

PATENT SPECIFICATION

(11) 1 445 981

1 445 981

- (21) Application No. 37499/72 (22) Filed 11 Aug. 1972
 (23) Complete Specification filed 10 Aug. 1973
 (44) Complete Specification published 11 Aug. 1976
 (51) INT CL² D04H 3/04 13/00
 (52) Index at acceptance



DIR 3B1 3C2B 3C2C 3C2G 3C2P 3C2X 3C2Y 3C5A 3C5D
 3D3C 3D3D 3D3E 3D3X 3D4A 3D4X

A1A 24

B5A 1G10 1G12 1G2 1M 1U2AX 2A1 2A2 2A3 2B2 2H6

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(54) NET AND METHOD OF PRODUCING SAME

(71) We, BEGHIN-SAY, formerly known as Société F. Beghin, a French Body Corporate, of Thumeries, Nord, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a net and a method of producing same. In more particular the invention relates to a net derived from a film or sheet.

Nets either derived from film or formed directly at the exit of an extrusion die are at present mainly used as reinforcement in paper articles or cheap textiles, e.g. in sanitary paper articles, paper cloth and heavy duty bags, and non-woven upholstery fabrics. They are further used, or have been suggested used, independently as window curtains, decorative net, wrapping material, mosquito net, protective gardening nets against insects or birds, backing for growing of grass or plants, sport nets, light fishing nets, and filter materials.

The nets formed directly at the exit of an extrusion die have the drawbacks or limitations that the mesh is relatively big, that orientation of the cross-points is difficult, and that the nets can generally not be made finer than about 20 grams per sq. m.

One type of net derived from film consists of two or more cross-laminated layers of uniaxially oriented film which have each been fibrillated to net form. This involves the need for a lamination process after fibrillation and at this stage lamination is generally complicated. For reinforcement in sanitary paper a fineness of 5 grams per sq. m. or finer is usually needed, and it is practically impossible to obtain this when two layers have to be laminated after fibrillation.

In a modification of this type of net, lamination can be avoided, as reinforcement filaments of a non-splitting polymer is incorporated in the splittable film, which is oriented at an angle to the incorporated filaments and then fibrillated at random. However, the randomness of the mesh is usually a drawback, and the randomly fibrillated material is relatively weak, as special admixtures are used to facilitate the random fibrillation.

Another type of net derived from film is formed by slitting a pattern of intermittent lines, and expanding the slit film while stretching biaxially. This process produces nets of a big mesh and with weak cross-points.

A third type of net derived from film is formed by embossment of the film in a suitable pattern followed by biaxial stretching under conditions which fibrillate the thin areas of the film at the same time as the material is expanded. Dependent on the pattern of the embossment different properties can be obtained, but the net is generally weak as the bosses remain unoriented.

A fourth type also makes use of embossment, but the bosses are formed as transverse stems which are subsequently oriented and form the main direction of strength. The thin, linear areas of the embossed film are oriented and split generally in the longitudinal direction and form relatively weak bridges between the transverse stems. For most uses this net has to be cross-laminated with another net or web, and this again involves the limitation that it is very difficult to produce the very low sq. m. weights required for reinforcement in sanitary articles.

Finally, it is known that net structures can be produced by extruding alternate streams of different polymers, and joining

the streams in the extrusion die, which contains moving parts that turn the streams to a transverse direction at the same time as they draw the streams to thin structures named "lamellae". Still in the die, one or both boundaries of the fluid sheet pass over a comb which drags longitudinal "tentacles" from the edges of the lamellae and the tentacles are collected in bundles. After solidification, the sheet is mechanically disrupted in accordance with the layered and fibrous structure produced in the die, and hereby a fabric is achieved with two interconnected thread directions. However, the fabrics produced by this method are several times heavier than the abovementioned usual requirements for nets in sanitary articles.

The present invention aims to provide an entirely new technique, generally speaking by a combination of side-by-side extrusion of streams, transversal embossment, and splitting. By means of the present invention there is obtained a particularly fast and reliable process whereby the desirable weight of about 5 grams per sq. m. or lower can be achieved without difficulty. Further there is conceived a novel and advantageous structure.

The net according to the present invention is composed of a regular array of longitudinal ribbon-formed continuous filaments of a polymer material, and of a regular array of transverse stems of a different polymer material having branches which are integral therewith, said filaments being embedded in said stems at their intersections with the branches and in the entire length of said branches.

Hereby is achieved a net structure which comes very close to a woven structure and consequently has similar good properties.

The two polymer substances may be incompatible and have different melting points.

In order to facilitate the embedding of the filaments in the stems, without causing damage to the filaments, the latter should preferably be formed of a polymer substance with higher melting point than the polymer matter of which the stems are formed. Due to the ribbon-form of the filaments the embedding produces only a small notch-effect in the stems.

In order to further reduce this notch effect, the ribbon-formed filaments are preferably tapered at their edges.

In a preferred embodiment of the net according to the invention said filaments are embedded in slipping relation with their embedment. During the production of the net, this is easily obtained when the filaments and the stems (or at least those portions of the stems which contact the filaments) are formed of mutually

incompatible polymer substances, that is substances which do not stick or bond together in the solidified state. By this slipping relationship the diagonal flexibility is increased, and further the orienting at the cross-points is facilitated.

The filaments are preferably oriented, and the stems are preferably also oriented.

In another embodiment of the net according to the invention the stems have ribbon-like branches integral therewith, said branches forming part of the embedment for said filaments and the total thickness of each branch being thinner than the corresponding stem. In the oriented stem the cavities in which the filaments are embedded are, of course, also elongated. The branches, however, serve to prevent an exaggerated movement of the filaments within the elongated cavities in the stems.

These branches may with advantage connect each set of adjacent stems.

In another embodiment of the net according to the present invention the stems are formed of several layers of different polymer substances. Such layered arrangement can easily be formed in connection with the embedment, as it will be described later, and important effects can be obtained in this manner.

Thus, when the net is used for reinforcement in sheets of cellulosic fibres, at least one surface layer of each stem can with advantage be formed of olefin copolymer capable of producing an adhesive bond with cellulose, e.g. ethylene-acrylic acid copolymer, ethylene-metacrylic acid copolymer, or an ionomer, that is a polymer the molecule of which contains metal ions, while the main portion of the stems is formed of essentially homopolymer olefin. The latter is used on account of its low price and relatively high strength.

As mentioned above, the filaments should preferably be formed of a polymer substance with higher melting point than the polymer matter of which the stems are formed, and a suitable choice is that said filaments are formed of polyamide, e.g. nylon 6 or nylon 66, or of polyethyleneterephthalate, and said stems are formed of polyolefin.

While the longitudinal filaments must always be ribbon-formed to avoid a notch effect in the transverse stems, the latter may have different forms. Thus, if relatively high stiffness is desirable, e.g. to obtain a suitable drape effect of light weight fabrics, the stems are preferably of generally circular to squared shape.

If, on the other hand, high softness is desirable, e.g. in sanitary articles such as surface netting on napkins, the stems are preferably of substantially flat shape.

As mentioned above, important effects can be obtained by forming the stems in a layered structure of different polymers. One application of such a layered structure has been described. It can further be used to obtain a bulky net, and for this purpose said layers are in a state of differential shrinkage producing a curling of the stem. In this case the filaments should preferably be considerably spaced apart from one another.

The invention also comprises a method for producing the net described above, comprising the steps of forming a film or sheet consisting of a regular array of continuous, longitudinal, ribbon-formed filaments of a higher melting polymer substance (A) which are spaced apart from one another and which are each embedded in a matrix of lower melting polymer matter, subsequently impressing said film or sheet at a temperature at which the matrix is molten to semi-molten, and (A) is pronouncedly more solid, and at a pressure adapted to collect at least the main portion of said lower melting polymer matter in a regular pattern of transverse stems, but leaving said filaments substantially undamaged, and subjecting the lower melting polymer matter to splitting between the filaments of (A) in said impressed areas.

When compared with other methods in which a film is impressed as a basis for splitting to a net structure, the method according to the present invention has higher efficiency due to the conveying action of the relatively solid longitudinal filaments.

A more vigorous impression action is therefore allowable, which means that higher process velocities can be achieved and that the accuracy of the apparatus and the adjustment of process conditions are less critical. As it will be further described below, it is even possible to combine the impression and the fibrillation to one step.

In an embodiment of the method according to the present invention at least those portions of said matrix which are brought in direct contact with (A) by said embedding consist of polymer substance(s) which are incompatible with (A). The filaments and the stems will hereby form a slipping type of join with each other with the advantages which have been described above.

The embedding of the filaments in the matrix can be carried out in many different ways, however the most expedient procedure found is to produce said embedding by extruding an intermediary layer formed of streams of (A) interspersed with another polymer substance (B), the streams of (B) being part of the matrix, and

forming the rest of the matrix by co-extruding on either side of said intermediary layer surface layers of (B) and/or of other polymer substance(s).

An embodiment of the invention is further characterized in that at least one of the surface layers is formed integral with said interspersed streams of (B) preferably by means of a profiled orifice for (B). This is a particularly simple way of producing the embedded arrangement. Instead of by use of such profiled die, the integral formation of a surface layer can also be achieved by merging the streams of (B) beyond one side of each stream of (A), e.g. by extruding the streams of (A) and of (B) into a common chamber, while the extrusion orifices for (B) fill a greater part of the chamber width than the extrusion orifices for (A).

In another embodiment of the invention, still based on the described interspersed co-extrusion of (A) and (B), at least one of the surface layers is formed of a distinct stream extruded independently of said interspersed streams of (B). This allows for variations of the layer thicknesses and the spacing-apart of the filaments, these variations being independent of each other.

Usually there is no particular advantage in placing the filaments right in the middle of the matrix or varying both surface thicknesses, and consequently the above features can with advantage be combined by forming a major (i.e. thicker) surface of a distinct stream extruded independently of said interspersed streams of (B), while the opposite, minor (i.e. thinner) surface layer is formed integral with said interspersed streams of (B). Suitable relative values of layer thicknesses are indicated later in this description.

In order to obtain high longitudinal strength it is preferable to intersperse only small amounts of (B) with the streams of (A) in the intermediary layer. E.g. the filaments should occupy about 2/3 or more of the intermediary layer.

With a view to the adhesion to cellulose fibres and the economical advantages of using polyolefins, an embodiment of the invention is characterized in that a major surface layer is formed of essentially homopolymer olefin and a minor surface layer is formed of an olefin copolymer capable of producing an adhesive bond with cellulose, e.g. ethylene-acrylic or ethylene methacrylic acid copolymer or an ionomer.

As regards a suitable choice of polymer for the filaments in relation to the choice of polymer for the matrix, hereunder considering differences in melting point and economical features, an embodiment of the invention is characterized in that (A) consists of polyamide, e.g. nylon 6 or 66, or of polyethyleneterephthalate, and the

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matrix consists, at least mainly, of polyolefin(s).

5 The impression according to a transverse pattern need not be perpendicular, or nearly perpendicular, to the machine direction, but if the net is intended for use in lamination it may be carried out under a pronouncedly acute angle, e.g. 45°.

10 Well known procedures of impression may be applied, for example the use of an embossed roller and a smooth roller as counter part. The application of vibrating edge and a flat or cylindrical anvil has also been suggested and can be used in connection with this invention. In any case it is preferable to take advantage of the conveying action of the relatively solid filaments and therefore to produce an effect more vigorous than otherwise possible.

20 Thus, a preferred embodiment of the invention is characterized in that said impression is carried out by means of an embossed preferably hard roller engaged with a smooth preferably hard roller, the two rollers carrying the film (sheet) in the same direction, but being rotated at different circumferential velocities, so as to increase the impression effect by means of shearing, the smooth roller being preferably the faster one.

30 When carrying out this procedure of impressing, it is preferred to feed the film (sheet) onto the smooth roller which is kept at a temperature adapted to bring the polymer substances in the aforesaid states for impression, while the embossed roller is kept at a lower temperature to avoid the material sticking thereto.

40 A substantial simplification can be achieved by carrying out said shearing action to an extent sufficient to produce said splitting simultaneously. This effect is based on a great difference in resistance to the disruptive effect of the pressure and shear between those areas which are directly conveyed by the filaments and those which are not.

50 Whenever the assembly of an embossed roller and a smooth counterroller is used in connection with the present invention, the best conveying action of the filaments is obtained when using a film or sheet having the filaments of (A) embedded closer to one surface than to the other surface, and in which the surface closest to the filaments is brought in contact with the embossed roller.

60 Both the longitudinal ribbons and the transverse bosses are preferably oriented by stretching. For the sake of regularity of the structure the longitudinal filaments of (A) are preferably oriented subsequently to co-extrusion and prior to impression. 65 However, it is usually also advantageous to

finalize the orientation of said filaments subsequently to the impression. Hereby the weight per sq. m. is reduced, and the spacing between the stems is increased. This increase is often required as the best impression appears to be obtained with a division not more than about 1 to 2 mm between the bosses or teeth of the roller.

When the stems are oriented, as usually required (except if they are made of elastomeric material) this orientation is carried out subsequently to the impression by cross-stretching preferably by means of a tenterframe.

80 The cross-stretching is usually carried out at a ratio between 5 to 10:1 and hereby the longitudinal ribbons are spread apart accordingly. The ribbons should therefore normally be extruded with a division as small as practically possible, e.g. about 1 mm, but a still smaller division may be desirable. An expedient way to obtain a close arrangement of the longitudinal filaments of (A) is achieved by stretching the film (sheet) subsequently to the co-extrusion and prior to the impression while allowing cross-wise contraction of the film (sheet). This stretching may be the same as the above-mentioned orientation, but may also fully or partly be carried out while the filaments are molten or semi-molten, whereby they will not become substantially oriented.

100 The embossment will normally produce stems of generally circular to square shape. This should be understood as a very approximate indication. When — in order to produce a softer product — flat stems are desirable, the stems can be flattened by calendering subsequently to the impression and preferably prior to the cross-stretching. This calendering may be carried out at an elevated temperature.

105 As mentioned, the conveying effect of the longitudinal filaments highly facilitates the step of impressing the film (sheet), in particular when the surface layer adjacent to the embossed roller is thin and when only small amounts of (B) are interspersed between the filaments. However, a still higher conveying effect and thereby still higher production rates can be obtained when the polymer substance interspersed with (A) and a polymer substance forming a minor surface layer are blends containing relatively small portions of an incompatible polymer having higher melting point, whereas the major surface layer is formed of a substantially homogeneous polymer substance, longitudinal fibrillation of said blended component(s) being carried out subsequently to the impression in the impressed areas. In this connection said blended component(s) can with advantage consist for the major part of polyolefin, the 130

admixture being polyamide or polyethyleneterephthalate in a percentage about or below 25%.

The above-mentioned fibrillation of the blended component(s) will usually occur sufficiently simply by the cross-stretching step by which the stems are oriented. In similar way other types of impressed film or sheet material according to the invention, when not split during the impression, can often be split to the desired net form by cross-stretching alone. However, splitting (fibrillation) can also be carried out as an independent step between the impression and the stretching of the stems. A convenient way to obtain this is to carry out the impression in a pattern at bias, e.g. about 60° to 75° to the machine direction and to deflect the sheet so that the angle between the filaments and the stems is increased, preferably to about 90°.

As regards the embedding of the longitudinal, ribbon-formed filaments in the matrix, in the foregoing the emphasis has been put on the co-extrusion process where different polymer substances are interspersed with one another and surface layers are formed in the same extrusion die. Although this has been found to be a particularly suitable process, there are also other ways to form said embedded arrangement. Thus a film (sheet) of interspersed streams can be formed in a first process step, while the surface layers are extruded or calendered hereon by a separate process step.

As a third way of forming the embedded arrangement, the longitudinal ribbon-formed filaments can be produced and arranged as an array by slitting and drawing of a film, and the matrix can thereafter be applied to both sides of the array and joined between the ribbons in a calender. Instead of by slitting of a film, the filaments can also be formed by ordinary extrusion from a row of orifices.

Finally, as regards apparatus required, a particularly simple way of forming the embedded arrangement yielding, however, a somewhat lower strength in the final product, is by forming an ordinary film (sheet) of 3 or more layers with the substance (A) as an interior layer, and the matrix substance(s) on either side of this layer. Subsequently this composite film (sheet) is slit to an array of ribbons which are normally drawn, and thereafter the matrix substance(s) are squeezed from either surface of the ribbons and joined in the spaces between the ribbons. This squeezing can be carried out simultaneously with the formation of the stems by the above-described impression, or there can preferably be a prior calendering at a suitable temperature.

Another aspect of the net described above is described and claimed in the present applicants' co-pending Patent Application No. 5111/76. (Serial No. 1445982).

The invention will now be described in more detail with reference to the accompanying drawings in which:—

Figure 1 is a cross-section, taken on the line I—I of Figure 2, of an extrusion die for carrying out of the invention;

Figure 2 is a longitudinal section, taken on the line II—II of Figure 1, of the same die;

Figure 3 is a cross-section of the structure of a film which is an intermediate product in the production of the net according to the invention, and is produced by the die shown in Figures 1 and 2;

Figures 4 and 5, which correspond to Figures 1 and 2, respectively, show a modification of the die;

Figure 6, which corresponds to Figure 3, shows the film structure produced by the die shown in Figures 4 and 5;

Figure 7, which also corresponds to Figure 3, shows another modification of the film structure;

Figure 8 is a schematic, perspective view of all the apparatus necessary to produce the net of the invention;

Figure 9 is a representation of the impression process, showing the film and the embossed roller in perspective view with displaced view section, III corresponding to the line III—III in Figure 3, and IV corresponding to the line IV—IV in Figure 3;

Figure 10 is an enlarged, perspective view, with partial sections of the net of the invention, before the final longitudinal stretching and before any cross-stretching has taken place; and

Figure 11 is a view similar to Figure 10, but on a reduced scale, of the net after final longitudinal stretching and cross-stretching.

In Figures 1 and 2, a higher melting polymer substance A and two lower melting polymer substances B and B₁ are extruded from separate extruders and distribution channels (not shown) into three slot-formed conduits as shown by the three arrows.

B and B₁ can be identically the same polymer substances, but still fed independently, or different modifications of the same polymer, or two polymers which are chemically different, but capable of forming a strong adhesive bond with each other. A is preferably incompatible with B and B₁.

The die is formed of an internal part 1 and two external parts 2 and 3. The slot-formed conduit for A is divided out on a large number of parallel channels at zone 4 in this part. As it appears particularly from

Figure 2, part 1 ends in a comb-formed profile, and the channels for A pass through each "tooth" of the "comb". In the chamber 5, A, B and B₁ join to a composite sheet. A is extruded into this chamber from a row of separate orifices, while B is extruded from a comb-formed orifice and B₁ is extruded from a straight slot. Hereby the structure shown in Figure 3 is formed, except that the streams (filaments) of A are not yet ribbon-formed.

The composite stream is narrowed and extruded through the exit slot 6, and thereafter the fluid sheet is drawn down, whereby the filaments of A become ribbon-formed. The relative layer thicknesses and the proportion between the width and the spacing-apart of the ribbon-formed filaments are determined by the relative extrusion through-puts and by the relative dimensions in the tooth-formed orifice for B.

Due to smearing-out, the ribbon-formed filaments have a tendency to become tapered at the edges, as shown. This form is advantageous and can be promoted by a suitable shaping of the channels for A.

In Figures 4 and 5, the die has been modified to form two surface layers of a third polymer substance C, applied from a third extruder. C can be, for example, a polymer capable of forming a bond with cellulose. The film C must form a strong adhesive bond with B and B₁, but not necessarily with A. Consequently, there is no need to cover one of the surfaces of the ribbon-formed filaments with B, but B is only interspersed with A as a large number of separate streams as shown in Figure 6.

To achieve this, B is extruded into the common chamber 5 from a row of orifices interspersed with the orifices for A instead of being extruded from a comb-formed orifice.

On the other hand it can also be advantageous to intersperse both component B and component B₁ between the streams of A so as to form the structure shown in Figure 7. To achieve this, die-part 1 is supplied with grooves on the side which in Figure 2 is shown straight, so as to make the orifice for B₁ comb-formed like the orifice for B.

In Figure 8, the film is co-extruded of components A, B, and B₁ in a die 9, which is the die shown in Figures 1 and 2. The heating elements are neither shown here, nor in Figures 1 and 2. The film is cooled first by air (not shown) then by a haul-off and cooling roller 10. All rollers shown in Figure 8 are driven rollers. Hereafter the film is stretched in a first longitudinal stretching process in zone 13 between a set of nip-rollers 11—12, which hold against the stretching, and roller 14 which pulls in

conjunction with an embossed roller 16 and its smooth counter roller 15. Roller 12 is heated to a temperature suitable for the stretching. This process has two objectives. One is partly to orient the filaments (a second longitudinal stretching following after the impression) another to bring the filaments closer together. Therefore the length of the stretching zone should be sufficient to allow an almost free contraction of the film, e.g. about 3—4 times the width of the film.

The roller 15 is heated to a temperature suitable for the impression of the film, i.e. to a range where component A is generally solid while B and B₁ are semi-molten to molten — preferably semi-molten — at a temperature in the lower end of their melting range. In order to increase the heat transfer to the film and thereby enable a faster process, roller 14 is also heated, but to a lower temperature where the film has no tendency to stick to the roller. The embossed roller 16 is cooled by water in order to facilitate the release of the net after the impression. In order to increase the impression effect and simultaneously split the film to a net structure there is produced a shear by moving the counter roller 15 at a higher circumferential velocity than the embossed roller 16. This is indicated by the longer arrow 17 and the shorter arrow 18. The ratio between these velocities should generally be in the range between 1.25:1 and 2:1. The distance between two adjacent bosses on roller 16 should generally be in the range 1 mm—5 mm.

With reference to the more detail Figure 9, the different velocities produce a shear with the effect that the material is pressed against one edge 19 of each tooth (boss) 20, and is "pumped" into the grooves between the teeth, whereby the stems are formed in generally circular to square form. By sufficient pressure and shearing all contents of B and B₁ can be broken and squeezed away from the areas between the stems, except a thin coat on the filaments of A. In spite of the fact that B and B₁ are disrupted in this manner, the filaments of A remain undamaged, when the pressure and shear are suitably adjusted. As it appears from Figure 9, the filaments of A are embedded closer to the surface facing the embossed roller than to the other surface. Hereby they are cooled somewhat more than the main portion of the matrix (B and B₁) in which they are embedded. Said cooling also serves to minimize the deformation of the ribbon-formed filaments.

As already mentioned, the cooling of the embossed roller facilitates the release of the net. Further for this purpose, the cross-

section of each tooth may advantageously be a trapezoid shape. The hot counter-roller 15 having a smooth surface, the net can usually be released from this surface without special precautions being taken, however, if a sticky surface component is used in the film, it may be necessary to apply a release agent to this roller. The product, now in net-form is pulled off from the embossed roller and its counter-roller at a very small draw ratio by means of nip-rollers 24 and 25, and is finally drawn in the longitudinal direction between these nip-rollers and nip-rollers 26 and 27. By installing roller 26 very near to roller 25, a lateral contraction of the net is almost prevented, and the straight perpendicular position of the stems is maintained. The net is then fed into a tenter-frame 28 to orient the stems, or, if flat stems are desirable, the net can be calendered at a suitable temperature prior to the cross-stretching.

The net shown in Figure 10 is taken at the stage between rollers 17—18 and rollers 24—25, where the stems, consisting of B and B₁, are unoriented, and where the longitudinal, ribbon-formed filaments of A have only been oriented in the first step of stretching. In order to show the features of the structure clearer, the filaments of A are spaced considerably apart from one another, while in actual fact they should usually lie much closer.

The filaments of A are embedded in the stems, and the latter have thin "branches" 22 which also consist of the matrix material, and also form part of the embedment for the filaments. These branches have the advantageous effect of keeping the filaments of A in position. The branches of matrix material are here shown surrounding the filaments, but depending on the conditions during the impression, they may lie only on one side of each filament. In this case it is advisable to apply small amounts of an adhesive, preferably before the cross-stretching. The drawing further shows that the filaments are straightened out, while on the embossed roller they were bent into the grooves (see Figure 9). By this straightening out of the filaments, the stems get an irregular shape at the cross-points, as shown. This deformation, however, has little or no influence on their strength, as the cross-sectional area of the stems are maintained. It supplies the net with an interesting optical effect, making the illusion of a woven fabric.

When A is incompatible with the matrix materials, the attachment is of a slipping character as in woven structures, thus there is a similar diagonal flexibility and drape effect. Due to these effects which give a similar appearance to woven cloth, the net can be used at the stage before cross-

drawing in particular for decoration purposes and the like.

If the matrix is made of an elastomer, no orientation of the stems is possible, and in this case Figure 10 represents the final stage as far as the stems are concerned. Such net material can be used, for example, in upholstery, where elasticity is an important advantage. Examples of suitable elastomers are block-copolymers consisting of polyurethane or of polystyrene-butadiene, or of polypropylene in which each molecule has both iso- or syndiotactic segments and atactic segments.

The "branches" 22 of matrix material in Figure 10 form "bridges" from stem to stem. During the final longitudinal stretching they may break between the stems, but will still have a useful effect in keeping the filaments of A in the right position.

In Figure 11, the longitudinal stretching has been finalized, and the stems have been oriented by cross-drawing of the net in the tenter-frame. The weight can thereby be brought down below 5 gr. per sq. m., and the tensile strength in both directions reaches values rather close to those of woven cloth of usual filaments of the same components. When the attachment of the filaments to the stems is non-adhesive, i.e. when A and the matrix substance or substances are mutually incompatible, the orientation of both filaments and stems take place without difficulty also at the cross-points.

In this case, the holes in the stems in which the longitudinal filaments are placed, are of course elongated similarly, but the filaments will still be kept in position by means of the branches 22. Due to the stretching in two directions, these branches form a kind of film at the areas adjacent to the stems, as shown.

If, instead of splitting the film to a true net during the embossment, there is left a very thin film between the stems, this film will often fibrillate during the cross-stretching and form fine fibres connecting adjacent stems. These fine fibres may often have a suitable decorative effect, as they represent a randomness in the otherwise very regular structure, and they may further serve adhesive purposes, if the net is combined with staple fibres, e.g. paper fibres, and further they may be advantageous for filtration purposes.

With the exceptions mentioned above, it is usually advantageous to produce a strong orientation in both filaments and stems. If the filaments consist of polyamide or polyester, the total longitudinal stretch ratio should preferably be between 3.5:1 and 6:1. If the stems consist of polypropylene or high density polyethylene,

the transverse stretch ratio should preferably be between 5:1 and 10:1.

All longitudinal orientation can be carried out before the embossment (impression) but then the spacing between the stems in the final product will be smaller, and it will be difficult to reach the extreme low square meter weights. On the other hand it is also possible to carry out all longitudinal orientation after the impression, but then it is difficult to maintain the rectilinearly arrangement of the stems. It is usually advisable to carry out about half of the orientation before and half of it after the impression.

Use is made in the following examples of the line shown in Figure 8 with the die shown in Figures 1 and 2. At the exit from the die, the division between the filaments, measured from middle to middle, is 1.2 mm, and the length of the die is 220 mm. The melt indices refer to ASTM, conditions specified below.

Example 1

Components B and B₁ are the same, viz. polypropylene of melt index 5 (condition L).

Component A is nylon 6, which according to condition K has about the same melt index as B and B₁ under similar conditions.

Composition: A 30%, B 20%, B₁ 50%.

Weight of extruded film: 100 gr. per sq. m.

First longitudinal orientation draw ratio 2.0:1, lateral contraction ratio 1:1.4.

Shear ratio (=longitudinal contraction) during impression 1:1.4.

Second longitudinal orientation: draw ratio 2.8:1.

Cross stretch ratio: 7:1.

Weight of final net 5 gr. per sq. m.

Pattern on embossed roller: 1 mm wide teeth with 2 mm spacing between the teeth.

Temperature of the film during impression: 155°C.

Temperature during cross-stretching: 130°C.

Example 2

Component A as in Example 1.

Component B₁ polypropylene with high atactic contents [trade-name Novolen] (Registered Trade Mark). Melt index as in Example 1.

Component B: an ethylene acrylic acid copolymer with same melt index as B₁.

B₁ and B form a strong adhesive bond with each other, partly due to the atactic contents. B is chosen for adhesion to cellulose.

Temperature during impression 145°C.

Temperature during cross-stretching 120°C.

Example 3

Component A as in Example 1.

Component B₁ is high density polyethylene with melt index as B₁ in Example 1.

Component B is a copolymer of 20% vinylacetate and 80% ethylene, melt index like B₁.

Temperature during impression 130°C.

Temperature during cross-stretching 110°C.

WHAT WE CLAIM IS:—

1. A net composed of a regular array of longitudinal continuous ribbon-like filaments of a polymer material, and of a regular array of transverse stems of a different polymer material having branches which are integral therewith, said filaments being embedded in said stems at their intersections with the branches and in the entire length of said branches.

2. A net according to claim 1, wherein the polymer material forming the filaments has a melting range higher than the polymer material forming the stems and branches thereof.

3. A net according to any of claims 1 and 2, wherein said ribbon-like filaments are tapered at their edges.

4. A net according to any of claims 1 to 3, wherein said two polymer materials do not stick together when solidified.

5. A net according to any preceding claim, wherein said filaments are molecularly oriented.

6. A net according to any preceding claim, wherein said stems are molecularly oriented.

7. A net according to any preceding claim, wherein the branches of a given stem are connected to branches of adjacent stems.

8. A net according to any preceding claim, wherein each of said stems is formed of several layers of different polymer materials.

9. A net according to claim 8, wherein at least one surface layer is formed of an olefin copolymer capable of producing a bond with cellulose, while the main portion of the stems is formed essentially of an olefin homopolymer.

10. A net according to any of claims 8 and 9, wherein at least one surface layer is formed of an ionomer, while the main portion of the stems is formed essentially of an olefin homopolymer.

11. A net according to any of claims 8 to 10, wherein said layers are in a state of differential shrinkage causing a curling of the stems.

12. A net according to any of claims 1 to 7, wherein said filaments are formed of a polyamide or of polyethylene-



the transverse stretch ratio should preferably be between 5:1 and 10:1.

5 All longitudinal orientation can be carried out before the embossment (impression) but then the spacing between the stems in the final product will be smaller, and it will be difficult to reach the extreme low square meter weights. On the other hand it is also possible to carry out all longitudinal orientation after the impression, but then it is difficult to maintain the rectilinearly arrangement of the stems. It is usually advisable to carry out about half of the orientation before and half of it after the impression.

10 Use is made in the following examples of the line shown in Figure 8 with the die shown in Figures 1 and 2. At the exit from the die, the division between the filaments, measured from middle to middle, is 1.2 mm, and the length of the die is 220 mm. The melt indices refer to ASTM, conditions specified below.

Example 1

25 Components B and B₁ are the same, viz. polypropylene of melt index 5 (condition L).

30 Component A is nylon 6, which according to condition K has about the same melt index as B and B₁ under similar conditions.

Composition: A 30%, B 20%, B₁ 50%.

Weight of extruded film: 100 gr. per sq. m.

35 First longitudinal orientation draw ratio 2.0:1, lateral contraction ratio 1:1.4.

Shear ratio (=longitudinal contraction) during impression 1:1.4.

40 Second longitudinal orientation: draw ratio 2.8:1.

Cross stretch ratio: 7:1.

Weight of final net 5 gr. per sq. m.

Pattern on embossed roller: 1 mm wide teeth with 2 mm spacing between the teeth.

45 Temperature of the film during impression: 155°C.

Temperature during cross-stretching: 130°C.

Example 2

50 Component A as in Example 1.

Component B₁ polypropylene with high atactic contents [trade-name Novolen] (Registered Trade Mark). Melt index as in Example 1.

55 Component B: an ethylene acrylic acid copolymer with same melt index as B₁.

60 B₁ and B form a strong adhesive bond with each other, partly due to the atactic contents. B is chosen for adhesion to cellulose.

Temperature during impression 145°C.

Temperature during cross-stretching 120°C.

Example 3

Component A as in Example 1. 65

Component B₁ is high density polyethylene with melt index as B₁ in Example 1.

Component B is a copolymer of 20% vinylacetate and 80% ethylene, melt index like B₁. 70

Temperature during impression 130°C.

Temperature during cross-stretching 110°C.

WHAT WE CLAIM IS:—

75 1. A net composed of a regular array of longitudinal continuous ribbon-like filaments of a polymer material, and of a regular array of transverse stems of a different polymer material having branches which are integral therewith, said filaments being embedded in said stems at their intersections with the branches and in the entire length of said branches. 80

2. A net according to claim 1, wherein the polymer material forming the filaments has a melting range higher than the polymer material forming the stems and branches thereof. 85

3. A net according to any of claims 1 and 2, wherein said ribbon-like filaments are tapered at their edges. 90

4. A net according to any of claims 1 to 3, wherein said two polymer materials do not stick together when solidified. 95

5. A net according to any preceding claim, wherein said filaments are molecularly oriented.

6. A net according to any preceding claim, wherein said stems are molecularly oriented. 100

7. A net according to any preceding claim, wherein the branches of a given stem are connected to branches of adjacent stems. 105

8. A net according to any preceding claim, wherein each of said stems is formed of several layers of different polymer materials.

9. A net according to claim 8, wherein at least one surface layer is formed of an olefin copolymer capable of producing a bond with cellulose, while the main portion of the stems is formed essentially of an olefin homopolymer. 110

10. A net according to any of claims 8 and 9, wherein at least one surface layer is formed of an ionomer, while the main portion of the stems is formed essentially of an olefin homopolymer. 115

11. A net according to any of claims 8 to 10, wherein said layers are in a state of differential shrinkage causing a curling of the stems. 120

12. A net according to any of claims 1 to 7, wherein said filaments are formed of a polyamide or of polyethylene- 125



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terephthalate, and said stems are formed of polyolefin.

13. A net according to any preceding claim, wherein said stems are of substantially circular or square cross-section.

14. A net according to any of claims 1 to 12, wherein said stems are flat.

15. A method of producing a net comprising the steps of forming a film or sheet consisting of a regular array of continuous, longitudinal ribbon-formed filaments of a higher melting polymer substance which are spaced apart from one another and which are each embedded in a matrix of lower melting polymer substance, subsequently impressing said film or sheet at a temperature at which the matrix substance is semimolten to molten and the filament substance is markedly more solid and at a pressure adapted to collect at least the main portion of the matrix substance in a regular pattern of relatively thick transverse portions or stems with relatively thin portions therebetween while leaving said filaments substantially unmodified, and subjecting the relatively thin portions to splitting between the filaments.

16. A method according to claim 15, in which at least those portions of said matrix which are brought in direct contact with (A) by said embedment consist of polymer substance(s) which are incompatible with (A).

17. A method according to claim 15, in which said embedding is produced by extruding an intermediary layer formed of streams of (A) interspersed with another polymer substance (B), the streams of (B) being part of the matrix, and forming the rest of the matrix by co-extruding on either side of said intermediary layer surface layers of (B) and/or of other polymer substance(s).

18. A method according to claim 17, in which at least one of the surface layers is formed integrally with said interspersed streams of (B) preferably by means of a profiled orifice for (B).

19. A method according to claim 17, in which at least one of the surface layers is formed of a distinct stream extruded independently of said interspersed streams of (B).

20. A method according to claim 17, in which a major (i.e. thicker) surface layer is formed of a distinct stream extruded independently of said interspersed streams of (B), while the opposite, minor (i.e. thinner) surface layer is formed integral with said interspersed streams of (B).

21. A method according to claim 17, in which polymer (A) comprises at least 2/3rds the intermediary layer.

22. A method according to claim 17, in which a major surface layer is formed at least mainly of a homopolymer olefin and a minor surface layer is formed of an olefin copolymer capable of producing an adhesive bond with cellulose or of an ionomer.

23. A method according to any one of claims 15 to 22, in which (A) consists of a polyamide or of polyethyleneterephthalate, and the matrix consists wholly or mainly of polyolefin(s).

24. A method according to any one of claims 15 to 23, in which said impression is carried out by means of an embossed roller engaged with a smooth roller, the two rollers carrying the film or sheets in the same direction but being rotated at different circumferential speeds, so as to increase the impression effect by means of shearing, the smooth roller being preferably the faster one.

25. A method according to claim 24, in which the film or sheet is fed onto the smooth roller which is kept at a temperature adapted to bring the polymer substances to the states specified for impression in claim 15, while the embossed roller is kept at a lower temperature to avoid the material sticking thereto.

26. A method according to claim 24 or claim 25, in which said shearing action is carried out to an extent sufficient to produce said splitting simultaneously.

27. A method according to any one of claims 24 to 27, in which a film or sheet is used having the filaments of (A) embedded closer to one surface than to the other surface, and in which the surface closest to the filaments is brought into contact with the embossed roller.

28. A method according to claim 17, in which a closer arrangement of the longitudinal filaments of (A) is achieved by stretching the film subsequently to the co-extrusion and prior to the impression while allowing cross-wise contraction of the film.

29. A method according to claim 17, in which the longitudinal filaments of (A) are oriented subsequently to co-extrusion and prior to impression.

30. A method according to claim 29, in which the orientation of said filaments is completed subsequently to the impression.

31. A method according to any one of claims 15 to 28, in which subsequently to the impression said stems are oriented.

32. A method according to any one of claims 15 to 28, in which subsequently to the impression said stems are flattened by callendering.

33. A method according to claim 17, in which the polymer substance interspersed with (A) and a polymer substance forming a minor surface layer are blends containing

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5 relatively minor portions of an incompatible polymer having higher melting point, whereas the major surface layer is formed of a homogeneous polymer substance, a longitudinal fibrillation of said
10 blended component(s) being carried out subsequent to the impression in the thinner portions.

34. A method according to claim 33, wherein said blended component(s) consist for the major part of polyolefin and the admixture is a polyamide or polyethyleneterephthalate in a percentage of not more than 25%.

15 35. A net substantially as hereinbefore described with reference to the accompanying drawings.

20 36. A method of producing a net substantially as hereinbefore described with reference to the accompanying drawings.

37. A method of producing a net

substantially as hereinbefore described with reference to the examples.

38. Apparatus for producing the net claimed in any one of claims 1 to 14, said apparatus including die means for extruding said film or sheet having filaments incorporated therein, roller means for impressing said film or sheet, and means for splitting and stretching the impressed film or sheet.

39. Apparatus for producing a net substantially as hereinbefore described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1976.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



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