Feb. 11, 1969 J. J. DEMPSEY 3,427,376

SOFTENING NONWOVEN FABRICS

Filed Sept. 27, 1966 Sheet 1 of 2

FIG. 1

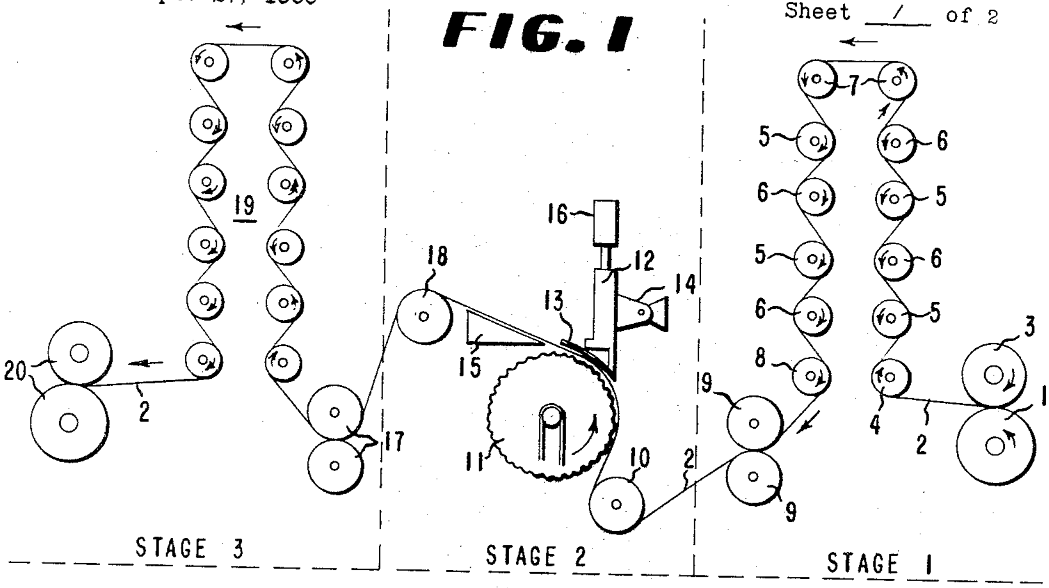
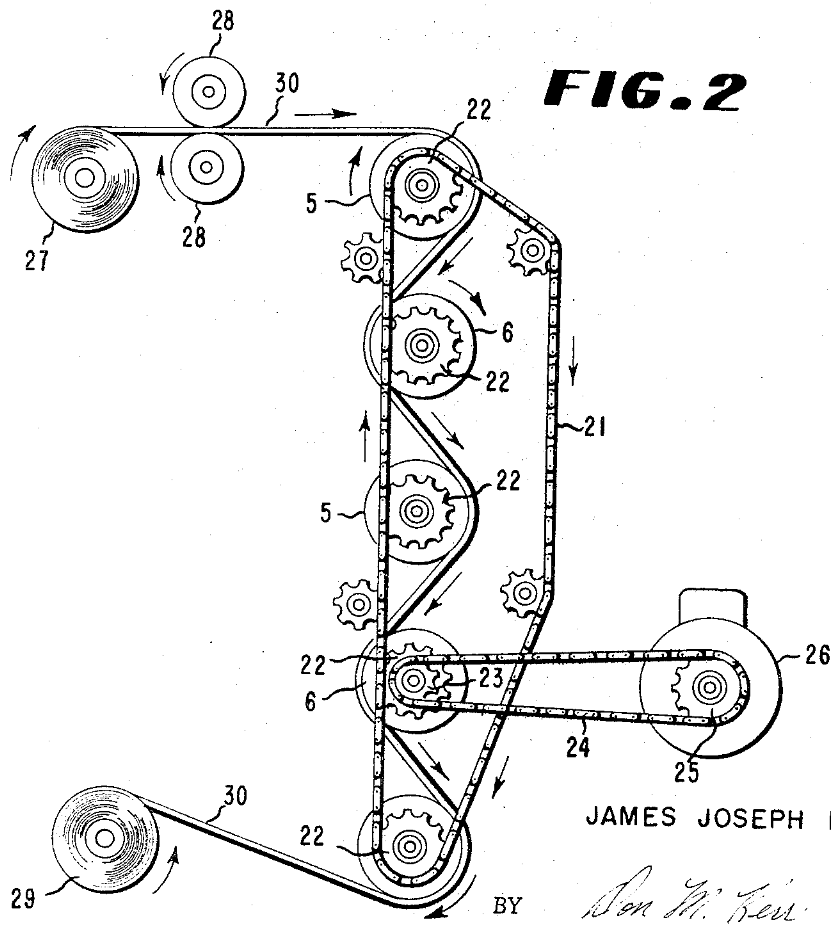


FIG. 2



INVENTOR
JAMES JOSEPH DEMPSEY

BY Don M. Kerr

ATTORNEY

FIG. 3

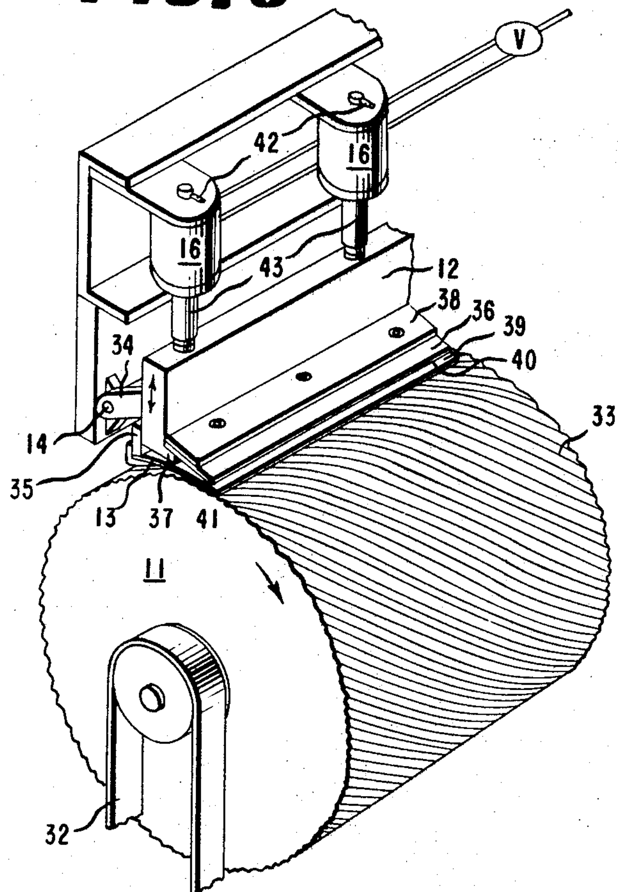


FIG. 4

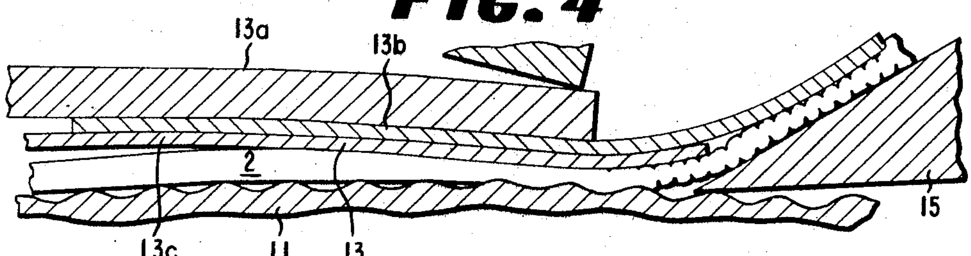
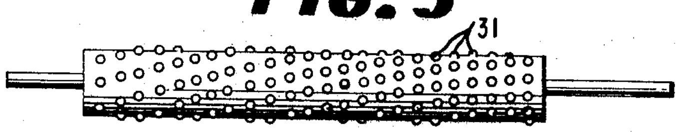


FIG. 5



INVENTOR
JAMES JOSEPH DEMPSEY

BY Don M. Kerr

ATTORNEY

United States Patent Office 3,427,376
Patented Feb. 11, 1969

3,427,376

SOFTENING NONWOVEN FABRICS

James Joseph Dempsey, Richmond, Va., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Filed Sept. 27, 1966, Ser. No. 582,292
U.S. Cl. 264—282 4 Claims
Int. Cl. B31f *1/12;* D06c *3/06*

ABSTRACT OF THE DISCLOSURE

Point-bonded, nonwoven film-fibril sheets are softened by a three step process which includes, in order, button breaking, creping, and button breaking. The button breaker is modified to permit stroking of the sheets counter to the direction of sheet travel. This method permits attainment of a desired level of softness, without delamination, at a commercially practical rate of sheet throughput.

This invention relates to nonwoven fabrics, and more particularly to an improved process for softening a fibrous nonwoven sheet composed of film-fibril elements.

BACKGROUND

A number of devices are known in the textile art for treating sheet materials to change aesthetic qualities such as drape, flexibility and softness. One of the devices is commonly referred to in the trade as a "button breaker," which consists of several free-running "button rolls," the roll surfaces each carrying a multitude of small projections somewhat resembling knobs or buttons. The generally parallel spaced-apart rolls are supported in bearings to permit easy turning in response to the frictional force exerted by fabric pulled over the rolls. In the traditional button breaker the button rolls are not power-driven. The fabric traverses a meandering path by passing approximately one-half turn around each roll and follows then to the next roll, passing around 10 to 20 such rolls during the course of a normal treatment. After processing in this fashion the sheet is finally wound up on a power-driven windup roll. Tension is applied to the fabric during treatment by various means such as by controlling the amount of wrap around each roll or by applying a brake on the feed roll. While the fabric is under tension it is thus softened by the pushing action of the roll projections against small areas of the fabric.

While the button breaker as above described is satisfactory for treating many fibrous sheet materials, it is frequently inefficient or ineffective in treating a new type of nonwoven fibrous sheet, namely "film-fibril sheets." These are randomly laid nonwoven fibrous materials prepared by depositing layers of flash-spun plexifilamentary strand web on a moving belt as described in Steuber U.S. 3,169,899 issued Feb. 16, 1965. The preparation of the flash-spun plexifilamentary strand material is described in Blades and White, U.S. 3,081,519, issued Mar. 19, 1963.

A common deficiency of the conventional button breaker when applied to these film-fibril sheets is that it fails to provide adequate softening, even with multiple passes, or else tends to form undesirable blisters or puffs in the fabric. For this reason an improved driven-roll "button breaker" has been developed and has been described in a copending application of Reitz, U.S. patent application S.N. 421,902, filed Apr. 29, 1964 which is commonly assigned. It comprises a series of generally parallel spaced web-working rolls, means for advancing web in a path about the rolls in a tensioned condition, and drive means for rotating the rolls at different relative speeds than that of the web. The web-working rolls are

provided with a pattern of spaced-apart rounded projections about the major portion of their curved surfaces for stroking the web as it passes in contact therewith. While the driven roll button breaker described in the Reitz application produces better results than earlier devices, further improvements are desirable for commercial operation. Thus an increase in sheet throughput rate results in decreased softness of the treated material. In order to obtain the desired softness at commercially acceptable throughput rates, therefore, multiple units must be provided, thus increasing the investment in equipment. Moreover, even with multiple units the results are not entirely satisfactory. Extensive treatment with the button breaker causes excessive delamination of the film-fibril sheet. Also the softening action of the button breaker is unequal in the two planar dimensions of the sheet. In other words, the sheet is not as soft in the machine (longitudinal) direction as it is in the cross (lateral) direction.

SUMMARY OF INVENTION

According to this invention there is provided a process for preparing a soft textile-like material from a paper-like nonwoven film-fibril sheet. The process involves a sequence of operations utilizing (1) a driven roll button breaker; (2) a creping device wherein lateral folds are produced in the sheet; and (3) a drawing apparatus to remove part or all of the crepe elongation. In a preferred embodiment of the process the final drawing operation is accomplished on a driven roll button breaker with stroking accompanying the drawing.

The process of this invention permits production of a sheet of given softness at a commercially acceptable rate without excessive delamination of the sheet. In addition, the three step process gives a specified level of softness at a higher sheet throughput rate than a two step process involving a creping operation either preceded or followed by a single button breaker operation. Softness measurements indicate that sheets treated in accordance with this invention are about equally soft in their two planar dimensions. Also, the sheets exhibit improved drape characteristics after treatment according to the invention.

The process of the invention comprises passing a bonded film-fibril sheet in sequence through three stages.

Stage 1.—Comprises passing the sheet through a stretching and mechanical agitation zone between a feed position and a take-up position, the speed of the sheet at the take-up position being faster than the speed at the feed position so that sufficient tension is applied to the sheet to stretch it between 0.1 and 10% in the longitudinal dimension of the sheet, intermediate said positions causing the sheet to be stroked in a predetermined pattern of small spaced apart areas across the width thereof to displace portions of the sheet from the general plane thereof, the stroking being directed first to one side of the sheet and then to the other and being applied successively, in any order, both with and against the direction of sheet travel.

Stage 2.—Comprises passing the sheet from the take-up position of Stage 1 through a creping position where the sheet is mechanically detained by the application of pressure exterted normal to the sheet between the two faces of the sheet, the pressure, input speed, and output speed being adjusted to provide numerous lateral fault lines across the sheet such that the spacing between fault lines along the length of the sheet is no greater than about 0.5 inch.

Stage 3.—Comprises passing the sheet from the creping position through a stretching zone between a feed position and a take-up position, the speed of the sheet at the take-up position being faster than the speed at the feed position so that sufficient tension is applied to the sheet to remove at least 80% of the crepe elongation. Crepe elongation, as used herein is defined as the precentage increase in length upon stretching the creped material just to remove all of the crepe. This stage may be a simple drawing operation, or the stretching may be and preferably is, accompanied by mechanical agitation as in Stage 1.

LIST OF FIGURES

FIGURE 1 is a schematic diagram showing three apparatus components arranged in sequence, the combined apparatus being useful for operating the process of the present invention.

FIGURE 2 is an end view of a power-driven button breaker which is useful for performing the operation of both Stage 1 and Stage 3 shown in FIGURE 1.

FIGURE 3 is a perspective view of a creping apparatus which in conjunction with a retarding member is useful for performing the operation of Stage 2 shown in FIGURE 1.

FIGURE 4 is an enlarged cross-sectional diagram of the sheet passing through the creping area between the dried roll, web contacting member, and the retarding member.

FIGURE 5 is a front view of a button roll.

PROCESS DETAILS

FIGURE 1 shows schematically the three stages of the process. While these three operations may be conducted separately, the figure shows one embodiment in which the three stages are coupled together. In any case the first stage of the process is conducted by passing the film-fibril sheet through a power driven button breaker as shown schematically in the area marked Stage 1, the second stage is performed in a creping apparatus, this portion being labeled Stage 2 in FIGURE 1. The final process element comprises passing through a stretching device, in this embodiment a power-driven button breaker as shown in the block marked Stage 3.

Considering first the power-driven button breaking operation of Stage 1 a roll of bonded film-fibril sheet **1** provides sheet **2** at a constant rate by means of the drive roll **3**. The sheet material **2** passes from the feed position to an idler roll **4** and then passed through the series of power-driven button rolls **5** and **6**. The action of the button breaker will be described in subsequent paragraphs in more detail. For the moment it should be observed that in the embodiment shown in FIGURE 1 the rolls on the right side of the machine rotate counter clockwise and those on the left side of the machine rotate clockwise. These rolls are power driven. This is, of course, not true with the commonly used "button breaker" of the textile trade. Each of the rolls **5** and **6** is provided with numerous protrusions or bosses otherwise known as "buttons" on the roll surface. Because of the manner in which the sheet is threaded into the machine some of these button rolls stroke the sheet material in the direction of passage through the machine, namely rolls **5**, while others rolls **6** stroke the sheet counter to its direction of movement. Idler rolls **7** at the top of the machine simply transfer the sheet from one side of the machine to the other side. It is obvious, however, that one of these rolls could be a spreader roll to remove wrinkles. Likewise roll **8** may be either an idler or spreader roll.

Take-up rolls **9** provide a positive nip for applying tension to the sheet during passage through the button breaker rolls. The take-up rolls are positively driven at a peripheral speed which is 0.1 to 10% faster than the feed roll **1**. The successive stroking operations both with and against the direction of movement of the sheet at a multitude of points throughout the sheet area provides a softer sheet and one which is more responsive to further softening operations in the creper.

The sheet product from the first button breaker operation passes to Stage 2 where it undergoes a creping treatment.

The sheet product fed at a constant speed from rolls **9** passes then under an idler roll **10** to the driving roll **11** of a creper. Pressure is applied to the sheet by the head member of the creper indicated by **12**.

A sheet-contacting member **13** presses the sheet into knurls of the creper drive roll **11** to assure that there is no slip of sheet relative to roll. This sheet-contacting member has an extended portion that projects in the form of a cantilever forwardly over roll **11**. The head member is supported by frame-work not shown through a hinge or pivot **14**. A retarding member **15** working in conjunction with the sheet-contacting member **13** provides a retarding action to the forward motion. The position of the retarding member **15** can be adjusted relative to the lip of the sheet-contacting member **13** to establish the dimensions of a cavity wherein the creping action occurs. Air piston **16** or other pressurizing device regulates the pressure on the sheet-contacting member **13**. The pressure at this point is adjusted to provide in the sheet fault lines which are no farther than 0.5 inch apart on the average along the length of the sheet. These fault lines will run laterally in the sheet. The pressure required depends on the location of the retarding member **15** relative to the sheet-contacting member **13**. However, when the pressure exerted by piston **16** is increased, the distance between fault lines becomes smaller-and-smaller and the amount of crepe elongation in the sheet product becomes larger-and-larger.

The input speed for the creper is governed by drive roll **11**. In the coupled process it is the same as the output speed of the take-up position represented by rolls **9** in Stage 1. Considerably more versatility can be obtained, of course, by providing a separate wind-up for collecting the product of Stage 1. This intermediate may then be fed at a convenient operating time from an unwind (not shown) to a separate creping machine. On the other hand the coupled machine offers certain savings in labor and transfer costs. The output speed of the creper is adjusted at a level sufficient to give a product with 2 to 50% crepe elongation. This level of elongation is obtained by setting the relative speeds of roll pair **17** and of drive roll **11**. In other words drive roll **11** should have a surface speed 2 to 50% faster than roll pair **17**. Again, it should be noted that if Stages 2 and 3 are separated, then a separate set of take-up rolls must be provided for Stage 2. In FIGURE 1, roll **18** is an idler roll, but it could be supplemented with a second driven roll to provide a nip if the operations are separated.

In Stage 3 as shown in FIGURE 1 the creped sheet passes through a pair of nip rolls **17** and then to a set of button rolls **19** similar to those of Stage 1. This operation differs in part from Stage 1, since the higher crepe elongation will initially provide considerable more stretch to the sheet product than was available in Stage 1. Stage 3 is then operated to remove at least 80% of the crepe elongation available in the sheet issuing from the creping position. In FIGURE 1 the percent stretch removed is determined by the speed ratio between wind-up rolls **20** and nip rolls **17**.

While FIGURE 1 shows removal of the crepe elongation by means of a button breaker, other stretching apparatus may be used to prepare a satisfactory soft product. Still the use of a driven-roll button breaker with the accompanying mechanical agitation of the sheet is much preferred when the products of still greater softness are desired.

In one variation of the process the nip rolls **17** are used simply as idler rolls and the crepe elongation is removed by controlling the speed of wind-up rolls **20** relative to the speed of drive roll **11**. If this method is used sheet passing from Stage 2 to Stage 3 can with certain speed settings show no appreciable crepe elongation, since this is removed immediately upon formation at the sheet-contacting apparatus. Nevertheless it should be understood that such a process falls within the scope of the present invention. In any case, fault lines will be evident in products made by the process of this invention. Fault lines are tiny creases which run for varying distances across the width of the sheet. They will be present on the average at intervals not more than 0.5 inch apart and preferably not more than 0.2 inch apart. If all of the crepe elongation is removed in Stage 3, then the fault lines may be the only visual evidence that creping has occurred. The existence of fault lines may be observed simply by pushing two ends of the sheet together along its length while holding with the fingers of both hands, leaving up to about 1 inch of the sheet between the two hands. When the sheet is relaxed in this manner, the fault lines become more pronounced and waves show up in the sheet.

The degree of softness obtained in the product increases with increasing amount of stretch in Stage 3. However, if stretching is excessive, delamination of the nonwoven sheet may occur. Considering this limitation, it has been found that a preferred high level of softness is achieved when all of the crepe elongation has been removed provided that any additional stretching is less than 10% based on the de-creped sheet. Products made by removing all crepe elongation are useful for garments, such as disposable swim wear which is acceptable for motel or resort use.

In the event that a simple nip roll draw is used for Stage 3, the resulting sheet is characterized by high drape in one direction as measured by the drape flex method. It has a combination of drape and softness which is desirable for many uses such as in industrial garments.

REQUIREMENTS FOR THE INITIAL SHEET

This invention is particularly effective when applied to randomly laid film-fibril sheets which have been point bonded by exposure to hot bosses as on an embossing roll and/or by coating with polymeric material on each side of the sheet. In such pretreatments it is important to obtain a sheet with sufficient surface stability to resist the heating action of the driven-roll button breaker and with sufficient resistanec to delamination. In any case, however, the bonding should be mild enough so that fiber mobility is maintained at the center of thickness. Materials which have been thoroughly bonded throughout their thickness, for example, by a hot palmer treatment with the sheet kept at about the melting point, are unsatisfactory because of excessive bonding. Cold rolled sheet is unsatisfactory because of insufficient surface stability when subjected to the softening operation.

By "point-bonding" is meant any type of discrete area bonding from resin treatment or from hot fusion, with or without the application of pressure which bonds fibrils at points all the way through the sheet thickness. The fibers in the point bonded sheets are firmly attached to one another within the discrete bonding areas, but can be worked loose from one another in other areas of the sheet. Where film-fibril sheets have been point bonded by heat and fusion, the material is translucent within the bonded areas. About 2 to 50% of the area is bonded. The over-all density of the sheet after point bonding is preferably between 0.19 and 0.40 g./cm.^{3} (11.8 to 25 lbs./ft.^{3}). The bonded areas may be in the form of various shapes such as circles, lines, or rectangles, and they may be placed in such a way as to provide geometric designs in the sheet. They also may exist as annular bonds surrounding perforated areas in the sheet. The point bonded patterns are advantageously applied to the cold contact bonded sheet by passing the sheet through one or more pair of rolls, one of each pair being a hard rubber roll and the other being an embossed roll with raised points over its entire surface. A variety of specific point bonding procedure are well known in the art.

EQUIPMENT DETAILS

A modified button breaker which is particularly useful for operation of the process of this invention has been described in Reitz, U.S. patent application Ser. No. 421,902, filed Dec. 29, 1964. A simplified form of the apparatus is shown in FIGURE 2 there being only five button rolls in this version. In the figure rolls **5** and **6** are interconnected by means of roller chain **21** through sprockets **22**. A second sprocket **23** is provided on an extension of the axle of one button roll **6**.

As shown in FIGURE 2 the second sprocket **23** is in turn connected by roller chain **24** to the sprocket **25** of motor **26**. The motor **26** therefore drives all of the five button rolls in this embodiment with a set speed ratio between each of the rolls and the motor. The ratios can be changed by changing the sprockets to provide ones with greater or lesser number of teeth. Supply roll **27** is used to continuously supply sheet material to the nip of feed rolls **28**. Feed nip rolls **28** are power-driven at constant speed. The winding mechanism of windup roll **29** is provided with a conventional form of constant tension device, not shown. The constant tension windup roll **29** working in conjunction with constant speed feed rolls draws, e.g. extends, the sheet lengthwise during treatment at least 0.1%, the sheet surface speed at the windup being essentially constant. An alternate system may be used whereby the speed of the fabric at the windup roll **29** is controlled by means of a positively driven constant speed roll flexibly mounted above roll **29** and running against the top surface of the accumulated sheet on roll **29**, sufficient frictional force being provided to avoid slipping by properly weighting the constant speed roll. A similar device may be used against supply roll **27**, thereby making it a feed roll of constant speed. In this case feed nip rolls **28** may be omitted. Depending upon the amount of bonding and crepe elongation in the sheet, the sheet may be drawn as much as 10% during treatment. The feed and windup speed ratios are adjusted to provide the required amount of stretch, depending upon whether Stage 1 or Stage 3, and upon the type of product desired.

Rolls **5** and **6** are each provided with a multiplicity of spaced-apart rounded projections **31** ("buttons," knobs or bosses) disposed about the major portion of their curved surfaces as shown in FIGURE 5 which independently displace and distend small areas of the fabric which contact them. In operation of the process the rolls move at a different speed from the fabric passing over them. Consequently, the knobs on the rolls provide a stroking action along the face of the sheet in addition to displacing small areas out of the plane of the sheet.

In operation of Step 1 and optionally of Step 3 of the process of this invention, sheet material **30** passes at a set speed from feed roll **27** as shown in FIGURE 2 to button rolls **5** and **6**. The take-up speed of the sheet is controlled by the speed of take-up roll **29**. With the button rolls **5** and **6** operating in a clockwise direction as seen in FIGURE 2 fabric is passed over the first, third, and fifth rolls in the direction of their rotation, and over the second and fourth rolls in a direction opposite their direction of rotation. The fabric passes around the front side of the fifth button roll and is wound up at roll **29**.

The sequence in which the two sides of the sheet are contacted and the direction in which each roll is turning relative to the direction of sheet travel are not critical. It is only essential that the stroking of the sheet be applied sequentially to both sides and that part thereof be applied in the direction of sheet travel and the remainder against the direction of sheet travel.

In operation of the process the forward moving rolls (relative to fabric) have speeds well above that of the fabric (e.g. 2 to 50 times). Reverse turning rolls may move more slowly, however. The overall fabric speed is controlled by the feed and windup speeds. In order to avoid tearing the fabric or excessive stretching thereof, the tension of the fabric against the button rolls must be controlled at a suitable level. In the embodiment of FIGURE 2 this can be achieved most readily by control of the surface speed ratio of windup roll to feed roll. A windup/feed speed ratio of at least 1.001 is satisfactory for a machine having buttons rolls of 4 inch diameter with centers 9¼ inches apart and the roll axis parallel as well as lying in a single plane. Other methods of varying tension will be apparent. For example to reduce tension the amount of contact of fabric to roll surface can be adjusted by arranging the roll to allow the fabric to follow a path more nearly planar. Regardless of the means used for tension control, however, the tension on the sheet as it is wound up on roll **29** is advantageously between 0.05 and 2.0 lbs. per inch of sheet width.

A creping apparatus which develops lateral folds or fault lines is required for the process. Such a creper permits a sheet of high elongation in the longitudinal direction to be obtained. The mechanical action which accompanies substantial crepe removal is especially beneficial in developing softness. The lateral folds are desirable too because they may be removed by longitudinal stretching which is a simple and inexpensive operation. One satisfactory creping machine is described in U.S. Patent 3,260,778.

One suitable form of the apparatus is shown in FIGURE 3. In the figure roll **11** is driven by means **32.** A gripping surface **33** is provided on the roll, preferably comprising projections and indentations, for example knurled bosses or ribs and grooves.

A pressing apparatus arranged above the roll, has arms **34** that pivot about axle **14**, this axle being parallel to the roll axis. On these arms **34** is mounted a head member **12** which vertically moves toward and away from the roll **11.**

A holder **35** mounted on the head member **12** supports a sheet-contacting member **13.** This sheet-contacting member has an extended portion that projects in the form of a cantilever forwardly over roll **11.** Also mounted on the head member **12** is a pressing member **36**, secured to forward portion **37** of the head member by mounting plate **38.**

Preferably, as shown, the pressing member **36** is a plate that projects forwardly from its mounting as a cantilever, and this plate is resiliently yieldable in the direction perpendicular to its sides. The lower side of the pressing plate **36** can be flat, as shown and at the free end it can intersect plate end surface **39** to define a continuous, straight pressing edge **40** that is parallel to the axis **35** of roll **11.** This edge **40** is pressed against the forward margin **41** of sheet-contacting member **13.**

A number of air cylinders **16** are mounted above the head member **12** and are provided with adjustment devices **42** which enable an adjustable downward force to be applied through piston rods **43** to the head member **12.**

FIGURE 4 shows a preferred arrangement of roll **11**, sheet-contacting member **13**, and retarding member **15.** The sheet-contacting member **13** comprises a plurality of spring metal layers **13*a*, 13*b***, and **13*c***. The layer adjacent the sheet (**13*c***) has a resilient lip portion, and the pointed leading edge of retarding member **15** is located under this lip portion. Metal layer **13*b*** extends beyond the lip of layer **13*c***, defining, with the surface of retarding member **15** a convergent passage which the sheet must traverse.

For further details of design, operation, and materials of construction for the creping apparatus, reference can be had to U.S. Patent 3,260,778. The entire disclosure of that patent is hereby incorporated by reference.

Example 1

A film-fibril sheet weighing about 1.3 oz./yd.^{2} was prepared from linear polyethylene (LPE). The sheet was prepared from networks of material flash spun by the method of U.S. Patent 3,081,519 using trichlorofluoromethane as solvent. The material was randomly deposited on a moving belt by the method of U.S. Patent 3,169,899. A 67 inch wide sheet was obtained. The sheet was lightly consolidated by passing through a pair of cold rolls which exerted a pressure of about 10 lbs./in. of axial length. The rolls were 12–14 inches in diameter.

The cold consolidated sheet was then passed through the nip of a pair of rolls to develop a fine point bonded pattern on one side of the sheet only. One of the rolls was a smooth, hard rubber backup roll while the other roll had a steel surface which carried an embossing pattern. The embossing pattern on the steel roll consisted of tiny raised ridges which followed the circumference of the roll. The circumferential ridges were disposed every 0.158 cm. (1⁄16 inch) across the axial length of the roll. Within the ridges were individual points which were 0.025 cm. (0.01 inch) high relative to the roll surface and which were 0.091 cm. (1⁄28 inch) apart. In preparing the embossed film-fibril sheet the cold consolidated sheet was passed at 20 yds./min. through the roll pair with the steel roll maintained at 158° C. The sheet was trimmed to 52 inches width. Next the sheet was coated on both sides with a dispersion of an ethylene/methacrylic acid (90/10) copolymer. The dispersion was applied by use of a two-side gravure coating method using 44% polymer in the dispersion. The resulting sheet contained 35% polymeric coating approximately evenly divided between the two sides. The center of thickness of the sheet still had movable fibers, the major part of the bonding being at the two surfaces of the sheet. The sheet was trimmed to 47 inches width.

The above prepared sheet was then subjected to a button braking operation using an apparatus similar to that of FIGURE 1, Stages 2 and 3 only. The apparatus consisted of a tandem arrangement of creper and button breaker. Treatment was provided in this apparatus by running first with the creper head lifted out of operating position so that the sheet fed directly to the button breaker. The sheet was then run through the coupled creper and button breaker to provide Stage 2 and 3 treatment.

In the first pass (Stage 1) through the button breaker the sheet wind-up speed was 100 yards per minute. The button breaker used in this experiment had 10 rolls of 4 inch diameter turning in the direction of the sheet at a speed of 600 revolutions per minute (r.p.m.) and 8 rolls of 4 inch diameter running counter to the direction of the sheet at 320 r.p.m. The take-up roll of the button breaker was set at a speed 1.9% faster than the feed roll speed. Due to slippage the actual draw was 1.5%.

In the Stage 2 and 3 operation of the sheet the feed and wind-up speed was 150 yds./min. The overfeed was 11.1% in the creping step, nip rolls **17** of FIGURE 1 being run at a speed of 135 yds./min. The sheet was passed continuously through the operating creper head, through a pair of nip rolls and directly to the power-driven button breaker.

In this Stage 3 pass through the button breaker the forward running rolls were rotated at 750 r.p.m. and the counter-rotating rolls at 400 r.p.m.

The sheet product from Stages 1, 2, and 3 in this experiment had no crepe elongation, all of the original 11.1% crepe elongation having already been removed in the last button breaker step. A soft product suitable for use in swimwear was obtained. The final sheet weighed 1.75 oz./yd.^{2}. The softness of the sheet was measured by means of the Handle-O-Meter using TAPPI Method T498–SU65. Lower values indicate greater softness.

Handle-O-Meter (HOM) results taken after each step during the production are shown in Table I. These data indicate that during the softening operation, softness directionally (MD/CD) increased in the button breaking step, but was reduced almost to that of the base material by the subsequent creping-button breaking step. The ultimate softness after Stage 3 indicated by the HOM test was also confirmed by subjective ratings using a number of judges.

TABLE I.—HANDLE-O-METER RESULTS

Process	CD HOM	MD HOM	MD/CD
Before Button Breaking	138.9	176.9	1.3
After 1 Pass Button Break	43.8	104.4	2.4
After Button Break/Crepe/ Button Break	36.1	54.9	1.5

In the table the results are expressed in grams force.

CD indicates cross-direction measurement and MD indicates machine direction.

Other physical properties for this product are shown in Table II.

TABLE II.—PROPERTIES OF SHEET FROM EXAMPLE I

Final basis weight, oz./yd.^{2}	1.75
Tensile strength MD/CD, lbs./in./oz./yd.^{2}	7.9/5.9
Elongation MD/CD, percent at break	22.8/28.6
Modulus MD/CD, lbs./in.^{2}	29070/17043
Tongue tear MD/CD, lbs./in.	3.12/3.09
Delamination resistance MD/CD, lbs./in	0.17/0.11
Drape flex MD/CD, cm.	3.66/3.53

Example II

A cold-consolidated film-fibril sheet was prepared as in Example I by depositing LPE plexifilamentary material on a moving belt and cold rolling. The belt speed was adjusted to produce a sheet weighing 1.5 oz./yd.^{2}. This sheet was hot embossed on one side by the embossing roll described in Example I, the roll temperature being 160° C., whereby a rib pattern was impressed on one side of the sheet. A linen pattern was impressed on the other side of the sheet by a similar technique. The sheet was coated on both sides as in Example I, using the same coating material. This sheet was then subjected to driven-roll button breaker operation with the feed roll operating slower than the take-up roll. It was then passed through a creper with 11.1% overfeed. Finally all of the crepe elongation was removed by drawing between a pair of rolls without benefit of mechanical stroking. In the drawing operation the first pair of rolls was set at about 64.5 yds./min. and the wind-up at about 70 yds./min. The product had improved softness based on Handle-O-Meter data as shown in Table III. In addition it showed a very favorable drape flex value (low values being desirable). is not as good. This example demonstrates the preferred process wherein all of the crepe elongation is removed and wherein this operation is accompanied by mechanical stroking action. In other tests it has been shown that Handle-O-Meter data correlate well with subjective evaluations on softness and these data are more reliable for softness measurement than drape flex values.

Examples IV and V

A linear polyethylene film-fibril sheet weighing 1.3 oz./yd.^{2} was embossed on one side only using the rib pattern described in Example I. The sheet was coated on both sides with the same polymeric coating. In both Examples IV and V, the Stage 1 operation comprised treatment on the roll driven button breaker with the feed roll running 5.5% slower than the take-up roll. Stage 2 comprised creping with 11.1% overfeed to provide 11.1% crepe elongation. Finally in Stage 3 the sheet of Example IV was subjected to a simple drawing operation to remove all of the crepe elongation. In Example V the Stage 3 operation comprised treatment on a driven roll button breaker to remove all of the available crepe elongation. Both products had improved softness. However, as shown by the Handle-O-Meter data in Table III, the Stage 3 operation involving the button breaker gave a softer sheet than was obtained in the simple drawing operation.

Examples VI and VII

These two examples demonstrate treatment of the film-fibril sheets without the use of coatings. Sheets weighing 1.3 oz./yd. were embossed on one side with the rib pattern and on the other side with the linen pattern and treated in Stages 1 and 2 as in Example II through V. In Stage 3 the simple drawing operation of Examples II and IV was used; for Example VI the button breaker drawing operation of Examples III, and V was used for Example VII. The product prepared by mechanical button breaking for Stage 3 was exceptionally soft and was therefore useful for industrial garments. Handle-O-Meter data for the two examples are given in Table III. Both of the products were much softer than the untreated embossed sheet.

Example VIII

A 1.5 oz./yd. LPE film-fibril sheet was embossed on one side with a rib pattern and on the other side with a linen pattern using the method of Example II. It was coated on both sides as in Example II. The efficiency of

TABLE III.—COMPARISON OF DRAWING ON SIMPLE DRAW ROLLS VERSUS DRAWING ON BUTTON ROLLS

Example No.	Initial Sheet [a]	Softening Process [b]	Drape-flex [c]		Handle-O-Meter,[d] Avg.
			MD	CD	
II	1.5 oz./yd.^{2} R X L Bonded 2-Side Coated	BB-Cr-D	3.30	3.80	94.5
III	Same as Ex. II	BB-Cr-BB	3.51	3.70	65.0
IV	1.3 oz./yd.^{2} R X O Bonded 2-Side Coated	BB-Cr-D	2.72	2.92	59.0
V	Same as Ex. IV	BB-Cr-BB	3.84	3.04	43.0
VI	1.3 oz./yd.^{2} R X L Bonded Uncoated	BB-Cr-D	3.40	3.30	44.0
VII	Same as Ex. VI	BB-Cr-BB	3.47	3.22	33.5

[a] R X L=Rib bonded one side; linen bonded other side.
R X O=Rib bonded one side; no embossing other side.
[b] BB-Cr-D=Button break-Crepe-Draw.
BB-Cr-BB=Button break-Crepe-Button break.
[c] Drape flex measured in centimeter.
CD=Cross-direction.
MD=Machine direction.
[d] Handle-O-Meter data in grams force (units), average of cross-direction and machine direction.

Example III

Example II was repeated except for Stage 3. In this final stage the simple drawing operation was replaced by a motorized button breaker operation and all of the crepe elongation was removed. As shown by the Handle-O-Meter data in Table III a higher degree of softness was obtained than in Example II but machine direction drape

the three-stage process was compared to a process using multiple passes through a power-driven button breaker of the type described in Reitz, U.S. patent application Ser. No. 421,902. The softening process was the same as in Example III. This process was then compared to that using simply multiple passes of the Stage 1 operation until the same level of Handle-O-Meter softness was obtained.

The delamination resistance was observed after each pass. Data are shown in Table IV.

TABLE IV.—COMPARISON OF PROCESS OF THE INVENTION WITH MULTIPLE PASS BUTTON BREAKER PROCESS.

Softening Method	Speed y.p.m.	HOM [a]	Visual Delamination
BB/Crepe/BB	75	65	Acceptable.
1 Pass, Button Breaker	50	116	No delamination.
2 Pass, Button Breaker	[b] 75	89	Acceptable.
3 Pass, Button Breaker	[b] 75	75	Questionable.
4 Pass, Button Breaker	[b] 75	65	Not acceptable.
5 Pass, Button Breaker	[b] 75	56	Totally delaminated.

[a] HOM means Handle-O-Meter measurement in grams force.
[b] First pass for each was 50 y.p.m. Lower sheet speeds in driven roll button breaker gives increased softness.

Taking the Handle-O-Meter softness 65 as a standard, four passes through the button power-driven breaker were needed at approximately 75 yards per minute. Only one pass through the three-stage process was needed. In addition the material prepared by the use of only the button breaker was deficient because of its tendency to delaminate. It was therefore unsatisfactory for use in articles such as rainwear.

The following references define the tests used herein:

Basis weight—TAPPI Method T410–OS61
Handle-O-Meter—TAPPI Method T498–SU65
Drape flex—ASTM Test D1388–64 (Option A)
Tensile strength—TAPPI Method T404–M–50
Elongation at break—Same
Tongue tear—TAPPI T414–M–49

For simplicity in measurement crepe elongation is considered to be the same as the percentage overfeed in the creper.

Delamination resistance is measured using an Instron Tester, 1 inch x 3 inch line contact clamps, and an Instron Integrator, all manufactured by Instron Engineering Inc., Canton, Mass. Delamination of a 1 inch x 7 inch specimen is manually started across a 1 inch x 1 inch edge area (so that the remaining 1 inch x 6 inch portion remains unseparated) by splitting the sheet with a pin. With a "C" load cell, the following settings are used: gauge length of 4.0 inch, crosshead speed of 5.0 inch/minute chart speed of 2.0 inch/minute and full scale load of 2 lbs. One split end is placed in each of the clamps and the force is measured which is required to pull the sheet apart. Delamination resistance (lbs./in.) equals the integrator reading divided by 2500.

I claim:

1. A process for producing a soft textile-like sheet from a paper-like, point-bonded film-fibril sheet which comprises:

(1) passing the sheet through a stretching and mechanical agitation zone between a feed position and a take-up position, the speed of the sheet at the take-up position being faster than the speed at the feed position so that sufficient tension is applied to the sheet to stretch it between 0.1 and 10% in the longitudinal dimension of the sheet, intermediate said positions causing the sheet to be stroked in a predetermined pattern of small spaced apart areas across the width thereof to displace portions of the sheet from the general plane thereof, the stroking being directed first to one side of the sheet and then to the other, and being applied successively in any order both with and against the direction of sheet travel; then,

(2) passing the sheet from the take-up position of Step (1) through a creping position where the sheet is mechanically detained by the application of pressure exerted normal to the sheet between the two faces of the sheet, the pressure, input speed, and output speed being adjusted to provide numerous lateral fault lines across the sheet such that the spacing between fault lines along the length of the sheet is no greater than about 0.5 inch; then,

(3) passing the sheet through a stretching and mechanical agitation zone between a feed position and a take-up position, the speed of the sheet at the take-up position being faster than the speed at the feed position so that sufficient tension is applied to the sheet to remove at least 80% of the crepe elongation, intermediate said positions causing the sheet to be stroked in a predetermined pattern of small spaced apart areas across the width thereof to displace portions of the sheet from the general plane thereof, the stroking being directed first to one side of the sheet and then to the other, and being applied successively in any order both with and against the direction of sheet travel.

2. A process as defined in claim 1 wherein the stretching of the sheet in Step (3) is sufficient to remove all of the crepe elongation.

3. A process as defined in claim 2 wherein the stretching of the sheet in Step (3) is accompanied by mechanical agitation as in Step (1).

4. A process as defined in claim 1 wherein in Step (2) the input speed to the creping position is between about 2% and about 50% greater than the output speed.

References Cited

UNITED STATES PATENTS

Re. 25,335	2/1963	Hamilton	162—113
2,705,497	4/1955	Johnson	128—290
3,047,444	7/1962	Harwood	154—46
3,203,850	8/1965	McCarty	162—113
3,260,778	7/1966	Walton	264—282

ROBERT F. WHITE, *Primary Examiner.*

RICHARD R. KUCIA, *Assistant Examiner.*

U.S. Cl. X.R.

26—51; 162—113; 264—288, 119