July 29, 1969 G. E. R. LAMB ETAL 3,457,609

METHOD AND APPARATUS FOR FIBRILLATION OF FIBERS

Filed Nov. 6, 1967 2 Sheets-Sheet 1

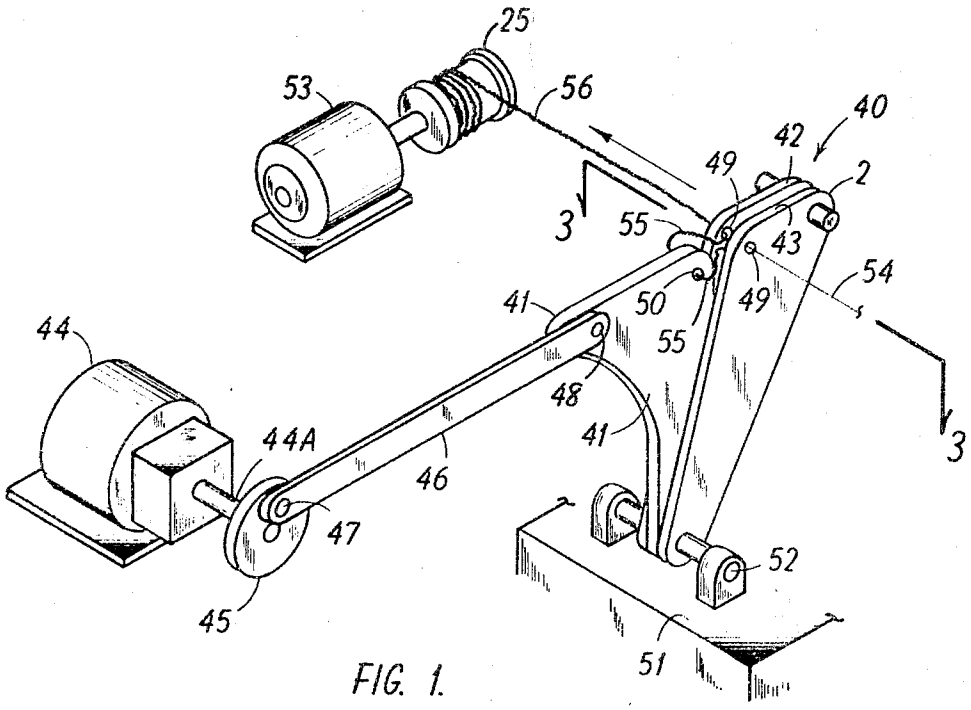

FIG. 1.

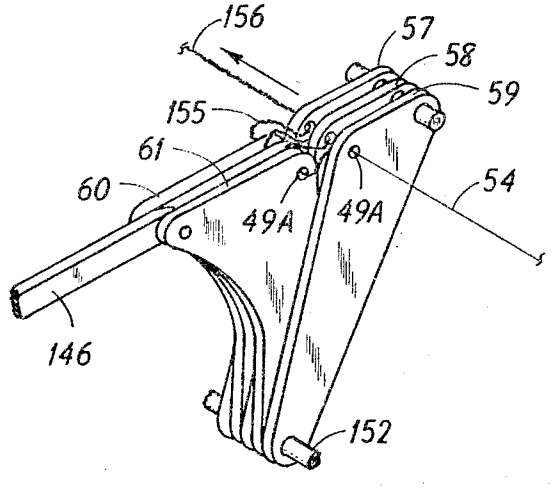

FIG. 2.

INVENTORS
GEORGE E. R. LAMB
BY DUSAN C. PREVORSEK

Arthur J. Prantis
ATTORNEY

July 29, 1969 G. E. R. LAMB ETAL 3,457,609

METHOD AND APPARATUS FOR FIBRILLATION OF FIBERS

Filed Nov. 6, 1967 2 Sheets-Sheet 2

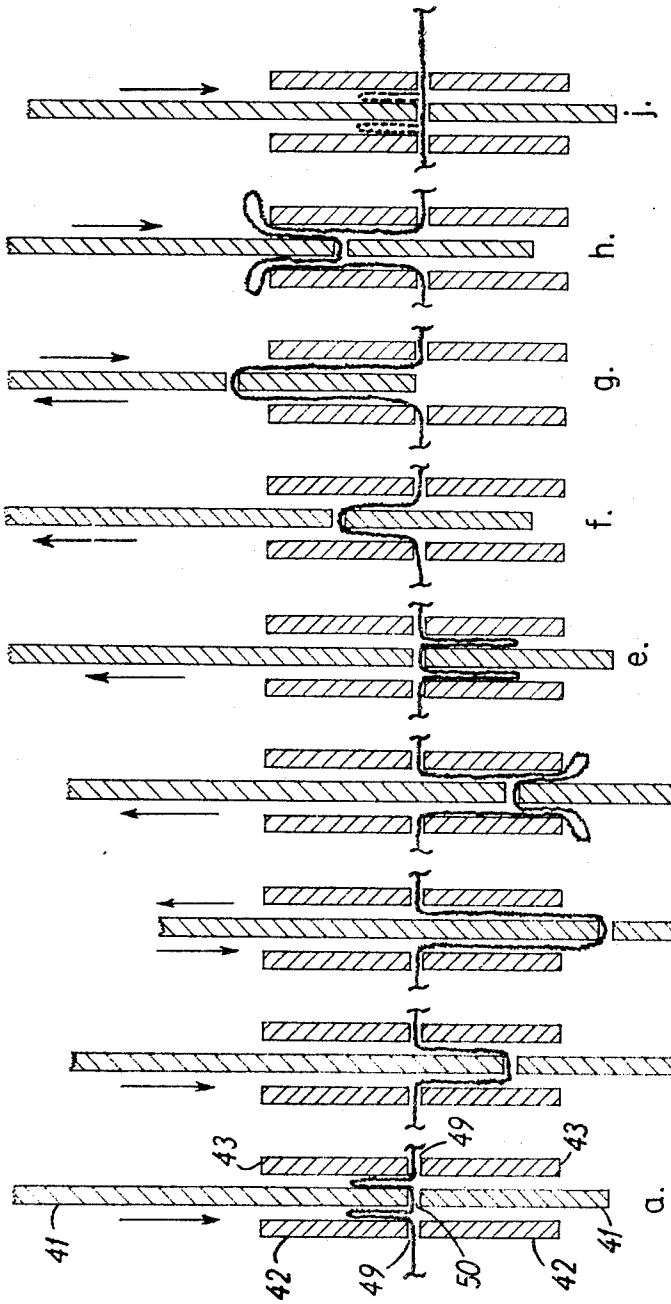

FIG. 3.

INVENTOR(S)
GEORGE E. R. LAMB
DUSAN C. PREVORSEK

BY Arthur J. Plantamura
ATTORNEY

United States Patent Office

3,457,609

Patented July 29, 1969

3,457,609

METHOD AND APPARATUS FOR FIBRILLATION OF FIBERS

George E. R. Lamb and Dusan C. Prevorsek, Morristown, N.J., assignors to Allied Chemical Corporation, New York, N.Y., a corporation of New York

Filed Nov. 6, 1967, Ser. No. 680,679

Int. Cl. D02g 3/00

U.S. Cl. 28—1.2 4 Claims

ABSTRACT OF THE DISCLOSURE

The invention involves an apparatus and method for producing a multifibrous yarn from a relatively heavy unitary strand, strip or monofilament, referred to for convenience as a "monofil," and prepared from a molten blend of at least two substantially immiscible polymers. The monofil is mechanically flexed by the apparatus to introduce fissures therein, i.e., to substantially fibrillate or separate the structure laterally and thereby to increase the bulk of the monofil. The apparatus comprises a plurality of closely contiguous, relatively movable plate elements, provided with an opening through which the monofil to be fibrillated is threaded and thereafter, by operating the apparatus, is flexed. The relatively high bulk yarn produced by the concept of the invention may be corded, spun and woven, substantially similarly to yarns spun from natural staple fibers or the product may be further processed to enhance its bulk.

This invention relates to a novel apparatus and method for fibrillating unitary strands to convert them to relatively bulky fibrillated yarn-like structures. More specifically, it relates to a mechanical flexing apparatus which permits the preparation of textile yarns having many fibrils extending from the matrix thereof and characterized by relatively high bulk, from molecularly oriented monofilaments, or tapes, or slit films, having a wide range of dimensions.

Yarns made from continuous filaments, as such, are not suitable for textile applications where good tactile properties, covering power, i.e., high bulk per unit weight of fabric, comfort, or aesthetic qualities are important factors. The main reason for the inadequacy is that, since the filaments have a smooth surface, a uniform diameter and a circular or near-circular cross-section, they have a tendency to pack closely. Consequently, the fabrics made from such yarns have too high a density which affects their insulating capacity and covering power. Furthermore, fabrics made from such dense yarn have a relatively high contact area when placed against the skin; this affects the tactile properties and comfort of the fabric, the latter disadvantage is often reflected by a clammy feeling on the wearer. Accordingly, a large percentage of the total production of continuous filaments of synthetic fiber-forming polymers intended for textile applications is cut and then spun into staple yarns in efforts to attain the desirable qualities of fabric prepared from bulkier yarns.

The production of yarns from staple fibers is a time-consuming and costly process which involves a series of complex operations. Cut fibers have to be combined into assemblies suitable for drawing operation where the fibers are aligned into bundles and the bundle is reduced to a smaller diameter while twisted. Twisting is necessary to

prevent excessive slippage of adjacent fibers past one another. It is obvious that such structures have a very low translational efficiency; that is, the strength of the fiber assembly is much lower than that of the individual component.

Additionally, the cost of staple yarn production increases rapidly as the denier of the spun yarn decreases, the higher cost being due primarily to the necessity for obtaining great uniformity of fibers in the smaller yarn bundle, the need of greater amounts of twist to secure adequate yarn strength, and the fact that machine output is lower on per pound basis. Other shortcomings of the conventional staple yarn technology include, for example, difficulty in achievement of a high degree of uniformity in the yarn texture and denier and of good translational efficiency. Also, it is more difficult with staple yarn to achieve intentionally random or regular non-uniformity in texture and/or denier. Those skilled in the art will recognize that such functional non-uniformity is required when fabrics with special aesthetic requirements such as material appearance are the consideration.

It will thus be apparent that the development of a bulky yarn from a monofil, rather than from staple fiber, offers considerable economical advantages since its production bypasses several complicated and costly operations requiring enormous pecialty equipment.

The invention provides a novel apparatus for the conversion of a monofil into a relatively bulky fibrillated yarn. In essence, the apparatus provides a simple yet efficient and reliable technique and apparatus for mechanically flexing the monofil or strand so that the strand divides and substantially fissures longitudinally into many fibrils. The divided product includes a plurality of separated essentially continuous strands and a plurality of thinner hair-like extensions appended thereto. The extent of mechanical working is continued until suitable fibrillation results but is terminated prior to loss of satisfactory strength. The number of "fibrils" of the fissured monofil, depending on the extent of mechanical flexing in the apparatus is correspondingly increased with the length of time of flexing. However, prolonged working may unduly weaken the strand. Optionally, for the purpose of further increasing the bulkiness of the treated yarn after the strand has been so flexed, the strand may be subsequently rubbed or brushed or subjected to a high velocity jet of gas which flagellates the strand as described in greater detail in the copending application of D. S. Prevorsek et al. entitled "Bulking of Yarn," Ser. No. 680,678, filed on even date herewith.

It is an object of this invention to provide a novel apparatus for preparing bulky yarns.

A further object of this invention is to provide a greatly simplified and relatively inexpensive device for producing a bulky yarn from a variety of oriented shapes including mono-filaments, tapes, relatively thick slit films, etc., i.e., of any cross-section in addition to the circular one which is the most difficult to fibrillate.

It is another object of the invention to provide the mechanism for the production of textile yarns having substantially increased bulk over the monofil from which it is formed without the necessity of forming staple fibers as an intermediate step and without the necessity of spinning and twisting of staple filaments into yarns.

Another object of the invention is to provide a process for production of textile yarns of good uniformity in denier and texture.

Other objects and advantages will be apparent from the following descriptions taken in conjunction with the accompanying drawing wherein.

FIG. 1 depicts perspectively the arrangement incorporating the invention for mechanically fibrillating a yarn fed therein.

FIG. 2 is a fragmentary portion showing an alternate flexing mechanism having a large number of plates through which the fibril is threaded to initiate fibrillation fissures into the monofil.

FIG. 3 depicts a sequence demonstration of the flexing action imparted to the strand or fibril to fibrillate it in accordance with the inventive concept.

In essence, the invention comprises an apparatus having a plurality of closely interleaved plates or arms at least one of which is reciprocated relative to the others, each of which is provided with an aperture through which the strand to be fibrillated is threaded. The resulting back and forth bending action on the strand, which is administered over a sufficient number of cycles and the looping of the strand between continguous faces of adjacent plates, causes the strand to separate into a substantial number of thin filaments and/or fibrils. This operation, as continued further, converts the strand into a bundle of finer threads which gives the appearance of and essentially produces the effect of a yarn produced from staple fiber.

Referring to the drawing, fibrillating unit **40** embodying the invention in a preferred arrangement of three plates is shown; a central reciprocating plate **41** and two outer fixed plates **42** and **43**. The arrangement may comprise plates **41**, **42** and **43**, one or more of which is fabricated of any suitable composition, e.g., metal, a thermosetting plastic, wood or other composition. Plate **41** is moved in a back and forth fashion by motor **44** on pivot **52** which is appropriately anchored at **51**. The reciprocating motion of plate **41** is provided through any suitable convenient mechanism such as the cam **45** and connecting member **46** through connecting pivot point **48** and offset pivot point **47** which rotates around driven shaft **44A** of motor **44**.

The monofilament, tape or split film **54** is fed through one hole **49** in each of the plates **42**, **43**, in the stationary plates and through hole **50** in reciprocating plate **41** and, as it is drawn through with the apparatus in motion, is bent, rubbed, twisted and beaten in the space between the plates where it is forced to reside briefly, during the reciprocating movement of plate **41** which effects a bending of the strand alternately essentially 180°. The forward passage of the filament which is continuous but incremental as loops **55** are formed is effected by taking up the processed fiber on a suitable wind-up roll **25** driven by motor **53**.

As shown in FIG. 2, the apparatus may comprise a larger number of plates; plates **57**, **58** and **59** being stationary while plates **60** and **61** are reciprocated. Each plate is provided with a suitable aperture through which the strand **54** is passed.

In each embodiment, the clearance between the stationary plates and the central reciprocating plate should be regulated and may be critical. If this clearance is large compared with the diameter of the fiber, the passing of the monofil through the apparatus, there may be undue slippage and this may not lead to an efficient fibrillation. On the other hand, if the clearance is too small, a very high tension is required to pull the fiber through the apparatus and this may produce frequent breakage of the monofil and high weight losses through abrasion.

We have found that it is often advantageous to construct the fibrillating apparatus in such a way that the stationary plates are maintained at a constant (adjustable) pressure (force) against the reciprocating plate(s). The optimum operating conditions, that is, a high degree of fibrillation at a sufficient zero twist strength of the fibrillated product, at high feed speeds and low weight losses due to the abrasion, etc., are achieved by proper adjustment of the stroke and frequency of the motion of the reciprocating plate(s), pressure or clearance between the stationary plates and reciprocating plate(s), tension on the fiber, diameter of the holes **49**, (**49***a*), etc.

The mechanical treatment imposed on the monofil during its passage through the device is a complex one and involves several modes of straining (stressing) such as bending, rolling, passing over an edge, etc., which lead to complex stress fields required to initiate and propagate simultaneously a multiplicity of cracks in the yarn structure. Under proper operating conditions, these cracks would propagate for a distance which is large compared with the distance between the cracks and as a result the monofil would split into numerous fibrils in a single passage through the apparatus.

To further illustrate the nature of the motion provided by the apparatus of FIG. 1, the movement of the fiber as it passes through stationary plates **42** and **43** and the reciprocating plate **41** is depicted in the sequences shown in FIG. 3. In sequence 3*a*, fiber from the previous half stroke is still between the plates which is in the next instant drawn out by the tension exerted by a conventional take-up device (not shown). At sequences 3*b* and 3*c*, fresh filament is drawn into the plates. At 3*d*, the mounting plate has begun moving back and two loops have been formed. These loops are caught between the plates so that the portion of the filament which undergoes a 180° bend moves along the filament as in sequence 3*e*. Sequence 3*f* shows the first phase of the next half stroke which is equivalent to the opposite sequence 3*b*. Sequences 3*g* and 3*h* are equivalent but opposite to sequences 3*c* and 3*d* respectively. Sequence 3*j* corresponds to sequence 3*a* except that the fiber is shown drawn out while the broken line shows the fiber between the plates as in the illustration of sequence 3*a*. Observations show that in most cases the minimum stroke at which the apparatus functions efficiently is the stroke which leads to the loop formation shown in the sequence 3*d*.

The yarn-like structure **56**, after the initial pre-treatment step afforded by processing it through the apparatus of the invention wherein fissures are introduced into the unitary structure, have additional covering power per unit weight, as compared to untreated monofilament, and provide an appearance and strength suitable for various applications such as carpets, reinforcements, etc. They have substantially improved tactile properties, bulkiness and compliance required in applications where the comfort of the wearer and insulating capacity is an important factor. The flexing of the yarn in this apparatus may be continued until maximum bulk is obtained although in some cases this may unduly weaken the yarn. Alternatively, yarn obtained by processing it in the apparatus of this invention may, to a moderate degree of fibrillation, be further treated as by brushing so that fibrils initially separated in the mechanical reciprocating treatment which still remain adhered to a substantial extent to the contiguous fibrils, are separated or fluffed from the axis. The opening of the structure, flagellation of free ends and their disorientation from the yarn axis, which is a second and optional treatment, may also be achieved by passing the mechanically fibrillated yarn through a zone of high velocity air jet as described in the earlier noted copending application of Prevorsek et al.

Various modifications may be made in the concept herein provided, without departing from the scope of the present inventive contribution.

We claim:

1. An apparatus for fibrillating a unitary strand of a synthetic plastic by mechanically flexing said strand, comprising a plurality of closely positioned plates, each of said plates being provided with an aperture through which said strand is continuously threaded, means to reciprocate at least one of said plates with respect to its contiguous plates between which the strand is interleaved and

means to continuously thread strand through said apertures while reciprocating said plate.

2. The apparatus of claim 1 comprising three plates wherein the central plate reciprocates with respect to the two outer plates.

3. The apparatus of claim 2 wherein at least the central plate comprises a plastic composition.

4. In a method for increasing the surface-to-volume ratio of synthetic polymeric strand whose composition comprises a plurality of incompatible polymers, the step comprising repeatedly mechanically flexing said strand so that it is reciprocally flexed and bends alternating substantially 180° by threading said strand through apertures

in a plurality of closely adjacent plates at least one of which reciprocates relative to an adjacent plate.

References Cited

UNITED STATES PATENTS

2,531,234 11/1950 Seckel.

LOUIS K. RIMRODT, Primary Examiner

U.S. Cl. X.R.

28—72.1