

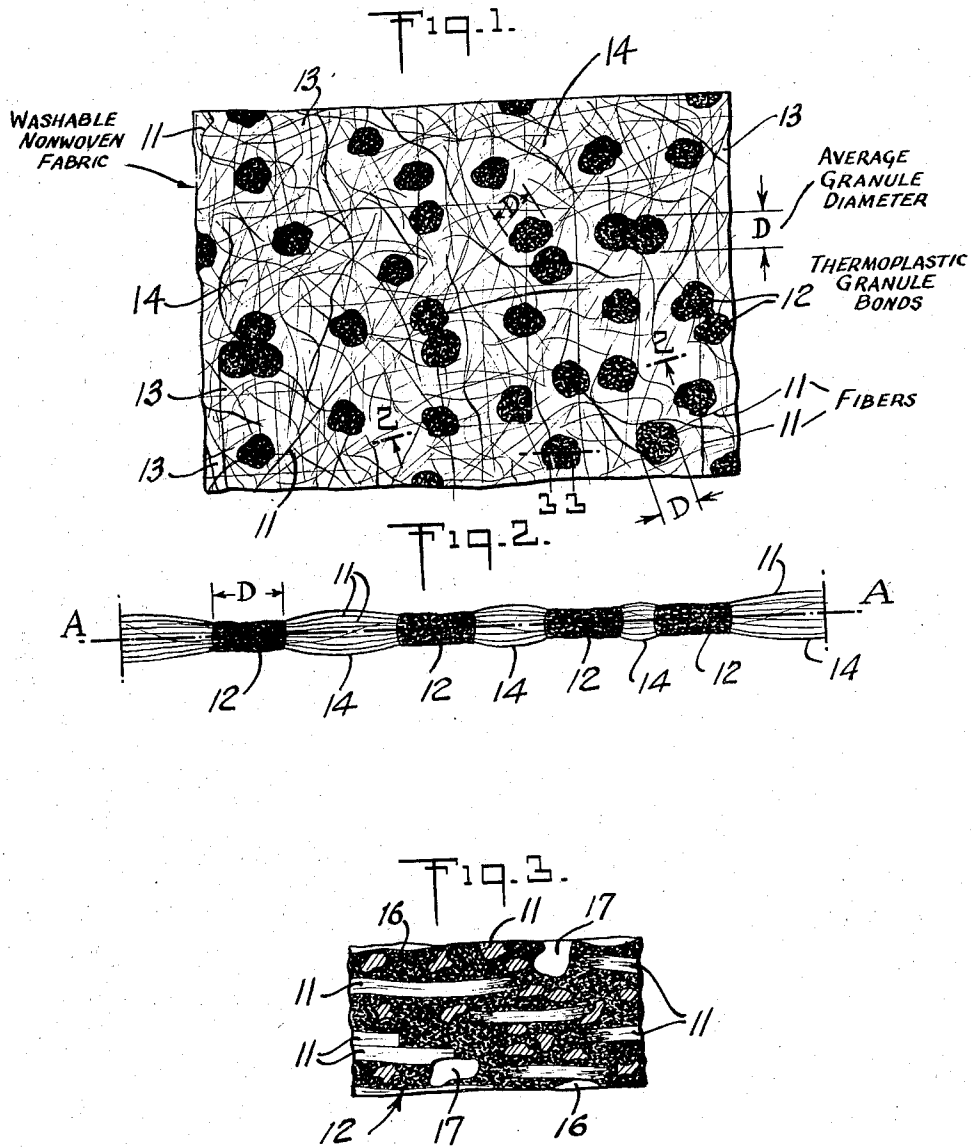
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DURABLE NONWOVEN FABRIC AND METHOD

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DURABLE NONWOVEN FABRIC AND METHOD

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The present invention relates to fibrous nonwoven fabrics, i.e., fabrics produced directly from fibers without the use of conventional spinning, weaving, knitting, or felting operations, more particularly to such fabrics which are open and porous and possess textile-like hand and drape as well as considerable strength, and methods for making these fabrics.

Nonwoven fabrics of various types have become increasingly important in the textile field during the past decade because of their low cost of manufacture for a given coverage compared to fabrics formed by weaving or knitting spun fibers and because of certain properties such as absorbency, fluffy or downy surface characteristics, and the like, which are peculiar to these fabrics.

As distinguished from felts, which often are described as being nonwoven, this invention is concerned with fabrics wherein the fibers are not compacted but instead are relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them. Additionally, the fibers lie in positions which are somewhat flat or generally parallel to the major plane of the fabric extending in various directions parallel to this plane, overlapping, intersecting and supporting one another to form a relatively open porous structure.

Such fabrics are conventionally manufactured at the present time by producing a more or less tenuous web or layer of loosely associated fibers, preferably of textile length using any one of a variety of well-known procedures or techniques and then subjecting the layer to a bonding operation to adhere the individual fibers together. Bonding has been effected by various techniques ranging from the deposition of resins or the like by overall impregnation to the printing of these materials in spaced discrete areas of the layer, and includes techniques wherein binder powders or fibers are distributed at random in the layer to form bonds.

In general, all of the prior art nonwoven fabrics can be divided into two groups; those which possess relatively good strength but are more or less stiff and board-like, possessing more of the properties of paper or board than of a woven textile fabric, and those which possess textile-like softness and drape but are relatively low in strength and are not at all suitable for applications where launderability is a prerequisite.

The present invention contemplates a fabric which surprisingly possesses washability and superior strength, as well as textile-like softness and drape. This combination of properties, particularly the combination of washability, on the one hand, and textile-like softness and drape, on the other, is unique in nonwoven fabrics of the character described. Due to this unusual combination of properties, this fabric is particularly adapted for use as a lining material for clothing, particularly where such materials may be worn next to the body, for inner and outer wear in general, for washable towels, napkins, tablecloths, handkerchiefs, and the like, sanitary napkins, surgical dressings, draperies, curtains, reusable industrial fabrics,

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as well as in a variety of other applications where the combination of these properties is important.

According to this invention, a multiplicity of relatively small granule bonds of heat fused material, which individually may be of any one or more of a number of different shapes, as described more fully hereinafter, are distributed approximately uniformly in a layer of overlapping and intersecting fibers, anchoring the fibers by surrounding and imbedding them in the bonds at least 2 or 3 times along the length of substantially every fiber. The bonds are relatively closely spaced as hereinafter more fully set forth. In general, the bonds have a cross dimension of the order of about 14 to 70 times the average diameter of the structural fibers, and each bond is large enough to imbed at least 5 fibers, preferably 20 or more, as they pass through the bond. The bonds are spaced sufficiently apart to provide a multiplicity of unbonded fiber areas between bonds wherein a high degree of the textile properties of the original fibrous layer is preserved. The resulting fabric is strong and washable due to the strong closely spaced bonds and the relatively high degree of fiber intersection by the bonds, while at the same time possessing a high degree of the softness and drape of the original unbonded fibrous layer.

The bonds preferably are formed in the fabric by distributing heat fusible granules substantially uniformly, yet at random, in the fibrous layer, and then fusing them to cause them to flow into or through the thickness of the layer to imbed a relatively large number of fibers, as described above. The granules are fused and caused to flow by the application of heat and pressure to form strong bonds which surround and anchor the fibers. The granules preferably have an average cross dimension before fusing of the order of about 8 to 30 times the average diameter of the fibers and about 14 to 70 times this diameter after fusing, as mentioned above.

I am aware that it has been proposed to use thermoplastic binder particles or fibers to bond together the fibers of a web or bat to form a flexible absorbent structure. In general, the binder members proposed have been of the same order of size as the fibers to be bonded and in the form of powder or a similar state of fine division, textile fibers of the same general diameter as the structural fibers to be bonded, and the like. Bonds are formed in these fabrics by heating the binder members to a sticky or coalescent state and then applying a relatively high amount of pressure to cause them to adhere to the structural fibers. In such fabrics when strength is desired, the structural fibers are bonded fiber to fiber by a relatively great number of very closely spaced particles or bonding fibers scattered throughout the breadth and thickness of the web. Due to the great number of bonds and their correspondingly close spacing, such fabrics are stiffened and compacted to a degree adversely affecting their loft and handle. On the other hand, when softness is desired, a much smaller number of particles or bonding fibers are used with the result that strength is sacrificed and, of course, washability is not obtained.

I have invented a fabric wherein the bonds are spaced in the fabric sufficiently apart to allow the structural fibers to predominate in determining hand, drape, flexibility, absorbency, and the like, while at the same time being spaced close enough to one another to provide washability and strength. For this purpose the bonds should be large enough that they may be spaced sufficiently far apart for hand, drape, and the like without sacrificing washability and strength, and small enough that they may be spaced sufficiently close for washability and strength without sacrificing the desired textile-like qualities. For effective bonding for this purpose and to enhance the textile-like qualities of the fabric, the structural fibers lie in positions which are generally flat or

parallel to the major plane of the fabric and extend in a plurality of diverse directions parallel to this plane, overlapping and intersecting one another. The fibers are relatively loosely assembled parallel to the major plane of the fabric and relatively closely assembled through the thickness of the fabric with intersecting fibers supporting one another to form an open porous structure.

In general, the granule bonds formed are substantially solid and extend through the fabric, preferably from almost one surface to the other, imbedding a relatively large number of fibers, as mentioned above, with the result that the fibers are held firmly where they pass through the bonds. Those portions of the fibers passing through the bonds are held by the binder in relatively compacted positions with respect to the thickness of the fabric, while the fiber segments between bonds generally are less compacted in this direction, providing a multiplicity of fibrous pillows which preserve the softness of the fabric. If the bonds formed are not spaced sufficiently, the fabric will be stiffened. If the granules are too small, there will not be sufficient bonding material to provide the desired strength and washability when the bonds are spaced to provide the desired textile-like hand and drape, and the like.

Textile-like softness and drape in fabrics are qualities which are well-known and recognized by those skilled in the art and even by consumers, but have not as yet been reduced to satisfactory quantitative measurement. In general, nonwoven fabrics of the character herein described possessing these qualities are soft, drapable, pleasant to handle and without palpable roughness due to the intermittent bonds.

In general, by washability is meant the ability of the fabric to withstand washing by modern techniques without serious effects on its appearance or strength with the result that the fabric is suitable for reuse for the same purpose after laundering. A single cycle wash in a modern horizontal tumbler washer, such as a Bendix home washer, may be used as a test for this purpose, although at least two or three or even more washes are preferred. Prior art nonwoven fabrics which do not possess washability may fail by breaking off of fibers between bonds or by splitting or disintegration of the bonds themselves, with result that the fabrics no longer have utility for their intended purpose. This particularly is true of fabrics comprising fibers of absorbent materials such as viscose rayon, which weakens considerably when wet. An important element affecting washability is the closeness of the spacing between bonds. Granule bonds having a cross dimension of the order of several, preferably about 14 to 70 times the average diameter of the fibers may be spaced sufficiently close to one another when distributed in the fabric approximately uniformly, yet at random, to provide washability, while at the same time allowing the structural fibers to predominate in determining the physical characteristics, i.e., the hand, drape, flexibility, and the like, of the resulting fabric.

As mentioned hereinbefore, the granule bonds must be spaced close enough to one another to provide washability and strength. When the bonds are distributed approximately uniformly in the fabric, average spacing may be estimated for a unit area or unit distance in any direction in the major plane of the fabric. Conveniently, the number of bonds in a representative unit area, say a square inch, may be counted and the square root of the number obtained may be taken to estimate the average number of bonds per linear inch in any direction in the fabric. For instance, in a fabric having approximately 600 granule bonds per sq. inch, which bonds have an average cross dimension or diameter of about 0.015 inch, the estimated average number of bonds per linear inch in any direction in the fabric is about 24.5. This generally is satisfactory from the standpoint of washability.

In general, by granules is meant relatively large particles, which may be approximately circular or square in outline, approximately spherical or of like regular or irregular shapes having over-all lengths and widths of the same general order of magnitude, although under certain circumstances they may have length to width ratios as high as about 3 to 1. In referring to the cross dimension of granules, I mean their average over-all diameter or cross dimension.

The preferred average cross dimension for approximately circular binder particles is between about 0.007 and 0.012 inch, while granules as small as 0.004 and as large as 0.015 inch in diameter may be employed and somewhat larger or smaller granules may be suitable under certain conditions. Corresponding ranges for the average cross dimension of the granule bonds reflect the expansion of the granules which occurs during fusing. For instance, the average cross dimension after fusing for granule bonds in accordance with this invention may range between about 0.007 and 0.035 inch while bonds having cross dimensions between about 0.010 and 0.30 inch are preferred.

The over-all amount or percentage of bonding material or binder in the fabric is an important factor affecting fabric characteristics. If there is not sufficient binder in the fabric, it will not be strong and washable. On the other hand, if there is too much, the fabric will be relatively stiff and possess a harsh hand, generally being low in softness, absorbency, and other textile characteristics. The optimum binder content for a given fabric according to this invention depends upon a number of factors including the nature of the binder material, the size and shape of the granules and their arrangement in the fabric, the nature and length of the structural fibers, total fiber weight, and the like. The most practical range of binder content for most materials appears to be between about 10 and 35 percent of the weight of the fabric, although somewhat lower binder contents may be satisfactory with very strong materials, such as nylon 6 (polycaprolactam), when long structural fibers are employed. In this connection, binder contents between about 15 and 20 percent generally are preferred.

In accordance with this invention, the granules may be distributed amongst the structural fibers during or after formation of the fibrous layer. The layer, with or without the granules, may be formed by any one of a number of conventional techniques for depositing or arranging fibers in a web or layer. These techniques include air laying, papermaking methods, and the like. Individual webs or thin layers formed by one or more of these techniques may be laminated to provide a thicker layer for conversion into a fabric. In general, in such a layer the fibers extend in a plurality of diverse directions in general alignment with the major plane of the fabric, overlapping, intersecting, and supporting one another to form an open porous structure.

In order to provide this open structure of overlapping, intersecting fibers, relatively long textile-like fibers above normal papermaking lengths, of close to normal textile length, say of about 1/4 inch to 2 inches or longer, are preferred, although shorter fibers, somewhat below 1/4 inch in length, as for example, certain papermaking fibers, may be used, particularly if they are mixed with longer fibers. It is preferred that the shorter papermaking fibers be unbeaten or substantially unhydrated.

In general, the average thickness of the fabric will vary with the weight of fibers employed. It is also true that somewhat different bonding problems may arise in forming light and heavy fabrics. For maximum efficiency in the use of binder members according to this invention, a layer of structural fibers weighing at least about 400 grains/sq. yd. is preferred. Satisfactory fabrics according to this invention may be produced from fibrous layers weighing between about 150 grains/sq. yd. or

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slightly lower and about 1200 grains/sq. yd. or even higher. Above about 2000 grains/sq. yd. the fabric may assume more of the characteristics of a fibrous bat than an open porous fabric of the type described.

Granules having average cross dimensions between about 0.004 and 0.015 inch may be distributed in the fibrous layer during or after its formation approximately uniformly, yet at random. As mentioned above, they may be distributed in the layer during its formation by air laying, or papermaking methods. They may be distributed in the layer after formation by filtering an air or water stream containing the granules through the layer with the layer supported on a foraminous backing member or screen having holes small enough to prevent the granules from passing through the screen, or other techniques may be employed for sifting or sprinkling the granules in the layer as uniformly as possible, yet at random.

Bonds are formed by applying heat and pressure to the web or the fibrous layer to fuse the binder material and cause it to surround the fibers and imbed them in the binder members. Prior to fusing, the granules may lie in various positions in the fibrous layer or web with respect to its thickness. They may rest primarily on one side of the web if separately deposited from that side, or they may be more centrally located. However, it is safe to say that wherever they lie, they are supported primarily by the overlapping, intersecting fibers of the web. The granule containing layer is subjected to means capable of applying pressure to both surfaces of the layer at the same time. Heat may be applied before or during the application of pressure. Thus the layer may be placed under or between heated platens such as in a Carver press, passed under rollers which are themselves heated, run between pressure rollers located in an oven, or the like, or the layer may first be heated and then, while still hot, run between unheated calenders or the like, which apply the desired pressure. Sufficient heat is applied to melt or fuse the binder material in the granules to allow the binder to flow slightly under the influence of the pressure applied to pass substantially through the web and imbed the fibers passing above and below the granules. Both the temperature and pressure applied should be controlled so that the granule bonds formed do not distort undesirably.

For a given binder, there is an optimum temperature range for bonding within which the granules must liquify and flow under the relatively gentle pressure applied and not merely become tacky. For instance, for granules of nylon 11 (a polyamide of undecylic acid) bonding may take place at a temperature of around 375° F. with the web containing the rods under a platen pressure of about 50 lbs. per sq. inch or an equivalent roll pressure. Similarly, superior fabrics have been bonded with plasticized ethyl cellulose granules at a temperature of about 415° F. with the web under a pressure of about 50 lbs. per sq. inch. If too high a pressure is applied, the fused binder may be caused to spread excessively in the web thereby weakening the bond and detracting from fabric qualities.

The invention may be illustrated further by reference to the attached drawings, wherein:

Fig. 1 is an enlarged schematic plan view of a portion of a nonwoven fabric according to one embodiment of this invention.

Fig. 2 is an even more greatly enlarged schematic broken sectional view roughly along the line 2—2 of Fig. 1.

Fig. 3 is a very greatly enlarged schematic sectional view through a portion of one of the granule bonds of Fig. 1.

Referring to Figs. 1 and 2 there is shown, on an enlarged scale, a portion of a fabric comprising a layer of overlapping, intersecting fibers 11 which are bonded or held together by a multiplicity of spaced substantially

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solid granule bonds 12 which extend through the thickness of the fabric substantially from one surface to the other, as shown in Fig. 2. The bonds 12 are spaced in the major plane of the fabric A—A and more or less at the same level in the fabric with respect to this plane. Also, as shown particularly in Fig. 2, the fibers 11 lie in positions which are generally flat or parallel to the major plane of the fabric. As shown in Fig. 1, the fibers 11 extend in a plurality of diverse directions in the planes where they lie. This would be true whether or not the fibers 11 in the layer of Fig. 1 were predominately oriented in one direction, as in a card web, or whether they have no particular orientation, as in a random web. The fibers are relatively loosely assembled parallel to the major plane of the fabric, forming myriad small openings or interstices 13 between them as shown roughly in Fig. 1, and are relatively closely assembled through the thickness of the fabric, i.e., overlapping and lying on top of one another, roughly as shown in Figs. 1 and 2.

The over-all cross dimension D of the bonds in the fabric of Figs. 1 and 2 is considerably greater than the original diameter of the granules from which these bonds were formed. The increase in the cross dimension of the binder members is believed to be due mainly to the capillary spreading of the fused binder material under heat and pressure although there may be some direct deformation or flattening of the original binder member by the pressure applying means. The nature of this spreading will be discussed more fully in connection with Fig. 3. Normal spreading or increase in the cross dimension of the bond over that of the granule, itself, may be in the neighborhood of about 2 to 1.

Each bond 12 imbeds or surrounds a large number of fibers which are held firmly thereby. Those portions of the fibers passing through the bonds are held by the binder in relatively compacted positions with respect to the thickness of the fabric, while the fiber segments between bonds generally are less compacted in this direction, providing a multiplicity of fibrous pillows or fluffy web areas 14 which preserve the softness of the fabric. This effect may be achieved by compacting the web during bonding. The fiber containing bonds 12 will remain compacted to a large extent, while the fiber segments in the web areas 14 between bonds will tend to spring back to their original positions after pressure is removed.

The result of binder flow or movement is illustrated to an extent in the very greatly enlarged view of Fig. 3. In this figure, the fibers 11 are shown imbedded in a particular granule bond 12 and extending through the bond in section and in elevation generally in the direction of the major plane of the fabric. The binder material extends substantially from one surface of the fabric to the other, although indentations 16 are shown adjacent these surfaces. Of course, these irregularities would not be apparent when viewing the fabric with the naked eye. The bond 12, itself, is not an absolutely solid mass of binder material extending without interruption from one surface of the bond to the other. Under most conditions, the bonds contain some air-pockets or hollow spots 17.

As mentioned hereinbefore, nylon 6, or polycaprolactam, is considered to be particularly suitable for use in the binder members of this invention. Other binder materials which may be employed with some variations in properties depending upon the conditions of application and the size, shape, and number of the granules, themselves, include plasticized cellulose acetate, plasticized ethyl cellulose, nylon 11 such as sold under the trademark "Rilsan" by Organico, S. A., of France, saran, polyamides other than nylons 6 and 11, polyvinyl chloride, polyethylene, polyurethane, polystyrene, polyvinylidene cyanide, and the like.

Generally speaking, fibers of almost any material may be used for structural purposes in forming fabrics according to this invention. However, relatively flexible fibers are preferred. Fibers possessing particular qualities may

be employed to contribute the same or related properties to the resulting fabric. For instance, relatively absorbent fibers are preferred when a fabric possessing high absorbency is desired. Natural fibers of animal or vegetable origin and artificial fibers whether of materials such as regenerated cellulose or true synthetics such as nylon or the like, may be employed. Fibers of cellulosic materials, such as viscose rayon, cotton, wood and the like, may be used, although as mentioned hereinbefore, the wood fibers should be relatively long and substantially unhydrated for best results.

Nylon 6, nylon 11, plasticized ethyl cellulose and plasticized cellulose acetate granules seem to be particularly suitable for bonding viscose rayon and, in general, form superior bonds with fibers of this and other cellulosic materials. Since viscose rayon fibers, themselves, are very weak when wet, the fact that webs or layers of viscose rayon fibers may be bonded according to the invention to form washable nonwoven fabrics is a surprising demonstration of the efficacy of this bonding system and the strength of the bonds formed.

The following examples are illustrative of certain fabrics and methods according to this invention.

Example I

A layer of fibers and particles weighing approximately 735 grains/sq. yd. comprising approximately 600 grains/sq. yd. of fibers and about 135 grains/sq. yd. of particles is formed by papermaking techniques from a mixture of 1½ denier viscose rayon fibers approximately ½ inch long and about 0.0005 inch in diameter, and ethyl cellulose particles averaging about 0.010 inch in diameter. The ethyl cellulose particles are fused under pressure to force them into full bonding contact with the fibers to form a fabric similar to that shown in Fig. 1. A pressure of about 50 lbs./sq. in. is applied at a temperature of about 415° F. for this purpose. The resulting fabric is strong and capable of withstanding several washes in a modern horizontal tumbler washer such as described hereinbefore. It also is soft and absorbent according to this invention.

Example II

A nonwoven fabric weighing approximately 800 grains/sq. yd. is formed from about 14 percent by weight of approximately spherical granules of nylon 11 about 0.007 inch in diameter and the remainder ¾ inch, 1.5 denier dull viscose rayon fibers about 0.0005 inch in diameter by the techniques of the foregoing example, with the exception that the granules are fused at a temperature of 375° F. instead of 415° F. This fabric possesses textile-like softness and drape as well as absorbency, and is washable by modern techniques as described hereinbefore.

Having now described the invention in specific detail and exemplified the manner in which it may be carried into practice, it will be readily apparent to those skilled in the art that innumerable variations, modifications, applications, and extensions of the basic principles involved may be made without departing from its spirit and scope. Thus, the fabrics of the present invention may be employed in a host of ways that will be readily apparent to the skilled artisan. We therefore intend to be limited only in accordance with the appended patent claims.

The claims are:

1. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively closely assembled through the thickness of the fabric and relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an

average cross dimension in the order of 14 to 70 times the average diameter of the fibers, being in general spaced relatively closely but sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds.

2. A washable nonwoven fabric according to claim 1 wherein the bonds comprise a water resistant thermoplastic material.

3. A washable nonwoven fabric according to claim 2 wherein the bonds comprise a polyamide.

4. A washable nonwoven fabric according to claim 3 wherein the bonds comprise a polyamide of undecylic acid.

5. A washable nonwoven fabric according to claim 3 wherein the bonds comprise polycaprolactam.

6. A washable nonwoven fabric according to claim 2 wherein the bonds comprise ethyl cellulose.

7. A washable nonwoven fabric according to claim 2 wherein the bonds comprise polyethylene.

8. A washable nonwoven fabric according to claim 2 wherein the bonds comprise cellulose acetate.

9. A washable nonwoven fabric according to claim 1 wherein the layer comprises artificial cellulosic fibers.

10. A washable nonwoven fabric according to claim 9 wherein the layer comprises viscous rayon.

11. A washable nonwoven fabric according to claim 1 wherein the layer comprises natural cellulosic fibers.

12. A washable nonwoven fabric according to claim 11 wherein the layer comprises cotton fibers.

13. A washable nonwoven fabric according to claim 1 wherein the layer comprises nylon fibers.

14. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively closely assembled through the thickness of the fabric and relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an average cross dimension in the order of 14 to 70 times the average diameter of the fibers, said bonds comprising between about 10 and 35 percent by weight of the fabric and being in general spaced relatively closely but sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds.

15. A washable nonwoven fabric according to claim 14 wherein the bonds comprise between about 15 and 20 percent by weight of the fabric.

16. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively closely assembled through the thickness of the fabric and relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an average cross dimension in the order of 14 to 70 times the average diameter of the fibers, said bonds being in general spaced apart sufficiently to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds, but being sufficiently close to one another that substantially every fiber is imbedded by said bonds a plurality of times along its length.

17. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly dis-

tributed heat fused granule bonds having an average cross dimension in the order of 14 to 70 times the average diameter of the fibers, said bonds comprising between about 10 and 35 percent by weight of the fabric and being in general spaced relatively closely and sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds, the fibers being embedded in the bonds and relatively compacted with respect to the thickness of the fabric where they pass through the bonds and less compacted in this direction between said bonds.

18. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an average cross dimension between about 0.007 and 0.035 inch, said bonds being in general spaced relatively closely but sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds, the fibers being relatively compacted with respect to the thickness of the fabric where they pass through the bonds and less compacted in this direction between said bonds.

19. A washable nonwoven fabric according to claim 18, wherein the bonds comprise a water resistant thermoplastic material.

20. A washable nonwoven fabric according to claim 19, wherein the thermoplastic material is the polyamide of undecylic acid.

21. A washable nonwoven fabric according to claim 19, wherein the layer comprises viscose rayon fibers.

22. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively closely assembled through the thickness of the fabric and relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an average cross dimension between about 0.007 and 0.035 inch said bonds in general extending substantially through the thickness of the layer, imbedding the fibers passing through them and the bonds being in general spaced relatively closely but sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds, the fibers being relatively compacted with respect to the thickness of the fabric where they pass through the bonds and less compacted in this direction between said bonds.

23. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively closely assembled through the thickness of the fabric and relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them,

and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an average cross dimension between about 0.010 and 0.030 inch, said bonds comprising between about 10 and 35 percent by weight of the fabric and being in general spaced relatively closely but sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds.

24. A soft, textile-like washable nonwoven fabric comprising a layer of overlapping, intersecting fibers lying in positions generally parallel to the major plane of the fabric and extending in a plurality of diverse directions parallel to said plane, the fibers being relatively closely assembled through the thickness of the fabric and relatively loosely assembled parallel to the major plane of the fabric forming myriad small interstices between them, and a multiplicity of randomly but approximately uniformly distributed heat fused granule bonds having an average cross dimension between about 0.010 and 0.030 inch, said bonds comprising between about 15 and 20 percent by weight of the fabric and being in general spaced relatively closely but sufficiently apart to provide a multiplicity of relatively fluffy unbonded fiber areas between bonds, said fabric weighing between about 150 and 1200 grains per square yard.

25. The method of forming a soft, textile-like washable nonwoven fabric which comprises distributing a multiplicity of heat fusible granule binder members having an average cross dimension between about 0.007 and 0.035 inch approximately uniformly yet at random in a loosely assembled layer of overlapping, intersecting structural fibers, said layer comprising a predominate proportion of fibers above about 0.25 inch in length, said granules being relatively closely spaced in the layer, applying heat and pressure thereto to fuse the granules and cause movement of the binder into the thickness of the layer to imbed and anchor at least about five fibers per bond, said heat and pressure being controlled to fuse the binder without destroying the general shape of the binder members.

26. The method of forming a washable nonwoven fabric according to claim 25, wherein the binder is caused to imbed and anchor a majority of the fibers which passed above and below the granules in the layer.

27. The method of forming a washable nonwoven fabric according to claim 25, wherein the binder is caused to move substantially through the thickness of the layer and to imbed substantially all of the fibers which passed above and below the granules in the layer.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,880,113

March 31, 1959

Arthur H. Drelich

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 45, after "with" insert -- the --; column 4, line 21, for "about 0.010 and 0.30" read -- about 0.010 and 0.030 --.

Signed and sealed this 14th day of July 1959.

(SEAL)

Attest:

KARL H. AXLINE

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