May 5, 1970 A. R. OLSON 3,510,389

SPOT-BONDED NONWOVEN FABRIC

Filed Aug. 3, 1965 2 Sheets-Sheet 1

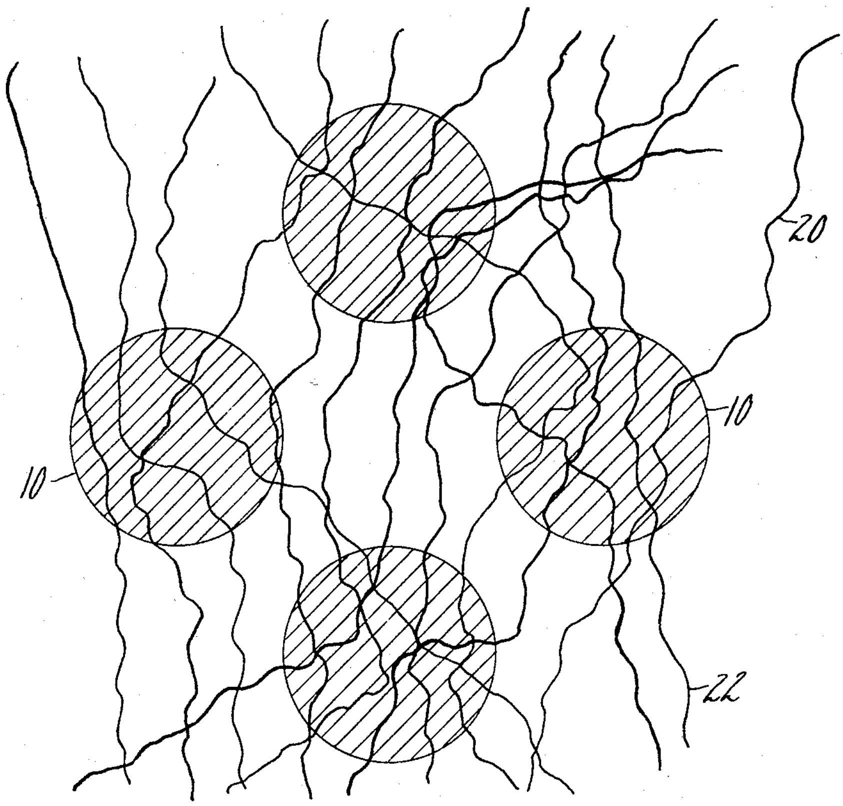


Fig. 1

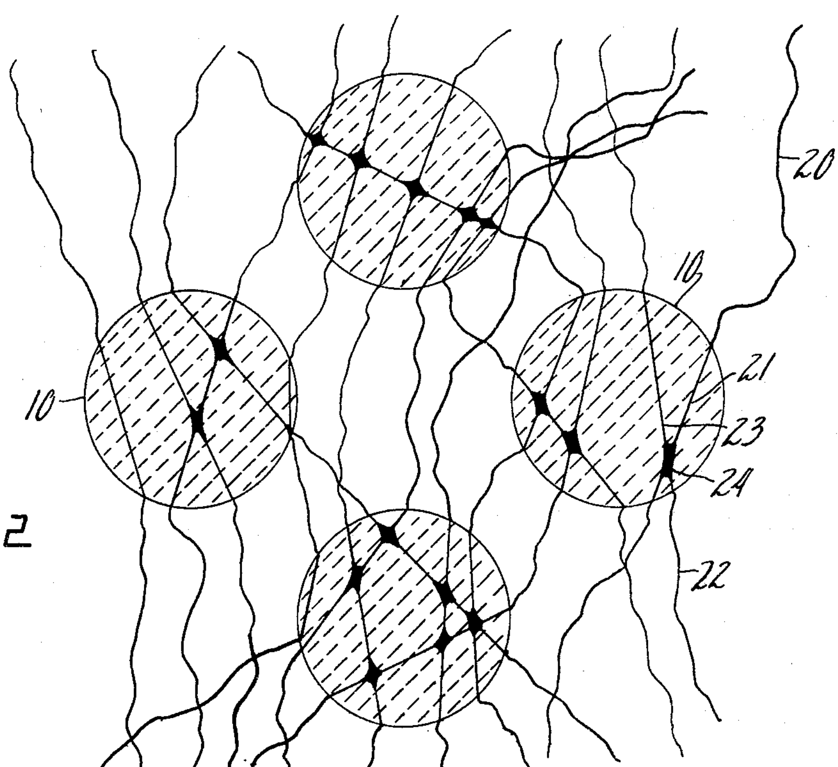


Fig. 2

Fig. 3

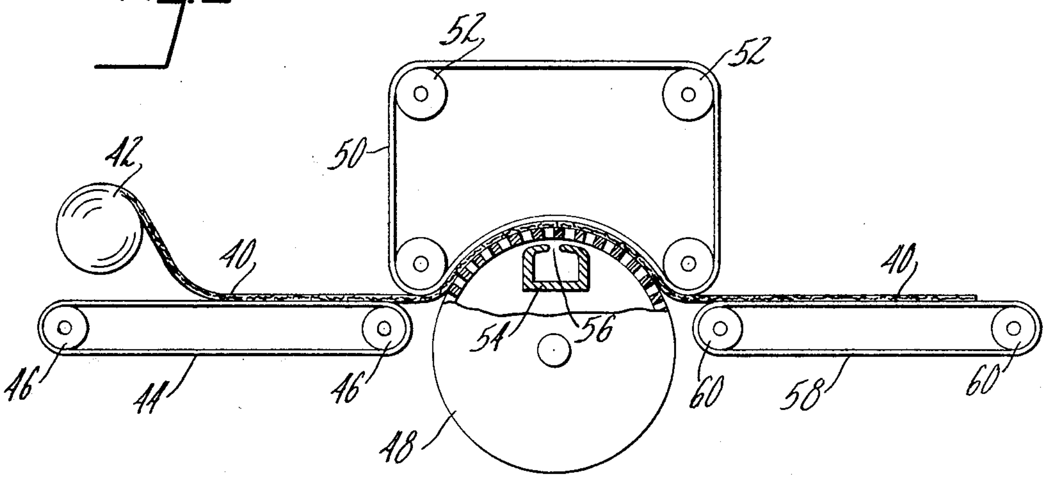
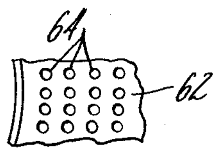


Fig. 4



United States Patent Office 3,510,389
Patented May 5, 1970

3,510,389

SPOT-BONDED NONWOVEN FABRIC

Arthur R. Olson, Walpole, Mass., assignor to The Kendall Company, Boston, Mass., a corporation of Massachusetts

Filed Aug. 3, 1965, Ser. No. 476,870
Int. Cl. D04h *1/04*
U.S. Cl. 161—148 2 Claims

ABSTRACT OF THE DISCLOSURE

A spot-bonded nonwoven fabric is made by supporting a web of textile-length fibers composed at least in part of thermoretractile fibers on a porous surface such as a screen. On the other surface of the web there is applied a screening member bearing a pattern of apertures, and a stream of heated gas is directed through the screening member and the web, to produce a spot-bonded nonwoven fabric wherein the fibers lying underneath the apertures are bonded to each other and are in a tensioned rectilinear configuration.

This invention relates to nonwoven textile fabrics, and their manufacture, in which the integrity of the fabric derives from the autogenous bonding of thermosensitive fibers in a set of spaced-apart and discrete bonded areas. It relates particularly to a method of so treating a web of thermoretractile fibers that certain minor segments of such fibers are bonded at some of their points of intersection and simultaneously tensioned into rectilinear configuration, while the major segments of said thermoretractile fibers remain in a generally relaxed and cursive configuration.

Nonwoven fabrics comprise an array of textile fibers assembled into sheet-like form without the use of conventional spinning and weaving or knitting operations. Such products are conveniently manufactured by bonding fibrous fleeces or webs derived from carding machines, garnetts, air-lay machines, or the like. Bonding may be accomplished by activating selected sensitive fibers included in the web, or by the addition of an auxiliary bonding substance.

It was early recognized in the art that the product resulting from overall bonding or impregnation with a bonding agent in a latex or emulsion form had inherent qualities of rigidity, stiffness, lack of elongation, and lack of fiber freedom which rendered it deficient and unsatisfactory where a soft, drapeable nonwoven fabric of maximum fiber freedom was desired. The desire to overcome this lack of softness and conformability led early to the concept of interrupted or discontinuous bonding, which historically began with the printing of straight or wavy lines of binder across the breadth of the web. Later, short discontinuous line segments, dots, rings, and varied other geometric designs of discrete areas of binder material were applied to fibrous webs in a technique that is commonly referred to as spot, zone, or island bonding, or in general terms as discontinuous bonding.

However, there are numerous disadvantages associated with the use of a liquid binder printing technique. Engraved printing rolls are expensive, as they must be made with great care to insure uniformity of design, and flexibility of operation is difficult to achieve. Moreover, the printing roll is generally capable of carrying only fluid printing media, such as solutions, emulsions, or hot melts, which necessitates the solid binder being put into fluid form during application and then restored to its normal solid condition. Since the printing roll comes in contact with the fibrous web, severe plucking and sticking problems arise unless the web is prebonded or premoistened. Either expedient is expensive and cumbersome.

To overcome such objections it has been proposed to prepare nonwoven fabrics from webs containing a proportion of thermoplastic fibers, by a process which employs a calender roll with raised embossments on its surface. By this method the thermosensitive fibers are compressed into a more dense and more highly unified condition in the vicinity of the embossments than throughout the rest of the web area. However, any sort of calendering operation involves a certain degree of compression of the whole web. Moreover, a heated calender roll is a massive heat source, and it is in general impossible to avoid a certain degree of fusing and hardening of the thermosensitive fibers in the areas away from the vicinity of the embossments. It is generally recognized, therefor, that the difference between the embossed and the unembossed areas is one of degree rather than of kind, and that the maximum softness, extensibility, and conformability of the fibrous web is not conserved.

Accordingly, it is an object of the present invention to provide novel discontinuously-bonded nonwoven fabrics, as well as to provide novel methods for the manufacture thereof, not subject to the above-recited disadvantages of products and methods known heretofore. It is a more specific object of the invention to provide a nonwoven fabric bonded in discrete and spaced-apart areas in which the fiber segments lying within the bonded area are in a tensioned and generally rectilinear configuration, while the fiber segments lying outside the bonded areas are in a generally relaxed and cursive configuration, capable of elongation, as explained more fully below.

It has been found that if a web or fleece of thermoretractile fibers is disposed between a porous support, such as a metal screen against one surface and an apertured masking member against the other surface, and a stream of hot gas is directed against the apertured masking member, a nonwoven product results which is autogenously bonded in a set of spaced-apart areas corresponding to the apertures in the masking member. The process is simple, rapid, and efficient, and is free from the objections involved in the application of extraneous binding material.

The invention will be more clearly understood by reference to the drawings, in which

FIG. 1 represents a section of a prior-art spot-bonded nonwoven fabric, magnified about 6 times,

FIG. 2 represents a section of a spot-bonded nonwoven fabric according to this invention, similarly magnified,

FIG. 3 is a schematic side-elevation of an apparatus suitable for carrying out the process of this invention, and

FIG. 4 is an enlarged detail of one element of the apparatus of FIG. 3.

Referring to FIG. 1, an array of textile fibers is shown in a spot-bonded prior art nonwoven fabric, the discrete and spaced-apart circular bonding areas **10** being made up of an extraneous binder material applied to the fibrous web. The size of the bonding areas has been magnified about 6 times, and only a few fibers are shown for the sake of clarity, two representative fibers being designated as **20** and **22**.

Most natural textile fibers, and man-made fibers intended to be carded, garnetted, or otherwise formed into a cohesive web or fleece suitable for processing into nonwoven fabrics, are curled or crimped, so that inter-fiber friction renders the web to a certain extent self-sustaining. Even when the fibers are to some degree parallelized by a carding operation, as is the case depicted by FIGS. 1 and 2, the fibers normally lie in what may be called a cursive configuration.

For a general description of the process of the invention, reference is made to FIGS. 3 and 4. A fibrous web **40**, containing a desired percentage of thermoretractile and thermofusible fibers, is delivered from a conventional supply source **42** to a conveyor belt **44** driven by rolls **46**, to the upper surface of a cylindrical drum **48**, said drum having its shell perforated into a desired pattern of apertures. The fibrous web is held against the surface of the revolving apertured drum by a porous belt or screen **50** driven by rolls **52**. At an appropriate stage, selected areas of the fibrous web in its traverse around the upper periphery of the revolving drum is exposed to a stream of heated gas, delivered by the hot gas manifold **54** through the slot **56**. It is important that the web **40**, during the bonding process, be held rather snugly between the porous support **50** and the apertured surface of the revolving drum **48**. Under these conditions, the effect of the discrete hot air jets formed by the masking effect of the drum surface on the hot air stream issuing from the manifold slit **56** is confined to selected and predetermined areas, within which the fibers are caused to retract and to fuse to each other at at least some of their points of intersection. The fibers of the web which lie between the apertures of the drum surface are substantially unaffected by the hot air jets which pass through the apertures, and are found to be in a relaxed and cursive configuration between the bonded areas, thus imparting flexibility and conformability to the fabric as a whole.

From the bonding zone the web is then carried around a suitable portion of the periphery of the drum and is removed therefrom by an auxiliary conveyor belt **58** driven by rolls **60**, whence it may be delivered to a conventional wind-up device, not shown.

Various alternative arrangements may be made in the elements of this apparatus without departing from the spirit of the invention. For example, the perforated drum may be mounted above, rather than below, the porous support, so that the hot air jets are directed downwardly. The drum may be replaced by an apertured belt or screen, mounted above or below the web. In the employment of either an apertured drum or an apertured belt, it is understood that the pattern of apertures on this member defines the pattern of bonded areas found in the final product, and that the porosity of the foraminous support or backing member **50** is fine-grained, as in a fine-meshed wire screen, said porosity merely serving as an expedient means for allowing the hot air jets to pass through the web without being deflected into turbulent streams which might distort the fibrous arrangement.

A partially broken-away view of the surface of the apertured drum is shown in FIG. 4, wherein the shell **62** is seen to be perforated with a pattern of apertures **64**. It will generally be found that radiational cooling will keep the drum surface cool enough so that the solid portions of the surface, between the apertures, are not hot enough to cause any appreciable fusing or retracting of the fibers in the regions between the areas which it is desired to bond. However, in the case of ultra heat-sensitive fibers with low transition points, auxiliary cooling of the drum surface may be resorted to. Normally, for conservation of maximum softness and hand, less than one-third of the total drum surface area is taken up by apertures, so that the resulting nonwoven fabric is bonded at separated points the total area of which constitutes less than one-third of the total area of the fabric.

A portion of thus-bonded nonwoven product is shown, enlarged, in FIG. 2, in which the original fiber distribution and configuration was an exact duplicate of FIG. 1. The bonded areas **10**, shown in dotted outline, are not solid areas of binder as in FIG. 1, but are regions within which the fiber segments of the thermosensitive fibers have been subjected to discrete jets of gas heated sufficiently to cause the said fiber segments to retract and to fuse together at at least some of their points of intersection. This is shown in FIG. 2 where the segments **21** of

fibers **20** and **23** of fiber **22**, said segments lying within the region of exposure **10**, have been retracted as shown into a straight-line or rectilinear configuration, and have fused to each other by autogenous bonding at the points **24** where they intersect. Similar fusion points are shown in the other bonded areas, said fusion points lying within the bonded regions **10**, within the confines of which the exposed fiber segments have also been retracted.

There is thus formed a soft, conformable, and extensible nonwoven fabric which owes its structural integrity to autogenous fiber-to-fiber bonding, without the necessity of using extraneous binding materials. Such extraneous binding materials are generally compounded latices or emulsions of polymeric material, including of necessity dispersing agents, surface-active agents, stabilizer, thickening agents and the like which render the binding agent in conventionally-bonded nonwoven fabrics more susceptible to the swelling effects of water and sovents than is the fibrous substance of the web.

The degree of softness and conformability of the products of this invention is surprising considering the recognized difficulties of heating such retractible fibers to their fusion points without encountering either excessive shrinkage of the web, or stiffening of the fibers, or both. The process of this invention, however, allows one to pass through the temperature range of retraction and to reach the fusion point of the fibers, so that they bond together, while confining these effects of heating to isolated and unconnected regions of the web. Due presumably to interfiber friction and to the web being held snugly between the apertured drum surface and the porous support, the retractive force set up within the fibers are not propagated along the fiber to points outside the bonding zone, but are confined within that zone to retract the fiber segments lying therein into a contracted, tensioned, rectilinear configuration. In the areas between the bonding regions, however, the fibers retain their relaxed and cursive configuration.

By thermoretractile and thermofusible fibers is meant those textile fibers composed of synthetic polymeric material which tend to shrink or retract when heated to a temperature below their melting point, usually due to the fiber having been drawn or extended in its manufacture to impart strength and a certain degree of crystalline orderliness. Included in this category are polyolefine fibers such as polyethylene and polypropylene; polyamides such as various nylons; polyacrylics and modacrylics; and polyester fibers. It is characteristic of the process of this invention that spot-bonded nonwoven fabrics can be made from webs consisting entirely of polymeric fibers whose retraction temperature, softening temperature, and fusion temperature are so close together that the bonding of such webs by conventional thermal methods of calender heat and pressure offers almost insurmountable difficulties of shrinkage, melting, and sticking. The production of a nonwoven fabric composed of polyethylene terephthalate fibers by hot-pressing methods, for example, conventionally involves forming and hot pressing an intimate blend of drafted or oriented polyethylene terephthalate fibers with a certain percentage of undrafted polyethylene terephthalate fibers of a lower order of crystallinity and hence a lower melting point. Avoidance of such an expedient by the process of this invention is set forth in the following example.

EXAMPLE 1

A carded web of 3 denier polyethylene terephthalate fiber of the drawn or oriented type, weighing 28 grams per square yard, was processed through the apparatus of FIG. 3 at a rate of 10 yards per minute. Air at a temperature of 550° F. at a velocity of 115 feet per second was directed against the inside upper surface of the drum, which was 15 inches in diameter and was provided with a series of circular apertures ⅛ inch in diameter. The hot air manifold slot was set at 0.020 inch in width. Microscopic examination of the resulting product revealed that in regions corresponding to the apertures in the drum surface, the fibers had been retracted into a tensioned rectilinear configuration, and that they were bonded at their points of intersection. Between the bonded areas, however, the fibers were relaxed, cursive in configuration, and unaffected by the treatment of the process. Unlike the unprocessed card web, which had no measurable strength, the spot-bonded product had a tensile strength of 1.8 pounds per inch-wide strip. Being composed entirely of autogenously bonded polyester material, it was suitable for use as an interlining.

EXAMPLE 2

The above general procedure was repeated on a web of 1.5 denier polypropylene fibers, weighing 15 grams per square yard. The web speed was 5 yards per minute, and in order to avoid over-fusion, the air temperature was reduced to 375° F. A spot-bonded nonwoven fabric resulted which had a strength of 1.6 pounds per inch-wide strip.

Having thus disclosed my invention, I claim:

1. A nonwoven fabric composed at least in part of fibers which are thermoretractile and thermofusible,
said fibers being autogenously bonded to each other at at least some of their points of intersection,

into a set of separated, discrete and spaced-apart bonded areas,
the thermoretractile fiber segments lying within said bonded areas being essentially tensioned and in rectilinear configurations,
while the thermoretractile fiber segments lying outside said bonded areas are in a relaxed and generally nonrectilinear configuration.

2. The product according to claim 1 in which the areas within which the thermoretractile and thermofusible fibers are tensioned constitute not more than about one-third of the total area of the fabric.

References Cited

UNITED STATES PATENTS

3,272,687	9/1966	Harrington et al.	161—170 X
3,276,944	10/1966	Levy	161—150
3,420,724	1/1969	Saunders	161—148 X
3,438,844	4/1969	Kumin	161—150

ROBERT F. BURNETT, Primary Examiner

R. L. MAY, Assistant Examiner

U.S. Cl. X.R.

161—150, 170