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**Description**

This invention is concerned with the extrusion of thermoplastic polymers to form a novel filamentary structure.

According to the invention, a filamentary structure comprises a helical thermoplastic core filament disposed within a thermoplastic sheath component which is fused to the successive turns of the helical core filament.

The sheath component is preferably a cage formed by at least three thermoplastic filaments each of which is fused to the successive turns of the helical core filament. Alternatively, the sheath component may comprise a tube.

The invention includes a process for making such a filamentary structure comprising feeding molten thermoplastic polymer to a spinning jet having an inner jet hole ringed by outer jet holes, extruding the polymer through the inner jet hole at a greater velocity than polymer is extruded through the outer jet holes to form a helical extrudate disposed within an extruded sheath component to which its successive turns are fused, and cooling the extrudates to solidify them to a unitary structure.

The thermoplastic polymer may be any which can be melt spun into filaments including polyamides, polyesters and polyolefins. The polymer extruded through the inner jet hole to form the helical core may be the same as or different from the polymer extruded through the outer jet holes to form the sheath component. Preferably it is the same in order to simplify spinning and ensure good fusion between the turns of the helical core filament and the sheath component.

An elastic filamentary structure may be formed by making the helical core filament from a non-elastomeric polymer and the sheath component from an elastomeric polymer.

The polymer extruded through the inner jet hole is required to have a greater velocity than that flowing through the outer jet holes in order that it will take up the desired helical form. With a common supply of molten polymer, this greater velocity may be achieved by having the inner jet hole of greater cross-sectional area and/or of shorter capillary length than each of the outer jet holes. Preferably it is of greater cross-sectional area for two reasons: the first being that in the most desirable filamentary structure of the invention the cage filaments which comprise the sheath component are of smaller cross-sectional area than the helical core filament; and the second being that jets having holes of a common capillary length are much easier to make.

The sizes and cross-sectional shapes of the jet holes determine the size and shape of the filaments extruded through them. The preferred shape is circular, particularly for the inner jet hole. For a given spacing between the inner jet hole and the outer jet holes, the pitch of the helical core filament is determined by the relative polymer velocities through the inner and outer holes. That is, the pitch reduces as the velocity differential increases.

Preferably, the axes of the inner and outer jet holes are all parallel to one another so that, in the embodiment where the sheath component comprises a cage of filaments, these filaments are in substantially parallel alignment with the axis of the helical core filament.

The diameter of the helix of the core filament is determined by the sheath component which holds it in place and which stabilises it by becoming fused to its successive turns. When the sheath component comprises a cage of filaments it has been found that it is necessary to have at least three cage filaments for this purpose otherwise the core filament 'breaks out' and is uncontrolled. Preferably each cage filament is spaced apart from its adjacent cage filaments by substantially equal distances. This may be arranged by using a spinning jet with a central inner jet hole ringed by at least three outer jet holes pitched at substantially equal angles to and substantially equidistant from the central inner jet hole.

The number of cage filaments can be increased to any desired number commensurate with the dictates of jet geometry. In the limit, each outer jet hole is positioned sufficiently closely to its adjacent outer jet holes that because of die swell the extruded cage filaments merge to form a tube. The outer jet holes are preferably of circular cross-section, although other suitable cross-sections may be used, for example arcuate slots which may be used to produce a tube as described.

The extruded structure may be cooled in air to solidify it, but it is preferred to stabilise it more quickly by quenching it in a liquid bath which is conveniently water.

The filamentary structure of the invention may be used as yarn, cord or twine, or as a reinforcement for a tube. In the embodiments described where the sheath component comprises a tube, it constitutes a reinforced tube itself. It may also be used to construct an abrasive pad such as a pan scrub.

The invention includes a fabric structure comprising a plurality of filamentary structures according to the invention fused to each other with the axes of the helical filaments in substantially parallel relation. This fabric structure may be produced directly by extrusion using a bank of adjacent sets of jet holes from which adjacent filament structures are extruded. These merge and become fused so that after being cooled to solidify them, they remain fused as a unitary fabric structure. The component filamentary structures may be arranged in a planar array by a corresponding arrangement of the adjacent sets of jet holes, to produce a planar fabric structure. Three-dimensional fabric structures may be made using appropriate groupings of the sets of jet holes from which the component filamentary structures are extruded.

The fabric structure of the invention has a variety of uses including use as drainage, earth-support and other civil engineering fabrics, and as matting such as door mats.

In the embodiment of the invention where the sheath component comprises a cage of filaments, limited stretching of the filamentary structure produces elongation of the cage filaments between the successive points of fusion, with the result that after removal of the stretching forces and contraction of the helical core, the cage filaments balloon out between the points of fusion, giving an expanded structure.

Greater stretching causes the cage filaments to break between the points where they are fused to the helical core filament, close to those points, to produce a modified filamentary structure which is a further aspect of the invention. The broken cage filaments constitute fibrils which are substantially uniform in length, with the majority of the fibrils being raked in a common direction.

The modified filamentary structure has decorative qualities and may be used as fancy yarn, or twine, especially if coloured. The rake of the fibrils gives it a particularly distinctive appearance and also imparts good knot-tying properties. The roughness of the fibrils, particularly at the points of fusion, gives the product abrasive properties making it suitable for the construction of scouring pads, for example.

The invention is illustrated by the accompanying drawings in which:—

Figure 1 is a plan of the face of a jet suitable for use in the process of the invention,

Figure 2 is a cross-section on the line II . . . II of Figure 1,

Figure 3 is an elevation of a filamentary structure in accordance with the invention,

Figure 4 is an elevation of a modified filamentary structure formed by stretching the structure of Figure 3,

Figure 5 is a sectional elevation of another filamentary structure in accordance with the invention,

Figure 6 is a plan, on an enlarged scale, of the face of a jet suitable for spinning the filamentary structure shown in Figure 5,

Figure 7 is an elevation of the structure of Figure 3 after being partially stretched,

Figure 8 is an elevation of a fabric structure in accordance with the invention,

Figure 9 is a plan, on an enlarged scale, of the face of a jet suitable for spinning the fabric structure shown in Figure 8, and

Figure 10 is a diagram of apparatus for spinning a filamentary structure in accordance with the invention.

Referring to Figures 1 and 2, a spinning jet 1 has a circular jet face 2 in which are drilled an inner jet hole 3 encircled by a ring of four outer jet holes 4. The jet holes have the same capillary length and the inner jet hole is shown as about twice the diameter of the outer jet holes.

Figure 3 shows a filamentary structure 5 spun from a jet similar to that shown in Figures 1 and 2, but comprising eight outer jet holes instead of four. The filamentary structure 5 comprises a helical core filament 6 held within a cage of eight finer filaments 7 which are fused to the successive turns of the helical core filament at points 8.

Figure 4 shows a modified filamentary structure 9 produced by stretching the structure 5, whereby the cage filaments 7 have broken close to the points 8. The resulting fibrils 10 are regularly spaced and uniform in length. As shown they are raked in a common direction. The points at which they are fused to the core filament 6 lie on a generally helical path around the core filament.

The filamentary structure 11 shown in Figure 5 comprises a helical core filament 12 held within a tubular sheath 13 which is fused to the successive turns of the helical core filament at points 14. The structure 11 may be spun from a jet of the type shown in Figure 6 in which the jet 15 has a central inner jet hole 16 ringed by two outer jet holes 17 in the form of two arcuate slots. The extrudates from the outer jet holes merge below the jet to form a tube enclosing the helical core filament formed from the higher velocity extrudate from the inner jet hole.

Figure 7 shows a filamentary structure of the type shown in Figure 3 after being stretched to a degree which elongates the cage filaments without breaking them. On being allowed to relax, the helical core filament 18 contracts and causes the elongated cage filaments 19 to balloon out as shown to produce an expanded filamentary structure 20.

The fabric structure 21 shown in Figure 8 comprises three filamentary structures of the type shown in Figure 3 with the axes of their helical core filaments 22 parallel and adjacent cage filaments 23 fused together. This fabric structure may be produced by a jet of the type shown in Figure 9 which has a rectangular jet face 24 with three sets 25 of jet holes lying adjacent to each other in a line. Each set 25 comprises an inner jet hole 26 ringed by eight outer jet holes 27 of smaller diameter. The cage filaments extruded from the adjacent pairs of outer jet holes 28, 29 and 30, 31, respectively, merge below the jet face to fuse the extruded filamentary structures together as a fabric.

The number of sets of jet holes may be extended beyond three to produce wider fabric structures, and may also be grouped other than in line, for example as a grid, to provide three-dimensional fabric structures.

In Figure 10, the apparatus shown diagrammatically comprises a spinning jet 32 from which a filamentary structure 33 according to the invention is extruded downwardly into a water quench bath 34. The solidified structure is withdrawn from the jet by driven rollers 35 in a 'clover leaf' formation and located below the surface of the bath. The structure is withdrawn from the bath by a godet 36 and, if desired, stretched between the godet 36 and a further godet 37 to produce a structure as shown in Figure 4 or Figure 7 depending upon the degree of stretch.

The invention is illustrated by the following Examples:—

Examples 1 to 6

Nylon 6 polymer was melted and extruded through various spinning jets as shown in Figures 1 and 2 of the drawings, some with four outer jet holes and some with eight outer jet holes with variations also in the pitch circle diameter (PCD) of the outer jet holes. The extrudates were quenched in a water bath at room temperature and collected either by free fall or by nip rollers. Samples were taken and stretched at two different percentage stretches, one simply to bulk the product and the other a greater stretch to break the cage filaments and produce the modified filamentary structure.

The following jet dimensions and process conditions were common to all six Examples. Other conditions which varied between Examples and the product properties are shown in the succeeding Table.

| | | |
|---|---|---|
| Inner jet hole diameter | — | 350 μm |
| Outer jet hole diameter | — | 175 μm |
| Capillary length of all jet holes | — | 437 μm |
| Head temperature of jet | — | 260°C |
| Polymer throughput | — | 13.46 g/min. |

TABLE

| Example | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of outer jet holes | 8 | 8 | 4 | 4 | 8 | 8 |
| PCD of outer jet holes (μm) | 844 | 844 | 900 | 900 | 1000 | 1000 |
| Distance from jet face to quench bath (cm) | 1.5 | 10 | 1.5 | 10 | 1.5 | 10 |
| Take-up speed m/min | 13.3 | Free Fall | 17.7 | Free Fall | 12 | Free Fall |
| Diameter of extrudate (cm) | 0.18 | 0.21 | 0.20 | 0.25 | 0.21 | 0.23 |
| Diameter of spiral core filament (cm) | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Pitch of spiral (cm) | 0.21 | 0.17 | 0.31 | 0.30 | 0.22 | 0.21 |
| Direction of spiral (cw or acw)* | acw | acw | cw | acw | cw | cw |
| Diameter of cage filaments (cm) | 0.02 | 0.025 to 0.030 | 0.02 | 0.020 to 0.028 | 0.025 | 0.025 |
| Weight/unit length of extrudate (g/m) | 0.973 | 1.311 | 0.760 | 0.886 | 1.210 | 1.260 |
| Stretch to bulk (*per cent*) | 120 | 130 | 100 | 110 | 130 | 120 |

TABLE (Continued)

| Example | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Stretch to break (*per cent*) | 425 | 400 | 500 | 520 | 420 | 410 |
| Percentage of fibrils raked – towards jet | 95 | 70 | 95 | 95 | 90 | 95 |
| – away from jet | 5 | 30 | 5 | 5 | 10 | 5 |

* cw = clockwise
acw = anticlockwise

## Claims

1. A filamentary structure characterised in that it has a helical thermoplastic core filament (6, 12) disposed within a thermoplastic sheath component (7, 13) which is fused to the successive turns (8, 14) of the helical core filament.

2. A filamentary structure as claimed in claim 1 characterised in that the sheath component comprises a cage formed by at least three thermoplastic filaments (7) each of which is fused to the successive turns (8) of the helical core filament.

3. A filamentary structure as claimed in claim 2 characterised in that each cage filament (7) is spaced apart from its adjacent cage filaments by substantially equal distances.

4. A filamentary structure as claimed in claim 2 or claim 3 characterised in that the cage filaments (7) are in substantially parallel alignment with the axis of the helical core filament (6).

5. A filamentary structure as claimed in any of claims 2 to 4 characterised in that each of the cage filaments (7) is of smaller cross-sectional area than the helical core filament (6).

6. A filamentary structure as claimed in claim 1 characterised in that the sheath component comprises a tube (13).

7. A filamentary structure as claimed in any of claims 1 to 6 characterised in that the helical core filament (6, 12) and the sheath component (7, 13) comprise the same thermoplastic polymer.

8. A fabric structure characterised by a plurality of filamentary structures as claimed in any of claims 1 to 7 fused to each other with the axes of the helical filaments (22, 23) in substantially parallel relation.

9. A fabric structure as claimed in claim 8 characterised in that the component filamentary structures are arranged in a planar array.

10. A process for making a filamentary structure characterised by feeding molten thermoplastic polymer to a spinning jet (1) having an inner jet hole (3, 16) ringed by outer jet holes (4, 17), extruding the polymer through the inner jet hole (3) at a greater velocity than polymer is extruded through the outer jet holes (4) to form a helical extrudate disposed within an extruded sheath component to which its successive turns are fused, and cooling the extrudates to solidify them to a unitary structure.

11. A process as claimed in claim 10 characterised in that each outer jet hole (4) is positioned sufficiently closely to its adjacent outer jet holes (4) that the extrudates from the outer jet holes merge to form a tubular sheath component.

12. A process as claimed in claim 10 or 11 characterised in that each of the outer jet holes (4) of the spinning jet is of smaller cross-sectional area than the inner jet hole (3).

13. A process as claimed in any of claims 10 to 12 characterised in that the filamentary structure produced is stretched and then allowed to relax to cause the cage filaments (19) which comprise the sheath component to balloon out between the points where they are fused to the helical core filament (18) and thereby give an expanded structure (20).

14. A process as claimed in any of claims 10 to 12 characterised in that the filamentary structure (5) produced is stretched to the extent that the cage filaments (7) which comprise the sheath component break between the points (8) where they are fused to the helical core filament (6) to produce a modified filamentary structure in which the broken cage filaments constitute fibrils (10) which are substantially uniform in length with the majority being raked in a common direction.

15. A process for making a fabric structure by a process as claimed in any of claims 10 to 14 characterised in that a plurality of filamentary structures are extruded adjacent to each other with the axes of the helical core filaments substantially parallel whereby the extruded filamentary structures fuse to each other and after being cooled to solidify them remain fused as a unitary fabric structure.

16. A process as claimed in claim 15 characterised in that the filamentary structures are extruded as a planar array and become fused to each other in the form of a planar fabric.

**Patentansprüche**

1. Filamentartige Struktur, dadurch gekennzeichnet, dass sie ein schraubenförmiges thermoplastisches Kernfilament (6, 12) aufweist, das innerhalb einer thermoplastischen Mantelkomponente (7, 13) angeordnet ist, die mit aufeinanderfolgenden Windungen (8, 14) des schraubenförmigen Kernfilaments verschmolzen ist.

2. Filamentartige Struktur nach Anspruch 1, dadurch gekennzeichnet, dass die Mantelkomponente aus einem durch mindestens drei thermoplastische Filamente (7) gebildeten Käfig besteht, die jeweils mit aufeinanderfolgenden Windungen (8) des schraubenförmigen Kernfilaments verschmolzen sind.

3. Filamentartige Struktur nach Anspruch 2, dadurch gekennzeichnet, dass die Käfigfilamente (7) jeweils mit weitgehend gleichen Abständen von ihren benachbarten Käfigfilamenten abliegen.

4. Filamentartige Struktur nach Anspruch 2 oder 3, dadurch gekennzeichnet, dass die Käfigfilamente (7) weitgehend parallel zur Achse des schraubenförmigen Kernfilaments (6) ausgerichtet sind.

5. Filamentartige Struktur nach einem der Ansprüche 2 bis 4, dadurch gekennzeichnet, dass die Käfigfilamente (7) jeweils eine kleinere Querschnittsfläche als das schraubenförmige Kernfilament (6) aufweisen.

6. Filamentartige Struktur nach Anspruch 1, dadurch gekennzeichnet, dass die Mantelkomponente aus einem Rohr (13) besteht.

7. Filamentartige Struktur nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass das schraubenförmige Kernfilament (6, 12) und die Mantelkomponente (7, 13) aus demselben thermoplastischen Polymeren bestehen.

8. Gewebestruktur, gekennzeichnet durch eine Mehrzahl filamentartiger Strukturen nach einem der Ansprüche 1 bis 7, die mit im wesentlichen paralleler Anordnung der Achsen der schraubenförmigen Filamente (22, 23) miteinander verschmolzen sind.

9. Gewebestruktur nach Anspruch 8, dadurch gekennzeichnet, dass die filamentartigen Strukturkomponenten in planarer Anordnung gruppiert sind.

10. Verfahren zur Herstellung filamentartiger Strukturen, dadurch gekennzeichnet, dass man geschmolzenes thermoplastisches Polymer einer Spinndüse (1) zuführt, die eine von äusseren Düsenbohrungen (4, 17) umringte innere Düsenbohrung (3, 16) aufweist, das Polymer durch die innere Düsenbohrung (3) mit einer höheren Geschwindigkeit als durch die äusseren Düsenbohrungen (4) extrudiert, um ein schraubenförmiges Extrudat zu bilden, das innerhalb einer extrudierten Mantelkomponente angeordnet ist, mit der seine aufeinanderfolgenden Windungen verschmolzen sind, und die Extrudate abkühlt, damit sie sich zu einer einheitlichen Struktur verfestigen.

11. Verfahren nach Anspruch 10, dadurch gekennzeichnet, dass jede äussere Düsenbohrung (4) so nahe bei ihren benachbarten äusseren Düsenbohrungen (4) liegt, dass die Extrudate aus den äusseren Düsenbohrungen unter Bildung einer rohrförmigen Mantelkomponente ineinanderübergehen.

12. Verfahren nach Anspruch 10 oder 11, dadurch gekennzeichnet, dass die äusseren Düsenbohrungen (4) der Spinndüse jeweils eine kleiniere Querschnittsfläche aufweisen als die innere Düsenbohrung (3).

13. Verfahren nach einem der Ansprüche 10 bis 12, dadurch gekennzeichnet, dass man die erzeugte filamentartige Struktur reckt und sich dann entspannen lässt, damit die die Mantelkomponente darstellenden Käfigfilamente (19) sich zwischen den Stellen, wo sie mit dem schraubenförmigen Kernfilament (18) verschmolzen sind, auswölben und dadurch eine ausgeweitete Struktur (20) ergeben.

14. Verfahren nach einem der Ansprüche 10 bis 12, dadurch gekennzeichnet, dass man die erzeugte filamentartige Struktur (5) so weit reckt, dass die die Mantelkomponente darstellenden Käfigfilamente (7) zwischen den Stellen (8), wo sie mit dem schraubenförmigen Kernfilament (6) verschmolzen sind, brechen und dabei eine modifizierte filamentartige Struktur bilden, in welcher die gebrochenen Käfigfilamente Fibrillen (10) weitgehend gleicher Länge darstellen, die grösstenteils in derselben Richtung geneigt sind.

15. Verfahren zur Herstellung einer Gewebestruktur gemäss einem Verfahren nach einem der Ansprüche 10 bis 14, dadurch gekennzeichnet, dass man eine Mehrzahl filamentartiger Strukturen nebeneinander mit den schraubenförmigen Kernfilamenten im wesentlichen achsparallel extrudiert, wodurch die extrudierten filamentartigen Strukturen miteinander verschmelzen und nach Kühlung zu ihrer Verfestigung als einheitliche Gewebestruktur verschmolzen bleiben.

16. Verfahren nach Anspruch 15, dadurch gekennzeichnet, dass die filamentartigen Strukturen in planarer Gruppierung extrudiert werden und miteinander in Form eines planaren Gewebes verschmelzen.

**Revendications**

1. Structure filamentaire, caractérisée en ce qu'elle comporte un filament d'âme thermoplastique hélicoïdal (6, 12) disposé dans une gaine thermoplastique (7, 13) qui est soudée aux spires (8, 14) successives du filament d'âme hélicoïdal.

2. Structure filamentaire suivant la revendication 1, caractérisée en ce que la gaine comprend une cage faite d'au moins trois filaments thermoplastiques (7) qui sont chacun soudés aux spires (8) successives du filament d'âme hélicoïdal.

3. Structure filamentaire suivant la revendication 2, caractérisée en ce que chaque filament de cage (7) est espacé de ses filaments de cage adjacents de distances en substance égales.

4. Structure filamentaire suivant la revendication 2 ou 3, caractérisée en ce que les filaments de

cage (7) sont en substance parallèlement alignés avec l'axe du filament d'âme hélicoïdal (6).

5. Structure filamentaire suivant l'une quelconque des revendications 2 à 4, caractérisée en ce que chacun des filaments de cage (7) a une section transversale plus petite que celle du filament d'âme hélicoïdal (6).

6. Structure filamentaire suivant la revendication 1, caractérisée en ce que la gaine comprend un tube (13).

7. Structure filamentaire suivant l'une quelconque des revendications 1 à 6, caractérisée en ce que le filament d'âme hélicoïdal (6, 12) et la gaine (7, 13) sont faits du même polymère thermoplastique.

8. Structure de tissu, caractérisée par plusieurs structures filamentaires suivant l'une quelconque des revendications 1 à 7 soudées l'une à l'autre, de telle sorte que les axes des filaments hélicoïdaux (22, 23) soient en substance parallèles.

9. Structure de tissu suivant la revendication 8, caractérisée en ce que les structures filamentaires constitutives sont disposées en un ensemble plan.

10. Procédé pour fabriquer une structure filamentaire, caractérisé en ce qu'on fournit un polymère thermoplastique fondu à une filière de filature (1) comportant un orifice intérieur (3, 16) entouré par des orifices extérieurs (4, 17), on extrude le polymère par l'orifice intérieur (3) à une vitesse supérieure à la vitesse d'extrusion du polymère par les orifices extérieurs (4) pour former un extrudat hélicoïdal disposé dans une gaine extrudée à laquelle ses spires successives sont soudées et on refroidit les extrudats en vue de les solidifier en une structure monolithique.

11. Procédé suivant la revendication 10, caractérisé en ce que chaque orifice extérieur (4) est placé suffisamment près de ses orifices extérieurs (4) adjacents pour que les extrudats des orifices extérieurs fusionnent pour former une gaine tubulaire.

12. Procédé suivant la revendication 10 ou 11, caractérisé en ce que chaque orifice extérieur (4) de la filière de filature a une section transversale inférieure à celle de l'orifice intérieur (3).

13. Procédé suivant l'une quelconque des revendications 10 à 12, caractérisé en ce qu'on étire la structure filamentaire produite, puis on la relâche pour amener les filaments de cage (19) qui forment la gaine à bouffer entre les points où ils sont soudés au filament d'âme hélicoïdal (18) et ainsi à produire une structure expansée (20).

14. Procédé suivant l'une quelconque des revendications 10 à 12, caractérisé en ce qu'on étire la structure filamentaire (5) produite au point que les filaments de cage (7) qui forment la gaine se rompent entre les points (8) où ils sont soudés au filament d'âme hélicoïdal (6) afin de produire une structure filamentaire modifiée dans laquelle les filaments de cage rompus constituent des fibrilles (10) d'une longueur en substance uniforme qui sont pour la plupart inclinées dans un même sens.

15. Procédé pour fabriquer une structure de tissu par un procédé suivant l'une quelconque des revendications 10 à 14, caractérisé en ce qu'on extrude plusieurs structures filamentaires l'une près de l'autre avec les axes des filaments d'âme hélicoïdaux en substance parallèles, de telle sorte que les structures filamentaires extrudées se soudent l'une à l'autre de qu'après avoir été refroidies en vue de leur solidification, elles restent soudées en une structure de tissu monolithique.

16. Procédé suivant la revendication 15, caractérisé en ce qu'on extrude les structures filamentaires sous la forme d'un ensemble plan, ces structures se soudant l'une à l'autre pour former un tissu plan.

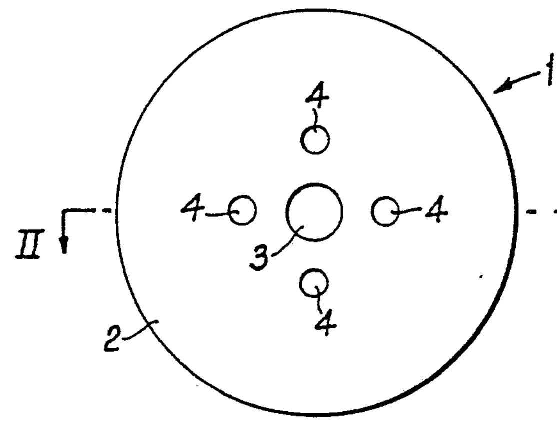


FIG.1

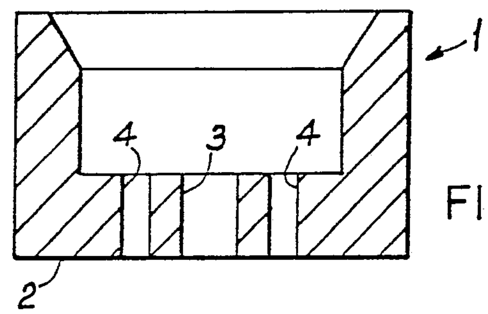


FIG.2

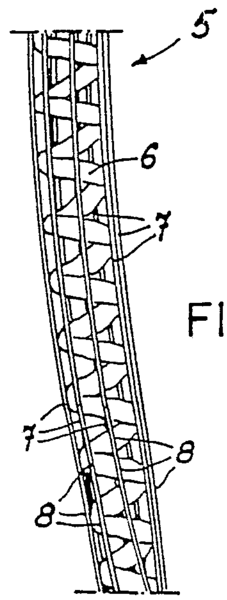


FIG.3

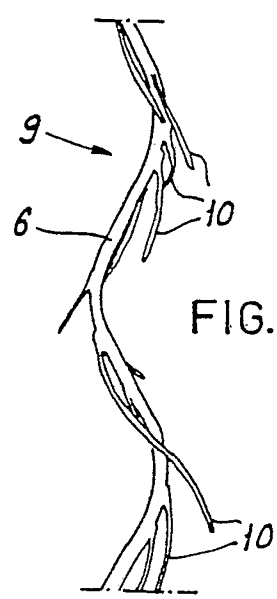


FIG.4

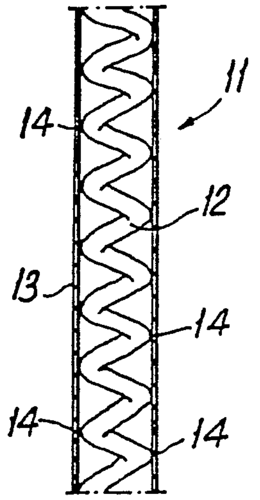

FIG.5

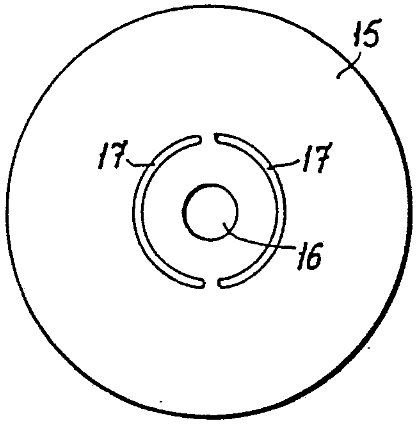

FIG.6

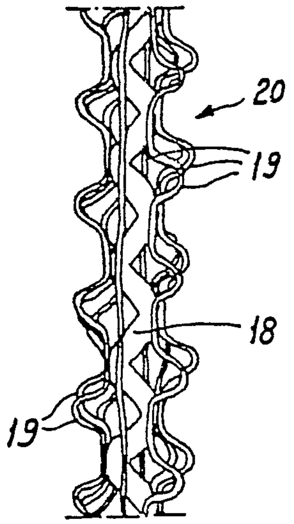

FIG.7

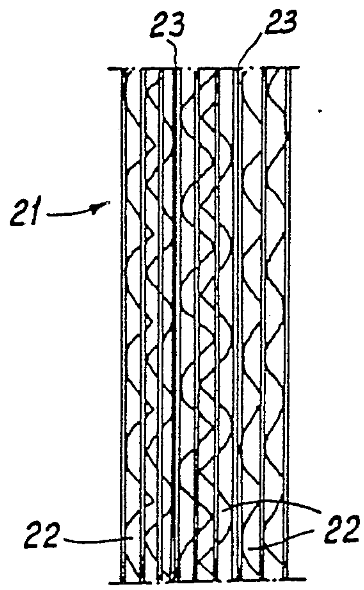

FIG.8

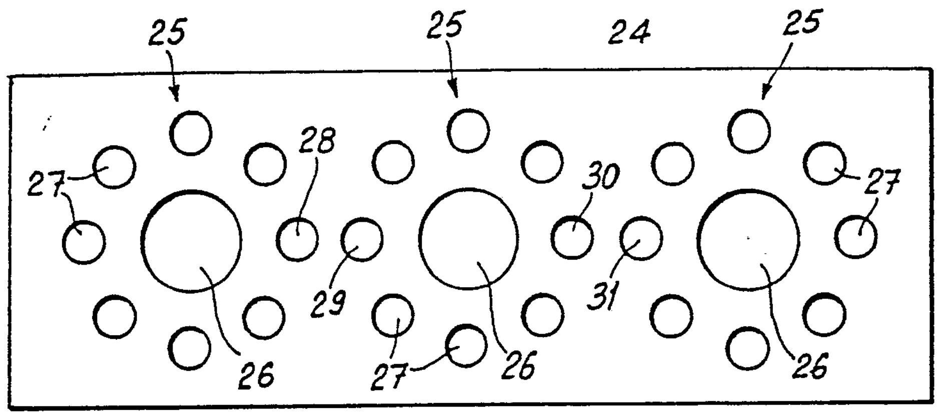


FIG.9

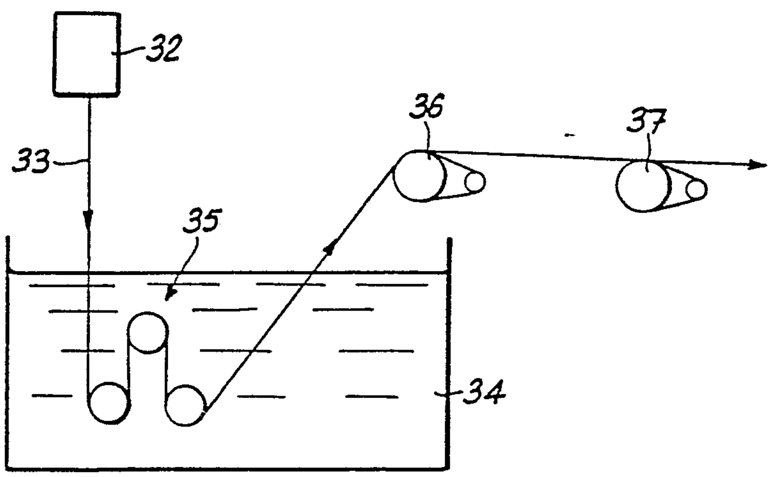


FIG.10