

[54] **METHODS OF MAKING NONWOVEN TEXTILE FABRICS**

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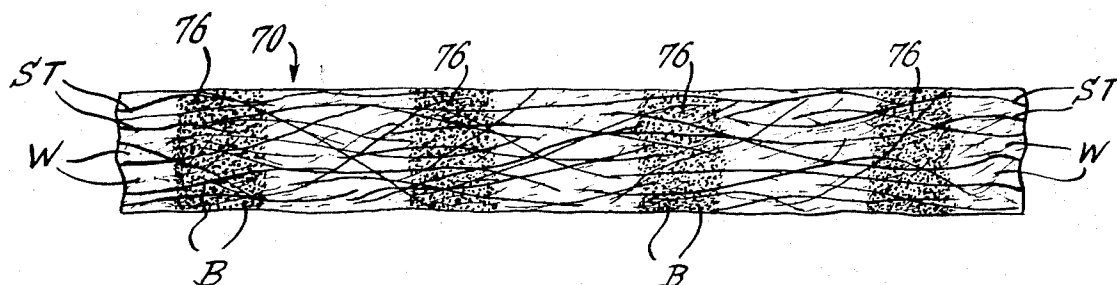
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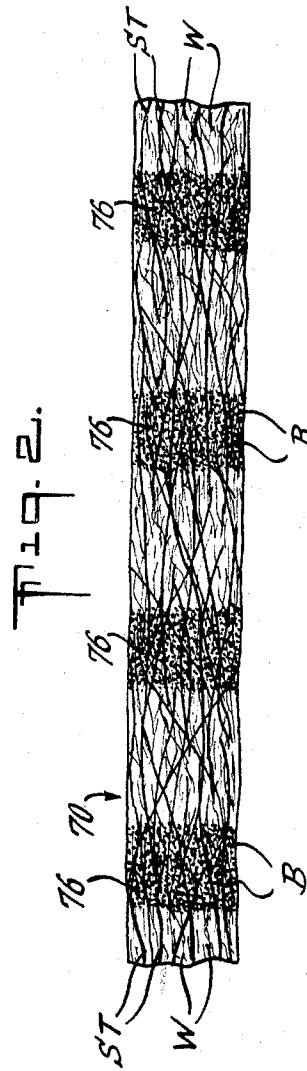
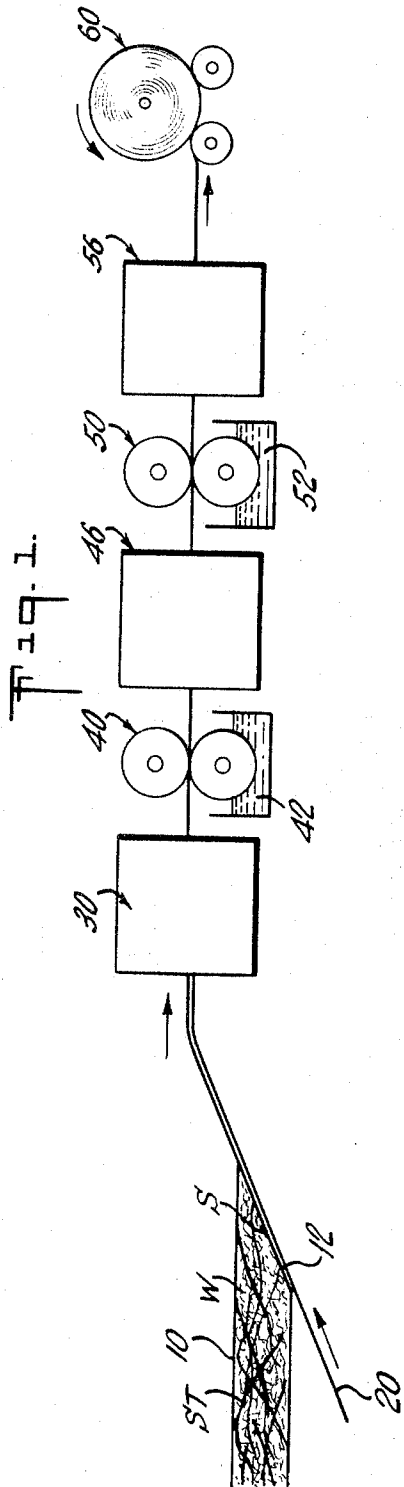
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[57] **ABSTRACT**

A nonwoven textile fabric having excellent softness, drape, and hand, good long and cross tensile strength, good wet abrasion resistance and good washability, and good absorptive capacity and opacity comprising: a relatively flat, sheet-like fibrous structure of from about 30 percent by weight to about 90 percent by weight of overlapping and intersecting structural fibers having an average length of from about ¼ inch to about 1¼ inches or more, and from about 70 percent by weight to about 10 percent by weight of relatively short fibers having an average length of from about 1/6 inch to about 1/25 inch or less; said structural fibers being bonded together by a closely-spaced, non-migrating, intermittent print pattern of discrete synthetic resin binder areas, and said relatively short fibers being bonded together by a substantially uniform, overall application of a relatively soft, synthetic resin binder in an amount of from about 2 percent by weight to about 10 percent by weight, based on the total weight of the finished nonwoven textile fabric. Methods of making such nonwoven textile fabrics, and particularly methods involving the use of wet-forming manufacturing techniques, are also included.

10 Claims, 2 Drawing Figures





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METHODS OF MAKING NONWOVEN TEXTILE FABRICS

BACKGROUND

Many people have been engaged for many years in the manufacture of nonwoven textile fabrics which can be made without resorting to the spinning, twisting, and twining of individual fibers into yarns and strands, and the subsequent weaving, knitting, or other fabricating of these yarns and strands into fabrics.

Such nonwoven textile fabrics have usually been manufactured by laying down one or more fibrous layers or webs of textile length fibers by dry textile carding techniques which normally align the majority of the individual fibers more or less generally lengthwise of the fibrous layer or web being prepared. The individual textile length fibers of these carded fibrous webs are then bonded by conventional bonding techniques, such as, for example, by intermittent print pattern bonding, whereby a unitary, self-sustaining nonwoven textile fabric having excellent softness, drape, and hand is obtained. Such manufacturing techniques, however, are relatively slow and it has always been desired that manufacturing processes having greater production rates be devised. Additionally, it is to be noted that such dry textile carding and bonding techniques, unfortunately, are normally applicable only to fibers having a textile cardable length of at least about $\frac{1}{2}$ inch, and preferably longer, and are not applicable to more economically desirable short fibers, such as wood pulp fibers which have very short lengths of from about $\frac{1}{6}$ inch (0.167 inch) down to about $\frac{1}{25}$ inch (0.040 inch), or even less. And, it is also to be noted that the absorptive capacity and opacity of the resulting nonwoven textile fabrics could stand improving in some uses and applications.

More recently, people have been engaged in the manufacture of nonwoven textile fabrics by wet-forming techniques on conventional or modified paper-making machines or similar apparatus. Such manufacturing techniques have much higher production rates and are applicable to very short fibers such as wood pulp fibers. Unfortunately, however, difficulties are often encountered in the use of the longer textile length fibers in such wet-forming manufacturing techniques.

Additionally, it has been found that such conventional or modified wet-forming manufacturing techniques, when subsequently combined with conventional saturation or over-all bonding techniques, are normally incapable of producing nonwoven textile fabrics which have the necessary softness, drape, and hand, and esthetic qualities of nonwoven textile fabrics, along with the other qualities, properties, and characteristics required for nonwoven textile fabrics. This is particularly true when the nonwoven textile fabrics are to be used in the single-use or limited re-use disposable field, such as for disposable apparel, linens, cleaning and wiping cloths, bandages, dressings, pads, surgical drapes and gowns, diaper linings and facings, etc.

THE INVENTIVE CONCEPT

It has been found that nonwoven textile fabrics having excellent softness, drape, and hand, as well as good long and cross tensile strength, good wet abrasion resistance and good washability, and good absorptive capacity and opacity can be made by:

1. forming a substantially uniform aqueous slurry of from about 30 percent by weight to about 90 percent by weight of structural fibers having an average length of from about $\frac{1}{4}$ inch to about $1\frac{1}{4}$ inches or more, and from about 70 percent by weight to about 10 percent by weight of relatively short fibers having an average length of from about $\frac{1}{6}$ inch to about $\frac{1}{25}$ inch or less;

2. forming a relatively flat, sheet-like fibrous structure of such structural fibers and relatively short fibers;

3. bonding said fibrous structure and particularly the structural fibers therein with a closely-spaced, non-migrating, intermittent print pattern of discrete synthetic resin binder areas; and

4. bonding said fibrous structure and particularly the relatively short fibers therein with a substantially uniform over-all application of a relatively soft, synthetic resin binder in an amount equal to from about 2 percent by weight to about 10 percent by weight, based on the total weight of the finished nonwoven textile fabric.

In the following specification and accompanying drawings, there is described and illustrated a preferred embodiment of the invention but it is to be understood that the inventive concept is not to be considered as limited to the particular embodiment disclosed except as determined by the scope of the appended claims. More specifically, the illustrative embodiment relates to wet-forming methods but it is to be appreciated that other equivalent manufacturing processes can be used in the application of the principles of the present inventive concept. Referring to the accompanying drawings:

FIG. 1 is a schematic drawing showing a typical flow chart of a wet-forming manufacturing process, representing a preferred embodiment of the present inventive concept; and

FIG. 2 is a schematic drawing showing in cross-section the idealized internal construction of the finished nonwoven textile fabric of the present invention.

In the drawings and with particular reference to FIG. 1, there is schematically shown the discharge portion 10 of a papermaking machine headbox associated with a conventional stock chest (not shown) wherein the fibers are formed into a substantially uniform aqueous slurry, preferably in the presence of discrete resin binder particles or like materials and a deposition aid, if required or desired.

STOCK CHEST PREPARATION

The concentration of the fibers in the stock chest aqueous slurry is on the order of from about $\frac{1}{20}$ percent by weight to about $1\frac{1}{2}$ percent by weight, on a dry fiber weight basis. Preferably, such range of fiber concentration in the aqueous slurry is from about $\frac{1}{10}$ percent by weight to about 1 percent by weight.

The concentration of the resin binder particles or like materials in the stock chest aqueous slurry depends on the amount of resin binder particles which are intended to be deposited on the individual fibers. The range extends from about 5 percent by weight to about 100 percent by weight of dry resin solids, based on the total dry fiber weight in the stock chest, and preferably extends from about 15 percent by weight to about 40 percent by weight.

The concentration of the deposition aid in the stock chest slurry should be enough to bring about satisfactory deposition of the resin particles on the fibers in the aqueous slurry. Normally, such concentration is in the

range of from about ½ percent by weight to about 1½ percent by weight, based on the total dry resin solids in the stock chest. Less than about ½ percent by weight of a deposition aid may be used, particularly in the case of nonionic or cationic resin emulsions. More than 1½ percent by weight may be used, particularly when the cationic charge on the particular deposition aid is low. This is basically not desirable inasmuch as a deposition aid having a low cationic charge will necessitate greater concentrations in its use which is commercially undesirable.

FIBERS USED

The substantially uniformly dispersed fibers in the stock chest leading to the discharge portion 10 comprise from about 30 percent by weight to about 90 percent by weight of structural textile length fibers ST having an average length of from about ¼ inch to about 1¼ inches or more and from about 70 percent by weight to about 10 percent by weight of relatively short fibers W having an average length of from about 1/6 inch (0.167 inch) to about 1/25 inch (0.040 inch) or less.

STRUCTURAL FIBERS

The structural textile length fibers ST may be selected from a large group of natural, synthetic or man-made fibers such as: the cellulosic fibers, notably cotton, regenerated cellulose (both viscose and cuprammonium processes), cellulose acetate, and cellulose triacetate; the non-cellulosic fibers such as: the polyamide fibers, notably nylon 6,6 and 6; the polyesters, notably "Dacron", "Fortrel" and "Kodel"; the acrylics, notably "Creslan", "Acrilan" and "Orlon"; the modacrylics, notably "Dynel" and "Verel"; the polyolefins, especially polypropylene and polyethylene, notably "Vectra" and "Herculan"; the spandexes, notably "Lycra" and "Unel"; the fluorocarbons, notably "Teflon" TFE and FEP; etc. These fibers may be used by themselves, or in various combinations and blends of two or more species in varying percentages, as desired or required.

The denier of the synthetic or man-made structural fibers ST may be varied relatively widely, depending on the circumstances, and vary from about 1½ denier to about 6 denier, with lower deniers to about ¾ or less, and higher deniers to about 9, 15, or more, being of use in special circumstances.

SHORT FIBERS

The remaining fibers in the stock chest slurry are wood pulp fibers, or other short fibers W.

Unbeaten or unrefined wood pulp fibers, or at least relatively unbeaten or unrefined wood pulp fibers are preferably used inasmuch as beating and refining are rather severe mechanical treatments, and beat and macerate the fibers whereby enhanced hydration bonding is obtained which is not desired in the present inventive concept and which leads to a product which undesirably has increased stiffness, harshness, and a papery hand.

Although unbeaten hardwood sulfite pulp will be disclosed as the preferred type of wood pulp fiber used in the application of the present invention, substantially any type of wood pulp, either hardwood or softwood, is of use. Examples of other types of wood pulp are: sulfite pulps in which the cooking liquor, calcium or magnesium bisulfite, is acid, or sodium sulfite which is neu-

tral or slightly alkaline; soda pulps in which the cooking liquor, caustic soda, is alkaline; kraft or sulfate pulps in which the cooking liquor, sodium hydroxide and sodium sulfide, is alkaline, etc.

Although wood pulp fibers are preferred in the application of the present inventive concept, other short fibers or fibrous materials are of use. Examples of such short fibers or fibrous materials having lengths of from about 1/6 inch to about 1/25 inch or less are: cotton linters, bagasse, flax, flax straw, jute, straw, bamboo, esparto grass, rayon, rags, and the like, as well as industrial waste products such as macerated or particulate materials from rag, cotton seed hulls, corn stalks, bamboo stalks, etc.

Viscose rayon fibers are the preferred structural textile length fiber. Other structural textile length fibers, as listed herein, may be included in amounts up to about 30 percent by weight of the total structural fiber weight. The relatively short fibers which are usually wood pulp fibers may be included in amounts from about 10 percent by weight up to as high as about 70 percent by weight of the total fiber weight and preferably from about 20 percent by weight to about 50 percent by weight.

It is essential that all these fibers be dispersible, or at least be capable of being dispersed, substantially uniformly in the aqueous slurry. Dispersion aids may be used to assist or promote such uniformity of dispersion.

RESIN BINDER PARTICLES

During the dispersion of the fibers in the stock chest, they may have incorporated thereon from about 5 percent by weight to about 100 percent by weight, and preferably from about 15 percent by weight to about 40 percent by weight, based on the weight of the dry fibers, of discrete particles of a synthetic resin binder B.

The particular resin binder which is incorporated on the fibers is selected from a relatively large class of synthetic resins well known in the art for bonding or adhering fibers of fibrous materials together. Such resins may be of the internal or self cross-linking type, the cross-linkable type which are cross-linked by added cross-linking agents, or the non-cross-linked or non-cross-linkable type. Examples of such synthetic resins include: polymers and copolymers of vinyl ethers; vinyl halides such as plasticized and unplasticized polyvinyl chloride, polyvinyl chloride-polyvinyl acetate, ethylene-vinyl chloride, etc.; polymers and copolymers of vinyl esters such as plasticized and unplasticized polyvinyl acetate, ethylene-vinyl acetate, acrylic-vinyl acetate, etc.; polymers and copolymers of the polyacrylic resins such as ethyl acrylate, methyl acrylate, butyl acrylate, ethylbutyl acrylate, ethyl hexyl acrylate, hydroxyethyl acrylate, dimethyl amino ethyl acrylate, etc.; polymers and copolymers of the polymethacrylic resins such as methyl methacrylate, ethyl methacrylate, isopropyl methacrylate, butyl methacrylate, etc.; polymers and copolymers of acrylonitrile, methacrylonitrile, acrylamide, N-isopropyl acrylamide, N-methylol acrylamide, methacrylamide, etc.; vinylidene polymers and copolymers, such as polyvinylidene chloride, polyvinylidene chloride-vinyl chloride, polyvinylidene chloride-ethyl acrylate, polyvinylidene chloride-vinyl chloride-acrylonitrile, etc.; polymers and copolymers of polyolefinic resins including polyethylene, polypropylene, ethylene-vinyl chloride and ethylene-vinyl acetate which have been listed previously; the

synthetic rubbers such as 1,2-butadiene, 1,3-butadiene, 2-ethyl-1,3-butadiene, high, medium and carboxylated butadiene-acrylonitrile, butadiene-styrene, chlorinated rubber, etc., natural latex; the polyurethanes, the polyamides; the polyesters; the polymers and copolymers of the styrenes including styrene, 2-methyl styrene, 3-methyl styrene, 4-methyl styrene, 4-ethyl styrene, 4-butyl styrene, natural latex; phenolic emulsions; etc.

These resins may be used either as homopolymers comprising a single repeating monomer unit, or they may be used as copolymers comprising two, three, or more different monomer units which are arranged in random fashion, or in a definite ordered alternating fashion, within the polymer chain. Also included within the inventive concept are the block polymers comprising relatively long blocks of different monomer units in a polymer chain and graft polymers comprising chains of one monomer attached to the backbone of another polymer chain.

RESIN DEPOSITION AIDS

The deposition of the synthetic resin binder particles on the individual fibers may be accomplished in many ways at various points in the manufacturing process but, preferably, is accomplished by stock chest deposition techniques. Such techniques generally include (1) the formation of a substantially uniform, aqueous slurry of the fibers which will make up the fibrous structure or web and (2) the inclusion in the aqueous slurry of the synthetic resin binder particles which are to be deposited on and adhered to the individual fibers. Deposition aids may be used, if necessary, to promote the deposition and adherence of the synthetic resin particles on the individual fibers. Examples of such deposition aids are Rohm & Haas Deposition Aid S-243, polyethylene imine, alum, polymeric amines, polymeric amides, cationic starch, etc.

FORMATION OF THE FIBROUS STRUCTURE

Returning to the drawings and particularly FIG. 1 therein, the aqueous slurry containing the structural fibers ST and the short fibers W which have incorporated therewith the discrete particles of resin binder B is discharged through discharge portion 10 onto the open screen-like surface of a moving forming surface 20 which is provided with underlying conventional suction boxes (not shown) whereby a considerable part of the water is drained rapidly from the aqueous slurry to form a relatively flat, sheet-like fibrous structure S in the area 12 of the forming surface 20.

A rectilinearly moving forming surface 20 is disclosed herein but it is to be appreciated that this is merely illustrative of the present inventive concept, and that other forming surfaces such as Fourdrinier wires, inclined wires, screens, belts, rotating cylinders, etc., are of use.

The fibrous structure S is then forwarded to drying means 30 which preferably take the form of a series of heated rotatable drying cylinders. Other drying means such as a single large drying drum, or a heated oven, or the like, are of use, if they are capable of providing an elevated drying, bonding and curing temperature in the range of from about 200° F. to about 350° F. or higher, if desired or required.

The drying at such an elevated temperature serves to activate the bonding characteristics of the resin binder particles, whereby the individual fibers become bonded

to each other. This is particularly important in the case of the short fibers, such as wood pulp fibers, which are effectively bonded and locked in position.

The resin binder particles thus act as a prebonding agent and stabilize the fibrous structure so that it is self-sustaining and can be readily handled and easily manipulated during subsequent processing. Other prebonding means may be employed, provided they are capable of supplying the necessary strength and coherency properties and characteristics required during subsequent processing.

The dried, pre-bonded fibrous structure is then passed through additional bonding apparatus 40 wherein there is applied an additional bonding agent 42 in the form of an intermittent print pattern of closely-spaced discrete binder areas 76. The particular print pattern is selected from a large group of commercially known intermittent print patterns such as, for example, illustrated in U. S. Pat. Nos. 2,705,498, 2,705,687, 2,705,688, 2,880,111 and 3,009,822.

These intermittent, print patterns are closely spaced and are intended to bond even the shortest of the structural fibers in more than one place to develop the required long and cross tensile strength and other qualities, properties, and characteristics required in the finished nonwoven textile fabric.

The synthetic resins which are used to additionally bond the individual structural fibers are selected from the group of synthetic resins listed hereinbefore. The amount of synthetic resin binder applied is in the range of from about 1 percent by weight to about 30 percent by weight, based on the weight of the nonwoven textile fabric being bonded.

Within the more commercial aspects of the present invention, however, the amount of the applied synthetic resin binder is in the range of from about 10 percent by weight to about 20 percent by weight, based on the weight of the nonwoven textile fabric being bonded.

The surface coverage of the binder areas varies widely, depending upon the requirements and needs of the particular circumstances. Normally, a surface coverage of from about 10 percent to about 35 percent of the nonwoven textile fabric is found satisfactory.

It is to be noted that the closely-spaced intermittent print pattern bonding takes place on a dry fibrous substrate in order to limit or restrict the binder migration which would take place if the bonding were to take place on a wet fibrous substrate. Limitation or restriction of binder migration maintains the softness, drape and hand of the resulting nonwoven textile fabric which otherwise could be lost if the binder migration was uncontrolled.

In the event that the application of binder takes place on a wet fibrous substrate, then resort is had to non-migrating binders, such as viscose (see U. S. Pat. 3,009,822), or to various binder migration control systems such as described in copending, commonly-assigned patent application entitled "Improved Resin Binder Compositions, Methods of Utilizing the Same and Resulting Products", Ser. No. 109,026, filed on or about Jan. 22, 1971, now U.S. Pat. No. 3,706,595.

A second dryer 46 is used to dry the fibrous structure subsequent to the intermittent print pattern bonding. This dryer 46 may comprise a series of heated drying cylinders, or a single large heated drying drum, or a heated oven, or the like, as described previously.

The dried, intermittently print pattern bonded fibrous structure is then forwarded to an overall or saturation bonding device or padder 50 whereat an additional binder 52 is applied in overall fashion. Such overall bonding securely ties together the fibrous structure and particularly the relatively short fibers therein. The amount of binder 52 applied in such treatment is in the range of from about 2 percent by weight to about 10 percent by weight, based on the total weight of the finished non-woven textile fabric.

Within the more commercial aspects of the present invention, however, the range of the weight of the applied overall binder is from about 2 percent by weight to about 5 percent by weight, based on the total weight of the finished nonwoven textile fabric.

The particular resin which is applied in overall fashion may be selected from the resins mentioned previously herein, with the condition, however, that the resin, when dried and cured, be relatively soft so as to provide the desired softness, drape and hand. Notable examples of resins suitable for such purpose include acrylic means such as polyethylacrylate; methacrylic resins such as copolymers of methyl methacrylate and ethyl hexyl acrylate; polyolefin and vinyl resins such as copolymers of ethylene and vinyl acetate; carboxylated butadiene-styrene copolymers; etc. The degree of softness is, of course, determined by the requirements and needs of the particular situation and the particular product.

Reactive type resins, and particularly those of the thermosetting variety, which actually react with and heavily cross-link a cellulosic fibrous structure, to yield hard, crease resistant finishes of a permanent press type are to be avoided. Examples of such reactive type resins are ethylene urea formaldehyde, melamine formaldehyde, etc., which not only cross-link with themselves but additionally and undesirably cross-link with the cellulosic fibrous structure itself.

Another dryer 56, similar to any of the drying devices described previously, may be employed to dry the nonwoven textile fabric. Subsequent to drying, the nonwoven textile fabric is forwarded to and wound on a batcher 60 or other re-wind device.

If desired, additional treatments may be applied to the nonwoven textile fabric subsequent to the drying operation in dryer 56 in order to achieve specific purposes and particular properties. An additional oversaturation in a second conventional padder or the like (not shown) with an additional binder or other additives or other treating agents may be resorted to, for example, in order to attain special properties. Such other additives and treating agents include water-proofing agents, water-repellent agents, flame-proofing agents, insect or vermin-proofing materials, dyes and pigments, and the like. Such additional treatment may be used to apply the additional specialty treatment agent or other additive to the extent of from about 2 percent by weight to about 50 percent by weight, based on the weight of the nonwoven textile fabric being treated. Another dryer (not shown), similar to any of the drying devices described previously, may be employed to dry the nonwoven textile fabric, prior to forwarding to the batcher or re-wind device.

In FIG. 2, there is schematically shown in cross-section the idealized internal construction of a typical nonwoven textile fabric 70 of the present invention.

The structural textile length fibers ST and the relatively short fibers W are shown, bonded into a unitary structure by the binder B in the areas 76 and by the overall saturation bonding which substantially uniformly impregnates the entire nonwoven textile fabric.

Nonwoven textile fabrics made by the techniques described herein are found to have excellent softness, drape, and hand, good long and cross tensile strength, good wet abrasion resistance and good washability, and good absorptive capacity and opacity. They are of excellent use as diaper and other facings, towels and wipes, operating room products such as drapes and gowns, and other uses mentioned herein.

The weights of such finished nonwoven textile fabrics vary widely depending upon the particular uses and intended applications. Within the more commercial aspects of the present invention, finished fabric weights of from about 200 grains per square yard to about 1,200 grains per square yard are contemplated. Within the broader aspects of the present invention, however, heavier or lighter fabrics may be made for special uses and applications.

The invention will be further described by reference to the following Examples wherein there are disclosed preferred embodiments of the present invention. However, it is to be appreciated that such Examples are illustrative and not limitative of the broader aspects of the inventive concept.

EXAMPLE I

A wet-formed, nonwoven textile fabric is prepared as follows:

The fibrous structure comprises: 75 percent by weight of rayon fibers having a denier of 1.5 and a length of $\frac{3}{8}$ inch; and 25 percent by weight of unbeaten and unrefined hardwood sulfite wood pulp fibers. These fibers are slurried to a consistency of about 1 percent by weight in a stock chest containing about 50 percent by weight, based on the total dry fiber weight, of Rohm & Haas Resin Emulsion E-631, a self cross-linking (methylol functionality) anionic ethyl acrylate acrylic binder, and about 1 percent by weight, based on the total dry resin solids, of Rohm & Haas Deposition Aid S-243, a moderate molecular weight cationic polyelectrolyte (hydroxy group functionality) deposition aid. When formed on a moving forming surface as shown in FIG. 1, the total weight of the fibrous structure is 230 grains per square yard, of which 184 grains is the fiber weight and 46 is the resin particle weight. This is equivalent to a 20% add-on of resin binder particles.

This fibrous structure is then dried by being passed over heated drying cylinders at a temperature of about 250° F. The individual overlapping and intersecting fibers are bonded to each other.

The dried nonwoven textile fabric is then passed through an intermittent print pattern bonding apparatus of a conventional design. The print pattern comprises a double-diagonal diamond pattern (see FIG. 3, U. S. Pat. No. 2,705,498) wherein there are five lines per inch, with each line 0.020 inch wide, as measured on the binder applying roll. The binder is Rohm & Haas HA-8, primarily a polyethyl acrylate. Lateral migration is minimal. The total finished weight of the nonwoven textile fabric is 291 grains. This represents a print binder add-on of 60 grains per square yard, or about 26

percent by weight, based on the weight of the fabric being bonded.

The dried intermittently print pattern bonded nonwoven textile fabric is then passed through a saturation bonding device or padder and approximately 3 percent by weight on a dry solids basis of a soft acrylic resin Rohm & Haas HA-8 (primarily a polyethyl acrylate) is substantially uniformly applied thereto.

Drying then takes place in a conventional dryer and the finished nonwoven fabric is wound on a take-up roll or batcher.

The nonwoven textile fabric has excellent softness, drape and hand, as well as good long and cross tensile strength, good wet abrasion resistance and good washability, and good absorptive capacity and opacity. It is suitable for use as a diaper facing.

EXAMPLE II

The procedures of Example I are followed substantially as set forth therein with the exception that the fiber blend is 40 percent rayon fibers and 60 percent wood pulp fibers.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE III

The procedures of Example I are followed substantially as set forth therein with the exception that the fiber mixture comprises 65 percent by weight of the rayon fibers, 25 percent by weight of the wood pulp fibers, and 10 percent by weight of polyamide nylon 6,6 having a denier of 6 and a length of $\frac{3}{4}$ inch.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE IV

The procedures of Example I are followed substantially as set forth therein with the exception that the rayon fibers have an average length of $\frac{1}{2}$ inch, instead of $\frac{3}{4}$ inch.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE V

The procedures of Example I are followed substantially as set forth therein with the exception that the rayon fibers have an average length of $\frac{1}{4}$ inch, instead of $\frac{3}{4}$ inch.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE VI

The procedures of Example I are followed substantially as set forth therein with the exception that the resin formulation used for the overall bonding is a soft, carboxylated butadiene (54%)-styrene (43%) resin.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE VII

The procedures of Example I are followed substantially as set forth therein with the exception that the

resin used for the overall bonding is a soft copolymer of ethylene (30%) and vinyl acetate (70%).

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE VIII

The procedures of Example I are followed substantially as set forth therein with the exception that the resin used for the overall bonding is a soft copolymer of methyl methacrylate (40%) and ethyl hexyl acrylate (60%).

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE IX

The procedures of Example I are followed substantially as set forth therein with the exception that the print binder resin comprises National Starch 25-4260, primarily a soft self-reactive acrylic copolymer resin. The saturation bath comprises the same resin formulation.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE X

The procedures of Example I are followed substantially as set forth therein with the exception that the intermittent print pattern binder is viscose instead of polyethyl acrylate. The fiber weight is increased to 220 grains per square yard, the stock chest resin add-on is 56 grains per square yard, and the binder add-on is reduced to 4 percent by weight, based on the weight of the nonwoven textile fabric being bonded, which reduces the finished product weight accordingly to about 295 grains per square yard.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE XI

The procedures of Example I are followed substantially as set forth therein with the exception that the closely-spaced intermittent print pattern comprises 12 lines per inch with each line 0.015 inch wide having an angle of 45° to the long axis.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE XII

The procedures of Example I are followed substantially as set forth therein with the exception that the closely-spaced intermittent print pattern comprises 10 lines per inch with each line 0.020 inch wide.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE XIII

The procedures of Example I are followed substantially as set forth therein with the exception that the closely-spaced intermittent print pattern comprises miniature circular areas 0.015 inch in diameter spaced 0.015 inch from adjacent binder areas in a square pat-

tern as described in Example III of U. S. Pat. 2,880,111.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

EXAMPLE XIV

The procedures of Example I are followed substantially as set forth therein with the exception that the nonwoven textile fabric is given an additional special treatment in another padder containing a conventional flame-proofing agent. The amount of add-on of the flame-proofing agent is 10 percent by weight.

The results are good and are generally comparable to those set forth in Example I. The resulting product is commercially acceptable.

Although several specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific features mentioned therein but to include various other equivalent features 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 method of making a nonwoven textile fabric which comprises:

1. forming a substantially uniform aqueous slurry of from about 30 percent by weight to about 90 percent by weight of structural fibers having an average length of from about $\frac{1}{4}$ inch to about $1\frac{1}{4}$ inches or more, and from about 70 percent by weight to about 10 percent by weight of relatively short fibers having an average length of from about $\frac{1}{6}$ inch to about $\frac{1}{25}$ inch or less, and from about 5 percent by weight to about 100 percent by weight of discrete particles of heat activatable resin binder solids, based on the total fiber weight in the aqueous slurry;

2. forming a relatively flat, sheet-like fibrous structure of such structural fibers and relatively short fibers and discrete particles of resin binder solids;

3. drying said fibrous structure at elevated temperatures whereby said discrete particles of heat activatable resin binder solids prebond said fibers in position;

4. applying a bonding agent to said dried, prebonded fibrous structure and particularly the structural fibers therein in a closely-spaced, intermittent print pattern of discrete synthetic resin binder areas;

5. drying said fibrous structure at elevated temperatures whereby said bonding agent bonds said fibrous structure in said closely-spaced, intermittent print pattern;

6. applying a bonding agent to said dried, intermittently bonded fibrous structure and particularly the relatively short fibers therein in a substantially uniform overall application of a relatively soft, synthetic resin binder in an amount equal to from about 2 percent by weight to about 10 percent by weight, based on the total weight of the finished nonwoven textile fabric; and

7. drying said fibrous structure at elevated temperatures whereby said relatively soft resin binder bonds said fibrous structure in overall fashion.

2. A method of making a nonwoven textile fabric having excellent softness, drape, and hand, good long and cross tensile strength, good wet abrasion resistance

and good washability, and good absorptive capacity and opacity which comprises:

1. forming a relatively flat, sheet-like fibrous structure of from about 30 percent by weight to about 90 percent by weight of structural fibers having an average length of from about $\frac{1}{4}$ inch to about $1\frac{1}{4}$ inches or more and from about 70 percent by weight to about 10 percent by weight of relatively short fibers having an average length of from about $\frac{1}{6}$ inch to about $\frac{1}{25}$ inch or less and from about 5 percent by weight to about 100 percent by weight of discrete particles of resin binder solids, based on the total fiber weight in the aqueous slurry;

2. drying said fibrous structure at elevated temperatures whereby said discrete particles of resin binder solids prebond said fibers in position;

3. applying a bonding agent to said dried, prebonded fibrous structure and particularly the structural fibers therein in a closely-spaced, non-migrating, intermittent print pattern of discrete synthetic resin binder areas;

4. drying said fibrous structure at elevated temperatures whereby said bonding agent bonds said fibrous structure in said closely-spaced, intermittent print pattern;

5. applying a bonding agent to said dried, intermittently bonded fibrous structure and particularly the relatively short fibers therein in a substantially uniform overall application of a relatively soft, synthetic resin binder in an amount equal to from about 2 percent by weight to about 10 percent by weight, based on the total weight of the finished nonwoven textile fabric; and

6. drying said fibrous structure at elevated temperatures whereby said relatively soft resin binder bonds said fibrous structure in overall fashion.

3. A method as defined in claim 1 wherein the concentration of the fibers in the aqueous slurry ranges from about $\frac{1}{20}$ percent by weight to about $1\frac{1}{2}$ percent by weight, on a dry fiber weight basis.

4. A method as defined in claim 1 wherein the concentration of the fibers in the aqueous slurry ranges from about $\frac{1}{10}$ percent by weight to about 1 percent by weight.

5. A method as defined in claim 1 wherein the concentration of the discrete particles of resin binder solids ranges from about 15 percent to about 40 percent by weight.

6. A method as defined in claim 1 wherein a resin deposition aid is included in the aqueous slurry to promote the deposition and adherence of the particulate resin solids to the individual fibers.

7. A method as defined in claim 6 wherein the concentration of the resin deposition aid in the aqueous slurry ranges from about $\frac{1}{2}$ percent by weight to about $1\frac{1}{2}$ percent by weight, based on the total dry resin solids in the aqueous slurry.

8. A method as defined in claim 2 wherein the structural fibers are rayon fibers and the relatively short fibers are wood pulp fibers.

9. A method as defined in claim 2 wherein the structural fibers comprise a mixture of rayon fibers and polyamide nylon fibers and the relatively short fibers are wood pulp fibers.

10. A method as defined in claim 2 wherein the relatively flat, sheet-like fibrous structure is formed on a moving forming surface.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,753,826 Dated August 21, 1973

Inventor(s) Charles H. Plummer

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the references: 5th one, "Walwaites" should read Kalwaites ---.

In Column 4, line 16, "Othr" should read "Other" --

In Column 7, line 22, "acrylic means" should read "acrylic resins" ---.

Signed and sealed this 21st day of May 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents