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[54] STENT AND METHOD OF MAKING A STENT

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[51] **Int. Cl.**[6] **A61M 29/00**

[52] **U.S. Cl.** **606/194**; 606/191

[58] **Field of Search** 606/191, 192, 606/194, 198; 623/1, 12; 604/96, 97, 106

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[57] **ABSTRACT**

A stent, which has an easier and better bendability and higher flexibility than known stents, has several meander paths (**2**,**2*a***,**2*b***,**2*c***) successively arranged in the axial direction (A) and extending over its circumference (U), and between axially facing areas (**3**,**3*a***,**3'*a***,**3*b***), interconnected by connecting areas (**4**,**4*a***,**4*b***,**4*c***), of the meander paths (**2**,**2*a***,**2*b***,**2*c***) in the circumferential direction (U) there are at least two facing, non-interconnected areas (**3**,**3*a***,**3'*a***,**3*b***) of each meander path (**2**,**2*a***, **2*b***,**2*c***).

16 Claims, 3 Drawing Sheets

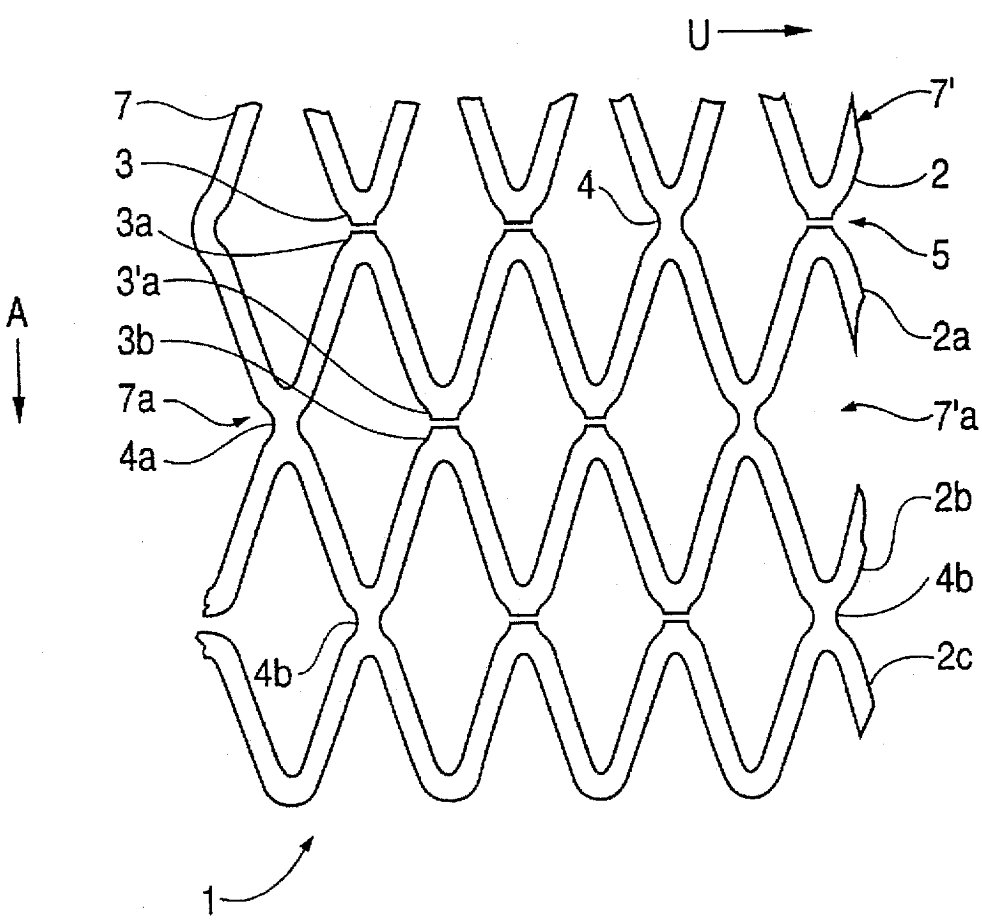


FIG. 1

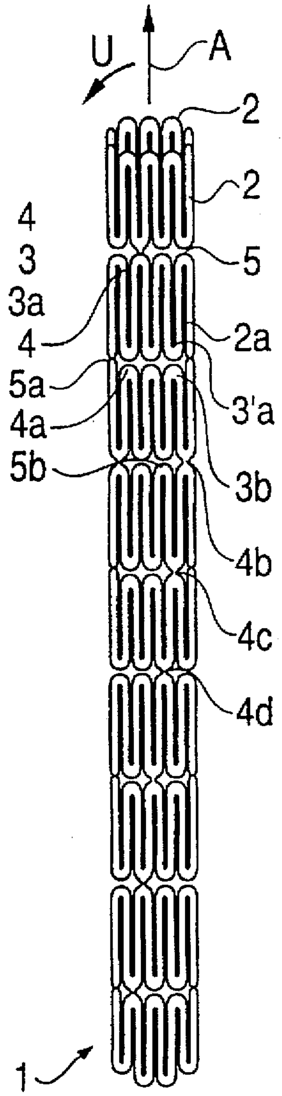
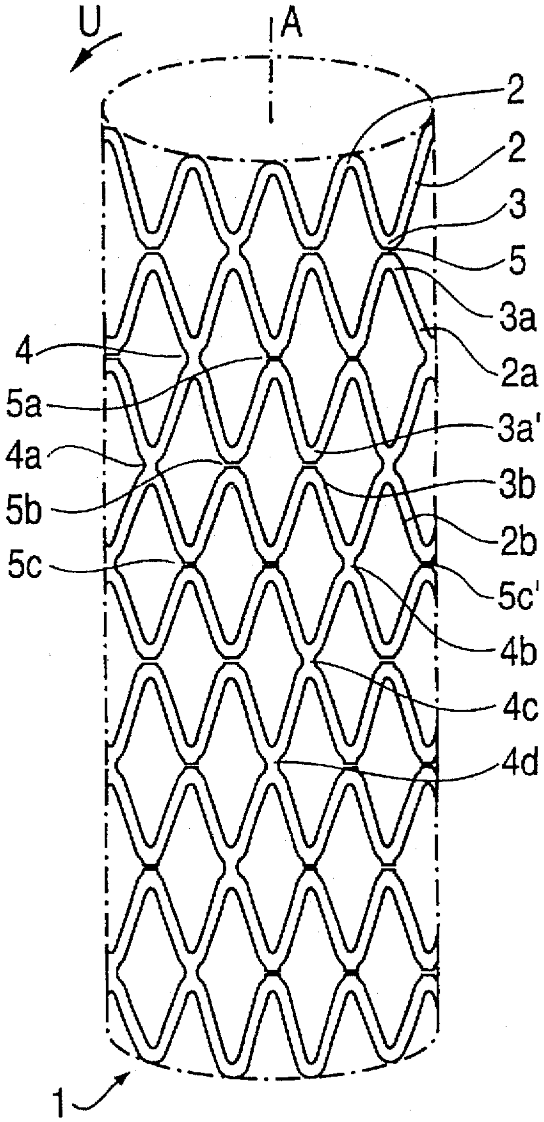

U
A
2
2
5
4
3
3a
4
5a
4a
5b
2a
3'a
3b
4b
4c
4d
1

FIG. 2


U
A
2
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3a
4
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5a
3a'
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3b
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2b
5c
5c'
4b
4c
4d
1

FIG. 3

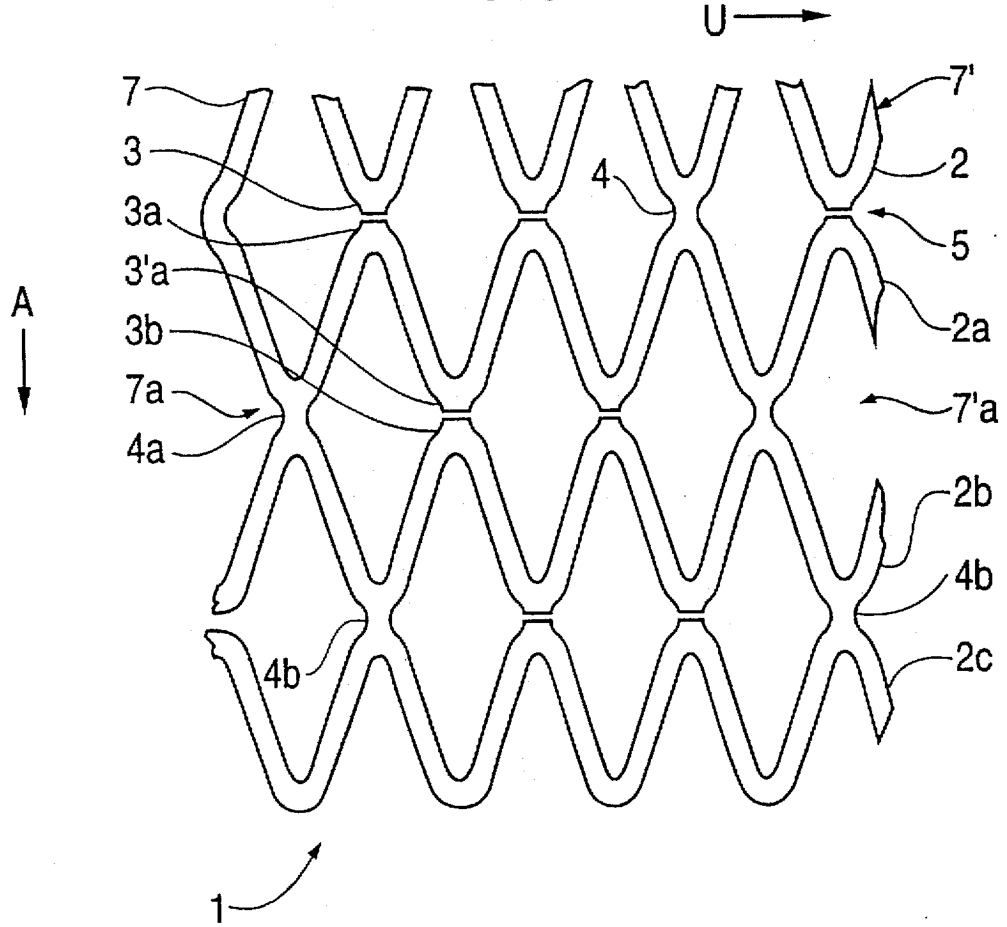
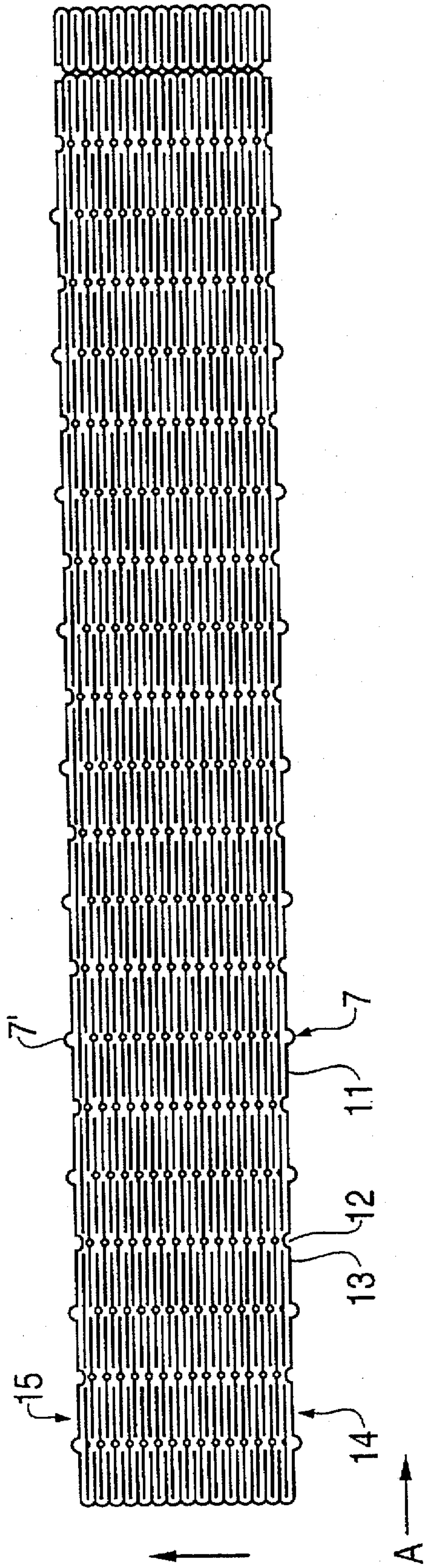


FIG. 4



STENT AND METHOD OF MAKING A STENT

FIELD OF THE INVENTION

BACKGROUND OF THE INVENTION

Such stents or implantable catheters, which can be inserted in a body cavity, a vessel or the like, can be made from plastic or an inert metal, such as steel or nickel-titanium alloys. Such stents are in particular known as endovascular or endoluminal stents or intraluminal tubes. The stents are e.g. used for widening the ureter in the prostate region in the case of benign prostate hyperplasia (BPH) or in the case of sclerotic blood vessels for widening and keeping open the same. The stents have material areas and gaps between them. Thus, the parietal tissue of the organ kept open can grow round the stent. Stents can have a spiral construction or can be in the form of a helically wound coil. They can also be made from woven, knitted or braided wire or plastic material. Such stents can have memory characteristics, such as e.g. occur with certain nickel-titanium alloys (nitinol).

A problem with such stents is their limited bendability, particularly on introducing through narrow organs, such as blood vessels, at the point where a widening can take place. There is a risk that on bending the stent it bends in in the center as a result of the action of axially vertically directed forces, in that its cross-sectional area is reduced in the direction of the acting forces, but is widened perpendicular thereto and to the axial direction thereof. This can make insertion more difficult and can also damage the surrounding tissue, particularly if the stent is to be inserted in a bend area of the vessel or the like. Stents are relatively stiff and inflexible. This more particularly applies with stents having a rhombic structure, which are e.g. produced by cutting from nickel-titanium sheeting and have memory characteristics.

SUMMARY OF THE INVENTION

The problem of the invention is consequently to provide a stent, which has a high bending flexibility in the case of axially vertically acting forces and which is in particular subject to no deformations of its contour, particularly suffering no cross-sectional changes in the case of bending.

According to the invention this problem is solved by a stent, which is characterized in that it has several axially succeeding meander paths extending over its circumference, that between axially facing areas of the meander paths interconnected by connecting portions in the circumferential direction there are at least two facing, non-interconnected areas of each meander path.

Due to the fact that with such a stent and with several axially succeeding material paths guided in meander-like manner over the circumference facing or directed towards one another, adjacent areas of two adjacent meander paths are not interconnected in all cases, but instead between such interconnected areas there are circumferentially at least two non-interconnected areas, a higher flexibility is obtained than would be the case with a stent in which all the facing, adjacent areas of two adjacent meander paths were firmly interconnected. This not only leads to a higher flexibility, but it is in particular achieved that no cross-sectional deformation occurs at bends under the action of axially vertical forces.

An important advantage of the invention is that a high bendability is achieved without multilayer material crossing points, such as is the case in knitted, woven and braided

structures. Due to the fact that there are no such material crossing points, the stent according to the invention grows better into the tissue. It also significantly reduces or eliminates the risk of the occurrence of thromboses, particularly in the vascular region.

According to a preferred development the connecting portions of axially succeeding meander paths are reciprocately displaced in the circumferential direction and in particular the connecting portions are circumferentially displaced by half a meander period, so that the desired axial strength is retained or obtained.

The meander paths can be formed in numerous different ways. Thus, according to preferred developments, the meander paths are zig-zag-like (with peaks), the meander paths are sinusoidal and that the meander paths have an oval construction. According to further preferred developments facing areas of the meander paths are aligned in the axial direction and/or that the width of the connecting areas in the circumferential direction is no larger than the width of the legs of the meander paths.

The stent is preferably self-expanding and is made from a memory metal material. In the low temperature state (well below body temperature), the individual meander legs engage with one another, whereas in the high temperature state (below but closer to body temperature) the stent is radially widened.

Further advantages and features of the invention can be gathered from the claims and the following description of the inventive stent with reference to the attached drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a preferred development of the stent according to the invention in its low temperature or insertion configuration.

FIG. **2** is the stent of FIG. **1** in its high temperature or positioning configuration.

FIG. **3** is a diagrammatic representation of a stent separated longitudinally at its welding positions and laid out flat in order to better illustrate the connection of the successive, axial, zig-zag meander paths.

FIG. **4** is a slotted plate for producing a stent according to the invention.

DETAILED DESCRIPTION OF DISCLOSED EMBODIMENT

In the represented embodiment the stent **1** according to the invention has a cylindrical shape, the outer contour of the stent being indicated by broken lines S in FIG. **2**.

In place of a cylindrical design the stent **1** can also have a conical, biconical, frustum-shaped or other contour. It always has an axis of symmetry A, which determines the axial direction. The circumferential direction is indicated by the arrow U.

As can in particular be gathered from FIGS. **2** end **3**, the stent **1** according to the invention comprises a number of meander paths **2**, **2*a***, **2*b*** succeeding one another in the axial direction A. In the circumferential direction the meander paths **2**, **2*a***, **2*b*** are arranged in such a way that in each case facing, adjacent peak areas **3**, **3*a*** or **3'*a***, **3*b*** of in each case juxtaposed meander paths **2**, **2*a***, **2*b*** are axially aligned.

FIGS. **2** and **3** clearly show that not all the facing, adjacent peak areas **3**, **3*a***, **3'*a***, **3*b*** of the meander paths **2**, **2*a***, **2*b*** are interconnected by connecting areas **4**, **4*a***, **4*b***, **4*c***, **4*d***, but between such connecting areas **4** to **4*d*** of two adjacent

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