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METHOD FOR CONTINUOUSLY EXTRUDING NET-LIKE STRUCTURES COMPOSED OF TWISTED MULTIFILAMENT YARNS

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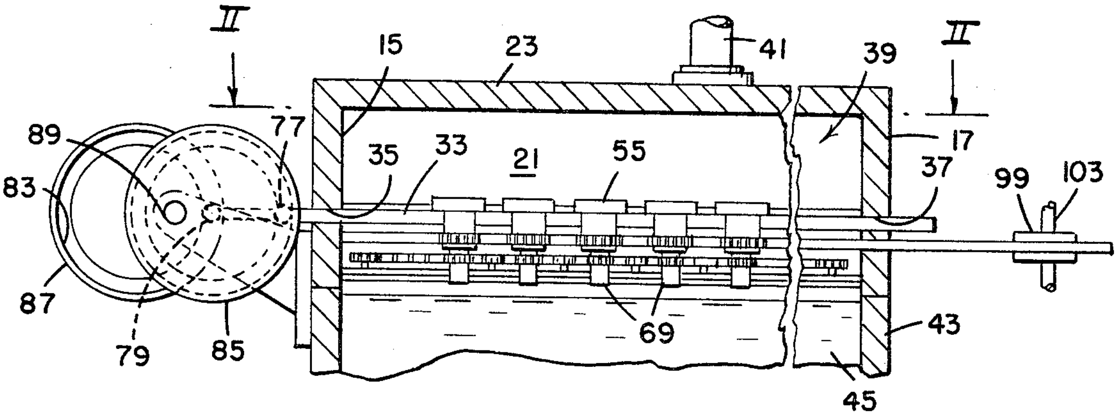

Fig. 1

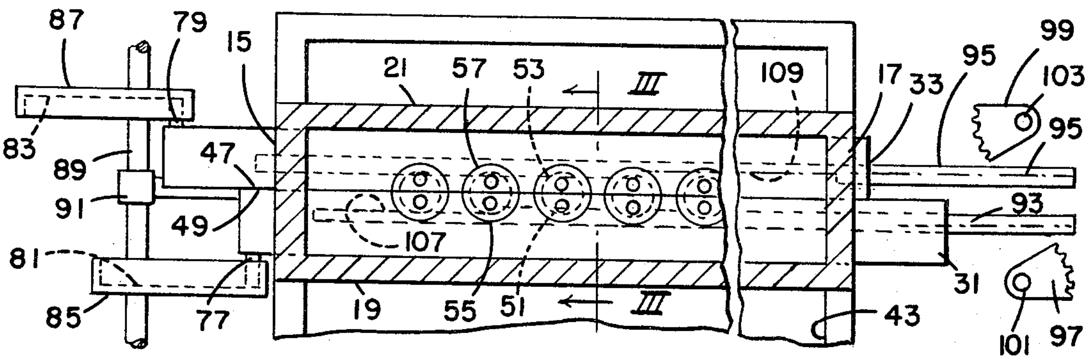

Fig. 2

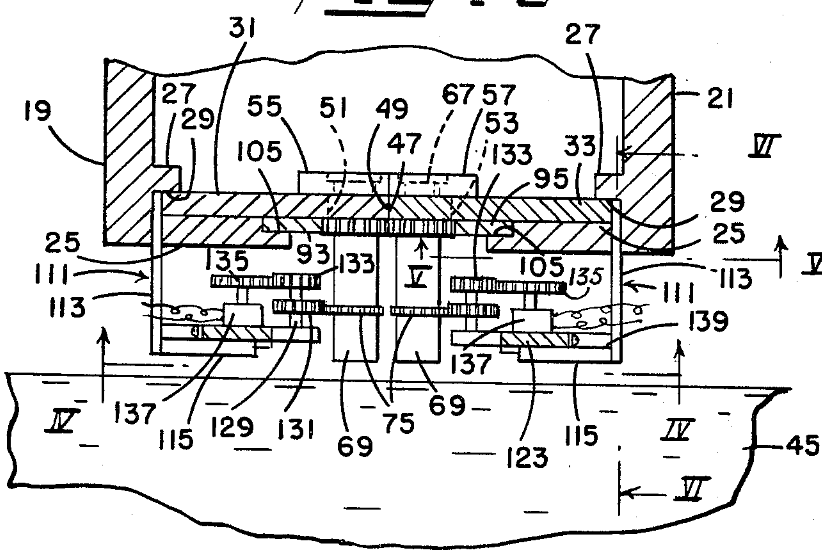

Fig. 3

3,709,969
METHOD FOR CONTINUOUSLY EXTRUDING NET-LIKE STRUCTURES COMPOSED OF TWISTED MULTIFILAMENT YARNS

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Continuation-in-part of application Ser. No. 825,213, May 16, 1969, now Patent No. 3,613,161. This application Jan. 5, 1971, Ser. No. 104,033
Int. Cl. D01d *3/00;* D02g *1/20*
U.S. Cl. 264—103 5 Claims

ABSTRACT OF THE DISCLOSURE

Method of making net-like structures in which paired groups of extruded filaments are periodically shifted to provide different pairs, while the filaments in each such group are twisted into a yarn. Alternately with such shifting, the paired groups of filaments are rotated a multiple of 180° about an axis between the group of each such pair.

This application is a continuation-in-part of my application Ser. No. 825,213, filed on May 16, 1969, now U.S. Pat. 3,613,161.

The present invention is directed to a method for making net-like structures of twisted multifilament yarns.

In U.S. Pat. No. 3,331,903 there is disclosed a method and apparatus for making a net from plastic material by extruding a plurality of pairs of monofilaments of plastic material in such a manner that the filaments in each pair are spaced from each other in a first direction and the pairs of filaments are spaced from each other a given distance in a second direction. The monofilaments of each pair of filaments are revolved, at the moment of their extrusion and before being solidified, about an axis extending between the filaments of each pair of filaments so as to twist the filaments of each pair together and to thus integrally connect the filaments. One of the filaments of each pair of filaments is then moved in a second direction a distance equal to the spacing between pairs of filaments while continuing the extrusion of the filaments, after which pairs of filaments are again revolved as heretofore described. By continuously repeating the above steps and setting of the extruded filaments of plastic material, a net-like structure is provided.

In my United States patent application entitled "Method for Continuously Extruding Net-Like Structures," Ser. No. 825,210, filed May 16, 1969, now U.S. Pat. 3,627,-863, there is disclosed a method of making net-like structures of woven or braided monofilaments using an apparatus similar to that described in U.S. Patent No. 3,331,903.

Using conventional knitting, weaving or knotting processes, the strength and flexibility characteristics of net-like structures can be brought into a desired balance using preformed twisted multifilament yarn. On the other hand, extruded net-like structures formed of monofilaments, as produced by methods disclosed in U.S. Pat. No. 3,331,903 and my above-noted U.S. Pat. 3,627,863, as well as other methods known in the art, generally exhibit either good strength and poor flexibility or poor strength and good flexibility. Accordingly, a primary object of this invention is the provision of an improved and more satisfactory method for making net-like structures.

Another object of this invention is to provide a method for making net-like structures which possess good strength and flexibility characteristics.

Still another object is the provision of a method for making, net-like structures having twisted multifilament yarns which are interlaced with each other and/or twisted together at their crossing points.

These and other objects are accomplished in accordance with the present invention by a method in which a plurality of separate groups of closely spaced filaments are twisted into yarns which are then interlaced and/or twisted with each other. The filaments employed may be preformed or, as hereafter described, may be formed continuously and concomitantly with their manipulation into a net-like structure.

In the preferred practice, a plurality of separate groups of closely spaced streams of flowable strand-forming material are continuously extruded, with the groups arranged in pairs. The groups of streams of each such pair of groups are spaced from each other in a first direction and the pairs of groups of streams are spaced from each other a given distance in a second direction. At least the surfaces of the extruded streams are set to provide groups of filaments, after which the filaments of each individual group are twisted to provide yarns. The groups of streams of each such pair of groups are revolved about an axis extending between the groups of each respective pair of groups to at least exchange the positions thereof. Relative movement is then imparted to the groups of streams in each such pair of groups in the second direction to arrange at least certain of the groups of each such pair of groups into different pairs. By continuously repeating the above sequence of movements concomitantly with the continuous extrusion of the groups of streams of strand-forming material, setting of such streams into groups of filaments and twisting of the individual groups of filaments into yarns, a net-like structure of interlaced or twisted yarns is provided.

Preferably, the streams in each group of streams are alike in number, size and spacing, the groups of streams in each of the pairs of such groups are spaced like distances in the first direction and the pairs of groups are spaced like distances in the second direction.

During the revolving of the groups of streams of each such pair of groups, they are moved through an angle equal to a multiple of 180°. More specifically, the groups of streams of each such pair of groups may be revolved through an angle of only 180°, providing that the direction of relative movement of the groups of streams in the second direction and the direction of revolution of the groups of each pair of groups is each reversed after the respective alternate movement has been completed. That is, relative movement of the groups of streams in each pair of such groups in a second direction is effected alternately with revolving of the groups of each pair of groups. Thus, if the direction of relative movement of the groups is reversed after each revolution of the groups of each such pair of groups, and the direction of revolution of the groups of each pair of groups is reversed after each relative movement of the groups, then each revolution of the groups may be limited to only 180°. With this procedure the twisted multifilament yarns are interlaced with each other so that the resulting net-like structure is of woven or braided construction.

Revolving the groups of streams of each such pair of groups through an angle of 360° or further multiple of 180° will cause the individual twisted multifilament yarns formed from the respective groups of streams to be twisted with each other at their points or locations of crossing. The resulting net-like structure will exhibit good strength, yet will be flexible in view of the absence of bonding between the filaments in the individual yarns and between the yarns which are twisted to each other.

Obviously, the groups of streams of each such pair of groups may be revolved only 180° in certain instances and 360° or further multiples of 180° in other instances so that the resulting net-like structure will exhibit interlaced and twisted junctions between the multifilament yarns.

If it is intended to revolve the groups of streams of each such pair of groups through an angle of 360° or further multiple of 360°, the pairs of groups of streams, and the filaments and yarns formed therefrom, may be arranged in a circular array.

Relatively moving the groups of streams of each such pair of groups in the second direction may be achieved by moving only one group of streams of each pair of groups or by moving both groups of each pair of groups oppositely of each other or in the same direction but at different rates of speed. Further, when in a circular array, the groups of streams of each such pair of groups may be moved relative to each other by oscillating or rotating the one or both of such groups about an axis common to all the pairs of groups.

The apparatus employed in the method of the present invention includes cylindrical extrusion nozzles which are arranged as a plurality of spaced pairs to which flowable strand-forming material is continuously delivered under pressure. Each of the nozzles has a multiplicity of extrusion orifices whereby the flowable strand-forming material delivered to each nozzle is extruded therefrom as a group of separate streams. The extruded streams of each individual group are rapidly set into filaments and the nozzles are continuously rotated to twist each group of filaments into a yarn.

Periodically, each pair of nozzles is revolved through an angle equal to a multiple of 180° about an axis located between the respective nozzles of each such pair of nozzles whereby the groups of streams issuing from such pair of nozzles at least exchange positions. Operative alternately with the nozzle revolving means are means for relatively moving nozzles of each pair of nozzles into positions as to be arranged in different pairs.

The revolving means of the apparatus includes a plurality of semi-circular tables, with each having an opening within which is rotatably mounted an individual nozzle. The apparatus may be equipped to revolve the tables which support each pair of nozzles through an angle of only 180°, with the direction of revolution of such tables being reversed after each relative movement of the nozzles of such pairs of nozzles and the direction of relative movement of the nozzles also being reversed after each revolution of the nozzles of each such pair of nozzles. The pairs of nozzles may be arranged in a circular array in which instance the apparatus would be adapted to revolve each pair of nozzles through 360° or further multiple of 360°.

As in conventional extrusion apparatus for making net-like structures, suitable means, such as nip rollers, are provided for continuously advancing the finished net-like structure away from the extrusion apparatus concomitantly with its production.

The teachings of the present invention are applicable for use with a variety of fiber-forming materials, which are referred to by the terms "plastic" and "strand-forming materials," including polyolefins, such as polyethylene, polypropylene, polybutylene, polystyrene, polystyrene-acrylonitrile blends, acrylonitrile butadiene-styrene blends, acrylonitrile-butadiene copolymers, polybutene, polyisobutylene, polyisoprene, and isobutylene-isoprene copolymers; halogenated olefins, such as polyfluoroethylene, polychlorofluoroethylene, polychlorofluoropropylene, polyvinyl chloride, polyvinylidene chloride, polyvinyl chloride-acetate copolymer, polyvinyl chloride-polypropylene copolymer, polychloroprene, fluorinated ethylene-propylene copolymers, vinylidene fluoride-chlorotrifluoroethylene copolymers, and vinylidene fluoride-hexafluoropropylene copolymers; polyesters, such as polyethylene terephthalate and copolymers thereof and polycarbonate; polyamides, such as polyhexamethyl adipamide, polycaprolactam, polyhexamethylene sebacamide, poly-aminoundecanoic acid; polyvinyl acetates; chlorinated polyethers, such as, ethylacrylate-chloroethylene vinyl ether

copolymer; acrylic resins, such as polyacrylonitrile, polyacrylates and methacrylates; natural rubbers; compounded silicones; polyurethanes; polyethers, such as polyformaldehyde, formaldehyde-ethylene oxide copolymers, and polytrioxane; polysulfur resins, such as polysulfones and polysulfides; water-soluble, alkali soluble, and organic solvent-soluble cellulose esters and ethers, such as cellulose nitrate, cellulose acetate, cellulose butyrate, cellulose propionate, ethyl cellulose, viscose or cellulose xanthate, cuproammonium cellulose, and carboxymethyl cellulose; glasses; metals, etc. Such materials may include various additives such as stabilizers, dyes, foaming agents, etc., if so desired.

For a greater understanding of this invention, reference is made to the following detailed description and drawing in which

FIG. 1 is a vertical section taken longitudinally of the apparatus employed in the method of the present invention;

FIG. 2 is a horizontal section taken substantially along the line II—II of FIG. 1;

FIG. 3 is a partial vertical section, on an enlarged scale, taken transversely through the apparatus substantially along the line III—III of FIG. 2;

FIG. 4 is a view of the bottom of the apparatus as viewed along the line IV—IV of FIG. 3;

FIG. 5 is a fragmentary section taken substantially along the line V—V of FIG. 3;

FIG. 6 is a section of a portion of the apparatus taken substantially along the line VI—VI of FIG. 3; and

FIG. 7 is a perspective view of one of the elements of the apparatus.

With reference to the drawing, the apparatus employed in the method of the present invention includes a pair of vertical support members **15** and **17**, side walls **19** and **21**, which terminate well above the lowermost ends of the support members **15** and **17** and a top wall **23**. Walls **25** and **27** project from each of the opposing sides of the walls **19** and **21** and together define channels **29** within which are slidably received elongated plates **31** and **33**. Openings **35** and **37** are provided in the support members **15** and **17** for the passage of the plates **31** and **33** therethrough. The plates **31** and **33**, together with the support members **15** and **17**, side walls **19** and **21** and top wall **23**, define a chamber **39**.

Flowable strand-forming material is continuously delivered under pressure into the chamber **39** through a conduit **41** from a suitable source, not shown. Gaskets are provided in the area of the openings **35** and **37** in the support members **15** and **17** to prevent leakage of strand-forming material during sliding movement of plates **31** and **33**. A tank **43** is provided for containing a suitable setting liquid **45** in the area below the plates **31** and **33**.

In the specific embodiment illustrated, the contacting opposing longitudinal edges **47** and **49** of the plates **31** and **33** lie in a common plane and are each formed with a series of like, equally spaced semi-circular recesses **51** and **53**, respectively. Tables **55** and **57**, having portions which correspond in shape to recesses **51** and **53**, are positioned within respective of such recesses for movement relative thereto, as hereafter described. The tables **55** and **57** are of like construction and, as best shown in FIG. 7, each include a straight or flat surface or wall **59**, a semi-circular wall **61** and a top flange **63** which projects over and rests on the top surface of the respective plates **31** and **33**. Gear teeth **65** are formed along the walls **61** of the respective tables **55** and **57** at a location as to be exposed below the bottom surfaces of the plates **31** and **33**.

Each of the tables **55** and **57** is formed with a suitable opening **67** within which is rotatably mounted a nozzle **69** having a flange **71** at one end and a plurality of openings **73** at its opposite end. The nozzle flanges **71** are seated within recesses extending annularly about the openings **67** in the respective tables **55** and **57**, as shown in FIG. 3. Each of the nozzles **69** is formed with teeth **75** along its outer periphery, by means of which the nozzles are continuously rotated as hereafter described in detail.

With the flat surfaces **59** of the tables **55** and **57** aligned with each other and with the opposing longitudinal edges **47** and **49** of the plates **31** and **33**, at least one of the plates **31** and **33**, and the tables **55** and **57** carried thereby, is moved or shifted longitudinally. Preferably, both of the plates **31** and **33** are shifted longitudinally in opposite directions relative to each other. This relative longitudinal movement of the plates **31** and **33** is effected through pins **77** and **79** which project from the respective plates **31** and **33** and ride along grooves **81** and **83** formed in opposing surfaces of cams **85** and **87**.

The cams **85** and **87** are of like construction and are fixed, in 180° out-of-phase relationship, to a shaft **89** which is supported by bearings, such as shown at **91**, and is intermittently driven by suitable means, not shown. As more fully described hereafter, the plates **31** and **33** are preferably moved a distance substantially equal to one-half of the center-to-center spacing of the respective recesses **51** and **53** so as to move the tables **55** and **57**, which are carried by the plates **31** and **33**, into different positions of alignment with each other.

Alternately with the longitudinal sliding movement of the plates **31** and **33**, aligned tables **55** and **57** which are carried by such plates are together revolved as a unit through an angle of 180° or further multiple thereof so as to at least exchange the positions of such pair of aligned tables. If in the practice of the method the tables are revolved through an angle of only 180°, each such revolving movement is in a direction opposite to the previous revolving movement thereof so as to provide for interlacing of yarns, as more fully described hereafter.

Revolving of the tables is effected by gear racks **93** and **95**, which mesh with the gear teeth **65** formed along the semi-circular walls **61** of such tables **55** and **57**. The racks **93** and **95** are themselves intermittently driven by gears **97** and **99**, respectively, which are fixed to shafts **101** and **103**. The racks **93** and **95** are guided for straight line motion by channels **105** which are formed by rabbeting the projecting walls **25**, as shown in FIG. 3.

In the arrangement illustrated in the drawing, the racks **93** and **95** are designed to revolve aligned tables **55** and **57** through an angle of only 180°, alternately with the shifting of the plates **31** and **33**, and thus gear teeth are present only along selected lengths of the racks **93** and **95** and are omitted from portions indicated at **107** and **109**. To provide for movement of the racks **93** and **95**, a distance necessary for revolving aligned tables **55** and **57** through an angle of only 180°, the gears **97** and **99** may be in the form of segment gears which are intermittently driven by oscillating the shafts **101** and **103** in opposite directions.

Fixed to and depending from each of the plates **31** and **33** are a pair of angle members **111** each having a vertical flange **113** and a horizontal flange **115**. As best seen in FIGS. 5 and 6, the vertical flanges **113** of the angle members **111** are each formed with rigid support hangers **117** which extend through spaced elongated slots **119** in the walls **25** and are secured by screws **121** to the respective plates **31** and **33**. By this arrangement, the angle members **111** will both travel with the plates **31** and **33** during their reciprocating movements.

Elongated platforms **123** are dovetailed to the horizontal flanges **115** of the angle members **111** for sliding movement generally perpendicular to the common plane, as defined by the abutting longitudinal edges of the plates **31** and **33**. As shown in FIG. 4, each of the platforms **123** is formed with a series of arms **125** which project toward the above-mentioned common plane. A sprocket **127**, carried by a shaft **129**, is rotatably mounted to the free end of each of the arms **125**. Laced about the sprockets **127** carried by the respective platforms **123** is an endless chain **131** which is adapted to engage with the teeth **75** projecting from the periphery of the nozzles **69**. The endless chains **131** are continuously driven through gears **133**, each of which is fixed to one of the shafts **129** carried by each of the platforms **123**. The gears **133** mesh with and are driven by gears **135** which are fixed to the output shafts of separate electric motors **137**.

The motors **137** serve to advance adjacent reaches of the pair of endless chain **131** in opposite directions so that the nozzles **69** are continuously rotated in the same direction. To insure continuous engagement of the endless chains **131** with the nozzle teeth **75**, notwithstanding the movement of the nozzles as their supporting tables **55** and **57** are revolved, the platforms **123** are resiliently urged toward such nozzles by a series of leaf springs **139** located between the respective platforms and the adjacent flanges **113** of the angle mmebers **111**.

In the practice of the method of the present invention with the specific apparatus described above, flowable strand-forming material is delivered under pressure through the conduit **41** and into the chamber **39**. With the elements of the apparatus positioned as shown in FIG. 2, the flowable strand-forming material issues from the orifices **73** of the nozzles **69** as a group of straight streams, which are rapidly set into filaments, as by the liquid **45**.

The motors **137** are then placed and maintained in continuous operation to drive the endless chains **131**. The adjacent reaches of the pair of endless chains **131** are driven in opposite directions and are maintained engaged with the teeth **75** on the nozzle peripheries by the action exerted upon the platforms **123** by the leaf springs **139**. Thus, the movement of the endless chains **131** serves to continuously rotate the nozzles **69** so that the group of streams issuing from the orifices of the respective nozzles **69**, and preferably the filaments formed from such streams, are twisted into yarns.

The cams **85** and **87** are now operated to shift the plates **31** and **33** in opposite directions, preferably a distance equal to one-half of the center-to-center spacing of the plate recesses **51** and **53**. During this movement, the angle members **111** travel with the respective plates **31** and **33**, as heretofore explained.

With different tables **55** and **57** now aligned with each other, plates **31** and **33** are held stationary while the racks **93** and **95** are shifted by the gears **97** and **99** to revolve only aligned pairs of tables **55** and **57** through an angle of only 180°. The nozzles **69** which are mounted within and moved with such tables are continuously rotated by the endless chains **131** so that the twisted yarns formed from the streams of strand-forming material issuing therefrom are moved from one side of the common plane to the other thereof.

The plates **31** and **33** are now shifted by the cams **85** **87** to the same degree but in opposite directions to their prior movement to align different tables **55** and **57** with each other. Again with the plates **31** and **33** held fixed, the racks **93** and **95** are driven to revolve only aligned tables **55** and **57** through an angle of only 180°. The direction of revolution of the tables **55** and **57**, however, is in a direction opposite to that in which aligned tables were previously revolved. By continuously repeating the above-described steps, a net-like structure results having twisted multifilament yarns which are interlaced with each other.

As heretofore mentioned, in lieu of revolving the aligned tables **55** and **57** through an angle of only 180°, the tables may be turned through 360° or a further multiple of 180° to provide a net-like structure in which individual extruded twisted multifilament yarns are themselves twisted with other of such yarns at their crossing points. Moreover, if the movement of the tables **55** and **57** is limited to complete 360° turns, or further multiples thereof, the various elements of the apparatus may be arranged in a circular array to thereby produce tubular net-like structures in which the twisted yarns are twisted with other yarns at their points of crossing.

I claim:

1. A method of making net-like structures including the steps of sequentially extruding a plurality of separate groups of closely spaced streams of flowable strand-forming material with the groups arranged in pairs, the groups of streams of each such pair of groups being spaced from each other in a first direction, and the pairs of groups of streams being spaced from each other in a second direction, setting the extruded streams of strand-forming material to provide filaments, twisting the filaments of each individual group of filaments into a yarn, revolving the groups of filaments of each such pair of groups about an axis extending between the groups of each respective pair of groups through 180° or further multiple of 180°, relatively moving the groups of filaments of each such pair of groups in the second direction to arrange at least certain of the groups of filaments of each such pair of groups into different pairs, and continuously repeating the above sequence of movement, with the relative movement of the groups of filaments in the second direction and the revolving movement of the groups of filaments of such pair of groups occurring in alternate relationship.

2. A method as defined in claim **1** wherein relative movement of the groups of filaments of each pair of groups is effected by moving such groups oppositely of each other in a second direction and wherein the groups of filaments of each pair of groups are revolved through an angle equal to only 180°, with each movement of the groups of filaments in the second direction and each revolving movement of the groups of filaments of each pair of groups being reversed after the respective alternate movement is completed.

3. A method as defined in claim **1** wherein the groups of filaments of each such pair of groups are revolved through an angle equal to a multiple of 360° and the pairs of groups of filaments and yarns formed from such groups of filaments are arranged in a circular array.

4. A mold as defined in claim **1** wherein the groups of filaments of each of the pairs of such groups are spaced from each other like distances in the first direction and the pairs of groups of filaments are spaced from each other like distances in the second direction.

5. A method as defined in claim **1** wherein the groups of filaments of at least some of said pairs of groups are revolved through an angle of 180° during certain of the revolving movements thereof and through an angle equal to a further multiple of 180° during other of the revolving movements thereof, with each movement of the groups of filaments in the second direction and each revolving movement of the groups of filaments of each pair of groups being reversed for at least such groups undergoing consecutive 180° revolving movements.

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JAY H. WOO, Primary Examiner

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28—1; 87—12; 139—1; 161—DIG. 6; 264—167, DIG. 81