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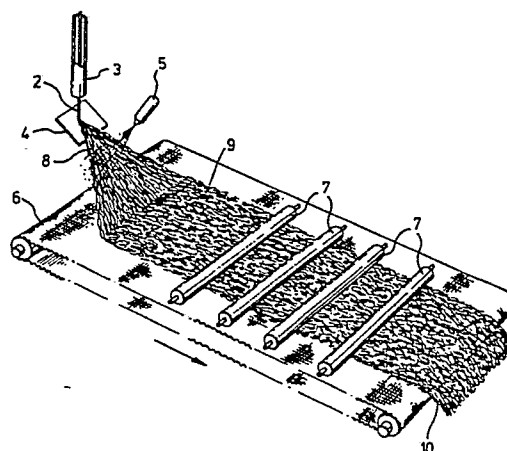
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54 **Thermally insulating bulky product and method for its manufacture.**

57 A thermally insulating nonwoven bulky product is made up of substantially continuous single filaments of between 0.01 to 2 deniers stabilized in the product by a surface binder on the filaments. The bulky product may be made from multifilament polyester (2) direct from the spinneret by passing it in a high speed air current through a nozzle (3) and against a surface (4) where it is broken into single filaments (8) which pass through a mist of binder emulsion ejected from a spraying nozzle (5) and so are deposited on a support conveyor (6). The speed of the conveyor (6) is adjusted so that the filaments settle in folds giving a pile of substantial thickness which is then dried and heat set under heated elements (7).

The product, which may well have a bulkiness between 50 and 550 ml/g, can be used for filling articles such as duvets, sleeping bags, anoraks, and the like, and has a thermal insulation comparable to that of down.



THERMALLY INSULATING BULKY PRODUCT AND
METHOD FOR ITS MANUFACTURE.

5 The present invention relates to fibrous nonwoven materials for stuffing and, more particularly, to light weight, resilient and bulky materials suitable for thermal insulation.

10 Down and feathers have been well known to have good properties as stuffing for articles, such as eiderdowns, sleeping bags, jackets and the like. However, they are very expensive on account of their short supply, and require considerable care so that they may not undergo damage by insects or microbes. They also have inherent drawbacks, e.g. the necessity
15 of quilting to avoid uneven distribution in stuffed articles and of using expensive closely woven or specially finished fabrics to avoid their leakage through the casing fabrics.

20 Natural or synthetic discontinuous crimped fibres have also been used as stuffing in the form of wadding or a lap. These fibres however, are inferior to down and feathers in their thermal insulation properties, necessitating the use of heavier stuffed articles to assure comparable thermal insulation. They also have
25 an undesirable tendency, after long use, to protrude through the enveloping material, and to agglomerate and lose their original bulkiness or to disassociate because of irreversible movement resulting from their crimp or surface scale.

30 It has been found that addition of bonding resin to bond the staple fibres at their cross-over points in the wadding or lap produces improved support for the bulk material and prevents the fibres from migrating.

Therefore, it is commercial practice today to cross-lap webs and spread resin on the surface of the layered structure. It has also been recognized that too much bonding causes the web to lose softness.

5 There has been proposed a stuffing material constituted by a highly corrugated web of continuous filaments, directed substantially in the same direction and wherein the undulations are fixed with the aid of an appropriate resin. The typical method for the
10 preparation of such webs consisted in passing a tow of continuous filaments between two rollers driven at different peripheral velocities, taking up the corrugated web thus formed, spraying a bonding agent on the said undulating lap and, finally, curing the
15 bonding agent thus deposited. The stuffing materials thus obtained retain the original alignment of filaments even though effort has been made to bring about a bulky form by the corrugation, and the anisotropy sometimes results in undesirable performance
20 when in use, e.g. contraction in the direction perpendicular to the alignment of the filaments or breakage along the alignment direction, which results in an insufficient thermal insulation property.

Although many proposals have been made to provide
25 stuffing material intended to solve the above-mentioned defects of staple fibres or tow and to simulate the good property of down, the ideal stuffing material which shall be equal or superior to natural down in its property for heat insulation has not been invented up
30 to the time of making the present invention.

The thermally insulating bulky product of the present invention is characterised in that it is structurally made up of substantially continuous single

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filaments of between 0.01 to 2 denier stabilised in the product by a surface binder on the filaments. It is preferable that its specific volume shall be not less than 40 ml/g.

5 It should be especially noticed that the substantially continuous filament which may be derived from multi-filament is incorporated in the bulky product as a single filament to provide as uniform a distribution as possible of minute spaces between the
10 neighbouring single filaments. It is also important to provide bulky accumulation of the single filaments. Compacted bundles of multi-filament and interlaced fibres should be minimized as far as possible.

15 Random crimp in each filament helps to avoid the above-mentioned unfavourable bundling in the accumulated product because the crimp makes filaments tend not to stick together.

20 Regular crimp such as can be induced by false twisting for example, is however, not desirable because the separation of multi-filaments into individual single filaments becomes difficult and because there is a possibility of the filament sticking together in use, resulting in reduction of bulkiness and of ability of heat insulation. Interlacing or twisting in the multi-
25 filament state should also be avoided for the same reason mentioned above. Filaments in the bulky product of the present invention should preferably have random crimp with uneven form and number of crimps between filaments; this contributes to bring about a stable
30 quality in the thermal insulation over long use because unfavourable agglomeration and loss of the bulkiness can be considerably reduced.

The average percentage crimp should not be too

large in order that the unfavourable agglomeration of the filaments may not occur, and it should also not be too small in order that sufficient bulkiness may be secured in use. It should be in the range of 1 to 20
5 percent, and preferably from 2 to 10 percent.

The percentage crimp of the filament is here defined by the equation:

$$\text{percentage crimp(\%)} = \frac{l_1 - l_0}{l_1} \times 100$$

10

where l_0 is a distance between an arbitrarily chosen points in the filament measured under a load of 2 mg/d, and l_1 is the distance between the same points measured under a load of 300 mg/d.

15 The average fineness of the single filament should be in the range of 0.01 to 2 deniers, and preferably from 0.1 to 1 denier. Each filament may be either uniform or have varying denier along its length. Mixing of filaments of different deniers can sometimes
20 be desirable. In any case, too great a thickness of the filament beyond the above-mentioned upper limit should not be used because the intended good thermal insulation property cannot be established, and the softness or drapability of the accumulated product
25 become insufficient. On the other hand, use of filaments of a fineness below the above-mentioned lower limit should also be avoided because the intended stable resilient bulkiness of the present invention cannot be brought about.

30 For industrial production, the filaments may be derived from multi-filament having a total denier not less than 10, and preferably in the range of 30 to 3000.

Synthetic polymers to constitute the filament of the present invention may be any known fibre-forming polymers such as polyesters and polyamides, for example poly(butylene terephthalate), and preferably
5 poly(ethylene terephthalate) and its copolymers containing not less than 85% repeating units of ethylene terephthalate. The remaining repeating units which can be copolymerised are preferably those of butylene terephthalate, butylene isophthalate and
10 ethylene isophthalate.

The filaments comprising the accumulated product of the present invention should have binder on their surface. This contributes to bind filaments at their cross-over points in the accumulated product and to
15 stabilise the bulkiness and to prevent the filaments from migrating. The binder should not be sticky in the final state of the accumulated product even though it is sticky at an intermediate state to bind the filaments at their cross-over points. Thermoplastic
20 polymers with melting or softening points below that of the filaments are suitable for this purpose. Polyvinylalcohol and polyacrylic esters (which can be used in the form of an emulsion) are the best selection. The emulsified binders should be deposited on the
25 filament as minute particles of mist before the accumulation of the filament so that uniform distribution of the binder in the accumulated product may be established.

It is desirable that the amount of the binder in
30 the accumulated product should be in the range of 0.5 to 20 percent, preferably from 2 to 10 percent. Too much binder should not be used because the softness or drapability of the accumulated product is considerably

reduced and accordingly the thermal insulation property also decreases. On the other hand, too little binder can fail to bind necessary amount of the cross-over points, resulting in decrease of the stability of the bulkiness in long use.

If the binder is used as an aqueous emulsion, its molecular weight should not be too large so that stable and minute particles of mist can be obtained from the predetermined concentration of the binder in the water.

In case of polyvinylalcohol, the average molecular weight should be in the range of 100 to 10,000, preferably from 200 to 2000, and its extent of saponification should be greater than 98 percent.

The accumulated product of the present invention may have a specific volume of not less than 40 ml/g, and preferably from 50 to 500 ml/g when measured under a load of 0.125 g/cm². Such a high bulkiness can be obtained by the accumulation on a suitable conveyor of filaments which already have the binder on their surface, and heat setting the bulky form by suitable means as exemplified later. The accumulated product of the present invention can thus exhibit stability of bulkiness even under repeated compression and decompression or repeated shearing and relaxing. The specific volume which is used to designate the bulkiness of the accumulated product is defined here by the following equation:

$$\text{Specified volume (ml/g)} = \frac{20 \times 20 \times h}{A}$$

where A is the weight of a sample whose length and width are 20 cm and 20 cm, respectively; and h is the average height of the sample measured under a load of

0.125 g/cm². The specific volume, as here defined, should be discriminated from the apparent specific volume, later referred to, this being obtained by calculation without the load above-mentioned.

5 The manner in which the filaments are laid down in order to form the accumulated product can be varied, provided that the bulkiness and drapability of the present invention are manifested. Preferably, the filaments should be repeatedly folded at both surfaces
10 of the accumulation, and remain in overlapping layers in a loose or relaxed state.

 The accumulated product of the present invention can additionally be modified later by using a binder which may be the same as or different from the binder
15 already used for the accumulation. Especially, surface treatment of the product with binders is sometimes desirable so that the product does not protrude through casing fabrics.

In the accompanying drawings:

20 Fig 1 schematically illustrates a method for the manufacture of a non-woven bulky product according to the invention; and

 Fig 2 illustrates in side view and with
25 exaggeration how the filaments are laid down on the conveyor.

 One method of producing the bulky accumulation of single filaments is illustrated, somewhat diagrammatically, in Fig. 1 of the drawings. Multi-filament 2 which is ordinarily one bundle of filaments,
30 but which may be more than one, melt-spun by a conventional method, gushes out through the nozzle 3 and impinges against a surface 4 where the filaments are crimped and individually separated. Then the

filaments 8 have binder deposited on their surface by going through the mist of binder emulsion ejected from the spraying nozzle 5, accumulate on the moving support conveyor 6 with an apparent specific volume of not less
5 than 80 ml/g, and successively undergo the treatment of drying and heat setting by passing under heated elements 7.

The multi-filament 2 may be produced by any known methods in the art, but the aerodynamic melt spinning
10 method, where the aerodynamic frictional force of high speed air is used to draw the extruded as-spun filament to provide the useful filament as such, is preferred. In case of polyesters, high take-up speed of the as-spun filament can provide a useful filament without the
15 additional drawing operation usually adopted in the art. This is, accordingly, quite suitable for the preparation of the multi-filament of the present invention. On top of that, weak crimp which is desirable in the present invention can easily be put in
20 if the temperature of the filament impinging against the surface 4 is controlled so as to be in a range higher than the glass transition temperature of the polymer concerned, but not more than 50°C above the glass transition temperature. The shape of the nozzle
25 3 from which the multi-filament 2 gushes out with the high speed gaseous fluid such as air may be of any form such as a circle, square, or slit. The multi-filament 1 fed to the nozzle 3 may be drawn multi-filament prepared beforehand, but the incorporation of the
30 nozzle 3 in the spinning line of the aerodynamic melt spinning is preferable.

The surface 4 against which the multi-filament gushing out from the nozzle 3 with high speed gaseous

fluid impinges may usually be a single plane surface, and the angle between the plane and the impinging multi-filament is determined by the required extent of the crimp and the separation of filaments. It usually
5 lies in the range of 45 to 90 degrees. The optimum angle may be readily determined by a few preliminary tests if necessary. A curved surface other than a plane can also be used to provide an enhanced control of the multi-filament. The distance between the exit
10 of the nozzle 3 and the point on the surface 4 where the multi-filament impinges may also be selected by the extent desired for the crimp and the separation of the filaments.

The multi-filament 2 after the impingement upon
15 the surface 4 runs on the surface in a relaxed state by the help of the turbulent flow of the accompanying gaseous fluid, and becomes separated into individual single filaments. The separated single filaments 8 undergo the deposition of binder on their surfaces on
20 their way to a supporting conveyor 6, and thereafter they are spread out and accumulated on the moving support to form an accumulation of desired width and weight per unit area. This deposition of the binder before the accumulation is essential for this process
25 because an appropriate amount of binder on the filament gives the filament additional weight which contributes to stabilize at least temporarily the not yet heat stabilized accumulation, and because relatively uniform deposition of binder on the filament surface can be
30 attained with an appropriate amount desirable for the embodiment of the present invention. An attempt to deposit the binder after the accumulation of the filament has failed to provide the accumulated product

of the present invention because it is almost impossible to deposit the binder at an appropriate amount throughout the inner part of the accumulation without losing the apparent specific volume.

5 The binder may be used either as such if it is in liquid state with an appropriate viscosity, or as solution or emulsion with solvent or water. The additional incorporation into the solution or emulsion of emulsifiers, surfactants, antistatic agents, 10 antioxidants, and colouring agents can be adopted if desired. The binder may be selected from the following lists: polyvinylalcohol, polyvinylpyrrolidone, polyurethane, synthetic latexes, and polyacrylic esters.

After the deposition of the binder on the 15 filament, the single filaments are spread out and accumulated on the moving support so that layered accumulation of the filaments may be established. The extent of the spreading out can be determined by the relationship between the impinging velocity of the 20 filaments and the moving speed of the collecting conveyor surface. Usually the former speed is considerably higher than the latter one so that the folding of the filament at both surfaces of the accumulated product may be attained. This folding of 25 the accumulating filaments on the first part of the conveyor is shown in Fig. 2 of the drawings, where it can be seen that the comparatively slow speed of the conveyor, compared with the rate at which the filaments are ejected from the surface 4, results in the 30 filaments being laid down in successive overlapping layers with folds 9 and 10 at the upper and lower surfaces respectively. These folds are hardly noticeable in the final product.

Especially if the filaments are obliquely laid with the length between the folds at both surfaces more than twice the height of the accumulation, the layered structure of the accumulated filaments thus obtained
5 provides the accumulated product with high drapability together with the stable bulkiness desired.

If the width of the fan of filaments 8 is smaller than the desired width of the accumulated product, periodical alteration of the point where the impinging
10 filament meets the surface of the conveyor can be adopted with good success. The provision of another spinning head is an alternative to bring about the accumulation of the desired width. A second spraying nozzle (not shown in Fig. 1) for spraying the binder on
15 the surface may be added separately for the filaments from the second spinning head to provide a product with surfaces enriched with the binder.

It is important to lay the filaments so as to form a bulky accumulation whose apparent specific volume is
20 not less than 80 ml/g, and to secure the final heat-set bulkiness of more than 40 ml/g. Accordingly, suction by vacuum from the underside of the support conveyor should not be used because such suction can cause a considerable reduction of the apparent specific volume
25 up to undesirable level.

The accumulated product thus obtained is next transferred to a drier to eliminate the solvent or water if they have been used in the previous step. In this case unnecessary strong blowing of hot air cannot
30 be recommended because significant loss of the bulkiness can result. Heating by the infrared rays is the most desirable drying method for the present purpose. Next, the dried accumulated product should

undergo heat-setting at a sufficiently high temperature to stabilize the bulkiness of the accumulated product. An accumulated product made up of polyethylene terephthalate, for example, can be heat-set at about
5 160°C for five minutes to stabilize the crimp and the binding of the cross-over points.

Moreover, polyvinylalcohol, when used as a binder, becomes insoluble in water by thermal treatment at around 200°C, and this can be a desirable phenomenon
10 for later use.

The above-mentioned two steps, e.g. drying and heat-setting, should be performed soon after the spread accumulation of filaments. Of course, the drying step can be discarded when neither solvent nor water is used
15 beforehand.

The bulky material thus obtained takes the form of a multi-layered structure of spread single filaments whose cross-over points have been partly united by binder and heat set to stabilize the bulky form. The
20 fact that a partial and appropriate number of cross-over points of the single filaments have been united and heat stabilized contributes to provide a bulky material which can easily deform by a minute compressing or shearing force, but at the same time
25 store the elastic energy to recover to its original state. Therefore high bulkiness and high drapability can coexist in the accumulation of the present invention. The weak crimp endowed in the filament also contributes to enrich the above-mentioned effect.
30 Coexistence of lubricant with binder on the surface of filament is also desirable to improve the resilience of the accumulated bulky product. The weight of lubricant used may amount to 0.01 to 0.5 percent of the weight of

the filament. The lubricant may contain poly-(organosiloxane).

The bulky materials thus obtained according to the present invention can be used in sleeping bags, bed coverings such as comforters and duvets and clothing such as anoraks, jackets and the like. They exhibit superior thermal insulation as good as the conventional downs and feathers.

The invention is further illustrated by the following preferred and comparative examples which are not intended to be delimitative.

EXAMPLE 1

From a melt spinning spinneret with 80 holes each of 0.20 millimeter in diameter, polyethylene terephthalate having an intrinsic viscosity of 0.65 measured in o-chlorophenol at 30°C was melt spun at 290°C into a chamber in which a pressure of 2.3 Kg/cm² was set by feeding compressed air. The extruded multi-filament entered the nozzle 3, whose inner diameter and length were 4 millimeters and 60 millimeters respectively, at 50 centimeters below the spinneret, and went through the nozzle with air whose velocity finally reached the sonic velocity at the exit of the nozzle 3.

The multi-filament gushed out from the nozzle at about 6000 meters per minute with the help of the aerofrictional force of the coexisting air of sonic velocity. The multi-filament 2 thus obtained comprised 80 filaments, each of about 0.8 denier. At seven millimeters below the exit of the nozzle 3, the multi-filament impinged against the plane 4 whose direction against that of the impinging multi-filament was 60 degrees, and then ran for 30 centimeters along the

surface of the plane 4. During the above processes weak crimp and separation of the multi-filament into individual single relaxed filaments had been accomplished. The single filaments 8 then left the
5 plane 4 and underwent the spraying of binder, and thereafter spread out and laid down on the conveyor 6 whose surface velocity was 0.3 metre per minute. The binder consisted of 100 parts by weight of polyvinyl-alcohol of molecular weight about 500 and whose extent
10 of saponification was greater than 99%, and one part by weight of a lubricant composition of 7 : 3 stearic acid ester and dodecylbenzene sodium sulfonic acid respectively. It was sprayed on to the single filaments in an emulsified state of 4% in water so that
15 the final deposition was about 5% by weight of the filament.

When the single filaments were spread out and laid on the conveyor, the deposition point of the filaments was reciprocated twice per minute so that 1.5 metre
20 width of the accumulated product was achieved. The resultant accumulation had 20 centimetres in thickness, and 400 ml/g in apparent specific volume. It was then carried for 18 minutes through a drier and heat setter in which an infra-red heater powered by 12 kilowatt
25 electricity had been installed. The temperature of the accumulation at the exit of the heat setter was about 160°C.

The final accumulation of the filaments thus obtained had a stable bulkiness of 104 ml/g and 200
30 grams per square metre, and exhibited an excellent drapability in spite of such a bulk form.

A comforter (i.e. a stuffed bedcover) in which the bulky material of the present invention was used showed

a good drapability and an excellent thermal insulation in long use. The apparent specific volume of the comforter was about 190 ml/g.

COMPARATIVE EXAMPLE 1.

5 Example 1 was repeated, except that the amount of the deposition of the binder was reduced to 0.1% by weight of the filament, the other factors remaining the same. The resultant accumulation of the filaments took at first a desirable bulky form, but the bulkiness
10 swiftly decreased when the product was used in a comforter. This was considered to be caused by a scant number of cross-over points united by binder, and by a poor resiliency for the same reason.

COMPARATIVE EXAMPLE 2.

.15 Example 1 was repeated, except that the amount of the deposition of the binder on the filament was increased to 25% by weight of the filament. The resultant accumulation had lost the drapability intended in the invention.

20 EXAMPLE II.

 The accumulation of the filaments obtained in Example I was further treated on its surfaces with additional polyvinylalcohol and an additional five percent by weight of filament was deposited on the
25 surfaces. The resultant accumulation took a more stable shape which made it easy to be cut or sewed for quilting use.

EXAMPLE III.

 The potential of the thermal insulation was
30 compared with the conventional materials for the same use. As was indicated in the Table I the bulky material according to the present invention had about twice the thermal insulation of cotton, and was almost

comparable with down.

TABLE I.

Item	Index * of thermal insulation
5 Bulky material of the present invention	2.2
Down	2.2
Silk	1.6
Polyester staple fibre	1.5
10 Cotton	1.0

* The clo-value for the thermal insulation measured under the same weight per unit area and the load was nondimensionized by taking the value of cotton as standard.

The cloe-value is a unit to designate the potential of the thermal insulation, and defined as follows:

One clo means such thermal insulation that a man who lies in rest and discharges heat of $50 \text{ Kcal/m}^2 \cdot \text{hr}$ feels comfortable with his skin temperature at 33 degrees centigrade under ambient conditions of 21.2°C and less than 50% relative humidity with an air flow of 10 cm/sec.

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CLAIMS:

1. A thermally insulating nonwoven bulky product characterized in that it is made up of substantially continuous single filaments of between 0.01 and 2 denier stabilized in the product by a surface binder on the filaments.
2. A bulky product according to claim 1, having a bulkiness which is not less than 40 ml/g when measured under a load of 0.125 g/cm².
3. A bulky product according to claim 2 wherein the bulkiness of the product lies in the range of 50 to 500 ml/g.
4. A bulky product according to any one of the preceding claims wherein the filaments are crimped, and the percentage crimp lies in the range of one to 20 percent.
5. A bulky product according to claim 4 wherein the percentage crimp lies in the range of 2 to 10 percent.
6. A bulky product according to any one of the preceding claims wherein the single filaments are derived from multi-filament having a total denier in the range of 30 to 3000.
7. A bulky product according to any one of the preceding claims wherein the single filaments have a fineness in the range of 0.1 to 1 denier.
8. A bulky product according to any one of the preceding claims wherein the amount of the binder deposited on the surface of the filaments lies in the range of 0.5 to 20 percent by weight of the filaments.
9. A bulky product according to claim 8 wherein the amount of the binder deposited on the surface of the filaments lies in the range of 2 to 10 percent by

weight of the filaments.

10. A bulky product according to any one of the preceding claims wherein the filaments are located in overlapping layers.

5 11. A bulky product according to any one of the preceding claims wherein the binder is synthetic thermoplastic resin whose softning temperature is less than that of the filament.

10 12. A bulky product according to claim 11 wherein the binder is polyvinylalcohol whose molecular weight is in the range of 100 to 10,000, and whose extent of saponification is not less than 98 percent.

15 13. A bulky product according to any one of the preceding claims wherein the filaments comprise polyesters.

14. A bulky product according to claim 13 wherein the filaments are of either poly(ethylene terephthalate) or poly(butylene terephthalate).

20 15. A bulky product according to any one of the preceding claims wherein the filaments are treated with lubricants to the extent of 0.01 to 0.5 percent by weight of the filament.

16. A bulky product according to claim 15 wherein the lubricant contains poly(organosiloxane).

25 17. A method of making the product of claim 1 which consists in separating multi-filament into single filaments of between 0.01 and 2 denier, spraying the filaments with surface binder and laying them down on a moving belt at a speed which causes the filaments to settle on the belt in folds.

30 18. A method according to claim 17 wherein the multi-filament is directed against a surface to separate and crimp the filaments.

19. A method according to claim 18 wherein the multi-filament is passed in a high speed air current through a nozzle.

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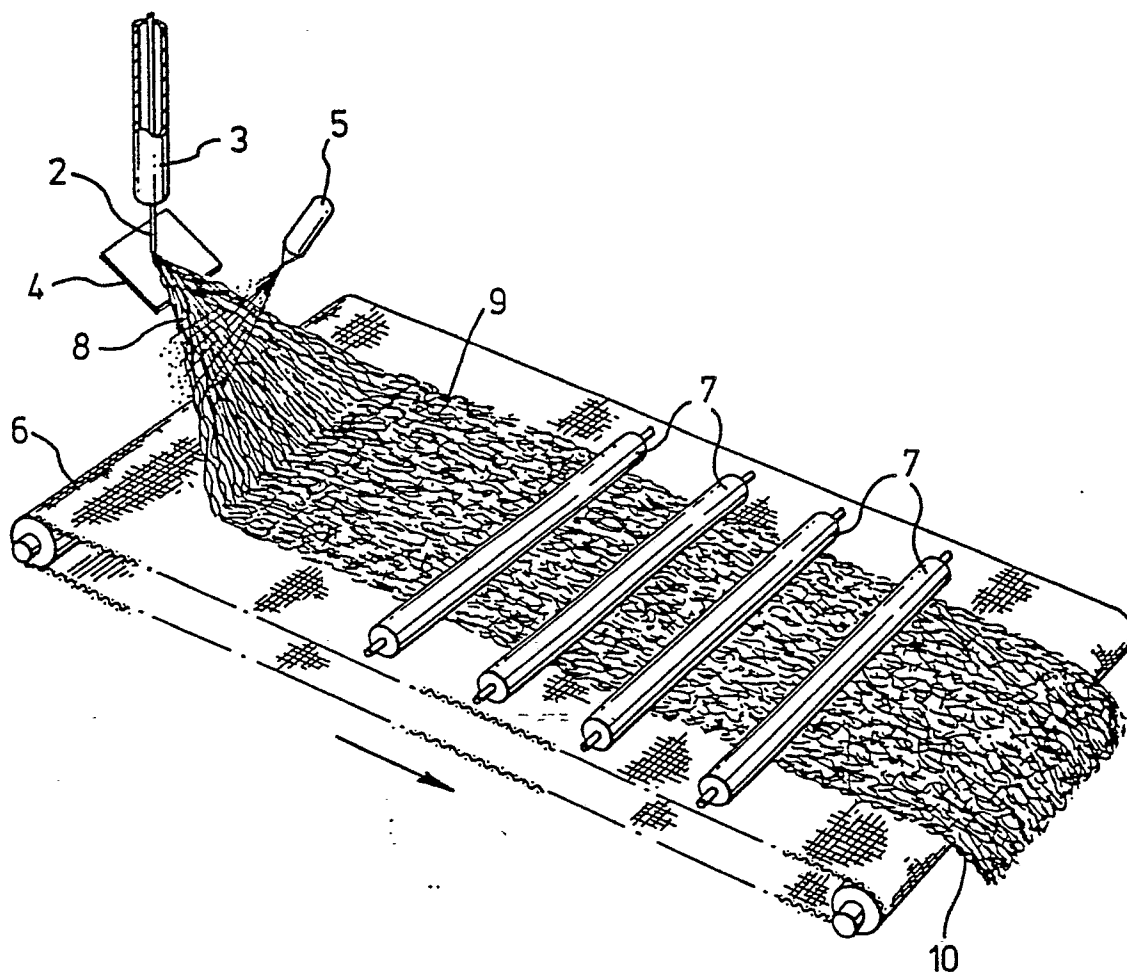
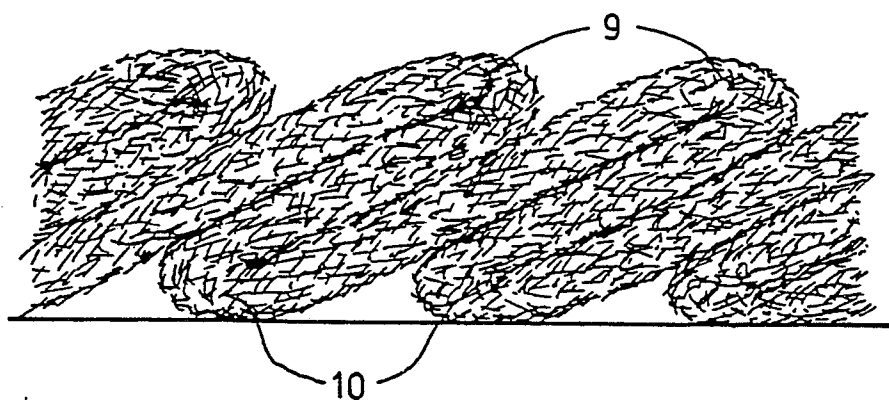
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*Fig. 2.*



DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>DE - A - 2 004 905</u> (LUTRAVIL) * columns 1-4 * ---	1	D 04 H 3/03
	<u>US - A - 2 736 676</u> (P.J. FRICKERT) * columns 12-15; column 5, lines 34-46 * -----	4	
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
			D 04 H 3/03 D 04 H 3/12
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
			&: member of the same patent family, corresponding document
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
The Hague	October 23, 1980	ELSEN-DROUOT	