APERTURED, BONDED, AND DIFFERENTIALLY EMBOSSED NON-WOVEN FABRICS

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ABSTRACT OF THE DISCLOSURE

Deformable sheets of textile fibrous material are reformed by passing them through rolls engraved in a pattern of lands and grooves in such a way that a repeating pattern of three degrees of compression are effected; high compression where a land has traversed a land; intermediate compression where a land has traversed a grooves; and little or no compression where a groove has traversed a groove. The areas affected by the three degrees of compression are discrete and spaced apart areas of rhomboidal shape. The high compression areas may be bonded, for example, by the presence of thermoplastic fibers which are fused during embossing, or the high compression areas may be in the form of actual apertures in the fabric. In other embodiments the fabric may have film or fibrous backings or may have an embossed adhesive coating to form adhesive tapes.

This application is a continuation-in-part of our co-pending application Ser. No. 801,681, filed Feb. 24, 1969, now abandoned, which is a division of our co-pending application Ser. No. 524,931, filed Feb. 3, 1966, which in turn is a continuation-in-part of our application Ser. No. 492,644, filed Oct. 4, 1965, now abandoned.

This invention relates to methods of reforming sheets of deformable textile fibrous material by permanently displacing and rearranging at least a part of the fibrous substance to provide set of discrete, spaced-apart rearranged areas, and to certain products produced by such methods. Illustrative of deformable textile fibrous sheet materials are fibrous webs containing a plastic bonding material in either set or unset condition; and woven or knitted fabrics, including fabrics treated or coated with organic polymeric materials, such as artificial leather or adhesive tape. Various embodiments of such textile materials may be used alone, or in laminated combination with other sheet materials such as polymeric organic films or paper.

It is known to emboss textile fabrics and films by passing them between a metal roll patterned in raised and depressed areas, and a solid "backup" roll. Processes are also known where the pattern to be applied to the fabric or film is divided between the two rolls. An extension of this type of embossing is found in U.S. Pat. 2,464,301, to Francis. In general, prior art pressure-embossing processes, on nonwoven fibrous sheets for example, have been confined in one of three ways. Both embossing rolls may be engraved with an identical pattern of areas in relief and areas in intaglio, so that a relief or raised area on one roll matches and opposes a relief area on the other roll, creating an area of high pressure. Conversely, a raised area on one roll may be designed to register with an intaglio or depressed area on the other roll. In both such cases, proper and exact synchronization of both rolls is essential to provide proper registry of the pattern, which is difficult and expensive to maintain. It is common practice in the commercial embossing art, therefore, to reproduce all of the desired pattern on just one roll, and to process the sheet material between such a roll and a plain, non-patterned roll, such a plain roll varying in hardness from rubber to metal depending on the particular pattern to be embossed. This chief disadvantage of such a process is that the pattern, being impressed by one roll, appears prominent and well-defined only on one face of the material.

We have found that novel and useful results may be realized by processing deformable material between a pair of rolls which are both engraved in a pattern of lands and grooves, as explained more fully below. Such a roll system we have found to have novel advantages in the rearrangement of fibers contained in deformable textile sheet material, including the printing in relief of a displacement pattern simultaneously on both faces of the sheet, spot-bonding of sheets containing pressure-sensitive or thermoplastic material, and to be particularly suitable for spot-apertureing of both woven and non-woven fabrics.

It is a primary object of this invention, therefore, to provide a new and useful process for rearranging fibers in a deformable textile fibrous sheet material. It is also an object of this invention to provide novel products made according to said process.

The invention will be more clearly understood by reference to the following specification and drawings, in which:

FIG. 1 is a view, partly broken away, of a preferred apparatus suitable for carrying out the process of this invention.

FIG. 2 is a stylized representation of the type of pattern produced by the apparatus of FIG. 1.

FIG. 3 is an alternative pair of rolls for carrying out the process of the invention, explained in detail below.

FIG. 4 is a rearrangement by rotation of the rolls of FIG. 3.

FIG. 5 is a partly broken-away view of another pair of embossing rolls useful in the practice of this invention, in which the angular pitch and direction of both rolls is the same, but the land and groove width on one rolls is twice the land and groove width on the other roll, and both rolls have their lands and grooves arranged in our preferred helical pattern.

FIG. 6 represents the stylized pressure-pattern produced by the rolls of FIG. 3.

FIG. 7 is a partly broken-away view of another pair of rolls suitable for use in this invention, with an upper helically-engraved roll and a lower roll with circumferential lands and grooves.

FIG. 8 represents the stylized pressure-pattern produced by the rolls of FIG. 5.

FIG. 9 is a partly broken-away view of still another pair of rolls useful in the practice of this invention.

FIG. 10 represents the stylized pressure-pattern produced by the rolls of FIG. 7.

FIG. 11 is a view of either surface of one product of this invention.

FIG. 12 is a cross-sectional view of the product of FIG. 9.

FIG. 13 is a view of the surface of a spot-bonded non-woven fabric made according to the process of this invention.

FIG. 14 is a view of the bottom surface of a piece of fabric-backed adhesive tape apertured by the process of this invention.
FIG. 15 is a view of an apertured nonwoven fabric, also made according to the process of this invention. By the term "stylized" in the references to FIGS. 2, 6, 8, and 9, it is meant that the tracings of the pressure areas as made by passing a sheet of paper and carbon paper through the apparatus. In dealing with the aperturing of nonwoven fabrics, for instance, it will be appreciated that the apertures may be somewhat oval in nature, due to plastic flow and plastic memory inherent in the fibrous web. It is also intended that the fibrous web may be formed in any of a variety of geometrical shapes, such as triangles, ellipses, parallelograms, hexagons, or trapezoids, or combinations thereof.

Basically, this invention resides in the pressure-deformation and rearrangement of deformable textile sheet material as set forth above through a pair of rolls each of which is engraved in a series of lands and grooves, preferably with at least one of the pair of rolls bearing a land-groove pattern in the form of a series of helices forming a pattern of continuous lands and grooves. In this manner, there is imposed on the sheet material a repeating pattern of pressure areas wherein the fibers are permanently displaced, such areas varying from condensed areas to actual apertures, of generally rhomboidal configuration, formed by the traverse of a land area on one roll over a land area of the other roll, as the rolls are caused to rotate. The shape and spacing of the pressure areas will vary with the configuration of the rolls, as set forth more fully hereinafter.

Referring to what may be regarded as a basic design of apparatus, reference is made to FIG. 1 which comprises a pair of metal rolls 10 and 12 each engraved with what we therein term a helical pattern of lands 14 and grooves 16. Rolls 10 and 12 are provided with journals 18 and 20, and are also preferably provided with heavy backup rolls 22 and 24, for equalizing the pressure distribution and for minimizing bowing, the journals 26 and 28 of the backup rolls, as well as the journals 18 and 20 of the embossing rolls, are preferably equipped with roller bearings, not shown. Pressure may conveniently be applied by an air cylinder or similar device 36, transmitted to the journals by pillow-blocks 30 and 32, the latter resting on a solid bedplate 34. Journals and pillow-blocks will be contained in a vertical casing, not shown. Also, provision may be made for conventional heating of the embossing rolls 10 and 12, as by the insertion of electrical heat elements disposed in coils drilled through said rolls, or by oil, gas firing, or the like.

When a deformable textile sheet material is passed through the nip 17 between rolls 10 and 12 of FIG. 1, a series of pressure-areas 52 of FIG. 2 is formed. In general, the overall character of the fiber-displacement pattern will comprise three components: a highly compacted area 52 where a land has traversed a land; more lightly compressed areas 50 and 51 where a land on one roll has traversed a groove on the other roll; and a substantially unaffected area 48 where a groove on one roll has traversed a groove on the other roll. There is an equal number of each of the three types of area in any modular portion of the fabric, and the areas are in the form of quadrilaterals with parallel but not necessarily equal sides, herein termed rhomboidal. The process of forming nonwoven fabrics according to this invention employs a continuous distribution of pressure by the lands of the rolls, since the formation of a highly-compacted area starts with point-contact of a land across a land, proceeds smoothly through maximum width contact as the land traverses the land on the other rolls, and dwindles to point-contact again at the end of the traverse. Since a multiplicity of lands on one roll is constantly engaged with a multiplicity of lands on the other roll, pressure distribution is even, there is no need for the synchronizing mechanism shown in FIG. 9. When a temporary skip or slippage in a roll does not demand that the process be halted and the rolls resynchronized. The nonwoven products therefore are characterized by a set of highly-compacted rhomboidal areas, each such area being fully bounded on its four sides by a rhomboidal area of intermediate-compacted materials, and being contiguous at each of its apices with a rhomboidal area of substantially uncompacted material. Thus the three degrees of compaction are found in adjacent but separated proximities, and the three are inscribed in any pattern of deformed nonwoven material of any one degree of compaction extending in any given direction across or along the face of the fabric. Thus there are no continuous lines of highly-compact ed material which weaken many embossed products by their lack of resistance to repeated flexing. Similarly, there are no continuous lines of subgrade uncompacted material, lacking in tensile strength. The combination of strength, softness, drape, and flexibility thus produced is not met with, in any other nonwoven fabric with which we are familiar.

The degree to which these areas are permanently impressed onto the deformable sheet material processed between such rolls will depend on the thickness of the sheet material, its nature, and the pressures and temperatures used in processing. At moderate pressures of not more than about 100 pounds per inch of nip width, thin fibrous webs usually show a pattern of unconnected rhomboidal impressions which may be thinned out areas, or may be actual apertures, usually bordered by a ridge or grommet of film substance. Such considerations pertain to the processing of nonwoven fabrics of the order of up to 0.005 inch in thickness and of generally light weight, up to 30 grams per square yard, as set forth in Examples 4 and 6 below.

On bulkier deformable fibrous sheet material, especially when weighing in excess of 50 grams per square yard and over 0.005 inch in thickness, and employing moderate pressures of not more than about 100 pounds per inch of nip width, the customarily expected pattern is one of heavily depressed areas lying within a trough of less depressed material, said troughs running diagonally across the deformed sheet and being separated by ridges of relatively undisplaced material, as shown in FIGS. 11 and 12 and explained in Example 1. If the fibrous sheet contains thermoplastic fibers or thermoplastic material dispersed therein, and if there is a temperature differential between the rolls 10 and 12, then there may be a difference in depth and in degree of permanence between a heated land on one roll traversing a groove on the other roll, and a cool land on the other roll traversing a groove on the one roll. That is, the semi-affected rhomboidally-shaped areas 50 and 51 may differ slightly in nature. Such differences are also noticed in the processing of plastic masses laminated to fibrous sheet material, such as adhesive tapes, where various patterned or apertured pressure-sensitive adhesive tapes can be produced by the process of this invention, with the apertures either isolated and discrete, or connected by channels which facilitate the transmission of moisture and moisture vapor from aperture to aperture. Especially in the case of adhesive tapes, the pattern impressed onto the product will vary not only with the physical variables of the apparatus, such as design, pressure and temperature, but with the properties of both the adhesive mass and of the backing, such as resilience, elastic memory, etc.

Using a fibrous sheet containing a proportion of thermoplastic fibers, with pressures in excess of about 100 pounds per inch of nip width and with fiber sheets weighing from 60 to 100 grams per square yard, the nature and degree of fiber displacement will vary with the nature of the fibers used. At pressures of 125 pounds per inch of nip width, blends of nylon with a minor proportion of polypropylene give a pattern of heavily depressed areas interconnected by troughs of less heavily depressed material, as mentioned above. Other fibers, such as cotton, viscose rayon, or modified acrylics, blended with polypropylene, will under the same pressures yield a product wherein the heavily depressed areas are actual apertures. The preparation of such apertured nonwoven felts is set forth in Example 9, below.

Considerable latitude may be exercised in the design
of the rearranging rolls, as shown in FIGS. 1, 3, 5, 7 and 9, provided that both rolls bear a land and groove pattern, so arranged that maximum pressure is exerted only intermittently and in a set pattern of rhomboidally-shaped areas.

In FIG. 1, both upper roll 10 and lower roll 12 bear a pattern of lands and grooves in a helical arrangement. In FIG. 3, the lands 15 on upper and lower rolls 11 and 13 are shown as a spaced set of parallel ellipsoids extending equidistant from the axes of the rolls and in a plane which is inclined relative to the roll axes. So long as the register of the lands remains as shown in FIG. 3, the desired intermittent pattern of pressure areas will be obtained. However, if either of the rolls 11 or 13 is rotated through 180°, the ellipsoidal discs forming the lands on that roll will now be inclined in opposition to the other roll, as shown in FIG. 4. In such a case, the lands 23 on both rolls 19 and 21 will mate continuously as the rolls revolve at uniform speeds, provided that the rolls are of the same diameter. Instead of maximum pressure being developed continuously at a set of spaced-apart points, the continuous mating of lands 23 and grooves 25 will result in maximum pressure being delivered in a series of curved lines running the length of the fabric, which is undesirable. Therefore, we prefer to employ helically-disposed lands 22 and grooves as shown in FIGS. 1, 5, 7 and 9, since the relative slipage of one roll relative to another has little or no effect on the desired intermittent pattern of pressure areas. This is a unique advantage of the helical configuration, which additionally seems to distribute roll pressure and roll wear better than separated lands in the form of inclined ellipsoids.

FIG. 5 represents a partly broken-away pair of rolls with the same helical pitch of 20° (20° lead), but with the lands 60 on the upper roll 62 twice the width of the lands 64 on the lower roll 66. FIG. 6 represents the displacement of roll 89, under pressure. The elongated and skewed compressed areas thus obtained are the solid black areas 67 of maximum pressure, where a land on one roll has made a transient crossing of a land on the other roll; the less-severely-distributed dotted areas 68, where a land has crossed a groove; and the unshaded areas 69, where the material has been substantially unaffected by a groove crossing a groove.

In FIG. 7, the top roll 70 has lands 72 angularly oriented at a 45° pitch to the roll axis, to make contact with a lower roll 74 in which the lands 76 were circumferentially oriented the perpendicular to the roll axis, and are not connected, instead of being helically oriented. In FIG. 8, the pressure-pattern diagram of FIG. 7, the dark areas 77, dotted areas 78, and unshaded areas 79 again represent the areas of maximum, intermediate, and minimum pressure, respectively.

In FIG. 9, the top roll 80 has lands 82 running at a 45° pitch in a northeast-southwest direction while the lands 86 of the bottom roll 84 are pitched at 26° in a northwest-southwest direction, the lands on the top roll being threes times the width of the lands on the bottom roll.

FIG. 10 represents the displacement pattern produced by the lands of FIG. 9, wherein the particular angles and land-widths of the rolls gives rise to a set of elongated rhomboidal maximum pressure points 87, similar areas of unshaded minimum pressure 88, and areas of stippled intermediate pressure 89. From the description of the rolls of FIGS. 1, 5, 7 and 9, from their displacement pattern of FIGS. 2, 6, 8 and 10, it will be appreciated that the patterns may vary from rectangles obliquely disposed to the transverse axis of the material, to narrow, elongated slits. The pitch angle of the lands on one roll should not be equal and opposite to the pitch angle of the lands on the other roll in order to avoid the special case where the lands on one roll mesh with the grooves on the other roll, or the possibility that a land on one roll with remain in such prolonged contact with a land on the other roll that a maximum pressure area of substantially continuous length is evolved. When the helical pitch on one roll is opposed to the helical pitch on the other, therefore, the pitch of the lands on one roll should be selected in relation to the pitch of the lands on the other roll so that on the material being treated, the lines formed by one set of lands will intersect with the lines formed by the other set of lands at an acute angle which is at least 15°.

In general, the surfaces of the lands in a pair of the grooved rolls of this invention may be considered to define the surfaces of a pair of coating cylinders in which the sum of the radii of such cylinders is at no time greater than the distance between the centers of the cylinder axes.

The process of the invention will be illustrated by the following examples. In each example, the apparatus of FIG. 1 was used, in which rolls 10 and 12 and pressure rolls 22 and 24 were of steel and were 3½ inches in diameter. Pattern rolls 10 and 12 were helically grooved in identical patterns, with lands 14 0.015 inch wide and grooves 16 0.040 inch wide. The depth of the grooves was 0.025 inch, and the helical pitch or lead was 30°.

EXAMPLE 1

A felted nonwoven fabric was prepared according to the procedure set forth in U.S. Pat. 2,774,128, consisting of a batt of eight superimposed card webs, the second and seventh card webs being composed of 85% bleached absorbent cotton fibers and 15% of 1½ inch 1.5 denier polypropylene staple fibers. All other card webs were composed of 100% bleached absorbent cotton fibers. After shrinking the layered batt to an extent of 60% in a refrigerated caustic, according to U.S. Pat. 2,774,128 the result was a nonwoven felt weighing 120 grams per square yard, with all-cotton surfaces and center, but with a layer of blended cotton and polypropylene immediately underlying each cotton surface. In this form, the batt product may be used as a lithographic or general purpose wiping pad, like its all-cotton counterpart. However, the material is smooth-surfaced, and lacks gripping action: it tends to ball up when used wet; and it has a dry crosswise tensile strength of only about 0.2 to 0.3 pound per inch-wide strip.

Felts consisting solely of cotton fibers may be processed under pressure to form a patterned or textured surface, but due to the rapid swelling which cotton fibers undergo when wet, any impressed pattern disappears rapidly when such a pad is wet out with water.

The dry felt containing polypropylene fibers thus prepared was therefore processed according to this invention by passing it through the rolls of FIG. 1, with both rolls heated to 440° F. A pressure corresponding to 94 pounds per inch of nip width was employed. The result was a lithographic wiping pad of the general configuration shown in FIG. 11 and in cross-section in FIG. 12, both magnified about 11 times, wherein diagonal ribs of un-compressed cotton fibers 58 are alternated with trough-like grooves 56, the general pattern being unified by the high pressure areas 61. In FIG. 11, the machine direction is from left to right. These areas 61 represent the spots 52 of FIG. 2, wherein a maximum pressure area resulting from the lands of the heated rolls crossing each other. Due to the combination of heat and maximum pressure in these areas, the polypropylene fibers are fused together within the interior of the felt, thus serving to render the alternating ridge-and-trough pattern insensitive to water. That is, when patterns of this sort are applied alone on pure cotton felts, the pattern is clear and prominent on the dry material, but disappears when the swelling action of water disrupts the transient cellulose-to-cellulose bonds thus established. For many types of lithographic work, and for general application, distribution, and removal of aqueous and other solutions, a certain degree of surface roughness or corrugated pattern is desirable. The practice of this invention on a mixed-fiber.
felt of the type set forth above results in a wiping pad which consists in dominant proportion of absorbent fibers, is soft, conformable, and lint-free, yet possesses a functional thermostatic surface which maintains its character even when wet out with swallowing agents. The dry cross strength of the embossed product is about 1.4 pounds per inch-wide strip, or about six times the strength of the unembossed felt.

As an alternative to the above procedure of Example 1, a layer of thermostropic fiber may be sandwiched between two layers of all-cotton felt made in accordance with U.S. Pat. 2,528,793, and the sandwich passed through the procedure of Example 1.

Useful products similar in appearance to FIG. 11 may also be made from batts of fibers, such as nylon or polyester fibers, which are not normally regarded as thermostropic, as illustrated by the following example.

EXAMPLE 2

A batt of 3 denier 1½ inch nylon staple fibers was processed through the apparatus of FIG. 1 at a pressure of 125 pounds per inch width of nip, and with both rolls heated to 420° F. The resulting product was similar to FIG. 11, with the rhomboidal areas 61 of maximum pressure converted to unbroken translucent windows of fused fiber substance. The presence of over 100 of these fused square inch serves to unify the nylon batt without the use of extraneous binder material, making a nylon felt of this character useful as a battery separator in alkaline batteries. Greater strength and decreased porosity may be achieved, if desired, by placing a film of cellophane or other film-forming material in the interior of the nylon batt prior to passing the assembly between the rolls.

Essentially similar results are obtained when polyester fibers are used instead of nylon.

EXAMPLE 3

Using the same pair of rolls as in Example 1, a card web consisting of 3 denier polypropylene fibers 1¾ inches long, weighing about 10 grams per square yard, was processed at a pressure of 94 pounds per inch of nip width with the top roll heated to about 340° F. and the bottom roll heated to 240° F. The result was the spot-bonded, open, porous nonwoven fabric of FIG. 13, which is magnified to 35 times. In FIG. 13, the polypropylene fibers 71 are fused together locally in a set of discrete spaced-apart areas 73, which in the actual fabric, using the roll specifications set forth above, were about 3/64 inch apart. In a light, thin web of this nature, the process of this invention in general effects a pattern only in a set of such uniﬁed areas where a land on one roll crosses a land on the other roll, the land-groove and groove-groove combinations being substantially ineffective in altering the interﬁber relationships. The fiber segments lying between the bonded areas 73 are therefore in a soft, ﬂexible and unfused condition, except for the intermittent appearance of fused ﬁber nodes 75, appearing on one surface of the web.

Such nodes are formed because although the fibers 71 in FIG. 13 are represented as being disposed in a two-dimensional plane, actually there is a minor but definite third dimension of thickness in any carded web of fibers. Certain ﬁber segments and ﬁber ends may be considered as being oriented in a path which carries them above and below the two-dimensional plane of FIG. 13. It has been our experience that when one roll is heated sufﬁciently to fuse the fibers, with the other roll below the fusion point, as in this example, those segments of the thermosensitive ﬁbers which project appreciably out of the plane of the web toward the more strongly heated roll are fused into small nodes or nodules 75. Not all ﬁbers are thus affected, nor is more than a quite minor part of the length of any one thermosensitive ﬁber involved, but the summation of the effects of such nodes, considering that FIG. 13 represents about one one-hundredth of a square inch, is to impart a distinctly harsh, rasping and dragging hand or feel to the face of the web which has been processed next to the hotter roll, while the face of smooth soft ﬁber segments lying between spaced-apart discrete areas, extending substantially through the entire thickness of the fabric, where the intercrossing thermosensitive fibers are fused together, while the other face of the fabric is additionally characterized by a randomly-spaced set of nodes or nodules of fused ﬁber substance, amounting to over one hundred of such minute points per square inch, which impart a harsh and rasping hand thereto, and a high degree of frictional engagement toward other fabrics or ﬁbrous assemblies. Although esthetically undesirable for contact with the human body, such a harsh hand frictionally anchors such a nonwoven fabric on the surface of layers of cellulose wadding, cotton, wood pulp, or other absorbent ﬁllers which commonly constitute the major absorbent in pads and napkins. Not only does the frictional engagement of one face of the nonwoven fabrics of this invention facilitate the wrapping operations involved in the preparation of combination dressings, but in addition dressing it prevents shifting or displacement of the absorbent contents, a common source of complaint in combination dressings employing a cover made from a nonwoven fabric which is smooth-surfaced on both faces. To the extent that close contact is maintained between a cover produced according to this invention and the absorbent ﬁller enclosed by such a cover, transfer of fluid exudate to the absorbent ﬁller is facilitated, lessening the degree of saturation of the cover and encouraging a dryer and healthier wound site.

Although the above specific example was made from polypropylene ﬁbers, it will be obvious that other thermostropic ﬁbers can be employed, such as polyethylene, vinyl ﬁbers, plasticized cellulose acetate, and other synthetic ﬁbers which can be thermally bonded to each other or to other ﬁbers at temperatures below their decomposition points. In addition to the above example, we have made spot-bonded nonwoven fabrics by the invention which contain 25%, 50%, or 75% thermostropic ﬁbers, the balance being, for example, viscous ﬁbers, or any other ﬁber selected for a particular property in the ﬁnal nonwoven fabric. Fibrous webs containing thermostropic ﬁbers can, by the process of this invention, be laminated to ﬁlms, to paper, to fabrics, to other nonwoven fabrics, or a multiplicity of such ﬁbrous webs, of varying composition if desired, may be bonded together.

Illustrations of the use of the process of this invention to prepare useful laminates may be found in Examples 4 and 5.

EXAMPLE 4

Nonwoven fabrics of enhanced absorbency and improved tensile strength balance may be produced by laminating together layers of textile-length ﬁbrous webs containing thermostropic ﬁbers with layers of short-ﬁbered cellulose wadding, as follows:

A blend of 75% dull cramped 1.5 denier rayon ﬁbers, 1¾ inches long, and 25% 1.8 denier polypropylene ﬁbers of similar length was carded into a set of four superimposed card webs, with a layer of cellulose wadding interposed between the ﬁrst and second webs. The assembly was then passed between rolls corresponding to those of FIG. 1, both rolls being heated to 450° F., and the pressure being about 200 pounds per inch of nip.

By this process there was created a multiplicity of rhomboidally-shaped bonded areas, 196 per square inch, where the rayon ﬁbers, polypropylene ﬁbers, and cellulose wadding were ﬁrmly bonded together into a strong and
flexible nonwoven fabric. The area of each spot was about 0.0011 square inch, and the bonded spots occupied 22% of the total area of the fabric, which weighed 67 grams per square yard.

The resultant product had a machine direction tensile strength of 6.6 pounds per inch-wide strip and a cross-direction strength of 1.1 pounds, a ratio of 6 to 1. On a dunk and drain absorbency test, the fabric picked up 1060% of its own weight in water.

By comparison, a similarly processed sample consisting of five superimposed card webs of the same fiber blend as above, with no cellulose wadding, and weighing 62 grams per square yard, had a machine-direction tensile strength of 6.2 pounds and a cross-direction tensile strength of 0.6 pound, a ratio of 10 to 1. Its absorbency in a comparable test was 630%.

EXAMPLE 5

It is also possible to produce apertured film-fiber laminates by the process of this invention. Carded webs of 75% 1.5 denier dull crimped 1% inch rayon blended with 25% of 1.8 denier 1% inch polypropylene, each web weighing 30 grams per square yard, were placed on either face of a one mill polyurethane film.

The assembly was then passed between rolls corresponding to those of FIG. 1, both rolls being heated to 450°F. The pressure was 40 pounds per linear inch of nip.

The result was a soft, absorbent apertured nonwoven fabric, both the fibrous material and the film being displaced into a set of rhomboidally-shaped apertures maximum pressure, where a land on one roll had traversed a land on the other roll. There were 64 clean-cut apertures per square inch, constituting 23% of the total area of the fabric, each spot being 0.0039 square inch in area.

Due in part to the absence of any overall bonding agent and in part to the properties of the polyurethane film, the resultant fabric is exceptionally soft and conformable, considering its tensile strength of over 2 pounds per inch strip in its crosswise, or weakest, direction. Additionally, it shows an elongation of up to 150% in the crosswise direction, with substantially complete recovery.

EXAMPLE 6

A further example of the utility of the process of this invention is in the preparation of porous pressure-sensitive adhesive tapes, capable of transmitting moisture vapor thereby eliminating the skin maceration which frequently accompanies the use of occlusive, moisture-impervious tapes. The gravity of dermal reactions to impervious tapes is evidenced by the numerous attempts which have been made to render tapes permeable, as by perforating the tape mechanically with a series of relatively large holes; or by printing the adhesive onto a porous backing in the form of disconnected spots as in U.S. Pat. 2,940,868; by coating with adhesive a perforated film as in U.S. Pat. 3,073,303; or by embossing a tape on the adhesive side with a patterned roll which carries a set of raised areas which displace the adhesive under pressure, as in U.S. Pat. 3,073,304.

We have found that a novel porous adhesive tape of an unusual and advantageous configuration in the adhesive mass may be produced by passing a suitable tape through the rolls of FIG. 1 as follows:

A pressure-sensitive adhesive tape was made employing an acetate satin fabric base, 25s and 70s warp yarns per inch, weighing 3.57 yards per pound. This fabric was solvent-coated with a heptane solution of a commercial pressure-sensitive adhesive mass comprising pale crepe rubber, tackifier resins, fillers, and age-resistors.

The tape thus prepared was passed through the nip created by the patterned rolls of FIG. 1, at a pressure of 94 pounds per inch width of nip. The adhesive face of the tape was exposed to the top roll, heated to 425°F, while the cloth face pressed against the bottom roll, heated to 440°F.

The adhesive face of the resulting product is shown in FIG. 14, the machine direction again being from left to right. Apparently due to the continuous traversing and shearing action of the helically-grooved lands 14 of the set of rolls, the adhesive mass has been displaced into a set of continuous transverse ridges 81, about 0.010 inch thick, running diagonally and uninterrupted from one selvage edge of the fabric to the other. In regular alternation with these ridges, and similarly spaced and oriented, is a set of grooves 83, in which the mass is about 0.005 inch thick. Regularly spaced in these grooves or troughs 83 is a dot-like, or snowstorm-shaped aperture 85 corresponding to a land on one roll crossing a land on the other roll as at 52 of FIG. 2, in which apertures the acetate backing fabric has been crushed and moved aside so that there is no substance therein, under the particular pressures employed.

Porous adhesive tapes prepared in this manner have several advantages over prior-art tapes. First, they are characterized by a series of continuous diagonal ridges of adhesive mass, the continuity of said ridges providing a greater holding power than prior art patterns in which the adhesive is printed in a pattern of isolated spots or areas which are completely surrounded with areas containing no adhesive. Second, the actual apertures 85 are interconnected, along any one trough, by areas in which the adhesive is only about one-half as thick as the adhesive on the ridges, thus providing auxiliary paths for moisture vapor from the skin to be transmitted to the air. Such an interconnection of apertures through a channelled adhesive mass allows fewer apertures to vent more moisture than is the case where individual apertures are undertaken by an encircling grooment of adhesive mass, and thereby allows the preservation of a higher proportion of the tensile strength of the backing material.

In cases where the backing of the adhesive is porous, as in the case of the acetate fabric above, it is not necessary actually to perforate the backing. The use of lower pressure and less drastic processing conditions will displace the adhesive mass from the rhomboidally-shaped areas 85 without cutting through the fabric, but still allowing moisture-vapor transmission therethrough due to the channels 83.

Although the above example was set forth in terms of an acetate fabric, the general procedure is equally applicable to adhesive tapes employing a backing of film, or of a variety of woven or nonwoven fabrics.

EXAMPLE 7

The process of this invention also finds particular utility in the preparation of novel apertured nonwoven fabrics, as well as in the aperturing of prebonded nonwoven fabrics. Apertured nonwoven fabrics are those in which a portion of the fibers of an unspun and unwebbed web, comprising textile-length fibers, are displaced from their normal overlapping and intermingled relationship to form a spaced set of apertures or areas which are essentially devoid of fibers, thus lending to the nonwoven fabric the appearance of certain woven fabrics. Such apertured nonwoven fabrics are described in U.S. Pat. 3,179,883 and 3,150,416, among others, and are of recognized utility as pad covering materials, surgical dressings, disposable towels, and the like.

An unbonded card web of 3 denier 9% viscose rayon fibers was saturated with an acrylic binder solution of 12% concentration and then pressed at 450°F and 150% of nip. The wet web was then passed through the rolls of FIG. 1 at a pressure of 94 pounds per inch width of nip, with both rolls heated to 430°F. Final drying was accomplished by passing the moist apertured nonwoven fabric over a steam-heated dry can.

The final product is represented by FIG. 15, magnified about 20 times, wherein the apertured nonwoven fabric
90 consists of a web of rayon fibers 92, marked by a pattern of generally rhomboidally-shaped apertures 94, said apertures being essentially devoid of fiber substance. The apertures occur where a land on the top roll traverses a land on the bottom roll, corresponding to the areas 52 of FIG. 2. As mentioned above, in thin and lightweight materials of this character, the land-groove coaction 50 of FIG. 2 is not apparent, and the apertured nonwoven product is essentially planar and unmarked by transverse ridges of fibers.

The apertures 94 of FIG. 15 are characterized by a rim or grommet of displaced fiber segments 96, apparently due to the shearing action of the traverse of land over land having aggregated said fiber segments. Such a traverse is initiated at a point, proceeds to its maximum width, and then recedes to a point again as the characteristic rhomboidal shape is generated. Especially when wet, textile fibers are somewhat plastic and are displaced to one side to form the reinforcing fibrous rims 96. This effect is a local displacement confined to the peripheries of the apertures, and the characteristic web configuration of the fibers lying between the apertures is essentially undisturbed. Each reinforcing fibrous rim surrounding an aperture is therefore independent, and the rims defining the apertures are interconnected only by unarranged fiber segments.

It is also possible according to this invention to produce comparable apertured nonwoven fabrics from textile webs which have been "prebonded"; that is, bonded and dried in a separate operation, in distinction to the above example where bonding and aperturing were done simultaneously. This is illustrated by the following example.

EXAMPLE 8
A card web of 1.5 denier 9% inch viscose rayon, weighing 12 grams per square yard, was saturated with 25% of its weight of an acrylic binder and dried, in the conventional manner for preparing bonded nonwoven fabrics. The bonded material was then cut out with water-adjusted to about 200% water pickup, and then run through the apparatus of FIG. 1 at a nip pressure of 125 pounds per inch of nip width with both rolls heated to 430° F. The result was an apertured nonwoven fabric resembling the material of Example 4 made from rayon fibers run through the apparatus while wet with binder solution.

In addition to nonwoven fabrics bonded by liquid binders in the form of latices or emulsions, so-called mixed fiber webs can also be apertured by the process of this invention. A web of 32"-length fibers of 12.5 denier 9% inch viscose rayon with a proportion of thermoplastic binder fibers such as polypropylene, vinyl fibers, or plasticized acetate fibers, mixed with nonbinder fibers. Not only are the apertured felts thus produced of interesting surface texture, with a twill-like structure, but the mechanical integrity and resistance to rupture of the product is of a very high order in view of the essentially soft and formable nature of the material. The preparation of such an apertured felt is set forth in the following example.

EXAMPLE 9
A blend of 75% bleached absorbent cotton fibers with 25% 1.5 denier 1.5 inch polypropylene fibers was carded to give a fibrous batt weighing 80 grams per square yard. This fibrous batt was then passed through the apparatus of FIG. 1, with both rolls heated to 450° F, and under a pressure of 120 pounds per inch of nip. The resulting apertured felt resembled the product of FIG. 11, wherein the rhomboidal areas 61 were actual apertures devoid of fibers, interconnected by diagonal trough-like depressed areas 56, and with the depressed areas 56 separated by soft, uncondensed ribbed diagonal stripes 58, so that a twill effect was prominent.

An especially useful characteristic is the high loft and low bulk density of the structure: the measured thickness of 60 thousandths of an inch represents a bulk density, for this weight of web, of 1.1 grams per cubic inch or 0.070 gram per cubic centimeter. This open structure enables the fabric to take up relatively large amounts of liquid, as high as 11 to 12 times its own weight, as determined in a standard test in which the product is immersed in water for 2 minutes, drained for 2 minutes, and weighted.

Another feature of considerable utility and interest is the manner in which the tensile properties of the structure are unaffected by the presence of water or other swelling agent therein. The fabric of this example showed a measured machine direction tensile strength of 2.57 pounds per inch of width and about one-fifth of this in the cross direction. When wet with water these values did not change significantly, measuring 2.20 pounds per inch width in the machine direction and 0.50 pound crosswidth.

The high absorbency and softness that is characteristic of this material makes it especially useful for many hospital product applications such as sponges, pads, rolls, etc. Its intrinsic softness on both sides results from the special feature of this process which locates the apertures, representing the bonding points of the structure, at approximately the mid point of the cross section in deep pockets of bulked fiber.

Carded structures of blended fibers similar to the above have been made in a range of weights from about 70 to 120 grams per square yard and with binder fiber fractions from 0.10 to 0.50, and nonbinder fibers other than bleached cotton, including viscose rayon, and Dynel (Union Carbide's modified acrylic fiber). Especially when synthetic fibers are used, or coarse deniers of viscose, the resulting apertured felts have a combination softness, conformability and resilience which makes them suitable for interfiling use.

The size and spacing of the apertures made by the process of this invention may readily be varied by changing the dimensions, spacing, and orientation of the lands and grooves on the forming rolls. In general, an acceptable range of aperture size seems to be from 0.03 to 0.125 inch in the long dimension of the aperture, at a spacing of from 0.25 and 0.50 inch on centers. Customarily, using textile-length fibers of from 1 to 2 inches in length, the average fiber length is at least eight times the maximum width of an aperture, though products of a special nature may demand departure from these dimensional characteristics.

Having thus described our invention, we claim:
1. A nonwoven fabric comprising an unspun and untextured array of textile-length fibers comprising the said array being bonded at a set of discrete and spaced apart rhomboidal highly compacted areas, each of such highly compacted areas being fully bounded on each of its four sides by a rhomboidal area of intermediate compacted fibers, and each of such highly compacted areas being contiguous at each of its four apices with a rhomboidal area of substantially uncompacted fibers.
2. The product according to claim 1 in which the array of textile-length fibers is laminated by heat and pressure to at least one layer of cellulose wadding.
3. The product according to claim 1 in which the array of textile-length fibers is laminated by heat and pressure to at least one layer of a polymeric film.
4. The product according to claim 1 in which the array of textile-length fibers comprises thermoplastic and nonthermoplastic fibers and the bonded areas are formed by the fusion of the thermoplastic fibers.
5. The product according to claim 4 in which the thermoplastic fibers are polypropylene and the nonthermoplastic fibers are viscose rayon.
6. The product according to claim 4 in which the array of textile-length fibers comprises a felted sheet of cotton fibers and polypropylene fibers.
7. A pressure-sensitive adhesive tape capable of transmitting moisture vapor comprising
an adhesive mass arranged in a pattern of thin adhesive portions and thicker adhesive portions to form alternating grooves and ridges of adhesive running diagonally from one lateral edge of said tape to the other lateral edge of said tape, the continuity of adhesive mass being essentially uninterrupted with the exception of a spaced-apart series of rhomboidally-shaped areas situated at regular intervals in the diagonal grooves of said adhesive mass, together with a moisture-vapor permeable backing for said adhesive mass, said backing being substantially continuous and imperforate, and the areas of said backing lying in contact with the rhomboidally-shaped areas in the adhesive mass being essentially free of adhesive.

8. A perforated adhesive tape which comprises a backing material selected from the class consisting of woven fabrics, nonwoven fabrics, films, paper, and combinations thereof, together with a pressure-sensitive adhesive mass adherent to at least one face of said backing material, said adhesive mass being arranged in a pattern of thin adhesive portions and thicker adhesive portions to form alternating grooves and ridges of adhesive running diagonally from one lateral edge of said tape to the other lateral edge of said tape, the continuity of adhesive mass being essentially uninterrupted with the exception of a spaced-apart series of rhomboidally-shaped areas situated at regular intervals in the diagonal grooves of said embossed adhesive mass, said rhomboidally-shaped areas being apertures devoid both of adhesive mass and of backing material.

9. A spot-bonded nonwoven fabric suitable for use as a cover for surgical pads and the like, which comprises an unspun and nonwoven array of textile-length fibers, a portion at least of said fibers being thermoplastic, the thermoplastic fibers being bonded to each other at a set of discrete and spaced-apart rhomboidally-shaped areas of fused fibers, one face of said nonwoven fabric being smooth to the touch and being characterized by soft and unfused fiber segments lying between said spaced-apart areas of fused fibers, the other face of said nonwoven fabric having a harsher feel than said one face, the thermoplastic fiber segments lying between the spaced-apart areas of fused fibers on said other face being characterized by a randomly-spaced set of nodes of fused fiber substance, whereby said other face of said nonwoven fabric has a high degree of frictional engagement toward other fabrics or fibrous assemblies.

10. The product according to claim 9 wherein the nonwoven fabric comprises between 25% and 100% thermoplastic fibers and between 75% and 0% of hydrophilic fibers.

11. The product according to claim 10 wherein the thermoplastic fibers are polypropylene and the hydrophilic fibers are viscose rayon.

12. An apertured fibrous felt comprising an unspun and nonwoven array of intermingled textile-length thermoplastic fibers and non-thermoplastic fibers, the surfaces of said fibrous felt being characterized by a set of alternately-spaced diagonal fibrous ridges and grooves, a part of said fibers comprising fiber segments which are locally aggregated into a rim-like conformation defining a set of spaced-apart rhomboidally-shaped apertures in said grooves, said thermoplastic fibers being bonded to each other and said non-thermoplastic fibers in said rim-like conformations, the aggregated fiber rims defining said apertures being interconnected only by unarranged fiber segments.

References Cited

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Inventor</th>
<th>Date</th>
<th>Filing Date</th>
<th>发明人</th>
<th>申请日</th>
<th>专利号</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,962,634</td>
<td>Dreyfus</td>
<td>6/1934</td>
<td>2/1934</td>
<td>264–284</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,896,618</td>
<td>Schaefer</td>
<td>7/1959</td>
<td>2/1959</td>
<td>128–156</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3,044,914</td>
<td>Bell et al.</td>
<td>7/1962</td>
<td>2/1962</td>
<td>161–150 X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3,130,412</td>
<td>Fox et al.</td>
<td>4/1964</td>
<td>2/1964</td>
<td>264–93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3,218,381</td>
<td>Such et al.</td>
<td>11/1965</td>
<td>2/1965</td>
<td>264–109 X</td>
<td></td>
<td></td>
</tr>
</tbody>
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