Dec. 17, 1968 B. SKINNER 3,416,714

METHOD OF FIBRILLATION

Filed July 5, 1966 2 Sheets-Sheet 1

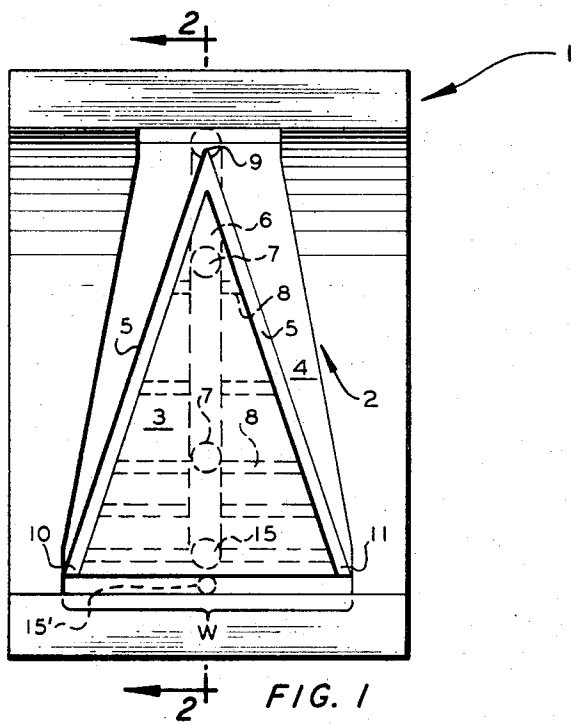


FIG. 1

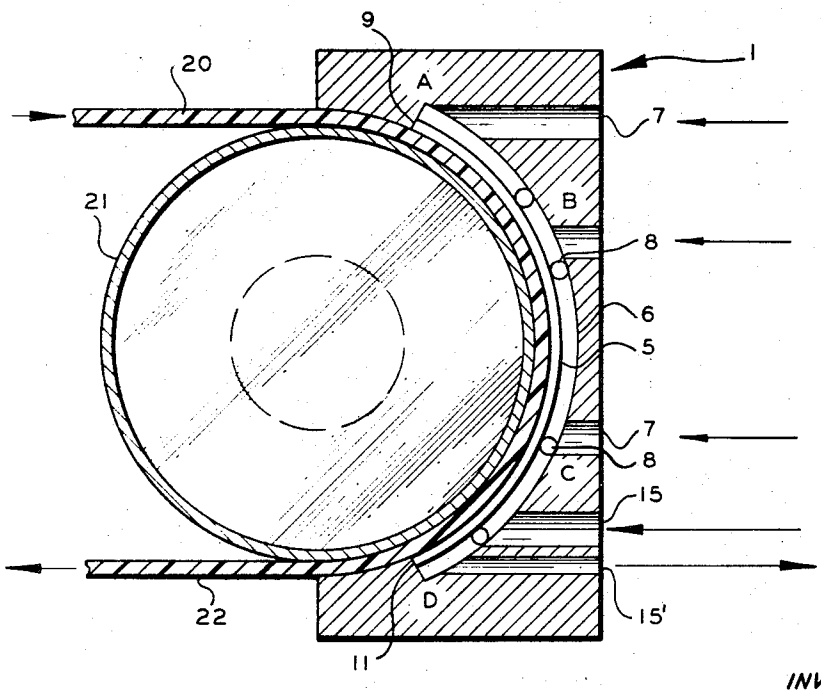


FIG. 2

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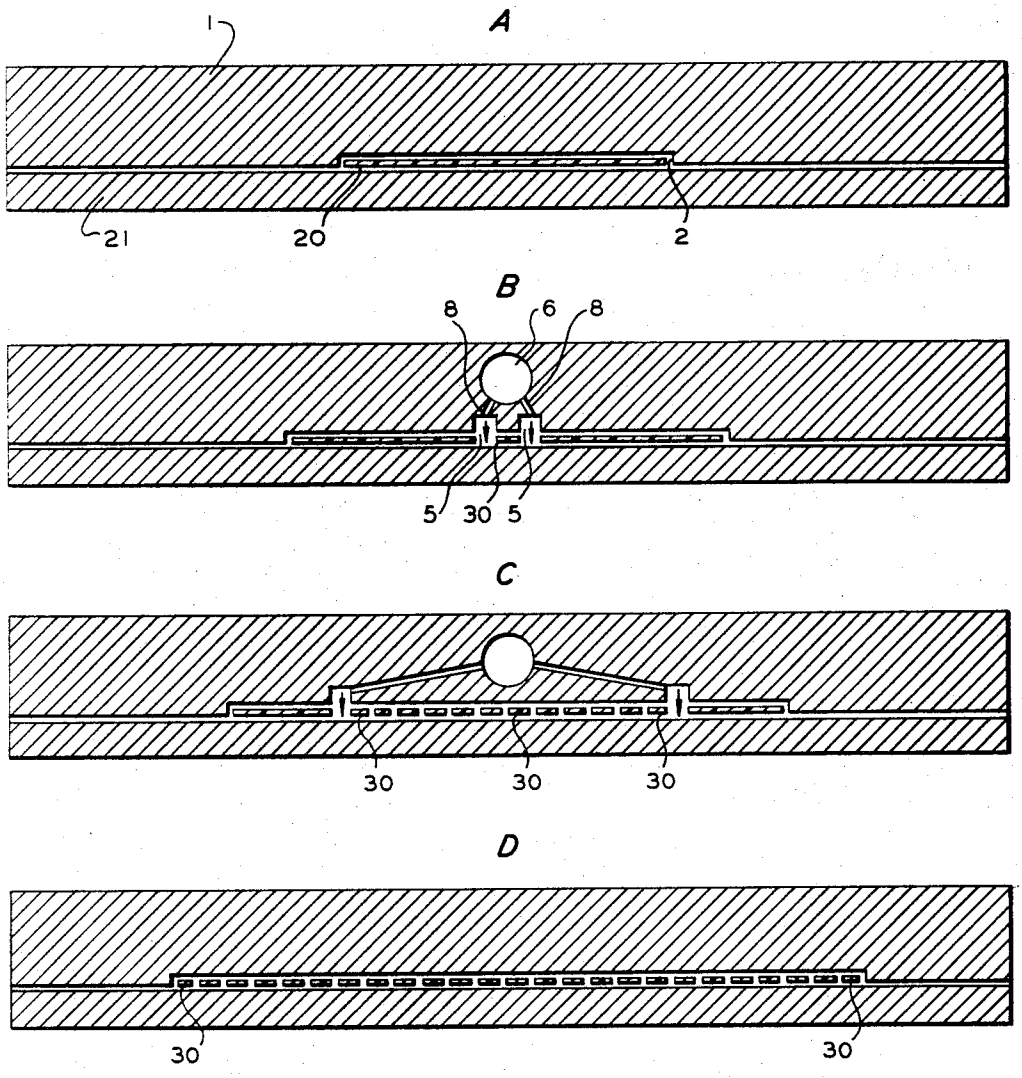


FIG. 3

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METHOD OF FIBRILLATION

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This invention relates to a method for making nonwoven fabric from a fibrillated plastic film or for fibrillating a plastic film.

Heretofore oriented plastic films have been fibrillated, i.e. split into a unitary, integral, coherent network of longitudinally extending fibers integrally joined to one another along the lengths thereof by smaller diameter and shorter fibers, by stretching, rubbing, piercing, beating, and the like. Various methods of fibrillating oriented film and opening out the fibrillated film so that the longitudinal fibers are substantially laterally spaced from one another to an extent greater than in the "as fibrillated" condition are fully disclosed in U.S. Patent 3,003,304, the disclosure of which is incorporated herein by reference. In general many of the processes employed heretofore have randomly applied fibrillation energy to the film. In the case of some of these processes minute areas of the film may be left relatively untouched and therefore not fibrillated.

According to this invention an extremely uniform application of fibrillation or opening out energy across substantially the entire width and length of the film to be fibrillated or fibrillated film to be opened out can be obtained by impinging a high energy fluid stream on a first small, localized area of the film, this first area being substantially smaller than the width or length of the film, and then gradually moving the fluid stream or a counterpart thereof across a succession of similar small, localized areas until the fluid stream has traversed substantially the entire length and width of the film.

Accordingly, the apparatus used in the method of this invention employs a pillow block having an elongate fluid emission means such as a groove extending across at least a part of the width thereof, the width of the portion of the pillow block that contains emission means being approximately the width of the film to be fibrillated or expanded into nonwoven fabric. A header means is operatively connected to the emission means through the pillow block or otherwise in at least one place for supplyign fluid to the emission means. Support means such as a rotary drum is employed in conjunction with the pillow block for moving the film past the pillow block in a substantially contiguous relationship with the emission side of the emission means and in a manner such that the emission means extends across substantially the whole width of the film. Fluid supply means is associated with the header means for supplying fluid to the emission means with sufficient energy to cause fibrillation or expansion of the film when the fluid impinges thereon.

Accordingly, it is an object of this invention to provide a new and improved method for fibrillating oriented film or for expanding a fibrillated film.

Other aspects, objects, and the several advantages of this invention will be apparent to those skilled in the art from the description, drawings, and appended claims.

In FIGURE 1 there is shown the emission side of a pillow block embodying this invention.

FIGURE 2 shows apparatus employing this invention including the pillow block of FIGURE 1.

FIGURE 3 shows a succession of steps effected by the apparatus of FIGURE 2.

In FIGURE 1 there is shown a pillow block denoted generally as **1** wherein there is an inset fibrillation zone denoted generally as **2**. Fibrillation zone **2** is divided

into an internal zone **3** and an external zone **4**, the two zones being divided by a groove **5** which serves as the fluid emission means for fibrillating the film. On the reverse side of the pillow block as shown in FIGURE 1 and extending therethrough in open communication with the groove **5** is a header means having a plurality of large feed conduits **7** openly connected thereto and a plurality of smaller feed conduits **8** openly connecting the header conduit **6** with groove **5**.

The distance W between the bottom two end points of groove **5** is substantially the same as the width of the film to be fibrillated, although narrower and wider films can be treated by the same pillow block if desired. In the case of the treatment of a wider film only a portion thereof will be treated and therefore to obtain complete fibrillation the film could be recycled past the same pillow block again so that the untreated portion could then be fibrillated. In the case of a narrower film complete fibrillation thereof will be obtained when the film reaches the point intermediate the upper point **9** and the bottom points **10** and **11** of groove **5**.

The film to be fibrillated will first pass into contact with groove **5** at the point **9** at which time only that portion of the film which is exposed to point **9** will be fibrillated, then as the film passes downwardly toward ends **10** and **11** successive areas of the film will be exposed to groove **5** and the fluid emitted therefrom. Thus, succeeding areas across the width and length of the film will be fibrillated until the film passes downwardly from points **10** and **11** at which point it has been completely treated with high energy fluid and therefore very uniformly and completely fibrillated. The localized area of the film exposed to the fluid stream can vary widely in size but its largest diameter or side length will generally be less than 50 percent, preferably 30 percent, still more preferably 10 percent, of the film length or width, whichever is the smaller.

A conventional fluid pumping means (not shown) is connected to large feeder conduits **7** to supply the high energy fluid which is emitted from groove **5**.

Conventional sealing means, e.g. a hard rubber flange strip, are applied between the outer edge of groove **5** and zone **4** so that substantial fluid leakage toward the outer edges of pillow block **1** is prevented. Similar conventional sealing means can be employed between the inner edge of groove **5** and zone **3** although this is not as necessary since zone **3** is of limited volume and supplemental amounts of fluid can be supplied by the larger feed conduits that are more closely located to the ends points **10** and **11**, i.e. in the areas of zone **3** of increasing volume. Thus, supplemental fluid is supplied to the header in the areas where the volume of zone **3** is increasing so that any leakage from groove **5** into zone **3** is compensated for. The bottom conduit **15** is an inlet conduit like conduits **7** whereas **15'** is, in effect, an outlet conduit which receives fluid from groove **5** in zone **3** for return to the pumping means and ultimate reuse as a fibrillating fluid. Fluid flow from zone **3** to zone **4** or vice versa should also be avoided since any substantial amount of this type of fluid flow will cause the film to split excessively or bunch toward the center of zone **3**.

Generally, any type of fluid can be employed. Although liquids such as water, or faster drying organic compounds, e.g. acetone, pentane, cyclohexane, and the like, can be employed, air, nitrogen, and similar gaseous materials or mixtures of gaseous and liquid materials can be employed successfully also. The velocity and pressure of the fluid as emitted from groove **5** and impinged on the film to cause fibrillation of same can vary widely depending upon the type of fluid, the composition of film, the degree of orientation of the film, the configuration of groove **5**,

and various other parameters. Thus, it is virtually impossible to quantify the energy required for the fluid emitted but in all cases the energy will be that which is at least sufficient to cause at least some fibrillation of the film when applied to a small, localized area of that film. The fibrillation fluid can be employed at elevated temperatures or the film to be fibrillated itself can be at an elevated temperature although suitable results are obtained when the process is carried out with the fluid and the film substantially at room temperature. Similarly, temperatures below that of room temperature can be employed if desired. Recycling of the film past the same pillow block can be practiced if a more finely fibrillated product is desired.

The configuration of groove **5** need not be triangular but can vary widely so long as its traverses a width portion of pillow block **1** which is on the order of the width of the film to be fibrillated, the fibrillation fluid thereby gradually coming into contact with substantially the entire width of the film. For example, the high energy fluid stream can be impinged on a first, localized area of the film which first area is between the longitudinal sides (edges) of the film. Thus, the first area is at a point in between and away from either longitudinal side (edge) of the film, and the high energy fluid can then gradually be moved in at least two directions from this first area, the two directions being away from one another and diagonally toward both longitudinal sides of the film. This diagonal movement in at least two directions can be in the form of an isosceles triangle (as shown in FIGURE 1) when the first area of impingement is at a point substantially centrally located with respect to the width of the film. Both legs **5** of the triangular path of the high energy fluid stream as shown in FIGURE 1 extend toward a single and the same end of the film, i.e., the end of the film closest to end points **10** and **11** of legs **5**. For example, a single diagonal groove can be employed with similar orientation to one leg of groove **5**.

The film can be moved through zone **2** at any desired speed, the faster the movement of the film through the zone the coarser the fibrillated product and vice versa. Pillow block **1** can be formed of any conventional material capable of maintaining fluid under pressure which can vary from metals such as steel to polymers such as hard rubber.

Generally any orientable plastic film can be employed in the process and apparatus of this invention. The film will generally be uniaxially oriented although any other condition of orientation which allows fibrillation can also be employed. The film can be oriented in any conventional manner known in the art including super-cooling film and then orienting same by stretching and the like or heating the film to a temperature below that at which the film is in the molten state and then stretching same. By orientation, what is generally meant to be covered is deforming, e.g. stretching the film below that temperature at which the film is substantially in the molten state, to thereby increase the strength of the film at least in the direction in which it is deformed.

Generally, films of polymers of 1-olefins having from 2 to 8 carbon atoms per molecule which have been oriented by stretching in at least one direction so that the film after stretching is at least 3 times longer in the direction of stretching than it was before stretching, i.e. 3 to 1, can be used. When film of polyethylene which has a density of at least about 0.94 gram per cubic centimeter is employed the ratio of length in the stretched direction to original length should be at least 4 to 1 and when polypropylene is employed this ratio should be at least 6 to 1. Polymers of 1-olefins can be made in any conventional manner. A particularly suitable method is that disclosed in U.S. Patent 2,853,741. The film can be made from the polymers in any conventional manner such as by extrusion, casting, flattening blown tubing, and the like.

Other conventional plastic films that can be employed in this invention include blends and copolymers of 1-olefins as above-described with each other and with other polymers such as polyamides, polyesters, polyvinyl alcohol, acrylic polymers, polyvinyl chloride, polyvinyl acetate, polyvinylidene chloride, and the like. Of course, homopolymers of the 1-olefins and other materials described can also be employed as well as copolymers. A stretch or orientation ratio of at least 3 to 1 can also be employed with these plastic films.

The film can be of any length and width and substantially any thickness, the minimum thickness of the film being that which will produce a substantially self-sustaining film and the maximum thickness being dictated by the fibrillating capability of the apparatus employed. Generally, the thickness will vary from that which is sufficient to form a self-sustaining film to about 6 mils. Thicker films can be treated by using fluids of higher energy content or by recycling the film past the same pillow block one or more times. Repeated passes of films past the same pillow block will allow the use of fluid at a lower energy state and still effectively fibrillate thicker and/or tougher films than could be ordinarily fibrillated adequately by the lower energy state fluid.

FIGURE 2 shows the pillow block of FIGURE 1 and its relationship with respect to film to be fibrillated **20** and the rotating support drum **21**. The film **20** enters the interface between the top drum **21** and pillow block **1** and exits from the bottom of drum **21** as fibrillated product, i.e. non-woven fabric, **22**. As the film passes between point **9** and **11** it is fibrillated and the degree of fibrillation at any given point between points **9** and **11** varies increasingly toward point **11**. Reference letters A, B, C, and D represent different degrees of fibrillation and are discussed in more detail with reference to FIGURE 3. Drum **21** can be any conventional drum made of any conventional material including a steel drum, a rubber-faced steel drum, and the like. The drum is rotated to move film **20** into a contiguous relationship with groove **5** of pillow block **1** and then away from pillow block **1** for subsequent treatment, storage, or other disposal as desired.

FIGURE 3 shows, inter alia, the state of the film in step A. The solid, oriented film is present in inset fibrillation zone **2** of pillow block **1** and carried on the surface of drum **21**.

Step B shows header conduit **6** and feeder lines **8** in pillow block **1** feeding high energy fluid to groove **5** and therefore causing fibrillation of the film in a small localized area to produce fibers **30** from that film. Fibers **30** represent the longitudinal stem fibers of a conventional non-woven fabric and the smaller length and diameter cross connecting fibers that are integral with adjacent stem fibers are not shown for the sake of simplicity.

Step C shows substantially the same situation as step B except that the film has traversed further along the length of fibrillation zone **2** so that a large number of successive areas of the film have been subjected to the fibrillation fluid and therefore larger numbers of stem fibers **30** are present, i.e. the film has a larger width thereof fibrillated than step B.

Step D shows the completely fibrillated film as obtained as the non-woven product **22** of FIGURE 2. When a liquid is used as the fibrillation fluid a conventional drying step is preferred for the product **22**. Such drying steps include similarly subjecting the product to a blast of hot, dry air, and the like.

Although the invention has been described relative to fibrillating a film it is equally as applicable to laterally spreading a fibrillated film to make a fabric wherein most all the fibers are sufficiently spaced from adjacent fibers to allow one to see through the fabric, the fibers in the as fibrillated condition being substantially contiguous with adjacent fibers. If the spread fabric tends to return to the closed "as fibrillated" condition the fluid employed in the process of this invention can contain setting additives or

can be heated to thermally fix the fibrillated film in the spread apart (opened out) condition.

EXAMPLE I

A film having a 2 mil wall thickness composed of a homopolymer of propylene having a melt flow of 2.5 to 4 (ASTM D1238–62T, Condition L, grams per 10 minutes) and a flexural modulus equal to or greater than 200,000 (ASTM D790–63, 73° F., p.s.i.) is stretched at a temperature of 250° F. until the length in the stretched direction is 7½ times that of the original unstretched length. The film is then passed through the apparatus of FIGURE 2 at a rate of about 10 feet per minute and water under pressure of about 2000 p.s.i.g. is fed to header **6**. The film and water are substantially at about 75° F.

The product recovered from the bottom of drum **21** is a very uniformly fibrillated non-woven fabric having extremely few and very small areas wherein substantially no fibrillation occurs.

EXAMPLE II

The process of Example I is repeated using a film composed of a homopolymer of ethylene having a density of 0.96 gram per cubic centimeter at 25° C. and a melt index of 0.2, and air is the fibrillating fluid.

Polyethylene film is stretched at 240° F. until the stretched length is 6 times that of the original unstretched length. The air supplied to header **6** is under a pressure of about 500 p.s.i.g.

A similar extremely uniformly fibrillated product is obtained.

Reasonable variations and modifications are possible within the scope of this disclosure without departing from the spirit and scope thereof.

Processes similar to those of Examples I and II are repeated on the fibrillated films of those examples and an opened-up, nonwoven fabric obtained.

I claim:

1. In a method for one of fibillating an oriented plastic film and opening out a fibrillated film, the improvement comprising impinging a high energy fluid stream on a first small, localized area of said film, said first area being substantially smaller than the length and width of said film, and gradually moving said fluid stream across a succession of similar small, localized areas until said stream has traversed substantially the entire length and width of said film, said first area is at a point away from either longitudinally side of the film and the gradual movement of the fluid stream progresses in at least two directions from said first area, said directions extending diagonally toward a single end of said film and toward both longitudinal sides of the film, the energy of said fluid being sufficient to cause fibrillation of said film.

2. The method according to claim **1** wherein said film is composed of homopolymers, copolymers, and blends of at least one of homopolymer and copolymers all formed from 1-olefins having from 2 to 8 carbon atoms per molecule, polyamides, polyesters, polyvinyl alcohol, acrylic polymers, polyvinyl chloride, polyvinyl acetate, polyvinylidene chloride, blends thereof, and copolymers thereof with one another or polymers of 1-olefins, and films that are fibrillated are oriented by stretching same at a ratio of stretched length to unstretched length of at least 3 to 1.

3. The method according to claim **1** wherein said first area is at a point substantially centrally located with respect to the width of the film and the largest diameter or side length of said area is less than 50 percent of the film's length and width, and the gradual movement of said fluid stream progresses from said first area diagonally toward the longitudinal sides of said film, the trace of the path of said stream thereby being represented by an inverted V, the two bottom points of the inverted V being substantially the same width as the film being treated.

4. The method according to claim **3** wherein said film is composed of at least one of polyethylene and polypropylene and the fluid stream is composed of at least one of water and air.

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U.S. Cl. X.R.

28—1, 72; 264—147, 93