

June 14, 1966

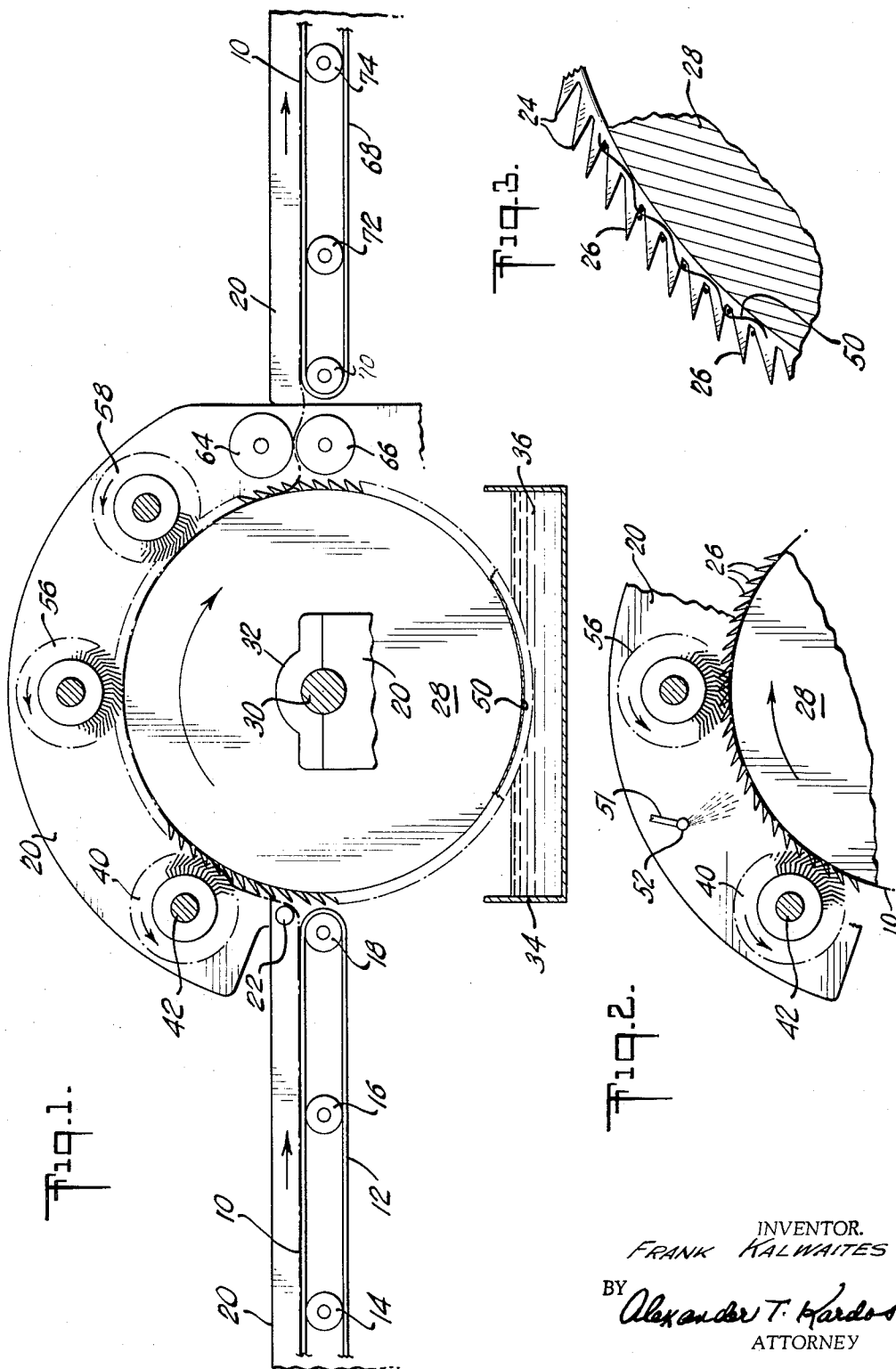
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METHODS OF PRODUCING PERFORATED NONWOVEN FABRIC

Filed Nov. 1, 1963

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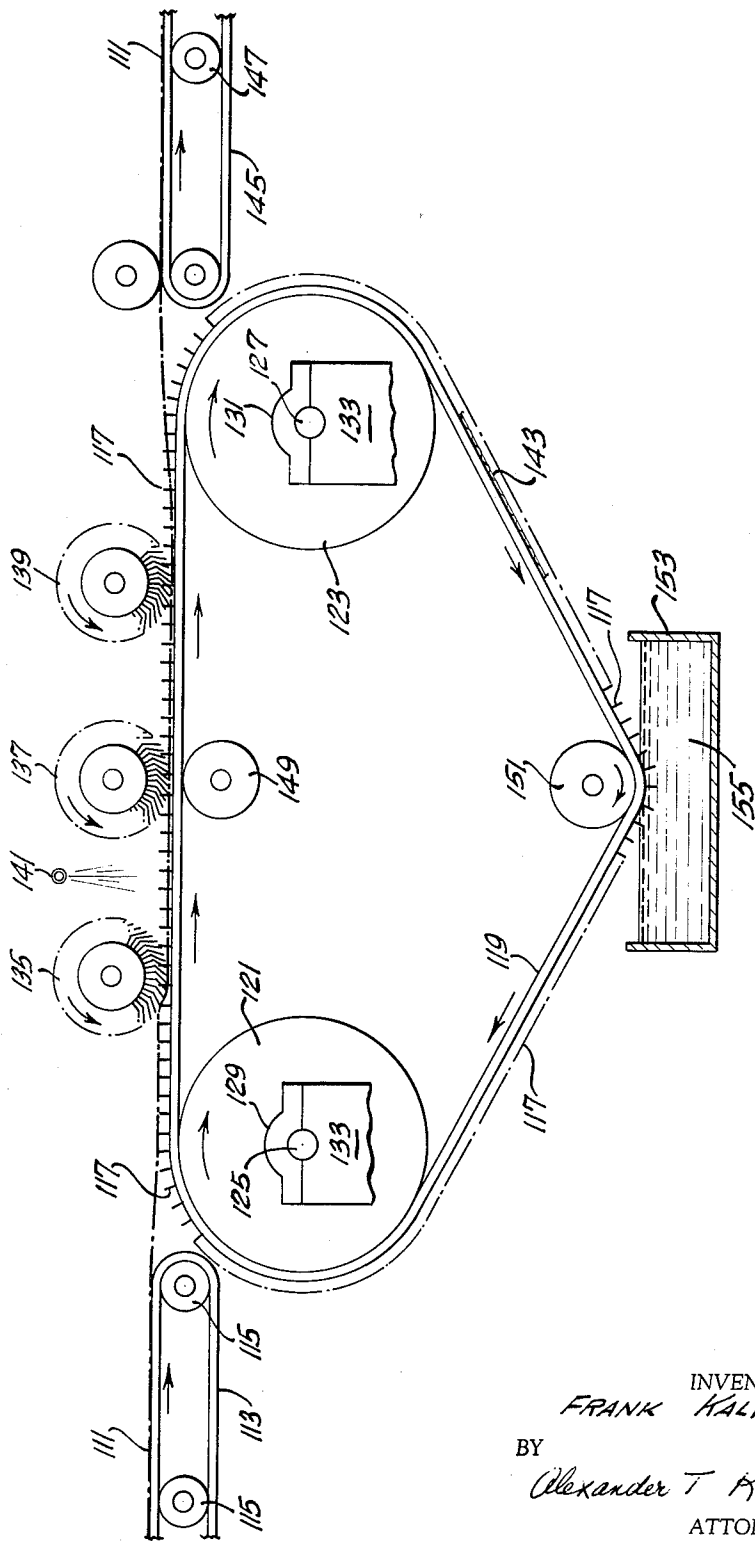
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Fig. 4.



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Fig. 5.

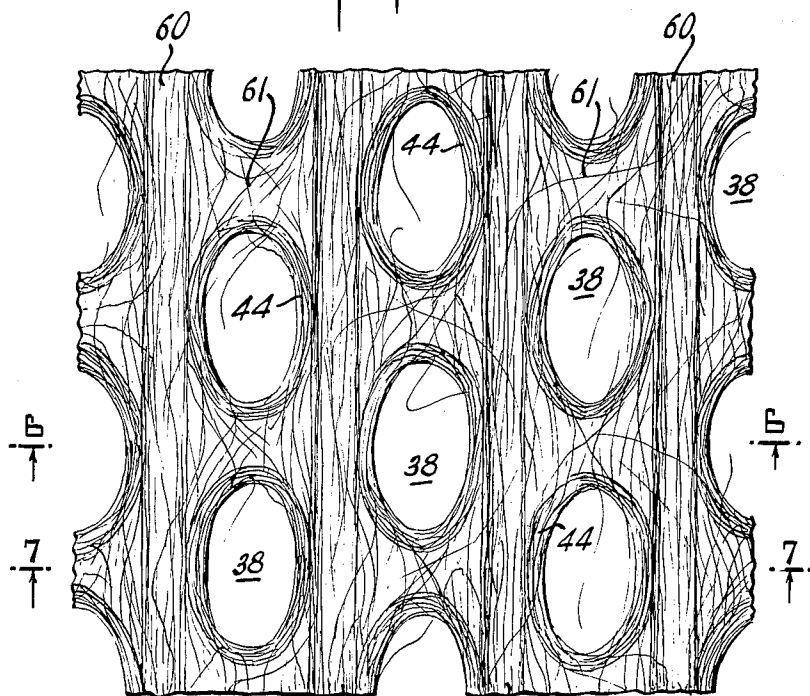


Fig. 6.

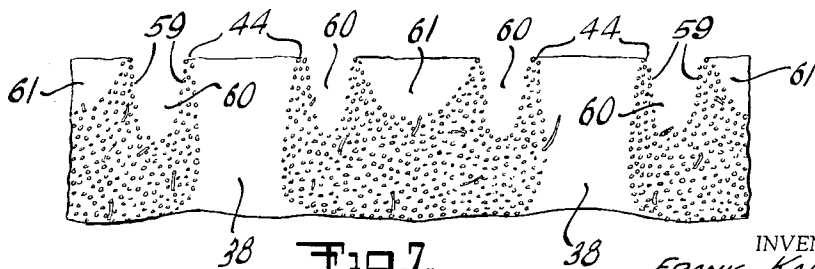
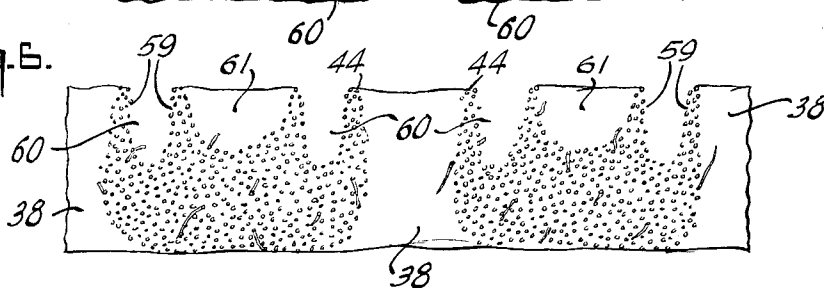


Fig. 7.

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METHODS OF PRODUCING PERFORATED
NONWOVEN FABRIC

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Filed Nov. 1, 1963, Ser. No. 320,688
7 Claims. (Cl. 19-161)

This invention relates to nonwoven fabrics and to methods and apparatus for producing such nonwoven fabrics, i.e., fabrics produced directly from fibers without the use of conventional spinning, weaving, knitting, or like fabricating operations.

Heretofore, nonwoven fabrics have been essentially different in structure from fabrics which have been woven or knitted. In a woven or knitted fabric, the natural or synthetic textile fibers making up the fabric do not occur individually, but are spun or twisted into yarns or threads which in turn are woven or knitted into the finished fabric. In the well-known spinning operation, staple-length fibers are spun or twisted together tightly into mechanical and frictional engagement with one another to form yarns which are substantially circular in cross-section. It is these yarns, and not the fibers acting individually, which serve as the structural members of the resulting woven or knitted fabrics. Generally speaking, these fabrics comprise reticular structures of intersecting, intertwining yarns which define interstices or openings between them.

Nonwoven fabrics have been primarily of two main types, felts and bonded webs. In each of these, the fibers making up the fabric occur individually and act individually as structural members. This is true even though the fibers in many felts are so highly interlocked and compressed together that it is difficult to identify individual fibers. Hat felts, for instance, are extremely dense, relatively "hard" fabrics without apparent interstices, which are quite dissimilar in appearance and qualities to woven or knitted structures.

On the other hand, the fibers in bonded webs are usually flatly arranged or organized in one or more layers, either more or less oriented or aligned in one predominant direction as in a card web, or assembled in a "random" manner as in the air-laid or water-laid isotropic web. Various agents have been used to print an intermittent binder pattern of spaced binder areas on such webs or to impregnate them completely over their entire surface to hold the individual fibers together. In these types of fabric, the fibers may remain relatively straight and overlapping one another with very little interlocking between them. They are usually arranged in a more or less uniformly spaced condition in the plane of the web, in such a way that only very small randomly-occurring interstices are apparent between the overlapped fibers and those fibers between interstices remain spaced and more or less flatly arranged, possessing little similarity to the yarns of woven or knitted fabrics.

The present invention contemplates a nonwoven fabric wherein the fibers are arranged preferably in a predetermined pattern to define holes or openings with most of the fiber segments bordering the holes extending in substantial alignment or parallelism with portions of the perimeters of the holes. In general, the fibers are arranged in interconnected groupings or web areas extending between the holes in a pattern corresponding to the pattern of holes. Closer study of the nonwoven fabric of the present invention reveals, among other characteristics, generally annular or elliptical, raised lips of accumulated individual fibers immediately surrounding the holes, along with a plurality of channels comprising sloping sidewalls extending substantially uninterruptedly longitudinally of the nonwoven fabric between the holes and

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their raised lips. The resulting fabric may be made to resemble a particular woven or knitted fabric.

The groupings or groups are connected by fibers extending from one to another in such a way that they are common to a plurality of groupings. It is preferred that the average length of the fibers be considerably greater than the lengths of the groups containing them with the result that the groups predominantly comprise only parts or segments of the fibers passing through them. Preferably, the fibers average at least about $\frac{1}{4}$ inch in length or over and are textile-like in nature, extending up to about $2\frac{1}{2}$ inches or even more in length. In general, the groupings are connected at junctures wherein the fibers extend in a plurality of diverse directions, while the fiber segments in the groups are relatively aligned or parallelized with respect to one another and more closely assembled than at the junctures.

In the foraminous structure formed by the interconnected fiber groupings, the fibers are in a state of mechanical equilibrium. The fibers are mechanically and frictionally engaged to the extent that the arrangement of fibers is one of equilibrium.

Due to their structure and appearance and other qualities, fabrics produced by the method and apparatus of this invention are particularly adapted for use in surgical dressings, absorbent dressings such as sanitary napkins and diapers, most suitably for covering sanitary napkins and diapers, in wiping cloths, toweling, filter materials, lining materials, industrial base fabrics, as a substitute for gauze and gauze-like fabrics in general, and a variety of other applications.

The present invention contemplates nonwoven fabrics and methods and apparatus for producing such nonwoven fabrics preferably having a predetermined pattern of holes or openings therein from a starting layer of irregularly arranged, dry fibers by first impaling the dry fibrous layer upon a group of prongs, pins or needles, preferably arranged in a predetermined pattern, then wetting the fibrous layer while impaled on the prongs, brushing the wet fibers into fiber accumulating zones and channels between the prongs, and finally removing the brushed layer of wet fibers from the group of prongs.

The starting fibrous layer may be a nonwoven web of fibers, for example, natural, synthetic or man-made fibers, preferably cellulosic fibers, such as rayon or cotton. The individual fibrous elements of the layer are capable of movement under the influence of an applied mechanical force. In general, any of the starting materials described in the following patents may be used as the starting materials in the methods and apparatus of this invention: Griswold U.S. Patent No. 3,081,514, dated March 19, 1963; Griswold and Pearce U.S. Patent No. 3,081,515, dated March 19, 1963; and Kaiwaites U.S. Patent No. 2,862,251, dated Dec. 2, 1958. The preferred starting material is an unbonded fibrous web.

The preferred method of this invention involves the application of external forces to a continuously moving layer of irregularly arranged dry fibers impaled upon a group of prongs by wetting the fibers while they are so impaled, and then by brushing the fibers of successive portions of the moving layer longitudinally, thereby moving individual fiber segments into positions within fiber accumulating zones and channels in the interconnected spaces between the prongs, where they lie in a state of mechanical equilibrium.

In a preferred embodiment of the apparatus of this invention, the prongs are carried on a rotatable cylinder against which a moving layer of irregularly arranged, dry fibers is positioned. The layer of dry fibers is first passed into contacting engagement with the pointed ends of the prongs. An embedding brush rotating in a direction normal to the peripheral surface of the cylinder, progres-

sively presses successive portions of the advancing layer of dry fibers downwardly about the prongs.

It has been determined that such pressing of dry fibers downwardly about the prongs is far more easily accomplished in the case of dry fibers than with wet fibers. Additionally, it has been observed that there is substantially less breakage of fibers when dry fibers are pressed downwardly about the prongs than in the case of wet fibers.

The prongs upon which the starting fibrous layer is impaled before the brushing action is carried out may have rounded, flat or pointed ends. They are preferably formed with a cylindrical or tapered body and long, gradually tapered conical points at their free ends. Conventional metallic card clothing, with the customary burrs removed from the free ends, may also be used. Prongs of various sorts are also suitable, including prongs having bodies of various cross-sectional shapes, round, oval, polygonal, etc., with chisel-shaped free ends.

The water or other aqueous medium which wets the fibrous layer on the rotatable cylindrical surface acts as a lubricant and facilitates the relative movement between the individual fibers in the direction of their respective longitudinal axes. The relative longitudinal movement between individual fibers places the fibers in mechanical equilibrium so that they remain in their rearranged positions in the resulting fibrous layer.

The rotation of the cylinder pulls each portion of the layer of fibers progressively past a series of rotary brushes disposed at right angles to the direction of travel of the layer, with their bristles in contact with the layer of fibers embedded about the prongs. These rotary brushes press the fibers downwardly about the prongs and toward the peripheral surface of the rotatable cylinder.

The rotary brushes, which have axes which are parallel to the longitudinal axis of the cylinder, move the individual fibers of the fibrous layer downwardly along the tapered sides of the prongs into contact with the peripheral surface of the cylinder, laterally into the spaces between the prongs, and in the direction of their respective longitudinal axes, with respect to the other fibers in the layer, to compact them in fiber accumulating zones and channels between the prongs.

In so doing, the brushes form a series of parallel, aligned channels or grooves which are cut into the fibrous layer in the spaces between the holes surrounded by the previously mentioned raised lips. These channels or grooves extend longitudinally and uninterruptedly for substantially the full length of the fibrous layer. The benefits and advantages of such lengthwise channels will become clear from the following discussion.

The resulting wetted and brushed fibrous layer is then removed from the prongs by passing it through the nip between a pair of doffing rolls positioned beyond the last of the rotary brushes. Either one of the doffing rolls may be driven to insure continuous movement of the fibrous layer away from the cylinder, or other suitable means may be provided beyond the doffing rolls to carry the fibrous layer into a drying area. It is obvious that the driven doffer roll or means for moving the fibrous layer from the rotatable cylinder to the drying area must be synchronized with the circumferential speed of the cylinder.

Advantages of the invention other than those generally described above will be apparent from the following description and claims, taken together with the drawings of preferred embodiments of the invention wherein:

FIGURE 1 is a schematic, fragmentary side view, partly in section and partly in elevation, of a machine embodying the invention, with a portion of the frame removed to clarify the illustration, the feed end to the machine being shown at the left and the discharge end on the right side of the figure;

FIGURE 2 is a schematic, fragmentary side view of a modification of the machine illustrated in FIGURE 1, showing another technique for applying the aqueous medium to the fibrous layer after it has been placed on the rotatable cylinder;

FIGURE 3 is a schematic, fragmentary side view of a portion of the machine illustrated in FIGURES 1 and 2 showing in enlarged scale some of the details of the peripheral surface of the carrier for the fibrous layer and the prongs thereon;

FIGURE 4 is a schematic, fragmentary side view of a modification of the machine and the fibrous web carrier of FIGURES 1-3;

FIGURE 5 is a schematic, fragmentary plan view illustrating a nonwoven fabric produced by the apparatus and methods of the inventive concept;

FIGURE 6 is a cross-sectional view of the nonwoven fabric of FIGURE 5, taken on the line 6-6 thereof; and

FIGURE 7 is a cross-sectional view of the nonwoven fabric of FIGURE 5, taken on the line 7-7 thereof.

In the embodiment of the invention shown in the drawings and with particular reference to FIGURE 1 thereof, a fibrous layer 10 which is preferably a card web is carried forwardly on a feed conveyor belt or other movable carrier 12 supported by a plurality of feed rolls 14, 16 and 18 mounted for rotation in the frame 20 of the apparatus.

The fibers of the fibrous layer are natural, synthetic or man-made fibers, preferably cellulosic fibers, such as cotton or rayon, but substantially any textile length fiber or shorter fiber may be employed. These fibers are dry, which term is not intended to cover only bone-dry fibers but is intended to cover fibers containing approximately their normal moisture regain or thereabouts. In the case of cotton, conditions of high temperature and high humidity could lead to the cotton fiber taking up as much as about 20 percent by weight of water without feeling damp to the hand. This value of 20 percent for cotton is not an absolute ceiling for applicability of the present inventive concept and may be exceeded at times. Thus, it is merely being employed herein to generally define the term "dry." This moisture-content value will vary according to the fiber used, the operating conditions involved, and so forth.

The fibrous layer 10 is advanced by the movable conveyor 12 under a rotatable guide-bar 22 mounted in bearings in the frame 20. The guide-bar 22 is so located that it positions the fibrous layer 10 on the points 24 of a group of prongs 26 mounted in a predetermined pattern on the peripheral surface of a rotatable cylinder 28. The rotatable cylinder 28 is mounted on a drive shaft 30 rotatably mounted in bearings 32 in the machine frame 20 and is driven by a conventional driving means (not shown).

The rotatable cylinder 28 generally resembles a conventional doffing cylinder as found on a conventional textile card and the prongs 26 may be positioned on the peripheral surface thereof in very much the same fashion as a steel band of metallic card clothing is helically wrapped around and periphery of a doffing cylinder in conventional practice. The size, shape and spacing of the prongs 26 are as many and as varied as the types of metallic card clothing found in the textile industry. Stainless steel is preferred as the material of which the prongs are made.

The lower portion of the cylinder 28 dips into an immersion tank 34 containing an aqueous medium 36 which wets the surface of the cylinder 28. The aqueous medium consists normally only of water but, if desired, relatively small concentrations of various wetting agents, surfactants, antistatic agents, rust preventatives, dyes, pigments, fiber lubricating agents, or other treating agents may be added. The purpose of wetting the surface of the cylinder 28 will become clear from a further consideration of this specification.

Rotation of the cylinder 28 progressively carries the fibrous layer 10 forwardly on the prongs 26 in clockwise direction, as viewed in FIGURE 1, under a rotatable brush 40 mounted on a shaft 42 in the machine frame 20. The brush 40 extends the full width of the cylinder 28 but is considerably smaller in diameter. The work-

ing surface of the brush is formed by the ends or tips of the resilient, flexible brush bristles which have a low knee, near the hub of the brush, with the major length of the wire bristle in the rake or bent position. The brush is so positioned and is so rotated that the bristles progressively contact and press the fibrous layer 10 down the sides of the prongs 26 which penetrate the fibrous layer 10 and form therein a plurality of holes 38 in the local spaces correspondingly occupied by the prongs 26. Study of the fibrous layer also reveals the presence of annular or elliptical raised lips 44 surrounding the holes 38 (see FIGURE 5).

It is to be appreciated that the fibers of the layer 10 are dry during this positioning and penetrating step and consequently they are more easily moved aside and rearranged into the new perforated configuration. If the fibers had been wet, more resistance to penetration and rearrangement would have been offered and more fibers would have been undesirably ruptured or broken.

Care should be exercised that the brushing action not be too severe or too harsh as to damage the fibers by rupturing or breaking them. Accurate positioning and adjusting of the bushes with respect to the peripheral surface of the cylinder 28 is therefore necessary.

Brush 40 and other similar brushes to be described more fully hereinafter rotate with a peripheral linear speed which is greater than the peripheral linear speed of the rotatable cylinder 28. The ratio of the peripheral linear speeds (brush:cylinder) is generally on the order from about 2½:1 up to about 15:1. Greater speed ratios are, of course, possible particularly with brush bristles which are more flexible and softer.

As the fibers move downwardly on the prongs 26 and finally reach the periphery of the cylinder 28, they come into contact with the water or aqueous medium adhered thereon. Absorption of the aqueous medium by the fibers is very rapid and the fibers may be considered as "wet" as they are leaving the penetrating zone occupied by the rotatable brush 40.

The amount of aqueous medium or moisture which is applied to and taken up by the travelling fibrous web may be varied within relatively wide limits. Normally, from about 100 to about 200 percent by weight of moisture, based on the bone-dry weight of the fibrous layer, is preferred.

The wetting procedure described is satisfactory for light fibrous webs but is not as satisfactory for heavy fibrous webs inasmuch as the amount of aqueous medium picked up by and remaining adhered to the rotatable cylinder 28 after it leaves the immersion tank 34 is limited and may not sufficiently wet out a heavy fibrous web to the desired degree. In order to provide additional aqueous medium, the following procedure may be followed. A relatively open, low count, absorbent fabric or similar material 50 (see FIGURE 3), such as gauze, scrim, lace, netting, or other relatively open, low count fabric, is tightly wrapped around the periphery of the cylinder 28 under such tension that it penetrates the tips of the prongs 26 and contacts the surface of the cylinder 28 itself. The absorbent material 50 is preferably made from absorbent yarns, such as cotton or rayon, and thus can absorb considerable amounts of the aqueous medium. If desired, several wraps of such absorbent fabric may be made round the cylinder 28, thus creating a greater capacity or source of available aqueous medium.

It is not essential that the absorbent material 50 be a fabricated product. Yarn or string may be used and may be tightly wrapped around the rotatable drum 28 to be positioned on the surface thereof between the prongs 26. Bleached cotton twine is especially suitable for such a use.

Upon passage through the immersion tank 34, the absorbent material 50 takes up a considerable amount of aqueous medium and subsequently transfers a substantial portion of the same to the fibrous layer 10 when it is pressed thereagainst by the rotating brush 40. The

amount of the aqueous medium transferred can be controlled by decreasing or increasing the number of wraps of absorbent fabric on the cylinder, selecting a more open or less open fabric, or thicker or thinner twine, and so forth.

In FIGURE 2, there is illustrated still another technique for wetting the fibrous layer after it has been positioned and penetrated by the prongs on the rotatable cylinder. A humidifier head or atomizer spray 51 provided with a nozzle 52 may be positioned adjacent the rotatable cylinder 28 at a zone subsequent in clockwise direction to the positioning and penetrating zone. The amount of aqueous medium applied to the fibrous layer 10 can be very easily controlled in this manner by adjusting the nozzle 52 or by using other equivalent flow-control means.

The wet, perforated fibrous layer is then advanced on the periphery of the rotatable cylinder 28 and is guided under additional rotatable brushes 56 and 58 which brush the fibrous layer as it passes thereby. Brushes 56 and 58 are usually similar in construction to brush 40. If desired, only one brush may be employed or, if required, a total of three, four or more brushes may be used.

The brushes 56 and 58 are positioned in such proximity and adjacency to the rotatable cylinder 28 and the fibrous layer thereon that the brushing of the fibrous layer is relatively thorough but gentle and creates therein a plurality of channels or grooves 60 (see FIGURES 5-7) which extend substantially uninterruptedly and continuously for the full length of the perforated fibrous layer. These channels 60 extend between the holes 38 and their surrounding raised lips 44. It is to be noted that these channels 60 are relatively straight and are actually cut into the body of the fibrous layer, possessing beds and sidewalls 59 which extend substantially uninterruptedly the full length of the fibrous layer in the longitudinal direction thereof. Such sidewalls 59 are actually formed; they are not indirectly created by the raising of the lips 44 around the holes 38.

It is often desirable to have the bristles of the brushes 40, 56 and 58 progressively come closer and closer to the peripheral surface of the rotatable cylinder 28. Thus, the clearance at the first zone (brush 40) may cause a light pressing of the fibrous layer against the wet surface in order to transfer the desired aqueous medium. The second brush 56 brushes more heavily and begins to create the desired channels. The third brush 58 brushes most heavily and completely forms the desired channels 60.

Consideration of FIGURES 5-7 will indicate the nature and the advantages of the fibrous layer which is produced by the techniques of the present invention. The holes 38 and their surrounding slightly raised lips 44 which are formed thereabout naturally affect the porosity of the fibrous layer and affect the flow of fluids therethrough. The continuous lengthwise channels 60 affect the flow of fluids along the surface of the fibrous layer and thus control and direct such flow in the lengthwise direction rather than in the widthwise direction. This is desirable when the fibrous layer is to be used as a cover for a sanitary napkin, or in a surgical dressing, etc.

A trough or dimple 61 is observed in the fibrous layer and is bounded by the raised lips 44 of two adjacent holes 38, as measured in the lengthwise direction, and by the raised sidewalls 59 of two adjacent channels, as measured in a widthwise direction. This trough is dimple shaped and forms a depression in the fibrous layer.

The fibrous layer 10, after having been perforated and brushed, is removed from the surface of the rotatable cylinder 28 by any desired doffing means, such as a pair of rotatable nip rolls 64 and 66. If desired, the nip rolls 64 and 66 may be pressed together with such force that they press the fibrous layer together and flatten the

raised lips 44 into a more compacted, more planar configuration.

The fibrous layer is then forwarded for additional processing, drying, printing or impregnating with a binder material, or other handling or treating by means of a movable discharge conveyor 68 supported on discharge rolls 70, 72 and 74 rotatably mounted in the frame 20.

Removal of the fibrous web in a wet condition provides advantages over procedures using dry fibrous webs throughout. Doffing of a wet fibrous web is considerably easier than doffing of a dry fibrous web. Additionally there is considerably less fiber spring-back which would tend to close up the holes which have just been formed. The holes are therefore cleaner, sharper and more uniform.

In FIGURE 4, there is illustrated a modification of the apparatus disclosed in FIGURES 1-3. In FIGURE 4, there is disclosed a fibrous web 111 which is advanced by a movable feed conveyor belt 113 supported by rotatable feed rolls 115 into contact with the prongs, pins or needles 117 located on a movable conveyor belt 119. The movable conveyor belt 119 is supported and driven by one of a pair of rotatable cylinders 121 and 123 mounted upon shafts 125 and 127 in bearings 129 and 131 in the machine frame 133. Cylinder 123 is preferably the driving cylinder.

Consideration of FIGURE 4 will reveal that the fibrous web 111 is advanced onto the points of the prongs 117 of the movable conveyor belt 119 and is advanced under rotatable brushes 135, 137 and 139 in a very similar manner to that described previously in connection with FIGURES 1-3. The positioning and penetrating action by the rotatable brush 135 is very similar to the positioning and penetrating function of the rotatable brush 40 in FIGURE 1. The operation of the rotatable brushes 137 and 139 is very similar to the operation of the rotatable brushes 56 and 58 of FIGURE 1. A spray nozzle 141 may be employed in a very similar way to the spray nozzle 52 in FIGURE 2. An absorbent fabric 143 may also be employed on the conveyor belt 119 in the same manner and for the same function as the absorbent material 50 in FIGURE 3.

The fibrous layer advances from left to right in FIGURE 4 and, after having been positioned, perforated, wetted and brushed, is removed from the prongs 117 of the conveyor belt 119 by a discharge conveyor 145 supported by discharge rolls 147. Nip rolls which apply pressure, if desired, to the fibrous layer may also be used for such removal purposes, similar to the nip rolls 64 and 66 of FIGURES 1-3. A rotatable supporting roll 149 may be employed to keep the upper reach of the conveyor belt substantially horizontal. If it is decided to employ an immersion tank similar to the immersion tank 34 of FIGURE 1, such may be done by using an immersion roll 151 which causes the conveyor belt 119 to dip down into an immersion tank 153 containing water or aqueous medium 155 to be wetted thereby.

The invention will be further illustrated in greater detail by the following specific examples. It should be understood, however, that although these examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration and the invention in its broader aspects is not to be construed as limited thereto.

Example I

The starting fibrous layer is a 45-inch width oriented card web comprising a blend of 50% dull and 50% extra dull viscose rayon staple fibers having a staple length of about 2 inches and a denier of 1.5. The web weight is approximately 300 grains per square yard.

This fibrous layer is processed through the apparatus illustrated in FIGURE 1. The rotatable cylinder has a diameter of 27 inches and is substantially identical to a doffing cylinder normally used in textile carding opera-

tions. Its peripheral surface is helically covered with stainless steel metallic card clothing. Five layers of 20 x 12 bleached cotton gauze are wrapped tightly around the rotatable cylinder as shown in FIGURE 3.

The rotatable brushes have outside diameters of about 8 inches and the bristles are substantially identical to fancy roll clothing such as used in the textile industry.

In this specific case, the brush is made by taking a 6½-inch outside diameter base roll and helically wrapping thereon a 1½-inch wide, 6-ply (32 ounce), heavy, rubber foundation in which have been embedded 1-inch staple wire, plated, low bend, fancy roll clothing.

The bristles have relatively low knees near the hub of the brush, as indicated in FIGURE 1. The aqueous medium is water to which has been added about 0.1% by weight of a surface active agent. The water pick-up is about 150% by weight.

The resulting perforated, brushed nonwoven fabric is delivered to the discharge conveyor and is found to possess the holes, lips, channels and sidewalls illustrated in FIGURE 5. There are approximately 176 holes per square inch, each hole measuring about 0.020 x 0.050 inch. The brushed nonwoven fabric is then over-all impregnated with a polyvinyl acetate binder.

It is noted that the holes naturally affect the flow of fluids through the nonwoven fabric whereas the raised lips around the holes and the substantially uninterrupted continuous lengthwise channels affect the flow of fluids along the surface of the nonwoven fabric, controlling and directing such flow in the lengthwise direction rather than in the widthwise direction. Such characteristics are desired in absorbent materials wherein flow control of fluids deposited thereon is required.

Example II

The procedures set forth in Example I are carried out substantially as set forth therein with the exception that cotton fibers having a staple length of about 1½ inches are used instead of the viscose rayon staple fibers in forming the starting fibrous layer. The results are comparable.

Example III

The procedures of Example I are carried out substantially as set forth therein with the exception that the web weight is reduced from 300 grains per square yard to about 120 grains per square yard. Additionally, the gauze fabric is removed from the rotatable cylinder.

The light-weight web is sufficiently wetted by the aqueous medium picked up by the rotatable cylinder and the results are generally comparable.

Example IV

The procedures of Example I are followed substantially as set forth therein with the exception that the gauze fabric wrapped on the rotatable cylinder is removed and an atomizing spray nozzle, as illustrated in FIGURE 2, is used to apply moisture to the fibrous layer. The results are generally comparable.

Example V

The procedures of Example I are followed substantially as set forth therein except that the absorbent material on the rotatable cylinder is a bleached cotton twine which is wrapped helically on the surface of the rotatable cylinder between the prongs thereon.

The results are comparable to those obtained in Example I.

Example VI

The procedures of Example I are followed substantially as set forth therein except that the apparatus of FIGURE 4 is employed using the spray nozzle, as shown. The results are comparable.

Although several specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific techniques

or elements mentioned therein but to include various other equivalent techniques and elements as set forth in the claims appended hereto. It is understood that any suitable changes, modifications and variations may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes therein arranged in a predetermined pattern which comprises: embedding said layer of dry fibers on a group of prongs arranged in a predetermined pattern to form holes having surrounding raised lips in said layer of dry fibers; wetting said layer of fibers with an aqueous medium while embedded at the base of said group of prongs; brushing said layer of wet fibers in the area between said prongs to form channels between said lips and longitudinally of said layer; and removing the brushed layer of wet fibers from said group of prongs.

2. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes therein arranged in a predetermined pattern which comprises: penetrating said layer of dry fibers with a group of prongs arranged in a predetermined pattern; positioning said layer about the base of said prongs to form holes having surrounding raised lips in said layer of dry fibers; wetting said layer of fibers while it is so positioned; brushing said layer of wet fibers in the areas between said prongs to form channels between said lips and longitudinally of said layer; and removing the brushed layer of wet fibers from said group of prongs.

3. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes arranged in a predetermined pattern and having channels located between said holes which comprises: penetrating said layer of dry fibers with a group of prongs arranged in said predetermined pattern; positioning said layer about the base of said prongs to move segments of the fibers from the local spaces in the layer occupied by the prongs whereby holes having surrounding raised lips are formed in said fibrous layer; wetting said layer of fibers while so positioned; brushing said layer of wet fibers in the areas between the local spaces occupied by said prongs to form channels between said lips and longitudinally of said layer; and removing the brushed layer of wet fibers from said group of prongs.

4. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes arranged in a predetermined pattern and having channels located between said holes which comprises: penetrating said layer of dry fibers with a group of prongs arranged in said predetermined pattern; positioning said layer about the base of said prongs to move segments of the fibers from the local spaces in the layer occupied by the prongs whereby holes having surrounding raised lips are formed in said fibrous layer; spraying said layer of fibers with an aqueous medium while so positioned; brushing said layer of wet fibers in the areas between the local spaces occupied by said prongs to form channels between said lips and longitudinally of said layer; and removing the brushed layer of wet fibers from said group of prongs.

5. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes therein which comprises: placing said layer of dry fibers on the points of a group of prongs arranged in said predetermined pattern; pressing said layer of dry fibers against said group of prongs whereby holes having surrounding raised lips are formed in said fibrous layer and said layer of dry

fibers moves from the points of said prongs to the bases of said prongs into contact with a surface thereat wet with an aqueous medium; maintaining said layer of fibers in contact with said wet surface for a sufficient time to wet said layer of fibers; brushing the layer of wet fibers in the areas between the local spaces occupied by the prongs to form channels between said lips and longitudinally of said layer; and removing the brushed layer of wet fibers from said group of prongs.

6. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes arranged in a predetermined pattern and having channels located between said holes which comprises: wetting a group of prongs arranged in a predetermined pattern and an absorbent material located adjacent the bases of said prongs with an aqueous medium; placing said layer of dry fibers on the points of a group of prongs arranged in said predetermined pattern; pressing said layer of dry fibers against said group of prongs whereby holes having surrounding raised lips are formed in said fibrous layer and said layer of dry fibers moves from the points of said prongs to the bases of said prongs into contact with said wetted absorbent material; maintaining said layer of fibers in contact with said wet absorbent material for a sufficient time to wet said layer of fibers; brushing the layer of wet fibers in the areas between the local spaces occupied by the prongs to form channels between said lips and longitudinally of said layer; and removing the brushed layer of wet fibers from said group of prongs.

7. A continuous method of converting a layer of dry fibers into a nonwoven fabric having holes arranged in a predetermined pattern and having channels located between said holes which comprises: wetting a group of prongs arranged in a predetermined pattern and an absorbent material located adjacent the bases of said prongs with an aqueous medium; placing said layer of dry fibers on the points of a group of prongs arranged in said predetermined pattern; pressing said layer of dry fibers against said group of prongs whereby holes having surrounding raised lips are formed in said fibrous layer and said layer of dry fibers moves from the points of said prongs to the bases of said prongs into contact with said wetted absorbent material; maintaining said layer of fibers in contact with said wet absorbent material for a sufficient time to wet said layer of fibers; brushing the layer of wet fibers in the areas between the local spaces occupied by the prongs to form channels between said lips and longitudinally of said layer; removing the brushed layer of wet fibers from said group of prongs; and applying pressure to the brushed layer of wet fibers to flatten the same.

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