

Feb. 26, 1963

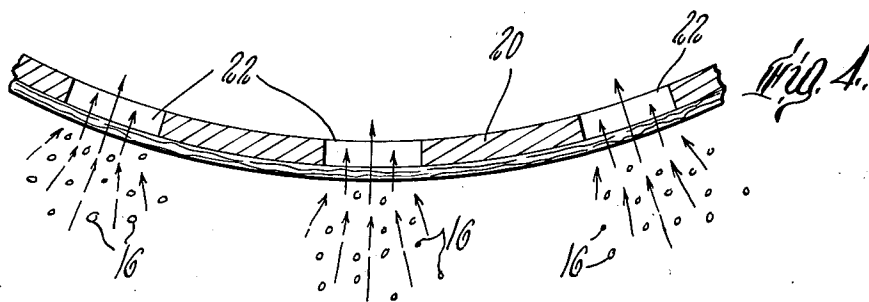
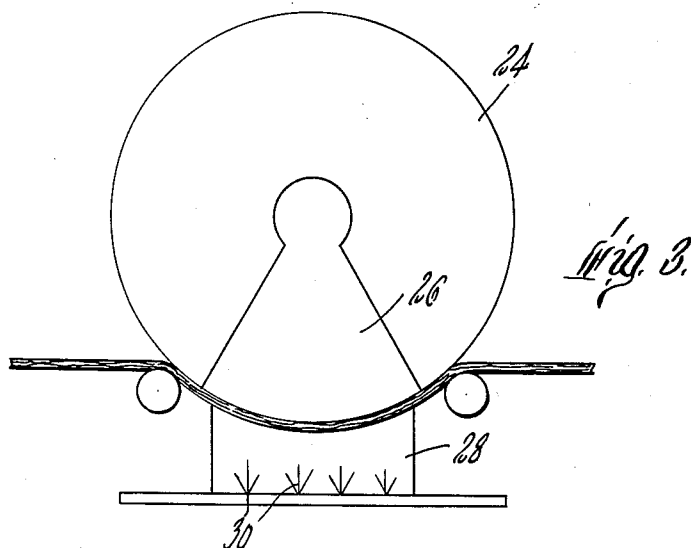
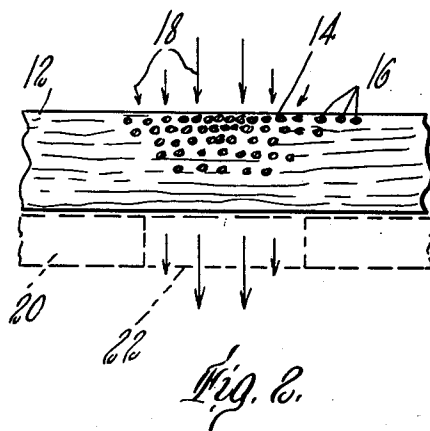
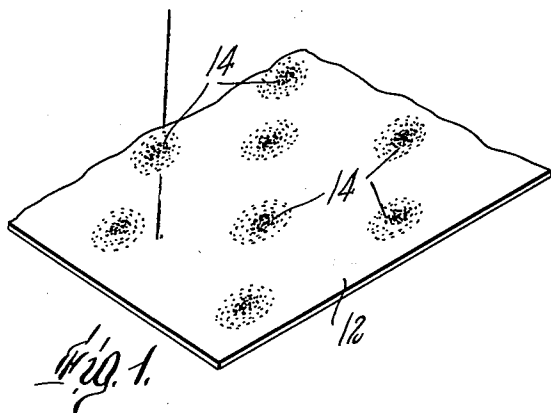
P. F. MARSHALL

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NON-WOVEN TEXTILE FABRIC

Filed Oct. 16, 1958

2 Sheets-Sheet 1



Feb. 26, 1963

P. F. MARSHALL

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NON-WOVEN TEXTILE FABRIC

Filed Oct. 16, 1958

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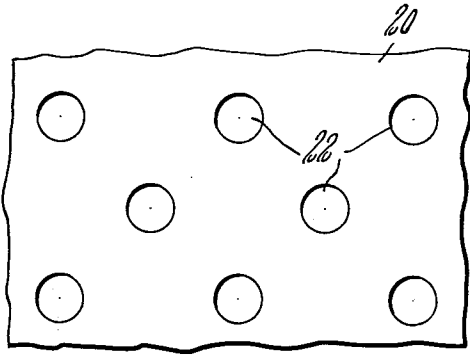


Fig. 5.

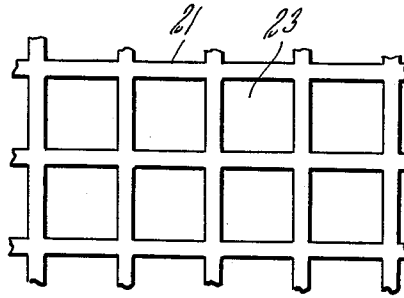


Fig. 6.

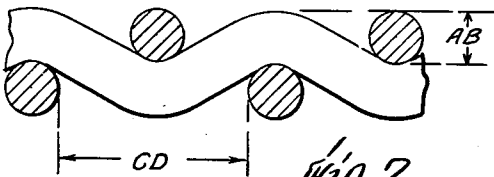


Fig. 7.

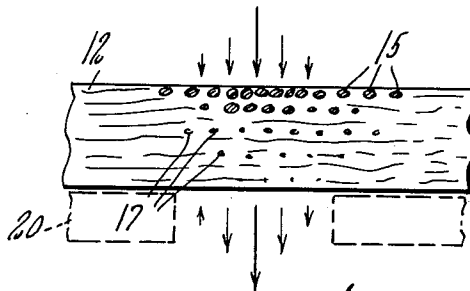


Fig. 8.

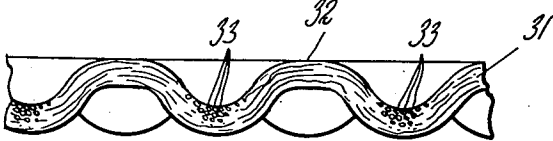


Fig. 9.

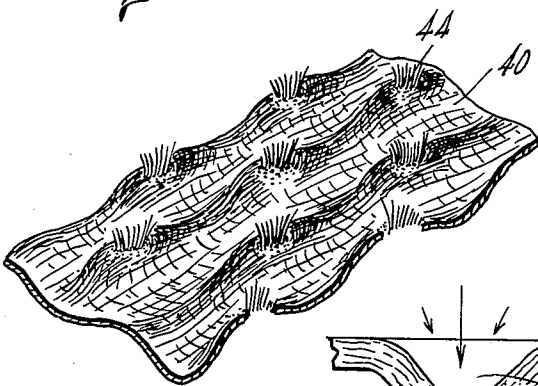


Fig. 10.

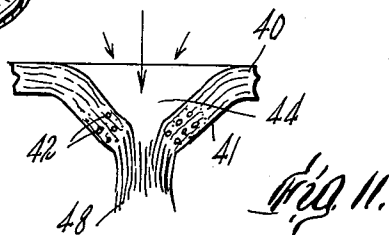


Fig. 11.

1

3,079,290

NON-WOVEN TEXTILE FABRIC

Preston F. Marshall, Walpole, Mass., assignor to The Kendall Company, Boston, Mass., a corporation of Massachusetts

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3 Claims. (Cl. 154-46)

This invention relates to non-woven textile products and their manufacture. More particularly, it concerns novel discontinuously-bonded non-woven textile fabrics, with or without patterned deformation, wherein the degree of bonding varies in a predictable and controlled manner through each of a plurality of discrete bonded zones. It also concerns novel methods of manufacturing such fabrics by utilizing a fluid passed through a non-woven web in discrete streams to bond together the fibers of the web in discrete zones defined by said streams, the streams carrying a bonding operator such as particulate or other media as binder or the like for immediate or subsequent bonding with simultaneous fiber rearrangement, if desired.

Non-woven fabrics, that is, fabrics comprising an array of textile fibers assembled without the use of conventional weaving, knitting or the like operations, have become well known in the textile art. Such products are conveniently manufactured by producing a web or array of textile fibers on equipment such as a card, air-lay machine, or the like, to produce a continuous fleece. However, the product so produced, if it is to have any strength, unless it be mainly of a feltable fiber such as wool, must be treated in some manner to bind the fibers thereof to one another.

It was early recognized in the art that the product resulting from overall bonding or impregnation, though suitable for many purposes, had inherent qualities of rigidity and stiffness which rendered it unsatisfactory where a soft, non-abrasive absorbent quality was required, and this was particularly true with lightweight, even diaphanous webs weighing up to about 50 grams per square yard. The desire to overcome this lack of softness and conformability led early to the concept of interrupted or discontinuous bonding. One such early attempt was the printing of lines, and later, spot bonding (utilizing discrete spots of various configurations) was used in an attempt to improve the softness of the bonded fabric, such bonding being accomplished by a printing technique, using engraved rolls and an adhesive emulsion.

However, there are numerous disadvantages in the use of a printing technique, both from the standpoint of method and the product produced thereby. In the first place, engraved printing rolls are expensive, as they must be made with great care to insure uniformity of design, and flexibility of operation is difficult to obtain. Moreover, printing rolls are capable of carrying only liquid printing media, such as solutions, emulsions, or hot melts. The binder, therefore, must be emulsified or melted or put into solution, which is expensive. Also, since the printing roll is the primary bonding mechanism, it must come in contact with the fibrous web. If an unbonded dry web is used, severe plucking and sticking problems arise. Therefore, it has been the practice either to bond the web overall prior to discontinuously bonding, thereafter removing the initial overall bonding, or to operate on wet webs. The first is expensive and wasteful; the second demands careful adjustment of the water carried by the web so that it will not unreasonably affect the pickup of the emulsion or binder solution to be superimposed thereon.

As for the product itself, the characteristic downy softness of the unbonded web was not preserved, not only because the bonding material was distributed entirely

2

through the web depthwise in order to bond together its fibers, but also because the usual sharp line of demarcation between the bonded and the unbonded areas of the web was itself to some extent responsible for a degree of harshness. This was because such bonding produced a multiplicity of surfaces on both sides of the web, usually comprising about 35 to 50% of its total area, which took the form of hard, boardy areas with abrupt edge terminations wherein the characteristic and highly desirable downy softness of the unbonded web was entirely destroyed. Thus, these areas, and particularly their edges, on both sides of the web, were rough and harsh to the touch, and such characteristic was especially apparent when the bonded web was utilized in a surgical or hygienic application where it became moistened and chafed the users' skin.

Accordingly, it is an object of the present invention to provide novel discontinuously-bonded non-woven products as well as novel methods of manufacture thereof not subject to the above recited disadvantages of heretofore known products and methods.

It is a more specific object of the invention to provide non-woven discontinuously-bonded fabrics wherein the degree of bonding in the bonded areas varies in density, especially in the plane of the fabric. For example, the invention can provide a fabric with circular bonded areas wherein the degree of bonding is concentrated in the center of the area and tapers uniformly in density outwardly to the periphery of the area. This avoids the abrupt discontinuity between bonded and non-bonded areas that is characteristic of prior art spot bonded fabrics as set forth above. By providing such a transition zone, a novel fabric is created that has a drape, conformability, and appealing softness hitherto not realized.

Furthermore, the degree of bonding may be varied in density throughout the thickness of the fabric, so that one side thereof may be essentially free of bonding to retain the unique softness of the unbonded web.

Also, the invention may provide a discontinuously-bonded non-woven fabric having patterned deformations, such as undulations, wherein the bonded zones may be created simultaneously with re-arrangement of the fibers to provide a series of said undulations, with or without apertures therein, the bonded zones preferably being located adjacent the tips on the concave side of the undulations to provide a novel bonded, non-woven fabric essentially free of bonded areas on both side surfaces thereof.

It is another specific object of the invention to provide novel methods for manufacturing discontinuously-bonded non-woven fabrics by utilizing a plurality of discrete streams of a fluid-borne bonding operator to establish a predetermined pattern of bonded zones as well as to control the distribution of degree of bonding within each of said zones and, if desired, simultaneously to rearrange the fibers within said zones to create a pattern of undulations or the like. The bonding operator preferably comprises dispersed particulate matter, but may be a fluid under special conditions hereinafter set forth.

The methods of the present invention are most easily accomplished by providing a mask closely adjacent to and preferably in contact with at least the downstream side of the web, such mask having a predetermined pattern of apertures which serve to rearrange and confine the fluid flow into a series of discrete streams which act for a sufficient length of time, taking into account the nature of the bonding operator, carrier fluid, etc. to create discrete bonded areas without overall bonding to an undesired degree. The bonding operator is thereby likewise discretely confined so that it simultaneously or subsequently serves to bond the web in spaced zones by depositing a binder, binder activator, or the like. It is the essence of the invention that the fluid streams

be discrete from one another, as established by the intimacy of contact between the surfaces of the web and mask, and that such surfaces be parallel to and closely spaced from one another except in a zone to be bonded by the creation of a fluid stream therethrough. Such intimate planar contact between the web and mask must be maintained over at least about 25 percent of the total area of the operating zone of the mask for practically small bonded areas. Thus, simply supporting the web on a conventional screen of woven filaments wherein there exists simply spaced points of tangential contact, will not function in accordance with the invention, since a plurality of discrete streams passing through the web cannot be produced thereby—rather, overall bonding results.

Further objects and features of the invention will become apparent from the following description of preferred embodiments thereof, together with the accompanying drawings, wherein:

FIG. 1 is an isometric view of the product of the invention;

FIG. 2 is a cross-sectional view of the product of FIG. 1 taken through one of the bonded areas thereof;

FIG. 3 is a diagrammatic view of apparatus useful for carrying out the methods of the invention to produce the product of FIGS. 1 and 2;

FIG. 4 is an enlarged view of a portion of the apparatus of FIG. 3 showing the operation of the method of the invention in greater detail;

FIG. 5 is an enlarged view of the mask portion of the apparatus of FIG. 3;

FIG. 6 is an enlarged view of a portion of a modified mask portion showing a decreased planar support area;

FIG. 7 is a cross-sectional view of a woven screen having less than the minimum planar support area;

FIG. 8 is a cross-sectional view of a modified product of the invention;

FIG. 9 is a cross-sectional view of another modified product of the invention;

FIG. 10 is an isometric view of still another modified product of the invention, and

FIG. 11 is a cross-sectional view of the product of FIG. 10.

Referring to the drawings, specific products and processes of the invention will now be described in more detail. First, as to starting material, the textile fibers employed are in general those capable of being carded, garnetted, or air-laid to produce a fleece whatever being the characteristics of the fiber arrangement, preferably weighing from about 5 grams to 100 grams per square yard. These preparatory devices and means for conveying such fleeces or assemblies of fleeces are so well known as to require no description. The fibrous array thus prepared is then brought into contact with a perforated masking surface, preferably a perforated support on the downstream side of the web, with which it must make intimate contact for discontinuous deposition of binder to be effected in accordance with the present invention.

Thus, as shown in FIGS. 1 and 2, a web 12 may be discontinuously bonded in discrete circular areas 14 by generally uniform binder particles 16 distributed by air or other fluid flow, as shown by arrows 18, in a saucer-shaped pattern in the web, the flow being controlled by a supporting mask 20 having a circular aperture 22 therein. The density of distribution of the particles is thus greatest centrally of the upstream side of the web and decreases both radially outwardly and throughout the thickness section of the web so that the novel variable density bonding of the present invention is provided in two directions and may even be mainly located essentially to one side of the web, the upstream side, is such be desirable.

Such product may be produced by apparatus such as is shown in FIGS. 3, 4 and 5 wherein the supporting mask 20 having circular apertures 22 is in the form of a cylinder 24, rotatably mounted and driven by any suitable means (not shown). A mask 21 having rectangular apertures 23, as is shown in FIG. 6, may also be used. The cylinder

24 is provided inside with a stationary suction zone 26, and a plenum chamber 28 is positioned outside of the cylinder opposite the suction zone. The web is led between the zone 26 and chamber 28 on the surface of mask 20. The supply chamber may be of different form for convenience in handling different types of binder or binder-activator, the principal requirement being that it deliver to the upstream surface of the web an appropriate uniform dispersion of binder or activator at a pressure higher than the pressure on the other or downstream face of the web, and that the supply chamber shall coact with the low pressure area underneath the web so as to distribute the binder or binder-activator in a variable density pattern through the web and, if desired, also coact to deform the web into an undulating or three-dimensional configuration.

In one embodiment, useful when a finely-divided solid bonding operator is dispersed in a stream of water, the supply chamber delivers a transversely extending curtain of binder-carrying water, supplied at suitable pressure, to the upper surface of the web, whence it is drawn down through the perforations in the advancing patterned belt by a suction box. By this means the binder is localized in patterns of varying density.

Alternatively, if the bonding operator is dispersed in air as an aerosol or dust, the supply chamber may serve as a plenum chamber, filled with air-borne dispersion of the desired bonding operator which is drawn through the web in localized areas governed by the pattern of the perforated support and the pressure differential across the two surfaces of the web. Air is then passed from chamber 28 through the web by reason of the action of the suction in zone 26, such air preferably carrying particulate matter 16, either solid or liquid, from nozzles 30, for deposition in the web. Such material may operate either to bond the web immediately, as is preferred, or thereafter, to create the product as above described. Usually air is employed as a fluid carrier for the particulate binding material, but other gases, or even liquids, may be employed for carrying solid or liquid particles, either as a dust or a dispersion, into the web. Even media such as heated fluid, for example, hot air, steam, solvent, catalytic, or other activating vapors and the like may be utilized as bonding operators to activate materials already incorporated in the web.

The particulate matter preferred in the practice of the invention may take many forms, depending upon the type of textile fibers making up the web, and upon the desired characteristics of the product. For instance, if the fibers of the web be of rayon, a dry thermoplastic binder such as particles of polystyrene, to be fused later, may be used, or a dispersion such as an acrylic solution in aerosol form may be used by spraying it into the plenum chamber. If desired, especially with dry binder, particle size may be varied, so that the depthwise distribution of particles in the web may be controlled to give a more uniform distribution of binder throughout the thickness of the web, as is shown in FIG. 8. In this case, the smaller particles 17 will penetrate more deeply into the web than will the larger particles 15, and such control will also enable two kinds of binder to be used, the one having larger particles being mainly on the surface of the web and the one having smaller particles being distributed throughout the thickness of the web. In this way, small particles of a hard resin with high bonding power may be combined with larger particles of softer and more elastic material, and by differential penetration, a bonded zone of graduated composition is effected. When two or more bonding agents are used, both binders may be activated in one operation if desired, or by proper choice of agents, one may be activated to serve as primary bonding agent to unify the fabric while the other agent remains unbonded until the fabric is subjected to some subsequent process such as lamination with some other material, etc.

Instead of being a primary binding material, the particulate matter or other media may be in the form of an acti-

vator or catalyst for binder materials, such as latent coalescent thermoplastic fibers, or it may even be in homogeneous form, as a vapor, such as steam or hot air, for thermoplastic fibrous webs, or acetone, or other solvent vapor for solvent sensitive fibrous webs. Similarly, a catalyst or resin component media in vapor, liquid, or solid form can be used, which medium can be applied to a web already containing the other components of a resin binder, so that only discrete areas are bonded. Again, an activating agent may be carried by solid particles as when heated solid particles are used to fuse thermoplastic fibers.

Furthermore, it is not essential that binding actually take place simultaneously with the application of the bonding operator, although such may occur either upon carrying a primary binder to the web in discrete streams or carrying an activator to a web already containing a binder. Later treatment, such as overall heating or vapor treatment, may conveniently be utilized to establish the actual binding in discrete zones established according to the invention by applying potential binding media in discrete streams to an unwoven web.

Instead of actually accomplishing the bonding, a partially or overall bonded web may also be treated as by a plasticizer to change the nature of an existing bond in a discrete area or by a solvent to render a discrete area free of bonding. Hence, the term "bonding operator" is employed in a broad sense herein to define an agent capable of any of the above recited effects, that is, it may operate to modify existing bonding or to render an area free of bonding or it may operate as an activator such as a catalyst, solvent, heating agent or resin component, or it may operate as a primary binder, all irrespective of whether the actual change in bonding takes place simultaneously with the application of the bonding operator carrying fluid or as a subsequent step in the process.

As has been explained above, it is the essence of the invention that the intimacy of contact between web and porous mask support on one side must be of such a nature that the flow of air or other carrier is confined to areas corresponding to holes in the porous mask support. What is done by proper manipulation of pressure differential is to convert the flow of the fluid carrier laden with bonding operator to a series of relatively high velocity discrete streams, as indicated in FIG. 4 as well as in FIGS. 2 and 8. For this purpose, a conventional screen woven of cylindrical filaments, as shown in FIG. 7, is inadequate. It has been found that at least about 25% of the total supporting area must be blocked off—i.e., impervious to air—in a planar manner for the change from overall diffused bonding to discontinuous discrete bonding to take place. Pervious screens, such as screen cloth woven from metal wire or plastic filaments, will not so operate. Such supports allow the bonding operator-laden air, flowing through the web under influence of the pressure drop, to seek a multiplicity of diverse and divergent paths, due to the crimp of the filaments so that the area of planar contact between web and support is not sufficient to establish the discrete-stream pattern essential to the process.

However, if such a screen be progressively flattened by pressure deformation, it begins to approach the planar figuration that is found to be operative according to the present invention. Again referring to FIG. 7, it has been found that when the distance AB, that is, filament thickness, approaches not more than 10% of the distance CD, that is, filament spacing, the transition from diffuse to discrete bonding becomes noticeable. Obviously, the lower the value of AB, the flatter the surface. Thus, as a practical matter, when operating at pressure differentials readily obtainable with conventional mill suction equipment, it is preferable to work with perforated flat surfaces where the ratio AB:CD becomes zero.

Assuming that proper contact between the operative elements is assured as set forth above, the transport path becomes a series of discrete streams so that substantially all of the bound zone is located in an area determined by

the shape and size of the perforations in the mask. Not only is the binding media thereby distributed in discrete zones, but the density of distribution of the binding within a zone varies in a surprisingly uniform manner, being characteristically high in the center and gradually tapering to the edges and the other side, like a plano-convex lens. This apparently results from the nature of the flow of a fluid carrying a bonding operator in a discrete stream wherein the maximum velocity of flow is found in the center of the stream, and the average velocity is anywhere from 0.5 to 0.83 times the maximum velocity, depending on whether the flow is laminar or turbulent. Whatever the nature of the flow, it is not unusual for the velocity in the center of such a stream to be three times as high as the velocity near the edge thereof. Such a variation in flow is apparently responsible for the desirable variation in the density of bonding throughout each individual zone, which allows the production of non-woven fabrics where the transition from bonded to non-bonded areas is so gradual as to be difficult to detect. Such a distribution, furthermore, allows the realization of very strong products which, nevertheless, retain many of the desirable attributes of unbonded webs.

In practicing the invention, the use of dry fibrous webs held against the perforated mask support with normal tension leads to a discontinuously bonded product as described above. However, it has further been found, in accordance with the invention, that the pressure differential utilized to create a series of discrete streams can also be utilized simultaneously to deform the web by rearranging its fibers into a three-dimensional configuration while simultaneously applying the bonding operator to the concave tip surfaces of the undulations, as is shown in FIG. 9, with or without actual bonding at the time of said application. To aid in such rearrangement, it is advantageous to facilitate deformation into three dimensions by wetting or otherwise lubricating the web.

As before, various types of bonding operator may be utilized, either binder or activator in liquid or solid particulate or other form, for the immediate or subsequent creation of variable density bonded zones. However, the rearrangement of the fibers of the web simultaneously with the application of a bonding operator to the rearranged fibers makes possible the creation of unique products having patterned deformation with variable density bonded zones at the undulations thereof. Thus, with the product of FIG. 9, undulations comprising rounded dimples 32 are created in the web 31, and the binder particles 33 are applied mainly to the inside concave surface of each of said dimples, the degree of penetration of the web by the binder particles being controlled as set forth above. Thus, if desired, the binder may be mainly confined to the inside of the dimples, leaving both the exposed sides of the undulating web essentially free of binder to preserve the downy softness of the unbonded web on both sides of the novel undulating product of the invention. It is also convenient in some cases to interrupt the deformation and bonding process by converting the suction box from a steady state to a pulsing condition, whereby the pressure differential across the web acquires an "off-and-on" frequency.

Also, the degree of fiber rearrangement may be controlled to produce undulating products of high bulk, nevertheless having essentially uniform web thickness, as in FIG. 9, or products having apertures, as in FIG. 10. Thus, by overfeeding the web at its initial contact with the perforated mask support, deformation can take place without any substantial attenuation of the web, whereas by reducing the amount of overfeed or increasing the degree of pressure differential caused by the resistance of the web to the flow of the carrier fluid, varying degrees of attenuation may be realized. Such attenuation, if carried to the point of rupture, will create an apertured product having openings with funnel-shaped walls, as shown in FIGS. 10 and 11, and allow the particulate bind-

ing media 42 to be carried through the lowermost point of the deformed area of the web 40 at the ruptured edge of the aperture 44, and be retained only on the funnel-shaped sloping walls 41 defining the deformed area and the edge of the aperture. At the same time, fibers 48 having free ends will extend out of the bonded area of said walls adjacent the smaller downstream end of the apertures to create a product having apertures with napped and bonded edges displaced from the plane of the web, with the web being substantially free of bonding between said bonded edges.

The inherent flexibility of the processes of the invention lies in the fact that the configuration or distribution of the bonding operator is not determined as in prior art by a transfer mechanism, but by a perforate patterned mechanism which controls the distribution and pattern of a fluid-borne stream thereof while simultaneously deforming the web, if so desired. Since this perforate pattern medium is effective and controlling only in the zone where the bonding operator acts, it may conveniently consist of a relatively short endless length of perforated film, thin rubber belt, or the like, as well as more durable supporting media such as porous metal belts. Furthermore, since the bonding operator is not physically transferred by a fluid flow through this mechanism, the distribution-controlling mechanism never becomes clogged or fouled-up by binder deposit, since in proper operation, it never comes in contact with binder or activating media, even during the manufacture of an apertured product.

Further in regard to the flexibility of the process of the invention, one may superimpose one perforated support on another and thereby get a variety of patterns, depending on the particular nature of the system of discrete streams of fluid-borne material that are generated thereby.

Various other modifications of the invention will be apparent to those skilled in the art.

As specific examples of the methods and products of the invention, the following will serve as illustrations without any intention that they limit the appended claims:

Example I.—A web of 3-denier rayon, weighing about 40 grams per square yarn, was moistened and brought into contact with a perforated mask such as that shown in FIG. 5, having holes $\frac{3}{16}$ inch in diameter and $\frac{1}{2}$ inch on centers. The rayon web was overfed to the mask at about 5%. The suction chamber adjacent the mask was operated at a vacuum of 2 inches of mercury, and while the web was in this position it was exposed to a cloud of particles of finely divided Vinylite VYNS resin from below. The resulting product, after being bonded by passing through an oven at 120° C., showed locally bonded areas, with the binder essentially concentrated in saucer-shaped areas and with the greatest binder density at the center of the holes and at the upstream side of the sheet opposite the mask, much as appears in FIGS. 1 and 2.

Example II.—15 grams per square yard card web made of 100% $1\frac{1}{2}$ denier viscose rayon was placed on a metal backing sheet. The backing sheet consisted of an apertured .032" thick brass plate with circular holes $\frac{1}{16}$ " in diameter faced $\frac{3}{4}$ of an inch on center. Air was drawn through the plate and web by imposing a vacuum on the uncovered side of the plate amounting to approximately .25" of water. A spray nozzle located approximately 20" from the upstream side of the plate emitted a fine spray of acrylic binder sold under the name of Krylon, manufactured by Krylon, Inc., Norristown, Pennsylvania. The direction of the spray was at 90° to the direction of air flow. This process was continued until the web had received a 25% increase in weight measured on a dry basis. The resulting product had the appearance of a lightly screened printed product.

Example III.—The experiment described in Example II was repeated, using a web that had been wet with water sufficiently to increase its dry weight by about 100%. The vacuum on the downwind side of the plate was increased to .50" of water. The resulting product was similar to the product of Example II except that deep impressions of a hemispherical nature were made at every place where a hole was present in the backing sheet. The area between the holes appeared under a microscope to be virtually free of binder.

I claim:

1. An unwoven textile fabric having a plurality of discrete funnel-shaped deformations defining openings therein, said deformations being bonded along their walls the bonding density in said funnel-shaped deformations decreasing outwardly from the center thereof.

2. An unwoven textile fabric as claimed in claim 1 wherein fibers having free ends extend out of the bonded area of said walls adjacent the smaller end of said deformations providing napped and bonded edge apertures displaced from the overall plane of the fabric.

3. An unwoven textile fabric as claimed in claim 2 wherein the fabric between said deformations is substantially free of bonding.

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