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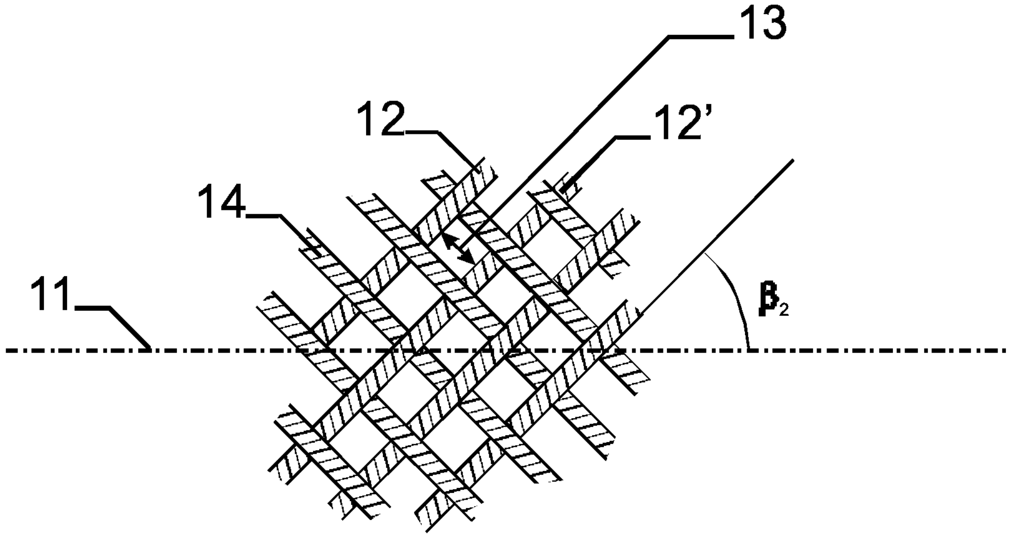
**(54) Title:** OPEN BRAIDED STRUCTURE WITH STEEL CORD




**(57) Abstract:** A braided structure (10) comprises at least two groups of elongated elements (12, 14) which have been braided with each other to form the braided structure. At least one of the groups comprise steel wires or steel cords (12, 14). The structure (10) comprises a longitudinal axis (11) and has a total length over its longitudinal axis (11). The structure has one of these two groups revolving in a first direction around the longitudinal axis (11). A first subgroup of individual elongated elements (12) belonging to one of the groups is spaced from a neighboring second subgroup of individual elements (12') belonging to the same of the groups with an inter-distance (13) that is greater than half the average element diameter of the individual elongated elements at a braiding angle β of 45 degrees. This inter-distance 13 allows change of cross-sectional geometry of the braided structure (10).

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# OPEN BRAIDED STRUCTURE WITH STEEL CORD

## Field of the invention.

The present invention relates in a first place to a braided structure that comprises elongated elements, which have been braided with each other to form the braided structure. The structure comprises steel wires or steel cords or both.

In a second place, the present invention relates to a use of said braided structure, e.g. to reinforce a plastic product.

## Background of the invention.

Braided structures of steel wires, and even of steel cords, are known to reinforce hoses. The matrix material of the hose itself is a flexible material such as natural or synthetic rubber or a thermoplastic material. The reinforcement in the form of a braided structure of steel wires provides an adequate resistance against medium to high internal pressures. In order to obtain this resistance, the braided structure includes a plurality of bands of parallel steel wires, closely arranged one in contact with the other. An example of braided wire reinforcement for hoses is disclosed in EP-A-0 069 957.

## Summary of the invention.

The present invention involves an alternative use of a braided structure comprising steel wires or steel cords. This alternative use results in particular geometrical features of the braided structure.

It is an object of the present invention to provide a structure that allows reinforcing shapes of different dimensions and forms. It is a further object of the present invention to provide a structure that – departing from one single structure - can take various cross-sectional geometries.

According to the present invention, there is provided a braided structure that comprises at least two groups of elongated elements, which have been braided with each other to form the braided structure. At least one of the groups comprises steel wires or steel cords. The structure has a longitudinal axis and has a total length over this longitudinal axis.

The structure having over a first part of its total length one of said two groups revolving in a first direction (S or Z) around the longitudinal axis. Over a second part of this total length a first subgroup of individual elongated elements belonging to one of the groups is spaced from a neighboring second subgroup of individual elements belonging to the same group with an inter-distance that is greater than half the average element diameter of the individual elongated elements. This inter-distance may also be greater than 1x, 2x, 3x or ever more times the average element diameter of the individual elongated elements. As will be explained hereafter, this inter-distance allows change of cross-sectional geometry along the longitudinal axis.

The first part and the second part of the total length may overlap or not.

Steel cords are preferred to steel wires, since steel cords have a greater flexibility for the same strength.

The other of the two groups may revolve in a second direction (Z or S), opposite to the first direction.

The first subgroup or the second subgroup or both may consist of one single individual elongated element. Alternatively, the first subgroup or the second subgroup or both may comprise more than one individual elongated element.

The inter-distance between neighboring individual elongated elements of one group allows the elongated elements to shift with respect to the elongated elements of the other group and take another braiding angle. The braiding angle is here defined as the angle between the longitudinal axis and a projection of the relevant elongated elements.

Preferably a comparable inter-distance is also present between neighboring subgroups of individual elongated elements of the second group. Here also, the subgroups may consist of a single elongated element or may comprise more than one single elongated element.

This inter-distance present between neighboring elements in the braided structure constitutes the distinction with existing braided structures for hoses or pipes. In hoses and pipes, the function of the braided structure is to resist high internal pressures. Consequently, the braided structure does not show opennesses and inter-distances.

The shifting of the individual elements enables changing cross-sectional geometries along the length of the braided structure.
A first example of a changing geometry is a braided structure where the subsequent cross-sections are all circles but where the diameter of the circles varies. The smaller diameters correspond to smaller braiding angles, the greater diameters correspond to greater braiding angles.
A second example of a changing geometry is a braided structure where the subsequent cross-sections all resemble to rectangles. The height and width of these rectangles vary over the length of the braided structure. So the cross-section of the braided structure may vary from almost a square with an aspect ratio of about 1 / 1 to a flattened shape with an aspect ratio of 1 / 4 , 1 / 8 or even smaller.
As a third example of a changing geometry, the subsequent cross-sections of the braided structure may take various geometrical forms, e.g. starting with a circle, going over to an ellipse and then to a rectangle to go to a square and end again with a circle.

The changing geometry along the length of the braided structure may, as outlined here above, the result of changing braiding angles obtained by mechanically deforming the braided structure after braiding.
Alternatively, the changing geometry may also be the result of changing braiding pattern during the braiding process itself.

According to a particular embodiment of the present invention, the braided structure may also comprise a third group of elongated elements. The majority of elongated elements of this third group runs substantially parallel to the longitudinal axis of the braided structure and thus has a braiding angle in the neighborhood of zero degrees. These elongated elements are often referred to as standing elements or

standing yarns. The standing elements contribute to the stiffness of the braided structure and to its longitudinal strength.
Standing elements with an elongation at break of more than four per cent may be provided.

In addition to the steel wires or steel cords, one or more groups of elongated elements may also comprise synthetic yarns or synthetic filaments. These synthetic yarns or filaments may be made of polyamide, polyethylene, aramide, high-density polyethylene, poly(p-phenylene-2,6-benzobisoxazole), polypropylene, polyethylene naphtalate, …
In addition to the steel wires or steel cords, one or more groups of elongated elements may also comprise carbon fibers or glass fibers or both.

According to an embodiment of the present invention, the braided structure may have, at least partially over its length, a split pattern where two or more separate structures are formed, with one structure split from another structure.

The braided structure according to the present invention may be wholly or partially coated with a rubber or a thermoplastic polymer or elastomer, such as polyamide, polyurethane, polyvinyl chloride, polypropylene, thermoplastic elastomers, and thermoplastic vulcanites, …

The present invention relates also to a composite material having a thermoplastic polymer or elastomer as matrix material and where the braided structure provides the reinforcement.
In a possible use of the invention, the braided structure is applied to reinforce the inner walls of plastic products. In other uses, the braided structure reinforces the outer walls or provides for reinforcement somewhere in the middle of the walls.

**Brief description of the drawings.**

The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1a is a longitudinal view of a first embodiment of a braided structure according to the invention;
- FIGURE 1b is an enlarged view of a part of the braided structure of FIGURE 1a;
- FIGURE 2 is a cross-section along plane II-II in FIGURE 1a;
- FIGURE 3 is a cross-section along plane III-III in FIGURE 1a;
- FIGURE 4 is a longitudinal view of a second embodiment of a braided structure according to the invention;
- FIGURE 5 is a cross-section along plane IV-IV in FIGURE 4;
- FIGURE 6 is a cross-section along plane VI-VI in FIGURE 4;
- FIGURE 7a is a longitudinal view of a third embodiment of a braided structure according to the invention;
- FIGURE 7b is an enlarged view of a part of the braided structure of FIGURE 7a;
- FIGURE 8 is a longitudinal view of a fourth embodiment of a braided structure according to the invention;
- FIGURE 9 illustrates the manufacturing of a braided structure according to the invention;
- FIGURE 10 illustrates the use of a braided structure according to the invention.

**Description of the preferred embodiments of the invention.**

FIGURE 1a is a longitudinal view of a first embodiment of a braided structure 10 according to the invention. FIGURE 1b shows an enlarged view of part of the braided structure. Braided structure 10 has two groups of steel cords, which have been braided with each other to form the braided structure. The first group revolves in S-direction around longitudinal axis 11. The first group comprises, amongst others, neighboring steel cords 12 and 12’. The inter-distance 13 between these two neighboring cords 12 and 12' is at least greater than the average diameter of the steel cords of the first group. The second group revolves in Z-direction around longitudinal axis 11. The second group comprises, amongst others, steel 14. Comparable inter-distances are also present between two neighboring steel cords of the second group.

The inter-distances between the neighboring cords allow the cords of one group to shift with respect to the cords of the other group and to take various forms. The inter-distances give the braided structure 10 a structural elasticity.

In the left part of the braided structure 10 on FIGURE 1a, the cords of the first group form a braiding angle $\beta_1$ with the longitudinal axis, which is also the direction of production. In the right part of the braided structure 10 on FIGURE 1a, the cords of the second group form a braiding angle $\beta_2$. Braiding angle $\beta_2$ is smaller than braiding angle $\beta_1$.

Reference is now made to FIGURE 1a, FIGURE 2 and FIGURE 3. The left part with the greater braiding angle $\beta_1$ corresponds to cross-sections 16 with the greater diameter, as illustrated in FIGURE 2, while the right part with the smaller braiding angle $\beta_2$ corresponds to cross-sections 18 with the smaller diameter, as illustrated in FIGURE 3.

FIGURE 4, FIGURE 5 and FIGURE 6 illustrate a second embodiment of a braided structure 10 according to the invention. The left part of the braided structure 10 has a cross-section according to plane V-V, which resembles a square with an aspect ratio about 1 / 1, as illustrated in FIGURE 5. The right part of the braided structure 10 has a cross-section according to plane VI-VI, which resembles a rectangle 22 with an aspect ratio of about 1 / 2.3, as illustrated in FIGURE 6.

FIGURE 7a is a longitudinal view of a third embodiment of a braided structure 10 according to the invention. FIGURE 7b shows an enlarged view of part of the braided structure of FIGURE 7a. The difference with the first embodiment and the second embodiment is that this braided structure additionally comprises a third group of steel cords 24, 26, 28, ... which run in the production direction, i.e. more or less parallel to the longitudinal axis. This third group, sometimes referred to as standing steel cords or standing yarns adds to the stiffness of the braided structure and increases its strength. These standing yarns also add to the bending stiffness of the braided structure.

FIGURE 8 is a longitudinal view of a fourth embodiment of a braided structure 10 according to the invention. The left part 30 of braided structure 10 on FIGURE 8 forms a unity of a single tubular structure. In contrast herewith, the right part 32 of the braided structure 10 on FIGURE 8 consists of two tubular structures 34, 36 split from each other.

FIGURE 9 illustrates how a braided structure 10 according to the invention may be manufactured. A braided structure according to the invention can be made by means of a braider machine 40, well known as such. Such a braider machine 40 is equipped with as many supply spools 42, 44 with steel cords as there are individual steel cords in the braided structure 10. The steel cords may be subjected to a helical performing before being braided, e.g. by drawing these steel cords with a certain tensile force around part of a pre-forming rod 46. This pre-forming rod 46 may be rotatably arranged or stationary. The supply spools 42 of the steel cords of the first group are arranged on a first ring 48, and the supply spools 44 of the steel cords of the second group are arranged on a second ring 50. When braiding, the first ring is rotating in a first direction (counter clock-wise on FIGURE 9) and the second ring is rotating in a second direction opposite to the first direction (clock-wise on FIGURE 9). During braiding the various steel cords are drawn from the supply spools 42, 44 in a production direction and may be guided through a central hole (not shown), around a mandrel 54 (which is removed later on) or around a core out of soft

material, such as a foam (not shown). This foam can be removed later on or not. The typical braided pattern is created when the steel cords of one group contact the steel cords of the other group.
The geometry of the braided structure 10 is determined, amongst others, by the speed at which the various steel cords are drawn from the supply spools in relation to the rotation speed of the first ring 48 and second ring 50. A preferable and efficient way of producing the braided structure according to the invention, is selecting a relatively high speed at which the various steel cords are drawn from the supply spools. This high speed, in comparison with the rotation speed of the two rings, results in small braiding angles $\beta$.

Instead of using rotating rings 48, 50, a more complex train of wheels may be provided where the various supply spools 42, 44 may travel along programmable tracks. Changing the tracks leads to other geometrical configurations of the braided structure 10.

FIGURE 10 illustrates the use of a braided structure 10 according to the invention. A purpose of the braided structure 10 may be to reinforce the internal walls 56 of a thermoplastic product 58. These internal walls 56 may take various geometries with varying cross-sectional areas. A braided structure 10 according to the invention is first brought inside the walls 56. As a second step a plastic bag (not shown) is brought inside the braided structure 10. The plastic bag is inflated and exercises a radially outward force on the braided structure 10 so that this braided structure 10 takes the form of the internal walls. The plastic bag may be removed or may remain inside the braided structure 10. A heating, e.g. an induction heating may be applied, to melt the surface of the inner walls 56 so that the braided structure adheres to the internal walls 56, and even penetrates somewhat inside the plastic product 58.
This use illustrates the advantages of the braided structure according to the invention. The braided structure 10 is made in an efficient way by means of a fast braiding process and takes a standard tubular

geometry with the same subsequent cross-sections. This same standard braided structure can then by used to reinforce the inner walls of largely varying geometries.

Alternatively, a plastic sheet may be brought into the braided structure before introduction of the plastic bag. In this way the braided structure 10 does not reinforce the inner wall but the center or middle of the wall.

An example of a thermoplastic product is an impact beam for use in automotive or along the roads.

Steel cords or steel wires, as the case may be, can have following technical features :

- the filament or wire diameters range from 0.04 mm to 1.1 mm, more specifically from 0.15 mm to 0.60 mm, e.g. from 0.20 mm to 0.45 mm ;
- the steel composition generally comprises a minimum carbon content of 0.60 % (e.g. at least 0.80 %, with a maximum of 1.1 %), a manganese content ranging from 0.20 to 0.90 % and a silicon content ranging from 0.10 to 0.90 % ; the sulfur and phosphorous contents are preferably kept below 0.03 % ; additional elements such as chromium (up to 0.2 % to 0.4 %), boron, cobalt, nickel, vanadium ... may be added to the composition ;
- the filaments are conveniently covered with a corrosion resistant coating such as zinc or with a coating such as a silane that promotes the adhesion to the thermoplastic material ;
the coating can also be brass, or a so-called ternary brass such as copper-zinc-nickel (e.g. 64% / 35.5% / 0.5%) and copper-zinc-cobalt (e.g. 64% / 35.7% / 0.3%), or a copper-free adhesion layer such as zinc-cobalt or zinc-nickel ; brass coated steel cords are largely available on the market as they are used in large scale for the reinforcement of rubber tires.

Steel cords or steel wires in the braided structure according to the invention are not limited to particular tensile strengths, but can take all common and available final tensile strengths from 2150 MPa to about 3500 MPa and more.

If steel cords or steel wires are used in the third group of elongated elements of the third embodiment of the present invention, i.e. if steel cords are used as standing elements, an additional elongation may be built in the steel cords. This additional elongation may be obtained by pre-forming the steel cords into a wavy form or crimp form. This mechanical pre-formating leads to a structural elongation. The additional elongation may also be obtained by a suitable thermal treatment such as a thermal stress relieving treatment resulting in an increased plastic elongation. Such a thermal stress relieving treatment is disclosed, amongst others, in EP-B-0 790 349.

Nothing prevents applying the just mentioned thermal stress relieving treatment to all of the present steel wires or steel cords in the braided structure. The advantage is that the braided structure then not only has a structural elasticity but also a capacity to elongate in the plastic zone, i.e. is increasing its capability of absorbing impact forces.
In this respect, if tensile strength is not of particular relevance, low carbon steel wires or steel cords made out of low carbon filaments can be used as elongated elements in the braided structure. With a suitable thermal treatment, these low carbon steel elements may have an elongation at break of five per cent or more.

If steel cords are used in the braided structure according to the invention, the steel cords are not limited to any particular structure. However, the type of cord construction may be selected with a view towards the purpose and particular use.

Following steel cord constructions may be possible :

- 1xn steel cord constructions, are twisted structures consisting of n individual steel filaments, where n ranges between two and six ; they can be made in one single twisting step and can have open cross-sections depending upon their pre-forming; these open cross-sections have the advantage of offering a mechanical anchorage with the thermoplastic matrix material of the product to be reinforced ; examples are 1x2x0.30 and 3 x 0.30 ;
- l + m + n steel cord constructions are structures with a core of l filaments, where l ranges between one and four, a layer of m filaments twisted around the core, where m is greater than l, and possibly, an outer layer of n filaments twisted around the layer of m filaments ; if the breaking load is to be maximized the number of filaments in the various layers are selected to form saturated layers with only small spaces available between the filaments, if the mechanical anchorage with a thermoplastic matrix is to be optimized, unsaturated layers may be chosen with a smaller population in the various layers and larger spaces available where thermoplastic material may penetrate ; examples are 1+6 ; 1+6+12, 3+9+15 ;
- 1xm compact steel cords comprise m individual steel filaments which are all twisted in one single operation in the same direction and with the same twisting step ; compact steel cords may have a very dense and compact configuration and provide a maximized breaking load per cross-section ; examples are 1x12 CC and 1+18 CC ;
- nxm steel cords are multi-strand steel cords having n strands, where each strand has m filaments ; an example is a 3x3 steel cord ;
- n+m steel cords are steel cords according to type as disclosed in US-A-4,408,444 and consist of a first group of n filaments with a great twisting pitch which are twisted with a second group of m filaments ; the twist pitch in the second group of m filaments is

the same as the twist pitch of the first group with the second group ; this type of steel cord has the great advantage that it can be made in one single step and that it has a very open structure allowing penetration of thermoplastic material.

**CLAIMS**

1. A braided structure comprising at least two groups of elongated elements which have been braided with each other to form said structure, at least one of said groups comprising steel wires or steel cords, said structure comprising a longitudinal axis and having a total length over its longitudinal axis, said structure having over a first part of its total length one of said two groups revolving in a first direction around said longitudinal axis,
   **characterized in that**
   over a second part of said total length a first subgroup of individual elongated elements belonging to one of said groups is spaced from a neighboring second subgroup of individual elements belonging to the same of said groups with an inter-distance that is greater than half the average element diameter of the individual elongated elements at a braiding angle of 45 degrees, said inter-distance allowing change of cross-sectional geometry.

2. A braided structure according to claim 1, wherein said first subgroup or said second subgroup consists of one individual element.

3. A braided structure according to claim 1, wherein said first subgroup or said second subgroup consists of more than one individual element.

4. A braided structure according to any one of the preceding claims, wherein the other of said two groups revolves in a second direction around said longitudinal axis, said second direction being opposite to said first direction.

5. A braided structure according to any one of the preceding claims, wherein said inter-distance is at least three times greater than the

average element diameter of the individual elongated elements.

6. A braided structure according to any one of the preceding claims, said braided structure having over said second part a changing geometry of the successive cross-sections.

7. A braided structure according to claim 6, wherein said successive cross-sections are circles and where said changing geometry comprises a changing diameter of said circles.

8. A braided structure according to claim 6, wherein said successive cross-sections resemble rectangles and where said changing geometry comprises a changing height of said rectangles.

9. A braided structure according to any one of the preceding claims, said braided structure comprising a third group of elongated elements the majority of which runs substantially parallel to the longitudinal axis of the braided structure.

10. A braided structure according to claim 9, wherein said third group of elongated elements has an elongation at break of at least four per cent.

11. A braided structure according to any one of the preceding claims, at least one of said groups comprising synthetic yarns or synthetic filaments.

12. A braided structure according to any one of the preceding claims, at least one of said groups comprising carbon fibers or glass fibers.

13. A braided structure according to any one of the preceding claims, said braided structure showing at least partially along its length a

split pattern with two or more parts split from the other parts.

14. A braided structure according to any one of the preceding claims, wherein said structure has at least partially been coated with a thermoplastic polymer.

**15.** A composite material comprising a thermoplastic polymer or thermoset polymer as matrix material and a braided structure according to any one of the preceding claims.

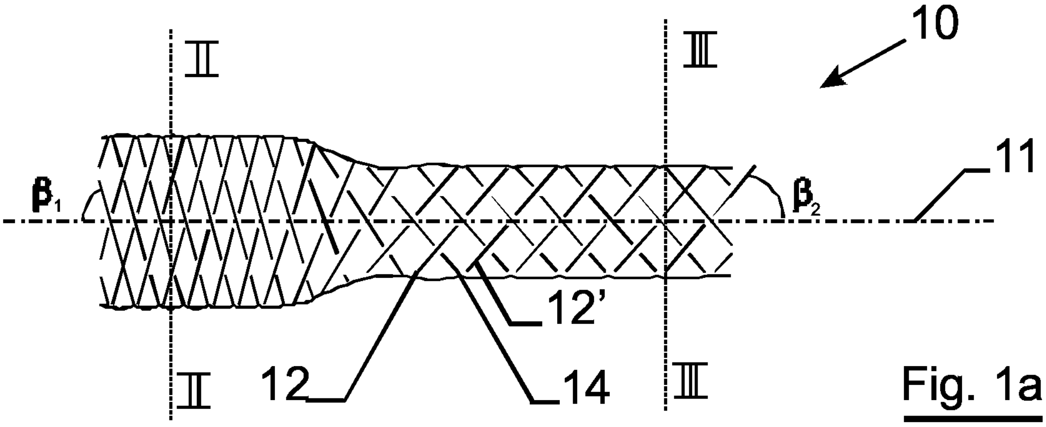


Fig. 1a

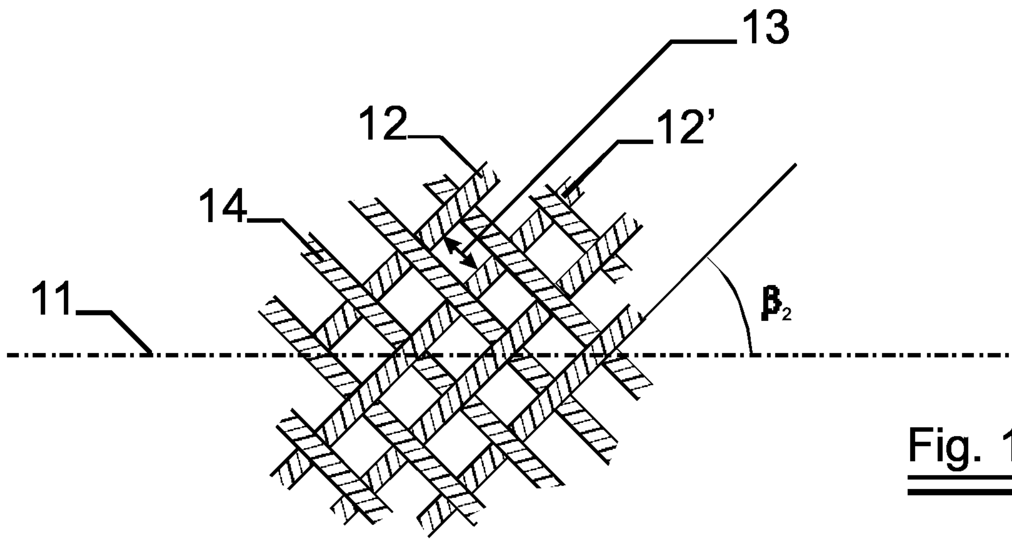


Fig. 1b

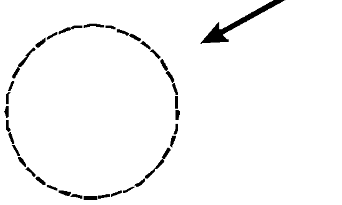


Fig. 2

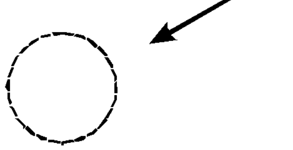


Fig. 3

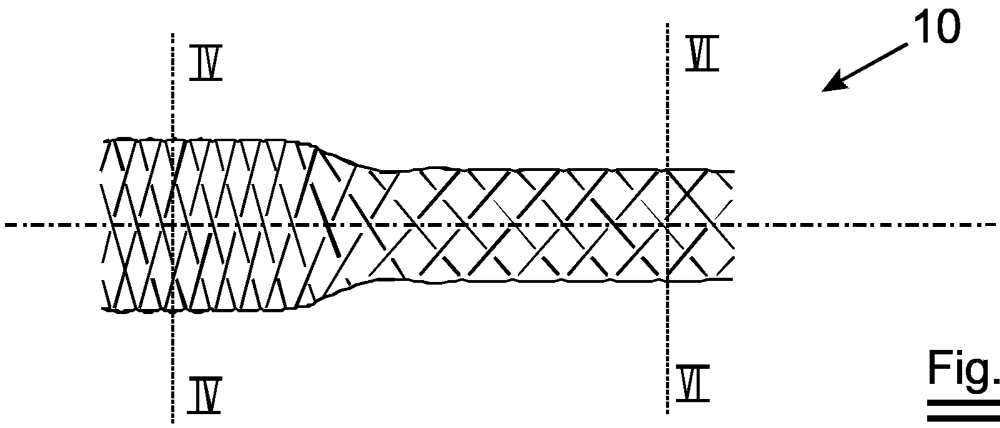


Fig. 4

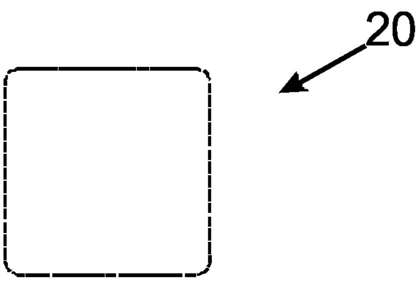


Fig. 5

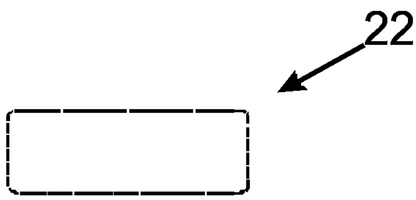


Fig. 6

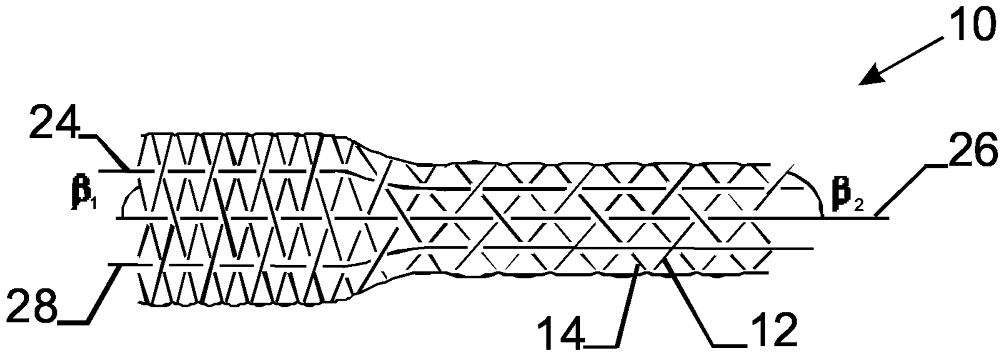


Fig. 7a

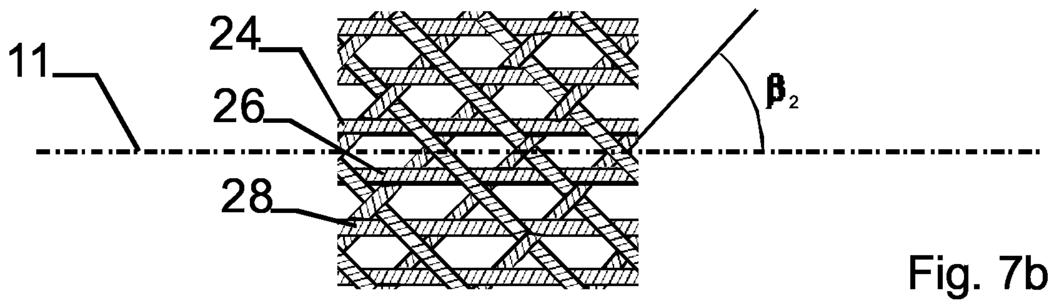


Fig. 7b

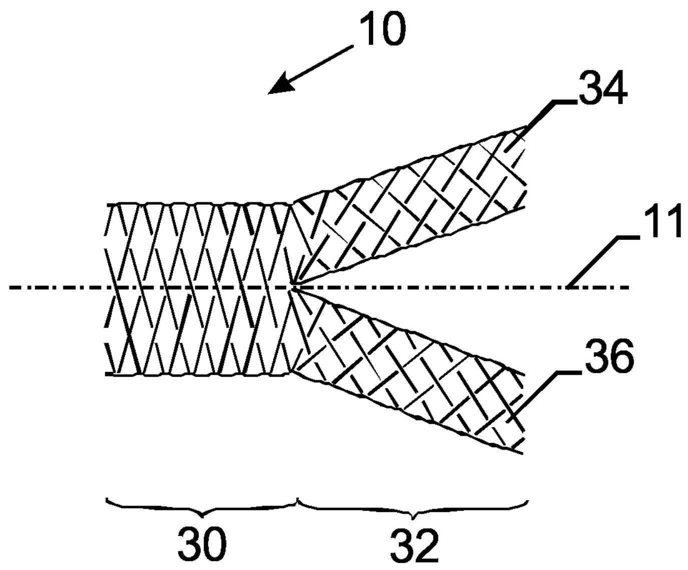


Fig. 8

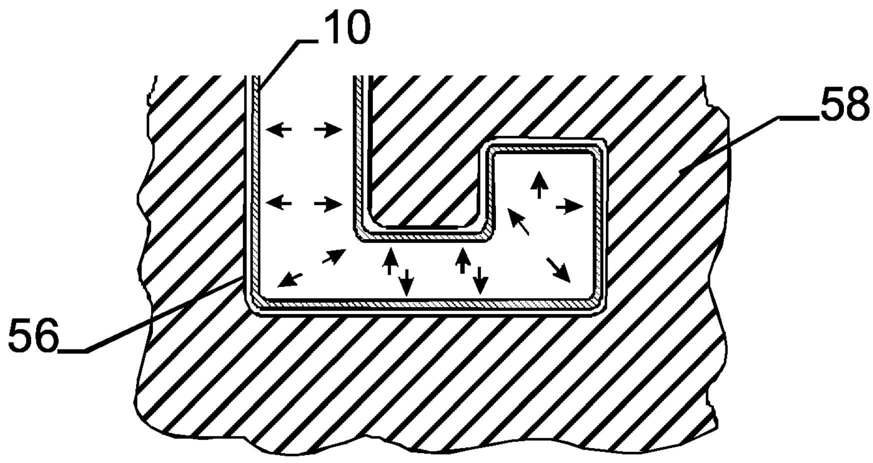


Fig. 10

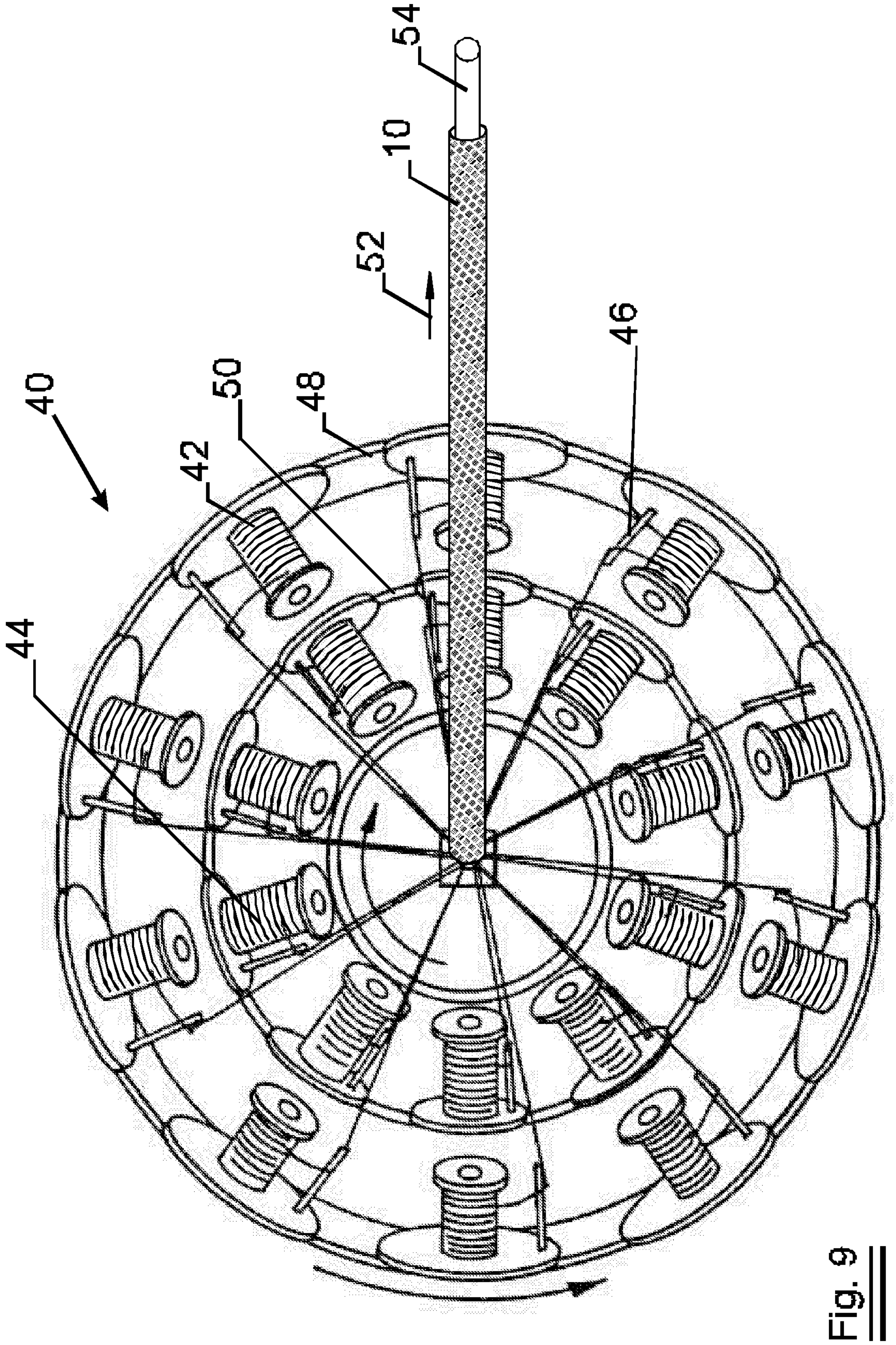


Fig. 9

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/060220

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. D04C1/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
D04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 6 779 563 B2 (SCHWERT SIEGFRIED ET AL) 24 August 2004 (2004-08-24) the whole document | 1-5, 9-12,14, 15 |
| X | US 5 695 008 A (BERTET ET AL) 9 December 1997 (1997-12-09) column 2, line 5 - column 4, line 57; claims 2-4; figures 1-3,8,11 column 6, line 50 - column 7, line 12; figure 11 | 1,2,4-7, 12,15 |
| X | EP 0 333 279 A (BENTLEY-HARRIS MANUFACTURING CO; THE BENTLEY-HARRIS MANUFACTURING COMP) 20 September 1989 (1989-09-20) column 1, line 35 - column 5, line 13; claims 2,6,8,9; figures 1-3 | 1-7,12, 14,15 |

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Information on patent family members

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