Nov. 3, 1970 R. J. SUMMERS 3,537,945

NONWOVENS FROM BULK-YARN WARPS

Original Filed Jan. 6, 1967

FIG. 1

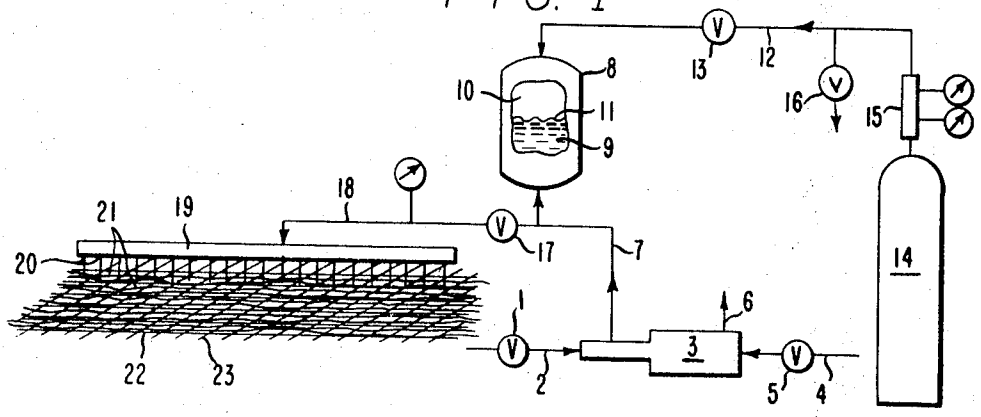
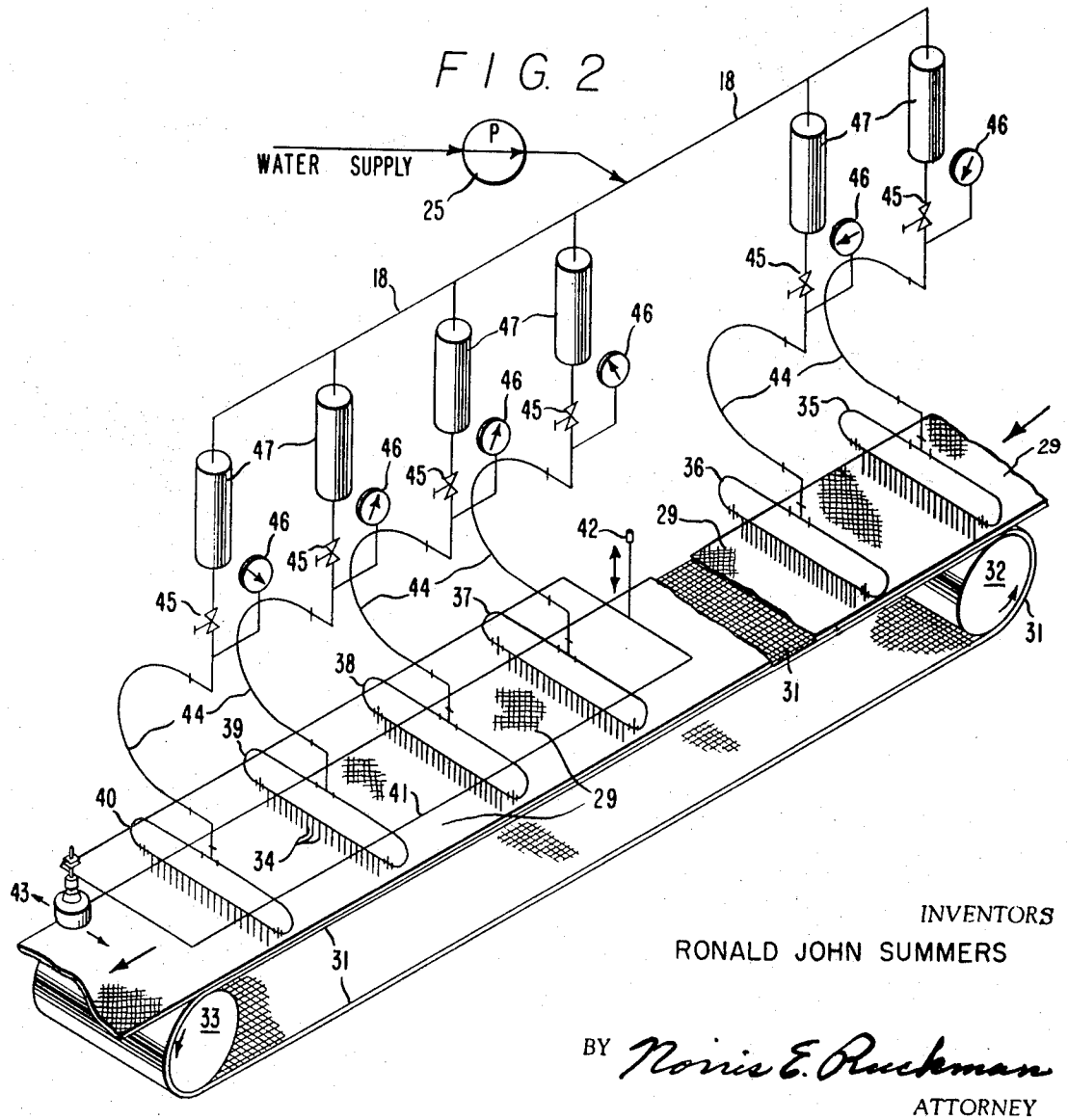


FIG. 2



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NONWOVENS FROM BULK-YARN WARPS

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Original application Jan. 6, 1967, Ser. No. 607,790, now Patent No. 3,434,188, dated Mar. 25, 1969. Divided and this application Jan. 17, 1969, Ser. No. 791,969

Int. Cl. D04h 3/04

U.S. Cl. 161—57 2 Claims

ABSTRACT OF THE DISCLOSURE

Nonwoven fabrics having the appearance and many of the properties of conventional woven textile fabrics are prepared from warp-like arrays of yarns. A layer of yarns is placed on an apertured support and treated with liquid streams of very small diameter formed at unusually high pressure. The treatment is continued until the fibers of adjacent yarns are interentangled to provide a strong nonwoven fabric which, upon removal from the apertured support, is useful for textile purposes without further treatment.

REFERENCE TO RELATED APPLICATION

This is a division of application Ser. No. 607,790 filed Jan. 6, 1967, now Pat. No. 3,424,188, Mar. 25, 1969.

SPECIFICATION

This invention relates to nonwoven fabrics made from warp-like arrays of bulk yarns and to a process for their preparation.

Nonwoven fabrics have been prepared in the past by assembling intersecting arrays of filaments or yarns and bonding the arrays at their intersections. Bonding was accomplished either by applying an adhesive or by using thermoplastic fibers in the arrays and subsequently heating the web to induce fiber-to-fiber fusion. Such nonwoven fabrics are generally stiff and harsh to the touch by reason of the presence of the adhesive or fiber-to-fiber fusion bonds. Moreover, the adhesive adds to the cost of the product and may adversely affect dyeability and other properties needed for optimum utility of the nonwoven fabric.

The present invention provides textile-like nonwoven fabrics which have a soft, aesthetically pleasing hand and which have none of the aforementioned disadvantages of adhesion-bonding or interfiber fusion bonding. The present invention further provides nonwoven fabrics which have the flexibility and drape characteristics of woven fabrics. The present invention also provides a process for the production of these nonwoven fabrics. These and other advantages of this invention will become apparent from the following disclosure.

In accordance with the present invention, nonwoven fabrics are prepared by assembling one or more warp-like arrays of bulk yarns on a suitable supporting surface, treating the assembly with fine, essentially columnar streams of liquid, such as water, at high pressure to interentangle the fibers of adjacent yarns, and continuing the treatment until a strong nonwoven fabric is obtained. Preferably, an array placed over and/or under other arrays is arranged so that the yarns of one array intersect with those of each adjacent array.

By "warp-like array," as used herein, is meant a layer of yarns which lie substantially in one plane and which are substantially parallel to one another.

The term "fiber" is used herein to denote the elements making up the bulk yarn and includes, for example, long or short fibers, continuous filaments, fibrils, or other fiber-like elements.

The term "bulk yarns," as used herein, includes bulky, textured and stretch yarns as defined by A.S.T.M. D123–63 "Standard Definitions of Terms Relating to Textile Materials." These yarns have, as an essential characteristic thereof, a fiber arrangement which provides sufficient free length or crimp along the fibers of the yarn and/or a number of free fiber ends, loops, kinks, curls, and/or twists capable of interentanglement with one another. Preferred yarns are continuous filament yarns which have been textured to impart a random loopiness of fuzziness to the surface of the yarns. These yarns may be of the type having crunodal loops as described in Breen U.S. Pat. No. 2,783,609 issued Mar. 5, 1957. Such yarns may be prepared by a process which involves passing the filament bundle through a fluid jet, jetting the fluid with sufficient force to separate the filaments and form the filaments individually into convolutions, then removing the filaments from the jetted fluid and combining them into a yarn while avoiding tension sufficient to remove the convolutions, as described in Breen U.S. Pats. No. 2,852,906, issued Sept. 23, 1958, and No. 3,017,737, issued Jan. 23, 1962.

Another type of bulk yarn, which may be used in the nonwovens of the present invention, is a yarn of crimped bi- or multi-component composite filaments of the type described in Breen U.S. Pat. No. 2,931,091, issued Apr. 5, 1960, wherein the crimp is brought about not only by a differential in shrinkage in the components of the composites, but by positioning the components in respect to helical crimps so that the component with better tensile recovery properties is the load bearing component. Also desirable are the bulk yarns of helically crimped composite filaments of the type described in French Pat. No. 1, 442,768 granted May 9, 1966.

The bulk yarn may have two types of crimp superimposed upon each other as described in Claussen U.S. Pat. No. 3,167,845 issued Feb. 2, 1965. Other suitable yarns include boucle yarns and bulk spun yarns, especially those of low twist.

The products of the present invention are textile-like nonwoven fabrics comprising at least one layer of bulk yarns which are aligned substantially parallel and joined to one another or to yarns of another layer solely by fiber interentanglement into a stable, unitary fabric. The nonwoven fabric may contain a single layer of these yarns running in one direction and interconnected with one another by fiber entanglement occurring at intervals or all along the adjacent yarns. Preferably, the nonwoven fabric contains at least two warp-like arrays of yarns with the yarns of one array positioned at an angle, desirably 90°, with respect to the yarns of another, the yarns of one array being united with those of the other array by entanglement of fibers of adjacent yarns at the intersections of the yarns.

In another preferred embodiment, the nonwoven fabric comprises three or more warp-like arrays of yarns arranged so that the yarns of the adjacent arrays intersect at a 90° angle while the yarns of non-adjacent arrays (for example the yarns of the first and third layers of the fabric) are in superimposed relationship with respect to one another, the yarns in the non-adjacent arrays being united to one another by entanglement of the fibers of the yarns at the regions where these yarns overlie one another, i.e., in the space between yarns of the intermediate arrays.

The products of the present invention are characterized by a three dimensional, random interentanglement of the fibers of adjacent or intersecting yarns.

In the drawing,

FIG. 1 is a schematic view of one type of apparatus for carrying out the process of this invention, and

FIG. 2 is a schematic isometric view of an apparatus for the high-speed, continuous production of nonwoven fabrics of this invention.

The strong entangled products of the present invention can be produced by treating the yarn assembly with essentially columnar streams of liquid jetted at high pressure, for example, 200 to 2000 pounds per square inch gauge pressure or higher. Such streams are preferably obtained by propelling a suitable liquid, such as water, at high pressure through orifices of small diameter, such as 0.002 to 0.060 inch, under conditions such that the emerging streams remain essentially columnar at least until they strike the yarn assembly. By "essentially columnar" is meant that the streams have a total divergence angle of not greater than about 5°. Particularly strong and surface stable fabrics are obtained by treatment with high pressure liquid streams having an angle of divergence of less than about 3°. The use of essentially columnar streams further provides the advantage of minimizing air turbulence at the surface of the yarn assembly during processing.

Described briefly, the process of the present invention involves placing an assembly of one or more warp like arrays of bulk yarns on a suitable supporting member, such as a screen, so as to permit drainage of liquid, and treating the assembly with the high-pressure, essentially columnar streams until a strong nonwoven fabric is produced. Suitably these streams are obtained by propelling the water through a series of orifices arranged in a single line in a manifold. A plurality of such manifolds can be used, with the axes parallel, for repetitive treatment. Depending on the type of product desired, the assembly may be passed under the streams with the warp-like yarns arranged in different directions with respect to the axis of the manifold. For example, if a plural-layer assembly of such yarns is used, with the yarns of one layer intersecting at right-angles with yarns of another layer, entanglement can be produced primarily at the intersections by passing the assembly under the streams in the bias direction, the streams being spaced so as to strike the assembly at intervals corresponding to the yarn intersections. Similarly, if entanglement is primarily desired between top and bottom arrays of a three-layer warp assembly, bias treatment may be employed with the streams being spaced so as to strike the assembly at intervals between yarn intersections. Another way of treating a plural-layer assembly is to move the assembly under the streams with the yarns of the top and/or bottom arrays perpendicular to the axis of the manifold, or parallel to the axis of the manifold, and to treat with liquid streams spaced to correspond to the yarn spacing.

Many factors influence the ease with which fibers can be entangled. Of particular importance in the products of the present invention is the presence of free ends or loops of fibers in the yarns available for entanglement. The greater the number of free ends and/or loops and the like, the greater will be the entanglement obtained. Other factors which influence entanglement include fiber mobility, which in turn is influenced by the density, modulus stiffness, surface friction properties, denier, and/or length of the fibers in yarns of the assembly. In general, fibers which are highly wettable, or have a high degree of crimp, or have a low modulus or a low denier, can be entangled more readily.

If desired, the yarn assembly may be treated first with a wetting agent or other surface active agent to increase the ease of entanglement, or such agents may be included in the liquid stream.

The extent of entanglement may be increased by varying the size of the orifices from which the streams emerge, by increasing the pressure at which the liquid is delivered, by decreasing the distance the warp is separated from the orifices, and by using more highly columnar liquid streams. Greater entanglement may be obtained by increasing the number of times the assembly is passed into the path of the streams, as by using a plurality of manifolds, or by moving the assembly at lower speeds, or both.

EQUIPMENT

A relatively simple form of equipment for treating the yarn assembly with water at the required high pressure is illustrated in FIG. 1. Water at normal city pressure of approximately 70 pounds per square inch (p.s.i.) (4.93 kg./cm.^{2}) is supplied through valve **1** and pipe **2** to a high-pressure hydraulic pump **3**. The pump may be a double-acting, single plunger pump operated by air from line **4** (source not shown) through pressure-regulating valve **5**. Air is exhausted from the pump through line **6**. Water at the desired pressure is discharged from the pump through line **7**. A hydraulic accumulator **8** is connected to the high-pressure water line **7**. The accumulator serves to even out pulsations and fluctuations in pressure from the pump **3**. The accumulator is separated into two chambers **9** and **10** by a flexible diaphragm **11**. Chamber **10** is filled with nitrogen at a pressure of one-third to two-thirds of the desired operating water pressure and chamber **9** is then filled with water from pump **3**. Nitrogen is supplied through pipe **12** and valve **13** from a nitrogen bottle **14** equipped with regulating valve **15**. Nitrogen pressure can be released from the system through valve **16**. Water at the desired pressure is delivered through valve **17** and pipe **18** to manifold **19** supplying orifices **20**. Fine, essentially columnar streams of water **21** emerge from orifices **20** and impinge on the yarn assembly **22** supported on member **23**.

The streams are traversed over the assembly by moving the member **23** and/or the manifold **19**, until all parts of the assembly to be treated are entangled. In general, it is preferred that the assembly be treated by moving member **23** under a number of fine, essentially columnar streams, spaced apart across the width of the assembly being treated. Rows or banks of such spaced-apart streams can be utilized for more rapid, continuous production. Such banks may be at right-angles to the direction of travel of the assembly, or at other angles, and may be arranged to oscillate to provide more uniform treatment. Streams of progressively increasing pressure may be impinged on the assembly during travel under the banks. The streams may be made to rotate or oscillate, may be of steady or pulsating flow, and may be directed perpendicular to the plane of the assembly or at other angles, provided that they impinge on the assembly at sufficiently high pressure.

Apparatus suitable for use in continuous production is shown schematically in FIG. 2. A pump **25**, which may be one of the types used for supplying water to high pressure steam boilers, is used to provide liquid at the required pressure.

A yarn assembly **29**, prepared by conventional means such as the cross-laying apparatus as described for example in Slayter et al., U.S. Pat. No. 2,797,728, issued July 2, 1957, is supplied continuously to a moving carrier belt **31** of flexible foraminous material, such as a screen. The carrier belt is supported on two or more rolls **32** and **33** provided with suitable driving means (not shown) for moving the belt forward continuously. Six banks of orifice manifolds are supported above the belt to impinge liquid streams **34** on the yarn assembly at successive positions during its travel on the carrier belt. The assembly passes first under orifice manifolds **35** and **36**, which are adjustably mounted. Orifice manifolds **37**, **38**, **39** and **40** are adjustably mounted on frame **41**. One end of the frame is supported for movement on a bearing **42**, which is fixed in position. The opposite end of the frame is supported on oscillator means **43** for moving the frame back and forth across the fibrous layer to provide more uniform treatment.

High pressure liquid is supplied from the pump **25** to the orifice manifolds through pipe **18**. Each manifold is connected to pipe **18** through a separate line which in-

cludes flexible tubing **44**, a needle valve **45** for adjusting the pressure, a pressure gage **46**, and a filter **47** to protect the valve and jet orifices from foreign particles. As indicated on the gages in the drawing, the valves are adjusted to supply each successive orifice manifold at a higher pressure, so that the assembly **29** is treated at increasingly higher pressure during travel under the liquid streams **34**.

The invention will be better understood from the examples of specific embodiments of entangled products and processes for producing them. The examples illustrate a wide variety of new and useful products, which are provided in accordance with this invention, but are not intended to be limitative.

EXAMPLE I

This example illustrates preparation of a non-woven fabric prepared from intersecting warp-like arrays of helically crimped and looped bulk yarn united by entanglement at the intersections.

The yarns used are 70 denier, 34 filament yarns of side-by-side bicomponent fibers having as one component polyethylene terephthalate, and as the other component poly (trimethylene terephthalate), each component being 50% of the filament. The individual filaments of the yarn have a modulus of 40.4 grams per denier (g.p.d.), tensile strength of 3.26 g.p.d. and an elongation of 19.1%. The filaments in the yarns become highly crimped and looped by steaming them at 100° C. in a relaxed condition. The crimp elongation at 1.5 milligram per denier (mg./d.) load is 25%. Preparation of such yarns is described in French Pat. No. 1,442,768. The yarns are placed substantially parallel to one another at a frequency of 20 per inch (7.9/cm.) in each warp-like array. One such array is laid on another at a 90° angle thereto and the assembly is placed on a 30 x 30 wires/inch (11.8 x 11.8/cm.) screen of 30% open area and held at the edges of the screen so that the yarns are at about 75% of their maximum extension capability. The screen serves only as a support. In this condition and with a top screen over the yarns to help hold them in place, the assembly is treated with essentially columnar water streams formed by supplying water at pressures up to 2000 p.s.i.g. (140 kg./cm.^{2} gauge) to a manifold having 0.005 inch (.012 cm.) orifices spaced at a frequency of 30 per inch (11.8/cm.). During treatment the assembly is spaced approximately one inch (2.54 cm.) from the orifices and the speed of passage under the streams is one yard per minute. The assembly is then removed from the screen and the treatment is repeated on the reverse side of the fabric. The product has good integrity due solely to entanglement between fibers at the yarn intersections. It is a soft flexible fabric of high stretch and recoverable stretch in both directions. The fabric properties are:

	Basis weight, oz./yd.^{2}	Strip tensile strength, lb./in.//oz./yd.^{2}	Elongation, percent	5% secant modulus, lb./in.//oz./yd.^{2}
MD	4.8	2.98	119.7	0.58
XD	4.8	4.26	286	0.36
	G./m^2	G./cm.//g./m.^{2}	Percent	G./cm.//g./m.^{2}
MD	162	15.7	119.7	3.05
XD	162	22.4	286	1.89

Machine and cross directions, MD and XD, respectively, are measured in the directions of the yarns of the fabric.

EXAMPLE II

This example illustrates preparation of a non-woven fabric from a warp-like array running in one direction only.

A single warp-like array of yarns (20/inch) of the type described in Example I is prepared. The yarns are capable of a crimp shrinkage of 65% on boil off. Two such warp-like arrays are laid in a generally parallel direction on a 30 x 30 wires/inch screen of 40% open area, the yarns being in two layers superimposed one on the other. The yarns are placed on the screen in a relaxed condition, the individual filaments being highly crimped and looped, the yarns being essentially parallel to one another. The assembly is treated with essentially columnar streams of water issuing from 0.005 inch orifices arranged at a frequency of 30 per inch in a manifold at pressures up to 1500 p.s.i.g. on each side of the fabric. The 30 mesh screen serves merely as a support during treatment. The assembly is spaced approximately one inch from the manifold during treatment and is passed under the streams at 0.5 yd./min. The product has good cohesion due to entanglement of the highly crimped fibers with adjacent crimped fibers (high amount of free length is available because of the crimped and looped nature of the fibers). The fabric thus obtained has high stretch (80%) in the machine (warp) direction and 40% at 90° to the warp direction.

EXAMPLE III

This example illustrates preparation of a non-woven fabric from textured (bulked) yarn of the type having crunodal loops, the fabric having yarns intersecting at a 90° angle.

A core-effect textured yarn wherein texturing is of the type described in Breen U.S. Pat. No. 2,783,609, having a denier of 2050 and having a high degree of surface loops, is assembled in a warp-like array at 16 yarn/inch. The core yarn is a bright nylon yard having a total denier of 200, containing 34 filaments, and having a twist of ½ turn per inch. The effect yarn, which is textured, i.e., bulked about the core yarn, is composed of a mixture of 200 denier, 34 filament, ½ turn-per-inch bright nylon yarn and 200 denier, 34 filament, ½ turn-per-inch black nylon yarn. Two warp-like arrays are separately prepared by winding yarns on a screen and each warp is wetted and thereby lightly entangled by treatment with water streams at 750 p.s.i.g. The warps are then cut from their screens and placed one on the other at a 90° angle thereto on a 20 x 20 mesh (wires per inch), 36% open area screen, the yarns being kept straight on the screen.

The screen serves as a support during treatment. The assembly is then treated with essentially columnar streams of water issuing from 0.007 inch orifices arranged at a frequency of 20 orifices per inch in a 12-inch long manifold. Treatment consists of four passes under the streams using 500 p.s.i.g. water pressure and two passes at 1000 p.s.i.g., the assembly being covered with a screen during this initial treatment to help hold it in place. The screen is then removed and the assembly is subjected to four passes under the streams at 1000 p.s.i. and four passes at 1500 p.s.i. without any top screen. The resulting fabric is a strong coherent structure resembling a woven fabric, the yarns of which are held together by entangling of the protruding loops of adjacent crossing yarns. The fabric is particularly suitable for outer wear uses. It has a woven-like structure with a high modulus in each of the warp directions and a good bias shear and bias shear recovery.

TESTS FOR EVALUATING PHYSICAL PROPERTIES

In the foregoing examples, the tensile properties are measured on an Instron tester at 70° F. and 65% relative humidity. Strip tensile strength is determined for a sample 0.5-inch wide, using a 2-inch sample length and elongating at 50% per minute, The 5% secant modulus is determined by A.S.T.M. Standard E6–61, part 10, page 1836.

I claim:

1. A strong textile-like nonwoven fabric comprising a layer of bulk yarns aligned substantially parallel and

joined together by fiber entanglement between adjacent yarns, and another layer of bulk yarns aligned substantially parallel and joined together by filter entanglement, the yarns of said layers being positioned at an angle to each other and joined by intertangled fibers at intersections of the yarns.

2. The nonwoven fabric as defined in claim 1 and composed of crimped stretch yarns providing a soft flexible fabric of high stretch and recoverable stretch having a strip tensile strength of about 3 to 4 lb./in. per oz./yd.^{2} in both yarn directions due solely to fiber entanglement between yarns.

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161—70, 173

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,537,945 Dated November 3, 1970

Inventor(s) Ronald John Summers

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

Claim 1, column 7, line 3, "filter" should read -- fiber --;

column 7, line 5, "intertangled" should read -- interentangled --.

GRANTED AND
ISSUED
JAN 19 1971

JAN. 19,1971

(SEAL)
Attest:

Edward M. Fletcher, Jr.
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