binder and subjected to the perforation prior to a setting of the binder. After the perforation, the web is treated in the usual manner, i.e., if the same has not been impregnated, by impregnation with the binder and the setting of the binder, or if the web has been pre-impregnated, by a setting of the binder. Any of the known or conventional binder materials may be used for the impregnation, either prior to or after the perforation, and/or for the pre-stabilization. These binder materials include natural and/or synthetic vulcanizable or pre-vulcanizable rubber latexes, which may for example contain, in addition to the binder material itself, suitable quantities of wetting agents, vulcanizing agents, vulcanization accelerators, foam-stabilizing agents, anti-oxidants, softening agents, fillers or the like, dispersions of synthetic rubbers, butadiene, acrylonitrile polymers, butadiene-styrene polymers, acrylic copolymers, thermosetting resins, as for example urea or melamine-formaldehyde condensates or pre-condensates, thermoplastic resins or the like.

As the action of the gas stream on the web is a mechanical action, any gas which will not have a delatorious action on the web may be used for this purpose. For economy reasons, air is generally preferred. In connection with treatment by a hot gas stream, combustion gases may prove suitable.

In certain instances it has been found, particularly when the fiber webs contain thermoplastic and/or water-soluble fibers, that the webs stick to the backing surface. In accordance with a preferred embodiment of the invention, it has been found that this may be avoided by using steam as the gas.

The particular velocity and pressure of the gas stream used is not critical and depends on the web being perforated and the desired effect. It is merely necessary to use a gas stream of sufficient velocity to displace the individual fibers of the web and thus achieve the degree of perforation desired. The suitable velocity may very easily be empirically determined in each individual case by initially starting with a low velocity stream and gradually increasing the velocity until the desired effect is achieved.

The imperforate backing surface may be any backing surface against which the web may rest during the gas perforation. The surface may be flat, curved or have any other desired shape, although for continuous operation it is often preferable to use the surface of an imperforate roller for this element. The imperforate surface need not be smooth or regular, but may be irregular, as for example provided with raised portions and/or impressions, as long as the same is imperforate.

The perforate surface, through which the gas stream is passed prior to passage through the web, may be any desired perforate surface, as for example a perforate or apertured plate, sieve or the like, but is preferably in the form of a mesh or screen. The perforations formed in the web will roughly correspond in shape and size to the perforations of this perforated surface. Thus, in general, the greater the size of the perforations in this surface, such as the width of the mesh of a screen used for this purpose, the greater the diameter of the apertures or holes produced by the gas stream. If the perforations or apertures of the perforate surface are square or rectangular, as for example in ordinary screen or wire mesh, the perforations formed in the web will have a corresponding shape with, however, generally rounded-off corners. With, for example, diamond-shaped perforations, correspondingly shaped perforations will be obtained in the web. The pattern of the perforate surface in thus, in effect, transferred to the non-woven fiber web. The size of the apertures in the perforated surface, such as the width of the mesh of the screen, should not substantially exceed the length of the fibers of which the web is composed, because otherwise the same will be blown through the perforated surface. It is, however, possible, in accordance with an embodiment of the invention, to use a perforated surface having perforations of a larger size than the fibers of the web by providing the imperforate backing surface with a multiple number of depressions, as described in further detail hereinafter.

The gas stream used for the perforation is preferably supplied through a tube closed at one end and connected at the other end to a source of compressed gas, such as compressed air. The tube is provided with a multiple number of apertures or jets, extending in alignment along its length and spaced apart at intervals of, for example, about 5 millimeters. The jets may have a bore, for example of about 0.5 millimeter in diameter. Preferably, the separate streams of gas issuing from the jets should overlap each other in, for example, the manner shown in FIGS. 3 and 3*a*, in order to form a uniform gas cushion which presses onto the web with the same intensity at all places. The tube is maintained adjacent the web with the jets directed toward the web, as for example at a distance of 0.5 to 5 millimeters. The air pressure supplied may, for example, amount to 3–10 atmospheres in most cases. If the web is passed along a level path, the compressed gas tube may be swept slowly over it. Generally, however, it is preferable in practice to pass the web past the tube. Especially favorable results are obtained if the tube is allowed to oscillate back and forth along its axis. It is also possible to use jets of different shapes, as for example slit-shaped jets, or to provide several rows of jets in a tube or to use several tubes.

For continuous operation, the apparatus as shown in FIG. 1 has proven particularly suitable. The imperforate backing surface is formed by the roller I provided with the smooth, imperforate surface. The perforate surface is formed by the endless belt III of wire or plastic mesh, for example, which runs over the rollers II. A gas tube, such as a compressed-air tube, provided with gas jets of the type described above, is positioned beneath the roller I and screen III and is designated IV. The screen III should pass at a distance of about 0.5 to 5 millimeters from the surface of the roller I. In operation, the roller I is rotated and the screen III moved at the same linear surface speed by rotation of the rollers II. The non-woven fiber web to be perforated is passed on the screen III, so that the same passes between the screen III and the roller I, being conveyed by the movement of the screen and rotation of the roller I. As the web passes between the roller I and the screen III, it is pressed against the imperforate surface by the perforate screen and is perforated by the gas stream flowing out from the jets of the tube IV, which are directed toward the surface of the roller I. Preferably, the tube IV is continuously oscillated back and forth along its axis, as for example with a stroke of about 1 to 2 centimeters. The action of the gas stream on the web is illustrated in further detail in FIGS. 3 and 3*a*. For the sake of illustration, the distances from the compressed-air tube IV to the screen III and from the web to the screen and to the roller are shown larger than they are in actual practice. The speed at which the web is passed between the imperforate backing surface and the perforate surface, i.e. the speed of travel of the screen III, is dependent upon the weight and thickness of the web and may, for example, vary between 1 and 15 meters per minute. Thus, for example, with a web weighing 15 grams per square meter, a speed of 5 meters per minute will generally prove suitable.

In place of the screen III, any other desired perforate surface may be used, as for example a perforate endless belt or the like. It is also possible to construct the roller I as the perforate surface by forming the same as a hollow roller or cylinder, provided with the required perforations therethrough, as for example a roller formed with a screen surface, and by positioning the air tube IV within this surface. With this latter arrangement, the screen III is formed as an imperforate surface, as for example, an imperforate endless belt of metal in perforate fabric, rubber, rubberized fabric, plastic, or the like.

As described above, the web can be treated with a binder prior to the passing of the web between the perforate and imperforate surfaces. Means for applying a binder are indicated in FIG. 1, wherein a binder can be sprayed onto the top surface of the web from the header VI. In such utilization of the apparatus, the web moves from right to left towards the imperforate roller I and prior to passage under the roller I, receives a light spray of binder from the header VI.

Apparatus according to the invention and including means for oscillating the gas supply pipe IV is indicated in FIG. 4. As here shown, the gas supply pipe IV is provided with a coupler VII which has a peripheral portion thereof formed with gear teeth VII*a* for cooperation with a pinion VII*b* to provide the rack and pinion VIII. Suitable means (not shown) are provided for rotating the pinion VII*b* in first one direction and then the other direction, to impart the desired reciprocating motion to the gas supply pipe IV. Also connected to the coupler VII is a nipple X, and this nipple is tightly connected to a flexible gas supply pipe IX by clamp XI.

The size and shape of the perforations formed in the web are dependent on the size and shape of the perforations in the perforate surface, as for example the screen III. If it is desirable to make as large as possible perforations in the web, and if the web is composed of short fibers, it has been found preferable to provide the imperforate backing surface with a multiple number of depressions or hollows, as for example providing the roller I with a surface configuration as shown in FIGS. 2a, 2b and 2*c*. As may be noted, the surface of the roller is provided with a hill-and-dale-like configuration. This configuration, for example, suitably has hollows of a depth of about 0.5 to 5 millimeters. With this configuration, the perforating gas stream will not blow the short fibers of the web out through the openings of the perforate surface, but will press the same into the hollows of the imperforate backing surface. With this surface configuration of the imperforate backing surface it is possible to produce large, round holes in the web. If the elevations and hollows of the imperforate backing surface are distributed completely and regularly thereover, then a corresponding pattern is obtained on the web. Care must be taken, however, that the height of the elevations on the imperforate backing surface is at least as great as the thickness in the wet condition of the fiber web which is to be perforated. The surface of the equipment which comes in contact with the web should preferably be as smooth as possible and may, for example, be suitably chrome-plated. After perforation, the web, as mentioned, is treated in the usual manner.

If a dry batt with an amount of thermoplastic fibers, as for example made from polyvinyl chloride or a mixed polymerizate, is used, the web perforated in the manner described above can be stabilized directly thereafter by pressure stabilization under the influence of heat, as for example on a calender, without damaging the perforation structure in any way.

In accordance with a preferred embodiment of the invention, if the web contains thermoplastic fibers, as for example of the type set forth above, the perforating gas stream may be a hot gas stream, as for example hot compressed air or combustion gases, having a temperature sufficient to soften the thermoplastic material. In this case, the web will be automatically stabilized after passing through the perforating gas stream and cooling. When operating in accordance with this preferred embodiment, it has been found preferable to use steam, having a temperature sufficient to soften the thermoplastic material, as the hot gas stream. Depending on the temperatures necessary, it may in certain instances be necessary to use superheated steam. The use of the steam as the hot gas stream prevents a tendency of the fiber webs to stick to the backing surface.

It is also possible to perforate a wet fiber web containing such thermoplastic fibers in this manner with a hot gas stream. The resulting perforated non-woven fabrics, formed in accordance with this embodiment, are more compact than those which are prepared from a dry web. In both cases, heating of the under-surface on which the web lies during the perforation is also preferred. In all other respects, the operation is identical to that described above, except, for example, the gas supplied through the tube IV is of a sufficiently high temperature for the softening of the thermoplastic material.

While the invention has been described in detail with reference to certain specific embodiments, various changes and modfications, which fall within the spirit of the invention and scope of the appended claims, will become apparent to the skilled artisan. The invention is, therefore, only intended to be limited by the appended claims or their equivalent, wherein we have endeavored to claim all inherent novelty.

We claim:

1. Method for producing a multiple number of spaced apertures in a non-woven fiber web, which comprises passing a stream of gas through a perforate surface having a multiple number of perforations therein and the web against an imperforate backing surface while maintaining the web between said perforate surface and said imperforate backing surface, the perforate surface pressing the web into contact with the imperforate surface, the velocity of said gas stream being sufficient to effect lateral displacement of fibers within the web and thereby provide said spaced apertures therein.

2. Method according to claim 1, in which said gas is air.

3. Method according to claim 1, in which said gas is steam.

4. Method according to claim 1, in which said non-woven fiber web is a non-woven fiber web of cardable fibers.

5. Method according to claim 1, in which said non-woven fiber web is impregnated with a bonding agent prior to said passage of said stream of gas therethrough.

6. Method according to claim 1, in which said non-woven fiber web contains fibers at least partially composed of a thermoplastic material and in which said stream of gas is a hot stream of gas having a temperature above the softening point of said thermoplastic material.

7. Method according to claim 6, in which said gas is steam.

8. Method according to claim 1, in which said imperforate backing surface is defined by a roller and in which said perforate surface is defined by an endless conveyor belt.

9. Method according to claim 8, in which said stream of gas is passed in the form of a multiple number of jets extending in longitudinal alignment coaxial with said roller opposite the portion of said endless conveyor belt adjacent said roller.

10. Method according to claim 9, which includes oscillating said jets back and forth in a longitudinal direction coaxial with the axis of said roller.

11. Method according to claim 9, in which said roller defines a multiple number of depressions over its surface.

12. Method according to claim 1, in which said imperforate backing surface defines a multiple number of depressions over its surface.

13. Apparatus for the perforation of non-woven fiber webs, comprising means defining an imperforate backing surface, a mesh screen defining a perforate surface adjacent said imperforate backing surface, means for substantially continuously passing a web of non-woven textile fibers against said imperforate backing surface between it and said perforate surface and then away from said perforate surface, and means for passing a stream of gas through said perforate surface against said imperforate backing surface to effect lateral displacement of the fibers within the web and thereby provide said perforation of the non-woven fiber web.

14. Apparatus according to claim 13, in which said means defining said imperforate backing surface comprises a roller, said means defining said perforate surface a perforate endless conveyor belt and said means for passing a stream of gas a tube defining a multiple number of substantially aligned gas jets therethrough positioned so that said gas jets are facing the portion of said perforate conveyor belt opposite said roller and directed toward the surface of said roller and means for passing gas into said tube for passage through said jets.

15. Apparatus according to claim 14, including means for oscillating said tube longitudinally back and forth.

16. Apparatus according to claim 14, in which said roller surface defines a multiple number of depressions thereover.

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