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APPARATUS FOR FORMING NONWOVEN WEBS

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2 Sheets-Sheet 1

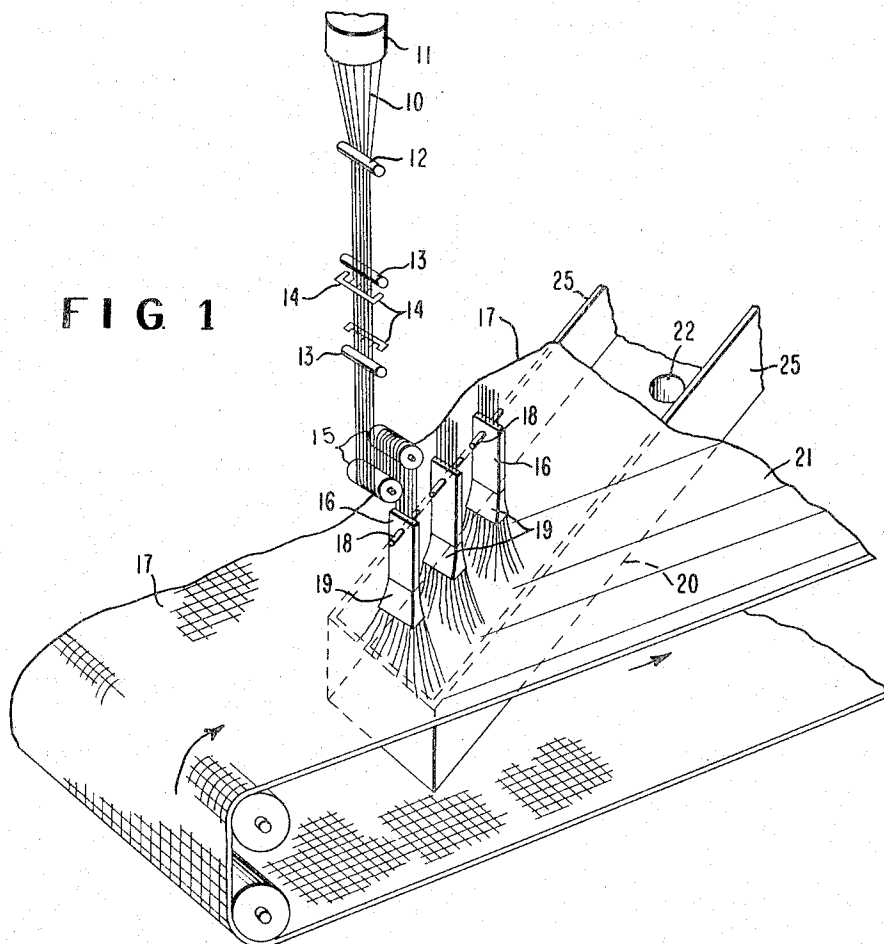


FIG. 5

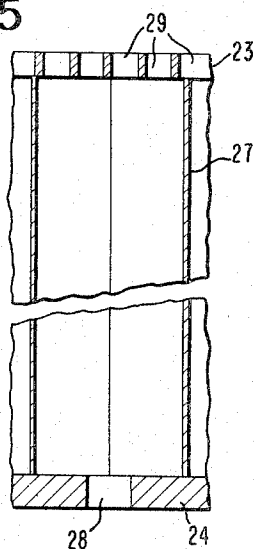
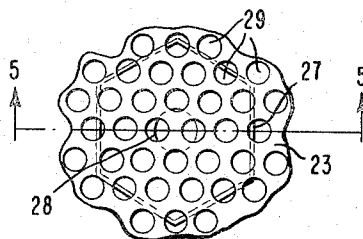


FIG. 4



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FIG. 2

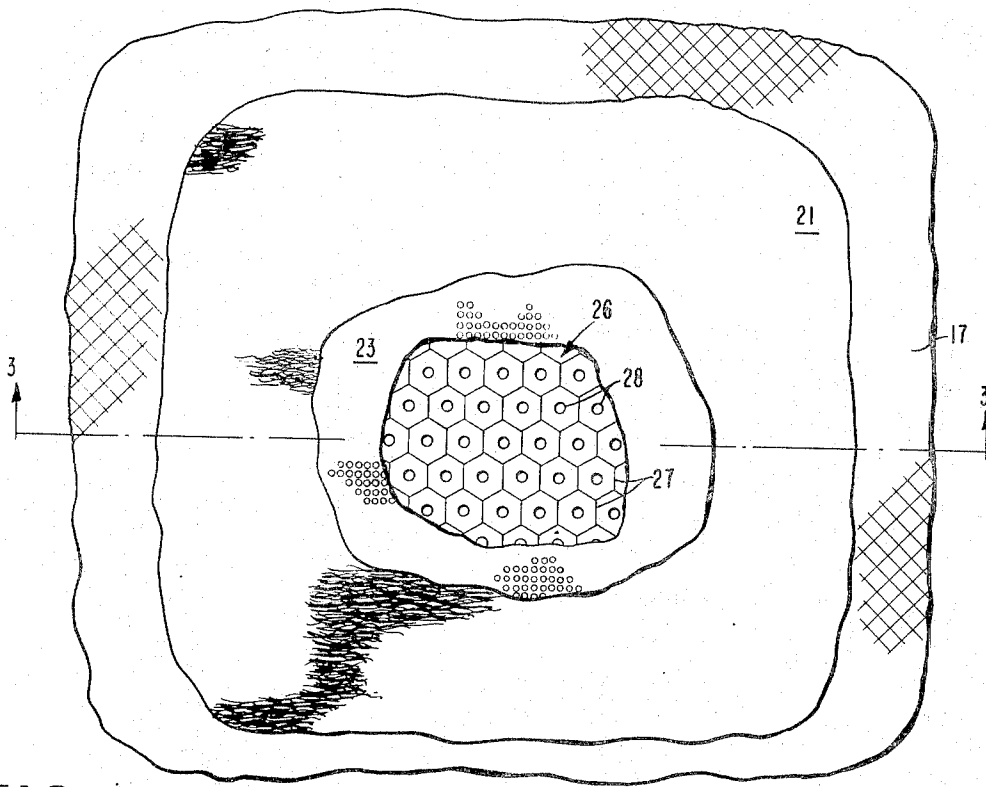
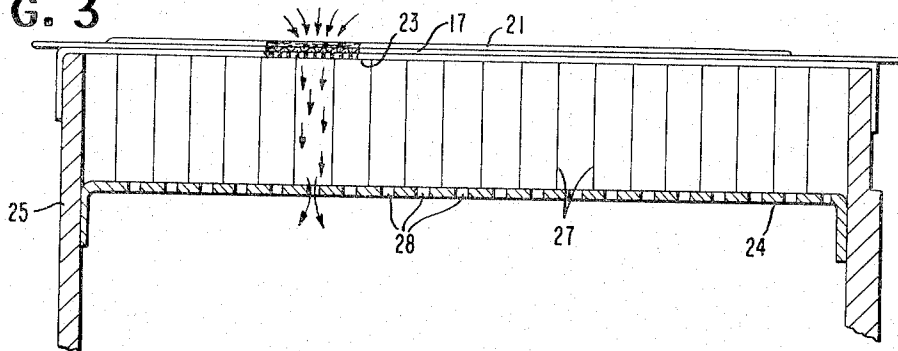


FIG. 3



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2 Claims. (Cl. 28—1)

This invention relates to an apparatus for the collection of fibrous materials as a nonwoven web, and in particular to apparatus which can be utilized for the production of variable widths of nonwoven webs from fibrous material being transported in a moving fluid medium, such as air.

In the adaptation of the recently developed process for the preparation of continuous-filament webs, described in British Patent 932,482, to economical commercial production of wide nonwoven webs, it is necessary, in order to obtain the desired productivity, to use a plurality of spinnerets or other filament-producing devices and collect the outputs from these spinnerets as a nonwoven web of the desired width. The spinnerets may be located across the width of the web to be produced, and positioned so that the plurality of filaments, after having been molecularly oriented by drawing and electrostatically charged, can be forwarded toward the laydown zone and deposited in overlapping ribbons to form the nonwoven web.

The electrostatic charge is applied to the filaments to cause them to separate when the tension on them is released and thus permit the collection of uniform, non-blotchy non-woven webs. Jet devices, which use a high-velocity stream of air flowing cocurrently with the filaments through the device, are preferred for forwarding the electrostatically charged filaments because the tension which the jet devices apply to the filaments is rapidly released as the filaments exit from the jet device and therefore the filaments are free to separate due to the applied electrostatic charge. When multiple jet devices are used, however, the air streams exiting from the jet devices and the electrostatic charge on the filaments cause interference between the filaments exiting from adjacent jet devices and prevents them from being combined uniformly into a non-directional web on the web-laydown receiver. It has been found that this interference between adjacent jet devices can be overcome by withdrawal of at least 5 times the amount of air supplied to the jet devices through the foraminous receiver into a suction or plenum chamber located below the web-laydown zone.

If it is desired to use only a part of the productive capacity and prepare narrower webs by the above-described method, the control of the pressure and amount of air flowing through the receiver at the web-laydown zone requires the use of dampers and baffles which are adjusted manually or automatically through sensing devices. Without such control, an adequate withdrawal of air to overcome the aerodynamic and electrostatic interference between adjacent jet devices and to firmly hold the web to the laydown receiver may not be obtained; and/or an excessive amount of air will flow through the receiver where no filaments are being deposited leading to turbulent conditions which cause overlapping, curling and non-uniformities in the web. The use of manually controlled dampers and baffles, however, is subject to operator error and automatic controls are expensive.

Another method of regulating the amount of air flowing through the receiver comprises placing a perforated plate next to the underside of the receiver which causes a substantial but relatively uniform pressure drop to occur as the air passes through regardless of the width of web laydown. However, this method would not be satis-

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factory since the air exiting from the jet device would encounter substantial land areas of the plate and bounce back, thereby interfering with proper laydown.

The apparatus of this invention provides substantially uniform, non-turbulent air-flow through the web-laydown receiver regardless of the width of nonwoven web being produced and without using moving parts which require manual or automatic control. The apparatus of the invention comprises a plenum chamber suitable for positioning below a moving, foraminous, web-laydown receiver, the chamber comprising a bottom, end walls, side walls, perforated cover plate, an orifice plate intermediate the cover plate and the bottom and in gas-tight arrangement with the end walls and side walls, the openings in the cover and orifice plates being uniformly distributed, and a multiplicity of independent fluid-diffusion cells located between the cover plate and the orifice plate, the cells being open at both ends, the lower end of each cell being in contact with the orifice plate and positioned over a single hole in the orifice plate and the upper end of each cell being in contact with the cover plate and under openings thereof.

The invention will be further understood by reference to the drawings in which

FIGURE 1 is an isometric view showing in part an apparatus for producing a wide nonwoven web and employing a conventional plenum chamber for withdrawing air through a web-laydown receiver;

FIGURE 2 is a plan view of a portion of the laydown belt and nonwoven web thereon with parts broken away to show the inner construction of one embodiment of the plenum chamber of the present invention;

FIGURE 3 is a transverse cross-sectional elevation of the plenum chamber of FIGURE 2 taken along line 3—3;

FIGURE 4 is a full-size plan view of one embodiment of the air-diffusion cells of this invention; and

FIGURE 5 is a transverse cross-sectional elevation of the air-diffusion cell of FIGURE 4 taken along lines 5—5.

The essential parts of an apparatus suitable for producing wide, continuous-filament nonwoven webs are shown in FIGURE 1. For clarity only one filament-spinning position including the means for electrostatically charging and drawing the filaments and only three filament-forwarding jet devices are shown. The additional positions and jet devices are identical to those shown and are provided in the number required to produce the desired width of nonwoven web by overlapping the adjacent ribbons of nonwoven web laid down on the moving receiver. In FIGURE 1, filaments 10 are extruded from spinneret 11 and combined into a bundle on snub bar 12. Snub bar 12 may be cylindrical as shown or may have a convex or concave surface to cause divergence or convergence of the filament bundle, respectively. Alternatively, a comb device may be used in place of the snub bar 12 to regulate the width of the filament bundle and maintain it in the desired alignment with the draw rolls and jet device downstream therefrom. The filaments are then electrostatically charged by means of corona-discharge devices comprising target bars 13 and charge heads 14. The filament bundle is passed into light contact with slowly rotating target bars 13 which are positioned adjacent charge heads 14 which have needle electrodes. A corona discharge is generated by applying a high electric potential to the electrodes and grounding the target bars.

The charged filaments pass over draw rolls 15 and then into stationary slot jet 16 which strip the filaments from the last draw roll and forward them toward the web-laydown receiver 17. The slot jets are provided with air through inlets 18. The jet devices are equipped with diffuser sections 19 to spread the filament bundles and provide elongated areas of deposition which are readily

blended by overlapping about 67% into a wide, uniform nonwoven web.

The filaments are collected on moving foraminous receiver 17 above the plenum chamber 20 as web 21. Air is withdrawn through the receiver into the plenum chamber and then through exhaust duct 22 which is attached to a suction-blower system not shown. The air withdrawn through the receiver serves to overcome the aerodynamic and electrostatic interference between laterally-adjacent jet devices. In order to utilize electrostatic attraction as well as aerodynamic forces to attract and hold the charged filaments to the receiver, the receiver may be a grounded metal screen or alternatively, if a fabric belt is used, the perforated cover plate of the plenum chamber is grounded and a grounded metal plate is positioned below the belt in the region downstream from the plenum chamber.

Referring to FIGURES 2 and 3, the plenum chamber comprises a perforated cover plate 23 and an orifice plate 24, both attached to the side walls 25 of plenum chamber 20. The perforated cover plate generally has an open area in the order of 50 to 65% with about 60% being preferred. It may provide rigid support for the porous receiver belt which is ordinarily flexible. The land area of the cover plate is kept small consistent with structural requirements and the individual openings are made large enough to avoid any plugging problems. The cover plate does not provide any substantial pressure drop. The orifice plate on the other hand is intended to provide resistance to fluid flow so that the aggregate pressure drop across the web and/or receiver in the laydown zone to the bottom of the plenum chamber is substantially uniform throughout the laydown zone. The orifice plate will therefore have a relatively small open area, generally between about 2 and 15% with about 7% preferred. Mounted between cover plate 23 and orifice plate 24 in this embodiment is a honeycombed section 26 comprising a multiplicity of hexagonal-shaped tubes 27 so positioned that essentially no waste volume occurs between tubes. These tubes form the air-diffusion cells of the apparatus of this invention. Each tube conducts air entering the cover plate open area directly above the tube to the orifice or open area in the orifice plate directly below the tube. Sufficient suction is applied beneath the orifice plate to remove air from each tube at substantially the same rate and at a rate at least equivalent to that at which air is directed at the laydown zone.

FIGURES 4 and 5 illustrate the location of orifice hole 28 in orifice plate 24 with respect to hexagonal tube 27. Alignment of holes 29 in cover plate 23 with hexagon tube 27 is unimportant since the open area in cover plate 23 is substantial. Alignment of hole 28 in orifice plate 24 with hexagon tube 27 is significant since the pressure drop across orifice plate 24 must be substantially the same for each section of the orifice plate in contact with a hexagon tube. Of course, if desired, hole 28 may in fact be replaced by two or more holes providing the pressure drop offered by hole 28. Although the preferred cross-section of tube 27 is a hexagon, it can be a triangle, a square, a polygon or even a circle, but triangles, squares and hexagons are preferred because these permit the closest packing. Instead of individual tubes, the diffusion cells can be in the form of a composite honeycomb structure or the like, in which the cells have common walls but each cell is independent.

In the production of nonwoven webs using the apparatus of FIGURE 1, as modified with the plenum chamber of FIGURES 2 to 5, it has been determined that 400 s.c.f.m. of air per square foot of 5.5 oz./yd.² unconsolidated nonwoven web of continuous polyester filaments is required to impress the web against the foraminous receiver. It has also been determined that for an apparatus designed to produce a maximum width of nonwoven web of 170 in., the minimum width of

material is 40 in., and that a bypass flow variation of 10% (e.g. 400 to 440 s.c.f.m. for a 5.5 oz./yd.² web) can be tolerated without causing turbulent air disturbance at the laydown position. Use of an orifice plate with 7% open area, a cover plate with about 60% open area, and the honeycomb structure has been found to properly regulate bypass flow characteristics. In operation of the apparatus to produce a 5.5 oz./yd.² web, flow through the web is maintained at 400 s.c.f.m. per square foot regardless of the width of web being produced but as the width of web is decreased, the bypass air, that is, that adjacent to both edges of the web, increases from 400 to 440 s.c.f.m. per square foot at the minimum width (40 in.). The honeycomb structure prevents bypass of air from outside the web width to the underside of the web as well as maintaining even distribution of the air among the orifices of the orifice plate. By permitting the location of the orifice plate at a distance, generally at least 4 orifice diameters, from the cover plate, turbulence that may be caused by air striking land areas of the orifice plate is avoided and uniform laydown is achieved.

While the apparatus of this invention has been described with particular reference to one embodiment of the web-laydown processes which utilize the principles of the basic process of British Patent 932,482, it is broadly useful in processes in which streams of fluid media transporting fibrous elements are not physically confined, as by a walled conduit or the like, in the region of 12 in. or more from the web-laydown zone. The advantage of processes of this type is that various widths of nonwoven webs can be produced merely by varying the number and positioning of the filament-producing and forwarding devices being used, thus the restriction on web width inherent in the use of a fixed conduit of any particular size is avoided. The apparatus of this invention simplifies these processes by providing an improved web-laydown system for collecting fibrous elements on a foraminous receiver, which system automatically and without any moving parts maintains the required substantially uniform pressure drops and fluid flows across the web-laydown zone.

What is claimed is:

1. In an apparatus for the preparation of nonwoven webs wherein a moving fluid medium transporting a plurality of filaments is directed toward the laydown zone above a moving foraminous receiver and the filaments are retained by the receiver while the fluid medium passes through, the improvement comprising a plenum chamber positioned beneath the receiver directly below the laydown zone, said plenum chamber comprising a bottom, end walls, side walls, a perforated cover plate, an orifice plate intermediate the cover plate and the bottom and in gas-tight arrangement with the end walls and side walls, the openings in the cover and orifice plates being uniformly distributed and a multiplicity of independent fluid-diffusion cells located between the cover plate and the orifice plate, the cells being open at both ends, the lower end of each cell being in contact with the orifice plate and positioned over a single hole in the orifice plate and the upper end of each cell being in contact with the cover plate and communicating with open area of said plate, the orifice plate offering substantial resistance to the flow of the fluid medium, and said plenum chamber having an outlet below the orifice plate for removal of the fluid medium from the chamber.

2. An apparatus for diffusing fluid in a plenum chamber comprising a perforated cover plate, a bottom, end walls and side walls, a cover plate constituting the surface through which the fluid enters, and an orifice plate intermediate the cover plate and the bottom and in gas-tight arrangement with the end walls and side walls, the openings in the cover and orifice plates being uniformly distributed, and a multiplicity of independent fluid-diffusion cells located between the cover plate and the orifice

plate, the cells being open at both ends, the lower end of each cell being in contact with the orifice plate and positioned over a single hole in the orifice plate and the upper end of each cell being in contact with the cover plate and communicating with open area of said plate, the orifice plate offering substantial resistance to the flow of the fluid medium, and said plenum chamber having an outlet below the orifice plate for removal of the fluid medium from the chamber.

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