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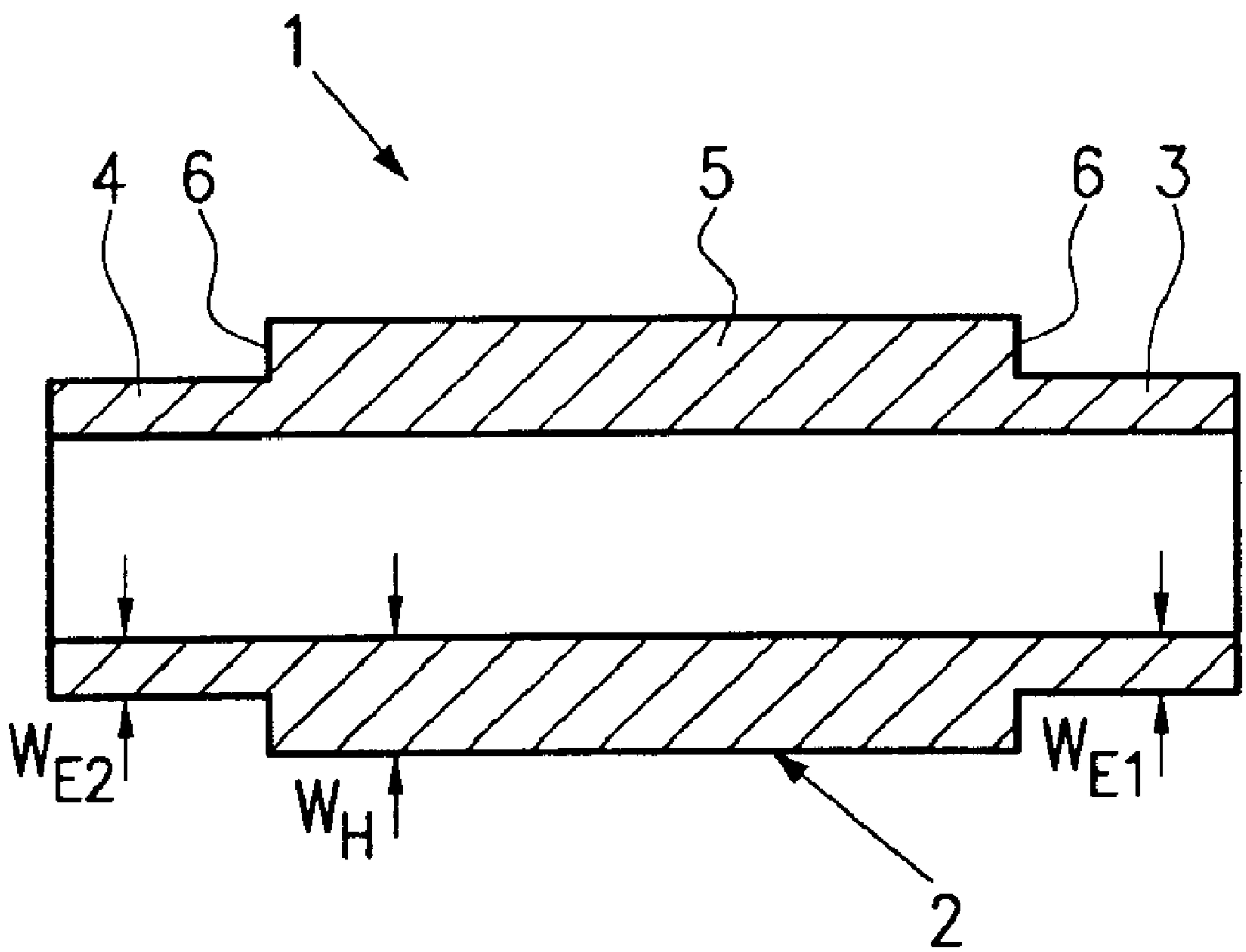


(57) Abrégé/Abstract:
The present invention relates to a stent to be implanted into narrowed portions of hollow vessels of a body. The stent (1) comprises a stent body (2) which has at least two different wall thicknesses (W_E, W_H). The different wall thicknesses result in different flexibility characteristics of the stent in the longitudinal direction. Thus the stent according to the invention prevents irritations of the wall of the vessel in the area of the implanted stent, whereby the risk of restenosis in said area can be reduced considerably.

Abstract

The present invention relates to a stent to be implanted into narrowed portions of hollow vessels of a body. The stent (1) comprises a stent body (2) which has at least two different wall thicknesses (W_E, W_H). The different wall thicknesses result in different flexibility characteristics of the stent in the longitudinal direction. Thus the stent according to the invention prevents irritations of the wall of the vessel in the area of the implanted stent, whereby the risk of restenosis in said area can be reduced considerably.

(Fig. 1)

Description

The present invention relates to a stent comprising a stent body which is in particular used for expanding narrowed hollow vessels.

Different types of stents are known from the prior art. These stents form a vascular prosthesis made from a physically compatible material. Stents are in general used for expanding hollow vessels, such as blood vessels or body orifices, and for keeping said vessels or orifices in an expanded state. To this end, the stent is normally positioned in its non-expanded state within a patient's body inside a narrowed hollow vessel and is then expanded by suitable means, for instance a balloon catheter. The stent body normally consists of a web structure which comprises a plurality of neighboring cells, each cell being defined by webs. During expansion the individual web portions of the stent are deformed, so that said portions permanently remain in said expanded form.

The problem of restenosis often arises in such expanded hollow vessels. After some time the portion of the hollow vessel which has been expanded by the stent is narrowed again. Such a restenosis may, inter alia, be caused by the inherent stiffness of the stent. As schematically shown in Fig. 6, the hollow vessel 10 is stiffened by the stent 1. Strong irritations R of the vessel wall which result in a restenosis of the hollow vessel can in particular be observed on the two end portions of the stent due to the inherent stiffness of the stent body 2.

The present invention provides a stent for expanding hollow vessels comprising an expandable stent body having a tubular cross-section with at least two different wall thicknesses, wherein the stent body comprises first and second end portions and a main portion located between the first and second end portions, wherein the main portion has a wall thickness (W_H) that is constant along its length, wherein the first end portion has a wall thickness (W_{E1}) that is constant along its length, wherein the second end portion has a wall thickness (W_{E2}) that is constant along its length, wherein the wall thickness (W_H) is greater than the wall thickness (W_{E1}) of the first end portion, and wherein the stent body has a constant inner diameter along its length.

The present invention also provides a stent for expanding hollow vessels, comprising an expandable stent body having a tubular cross-section with at least two different wall thicknesses, wherein the stent body comprises first and second end portions and a main portion located between the first and second end portions, wherein the main portion has a wall thickness (W_H) that is constant along its length, wherein the first end portion has a wall thickness (W_{E1}) that is constant along its length, wherein the second end portion has a wall thickness (W_{E2}) that is constant along its length, wherein the wall thickness (W_H) is greater than the wall thickness (W_{E1}) of the first end portion, wherein a transition is formed between the main portion and the first end portion, and wherein the transition has a wall thickness smaller than W_H and greater than W_{E1}.

In one embodiment, a transition (6) from the main portion (5) to the end portion (3,4; 3') is stepped. Alternatively, the transition (6) extends in a continuous manner, preferably in a linear fashion.

The wall thickness (W_{E1}) of the first end portion (3) can equal the wall thickness (W_{E2}) of the second end portion (4). Alternatively, the wall thickness (W_{E1}) of the first end portion (3) differs from the wall thickness (W_{E2}) of the second end portion (4). The length of the first end portion (3) can be equal to the length of the second end portion (4), or can differ from the length of the second end portion (4).

Hence, according to the invention there is provided a stent the wall thickness of which has been changed. This results in a stent having portions which due to the different wall thicknesses exhibit different inherent stiffnesses. Hence, the stent body within the portions of a reduced wall thickness has an increased flexibility, whereby irritations of the vessel wall at said places can be reduced or even be prevented altogether. Hence, the risk of restenosis in said portions can be reduced considerably.

Preferably, the wall thickness of the two end portions of the stent body is smaller than the wall thickness of a main portion of the stent body. As a consequence, the inherent stiffness of the two end portions of the stent body can in particular be reduced, so that the end portions exhibit an increased flexibility, whereby an abrupt "directional change" or a bending of the hollow vessel due to a different stiffness degree between the portion of the hollow vessel without stent and the portion of the hollow vessel with stent can be prevented. As a result, one obtains a more gentle transition between the hollow vessel and the stent, whereby a strong irritation on the end portions of the stent can be avoided.

According to a preferred embodiment of the present invention the stent body comprises exactly one end portion having a smaller wall thickness than the remaining portion of the stent body. Such a stent can preferably be used in branches or rami of hollow vessels. Said stent is arranged in the branched portion such that the end portion of a reduced wall thickness is oriented away from the branched portion. Hence, the stent portion is provided in the area of the branched portion or directly next to the branched portion with an increased wall thickness because the risk of irritations created by the stent is small on account of the natural extension of the branched portion in said area. In the area which is more remote from the branched portion, the stent, however, has a smaller wall thickness so that an increased flexibility of the stent is observed in said area and the stent can follow the natural course of the hollow vessel. Hence, the risk of irritations is reduced thanks to the high flexibility of the end portion of the stent.

To achieve a defined transition between the main portion and the end portion which has a reduced wall thickness, the transition between said two portions is stepped or graded. As a result, the stiffness of the stent can be changed abruptly and the desired flexibility of the stent can be obtained in defined portions of the stent body.

To attain a gradual change in the stiffness or flexibility, respectively, of the stent body, the transition between the portion of an increased wall thickness to the portion of a reduced wall thickness is made continuous. The transition between the two wall thicknesses may e.g. be configured such that it is linear or exhibits a gradually changing increase.

To provide different inherent stiffnesses of the two end portions of the stent body, the wall thicknesses of the two end portions may be different. To provide a symmetrical stent, the end portions of the stent body may also have identical wall thicknesses. Furthermore, flexible end portions may also be achieved by identical or different lengths of the end portions in the axial direction or, in the case of gradually changing wall thicknesses in the transitional portion, by different axial lengths of the transitional portions.

The present invention shall now be described with reference to embodiments taken in conjunction with the drawing, in which:

Fig. 1 is a schematic sectional view in the longitudinal direction of a stent according to a first embodiment of the present invention;

Fig. 2 is a schematic sectional view in the longitudinal direction according to a second embodiment of the present invention;

Fig. 3 is a schematic sectional view of a stent according to a third embodiment of the present invention;

Fig. 4 is a schematic view showing an arrangement of the stent according to the third embodiment of the present invention in a branched portion of a hollow vessel;

Fig. 5 is a schematic view showing the arrangement of a stent according to the first embodiment in a hollow vessel;

Fig. 6 is a schematic view of a prior-art stent within a hollow vessel.

A first embodiment of a stent according to the invention shall now be described with reference to Fig. 1 and Fig. 5. Stent 1 consists of a substantially cylindrical stent body which is made hollow in its interior to enable fluid to pass therethrough. The stent body 2 consists of a flexible web structure which is not shown for the sake of clarity. The stent body 2 of the first embodiment is subdivided into three portions, namely a main portion 5, an end portion 3 and an end portion 4 (cf. Fig. 1). The wall thickness W_E of the end portions 3, 4 is smaller than the wall thickness W_H of the main portion 5. In the present embodiment the wall thickness W_{E1}, W_{E2} of the end portions is about half the wall thickness W_H of the main portion 5. However, any desired wall thickness ratios W_E/W_H are possible between end and main portions. The wall thicknesses W_{E1}, W_{E2} of the two end portions 3, 4 can also be chosen such that they differ from each other. Moreover, it is possible to vary the flexibility of the stent through different lengths of the end portions 3, 4 having the reduced wall thickness W_E.

The main portion 5 and the end portions 3, 4 have arranged thereinbetween a transition or transitional portion 6 which connects the main portion to the respective end portions 3, 4. As shown in Fig. 1, the transition 6 from the main portion 5 to the end portions 3, 4 is stepped or graded. This means that different flexibilities of the respective stent portions are obtained because of the different wall thicknesses of main portion and end portions, resulting in an improved flexibility because of the smaller wall thickness W_E in said area. Since the transition 6 is configured to be perpendicular to the surface of the end portions and the main portion, respectively, a sudden change in the flexibility of the stent is obtained in said area.

As shown in Fig. 5, a stent of such a design can very easily be adapted to the respective conditions or natural extension of the vessel. As becomes also apparent from Fig. 5, the end portions 3, 4 can be adapted to a relatively strong curvature of the hollow vessel 10. As a consequence, the vessel extends in a uniform manner without any sudden directional changes, i.e. also in the area of the implanted stent. In particular, strong irritations, which are observed in conventional stents, can thus be prevented on the end portions of the stent, whereby the risk of restenosis is considerably reduced.

Fig. 6 shows, by way of comparison, a standard stent 1 which has been implanted into a hollow vessel 10. Since the stent body 2 of the stent has a uniform wall thickness, points or places R which are subjected to strong irritations are observed on the end portions of the stent 1, in particular in the case of the hollow vessel 10 extending in bent fashion. Such irritations R may be responsible for restenosis and thus for a narrowing of the hollow vessel 10, which means that a so-called restenosis is observed in the area of the implanted stent. Thanks to the end portions of the stent 1, which are made flexible according to the invention, such points or places R of considerable irritation can be avoided, since the whole stent can be adapted to the natural bent course of the hollow vessel 10 on account of the increased flexibility in the end portion. To be more specific, a sudden change in stiffness which is normally observed between the hollow vessel 10 and the portion of the hollow vessel that is provided with the stent is consequently weakened or attenuated by the flexible ends. Hence, restenosis caused by irritations on account of the implanted stent can be reduced in an efficient manner.

Fig. 2 shows a second embodiment of a stent 1 according to the invention. Identical parts of said stent are designated by the same reference numerals as are used in the first embodiment. The stent 1 has a tubular stent body 2 which consists of a main portion 5 and two end portions 3 and 4. The wall thickness W_E of the end portions 3, 4 is about half the size of the wall thickness W_H of the main portion 5. The main portion 5 is connected to the end portions 3, 4 via a respective transition or transitional portion 6. The transition 6 is designed such that a continuously extending transition is obtained between main portion and end portion (cf. Fig. 2). Starting from the end portions 3, 4 the wall thickness of the stent body 2 increases towards the main portion 5. As a result of such a gradual increase in the wall thickness from the end portion to the main portion, the flexibility of the stent 1 is also changed in said portion. This means that the flexibility of the transitional portion 6 is reduced from the end portion towards the main portion. In contrast to the first embodiment, there is no abrupt change in flexibility and no sudden change in the inherent stiffness of the stent in the transitional portion, but the stiffness changes slowly and continuously in the transition 6.

Hence, the stent 1 of this embodiment exhibits an increased flexibility in the end portion of the stent 1, whereby restenosis caused by irritations due to the implanted stent is prevented in an efficient manner. In addition, the transition 6 between the end portions 3, 4 and the main portion 5 can be designed in response to the desired requirements in such a manner that the flexibility of the transition 6 is changed progressively or stepwise. The transition 6 may be designed in any desired manner. For instance, a linear or parabolic transition 6 may be provided for, or a transition 6 including a plurality of small steps.

Figs. 3 and 4 show a third embodiment of a stent according to the invention. Identical parts of the stent have again be designated by the same reference numerals as used in the first two embodiments. The stent 1 of said embodiment comprises a tubular stent body 2 which has a main portion 5. In contrast to the two preceding embodiments, the stent body 2 of said embodiment has only arranged thereon one end portion 3' having a smaller wall thickness W_E than the main portion 5. The other end of the stent body 2 has the same wall thickness W_H as the main portion 5 (cf. Fig. 3). A transition 6 between the main portion 5 and the end portion 3' is stepped as in the first embodiment. Hence, there is a sudden change in the flexibility of the stent body 2 on the transitional portion 6 due to the different wall thicknesses. The transition 6, however, may be configured in any desired manner.

As shown in Fig. 4, the stent 1 of the third embodiment is primarily used on branches or ramifications of hollow vessels. Fig. 4 shows, by way of example, a branch or ramus 12 extending from the aorta 11 to the kidney 13. Since the ramus 12 directly next to the place branching from the aorta 11 extends substantially along the branching direction and is devoid of any torsions or curve-like or curved extensions, or the like, the stent body 2 may be given a standard flexibility in said area. As a consequence, the end of the stent body 2 in said area may have the same wall thickness as the main portion 5 (cf. Fig. 4). The other end portion 3' of the stent body 2 which is oriented towards the kidney 13 is again provided with a smaller wall thickness W_E than the main portion 5, by analogy with the first two embodiments. Hence, the stent 1 can be adapted in an ideal manner to the natural course of the ramus 12 of the hollow vessel, and irritations of the vessel wall can be reduced on the respective end portions of the stent. Since hollow vessels, such as the kidney, are moving on account of inhalation and exhalation processes, the vessel 12 which connects the kidney 13 and the aorta 11 to each other is also moved considerably. In comparison with a conventional stent, the flexibility of the vessel is thus increased considerably by the inventive stent of the third embodiment, and irritations of the wall of the vessel are attenuated. As a consequence, the risk of restenosis in the area of the implanted stent is reduced considerably.

The above description of the embodiments according to the present invention only serves the purpose of illustration and is not meant to restrict the invention. Various modifications or alterations are possible within the scope of the present invention without departing from the spirit and scope of the invention and its equivalents.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A stent for expanding hollow vessels comprising:
an expandable stent body having a tubular cross-section with at least two different wall thicknesses;
wherein said stent body comprises first and second end portions and a main portion located between said first and second end portions, wherein said main portion has a wall thickness (W_H) that is constant along its length, wherein said first end portion has a wall thickness (W_{E1}) that is constant along its length, wherein said second end portion has a wall thickness (W_{E2}) that is constant along its length, wherein said wall thickness (W_H) is greater than said wall thickness (W_{E1}) of said first end portion, and wherein said stent body has a constant inner diameter along its length.

2. The stent according to claim 1, wherein said wall thickness (W_{E2}) of said second end of said stent body is substantially equal to said wall thickness (W_H) of said main portion of said stent body.

3. The stent according to claim 1, wherein said wall thickness (W_{E1}) of said first end portion is equal to said wall thickness (W_{E2}) of said second end portion.

4. The stent according to claim 1, 2 or 3, wherein a transition is formed between said main portion and said first end portion that is stepped.

5. The stent according to claim 1, 2 or 3, wherein a transition is formed between said main portion and said first end portion that is continuously tapered therebetween.

6. The stent according to claim 5, wherein said transition is linearly tapered in a conical form.

7. The stent according to any one of claims 1 to 5, wherein said wall thickness (W_{E1}) of said first end portion differs from said wall thickness (W_{E2}) of said second end portion.

8. The stent according to any one of claims 1 to 7, wherein said first and second end portions have substantially equal lengths.

9. The stent according to any one of claims 1 to 7, wherein the length of said first end portion differs from the length of said second end portion.

10. A stent for expanding hollow vessels, comprising:

an expandable stent body having a tubular cross-section with at least two different wall thicknesses;

wherein said stent body comprises first and second end portions and a main portion located between said first and second end portions, wherein said main portion has a wall thickness (W_H) that is constant along its length, wherein said first end portion has a wall thickness (W_{E1}) that is constant along its length, wherein said second end portion has a wall thickness (W_{E2}) that is constant along its length, wherein said wall thickness (W_H) is greater than said wall thickness (W_{E1}) of said first end portion, wherein a transition is formed between said main portion and said first end portion, and wherein said transition has a wall thickness smaller than W_H and greater than W_{E1}.

11. The stent according to claim 10, wherein said stent body has a constant inner diameter along its length.

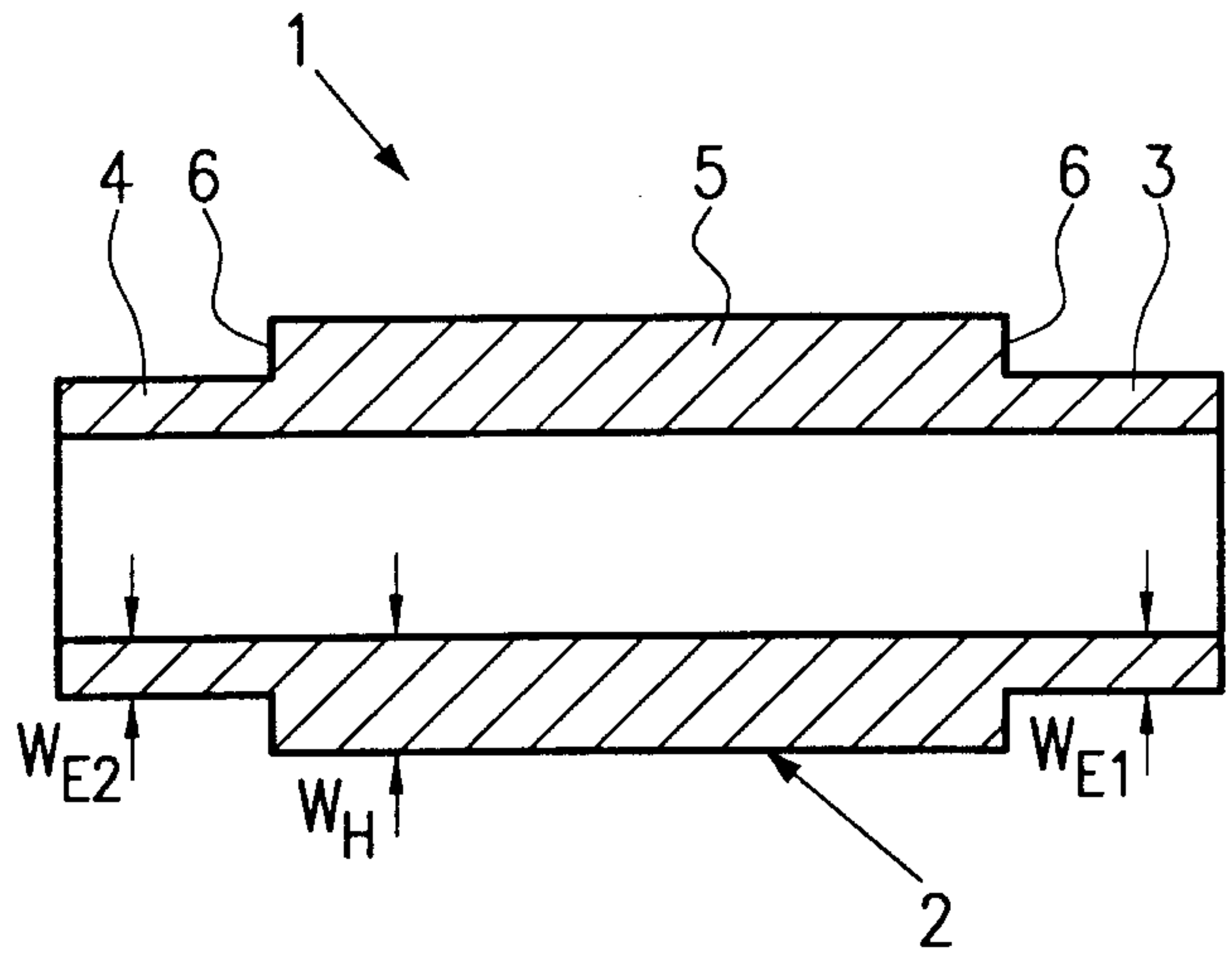


FIG.1

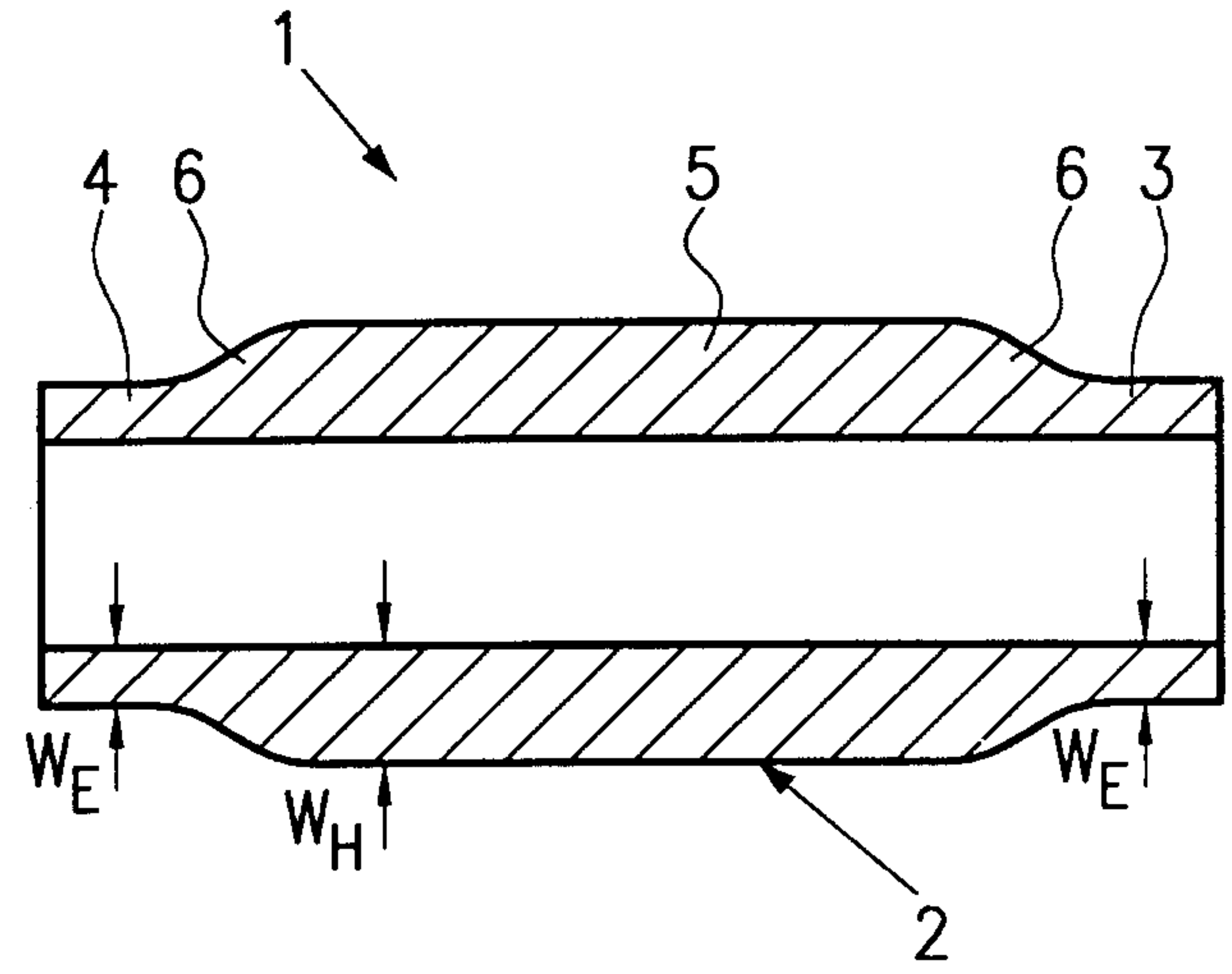


FIG.2

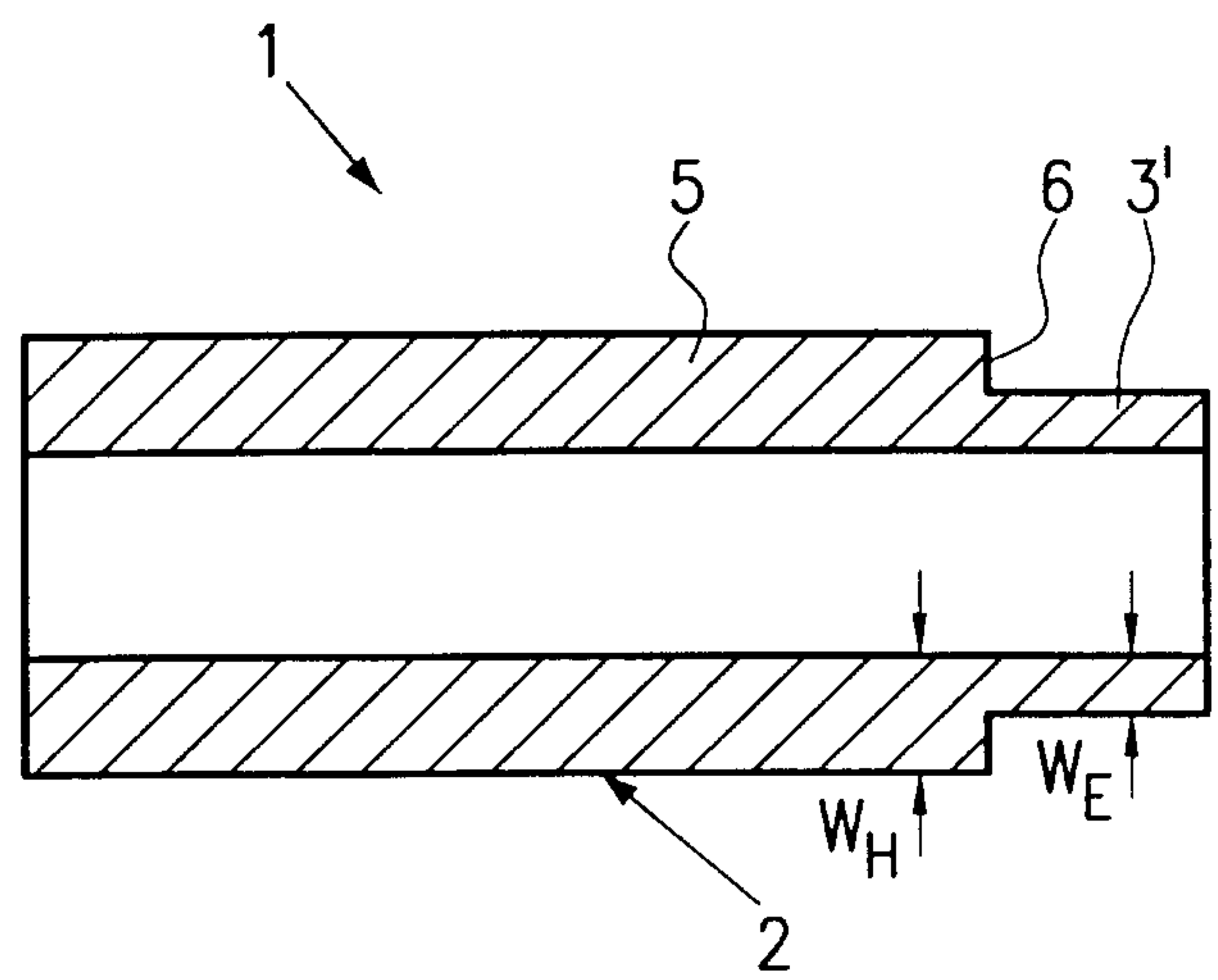


FIG.3

FIG.4

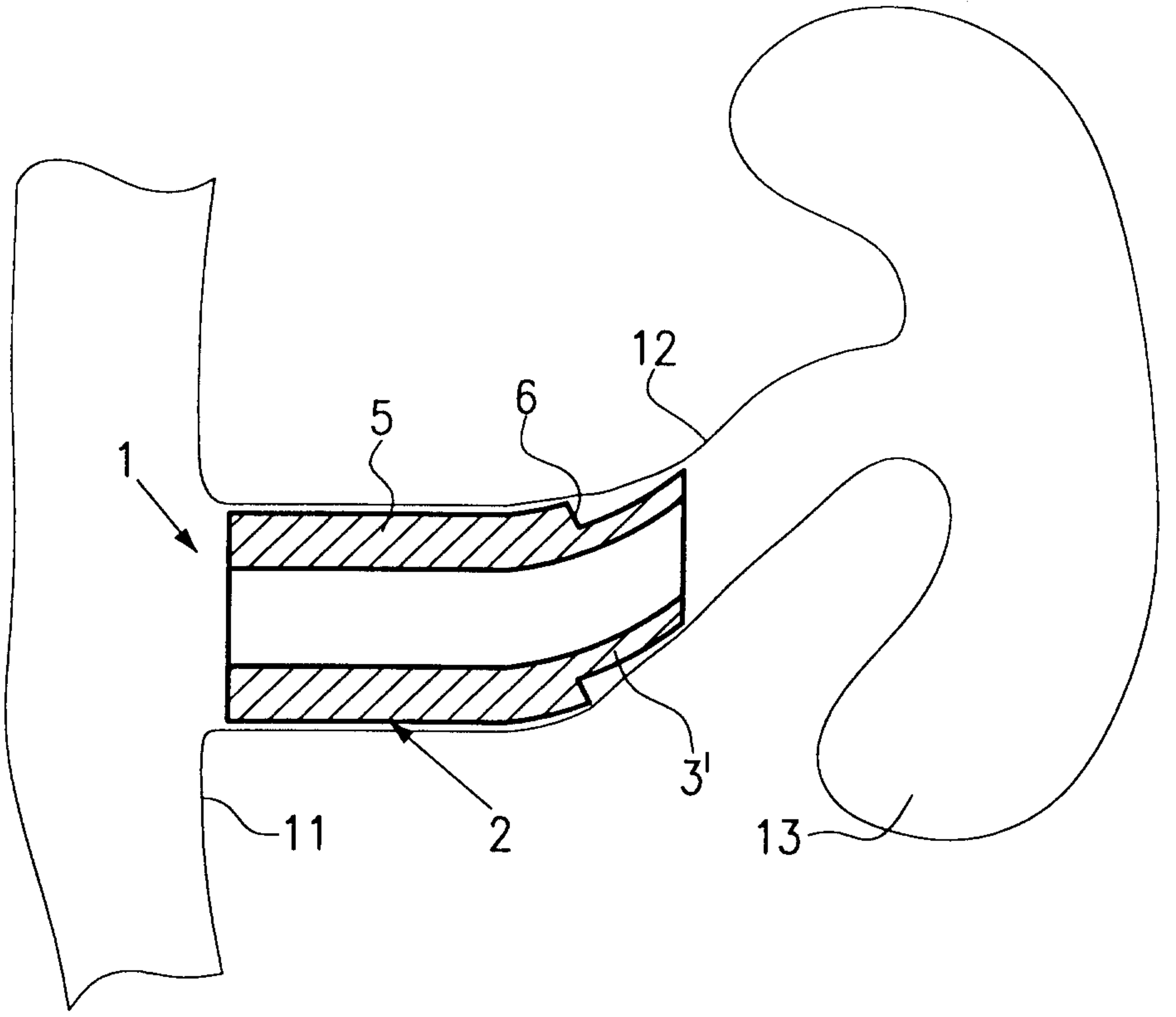


FIG.5

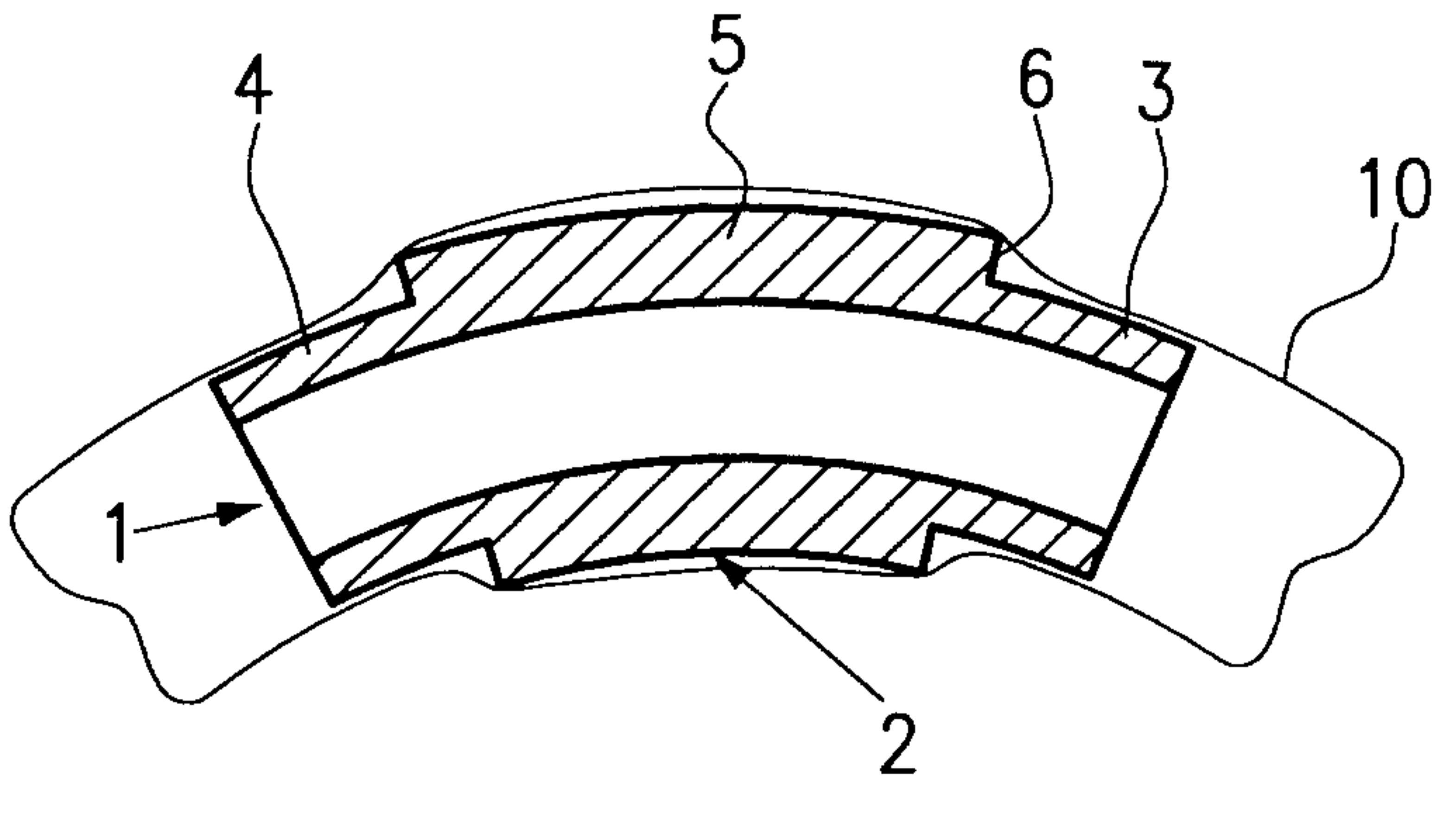
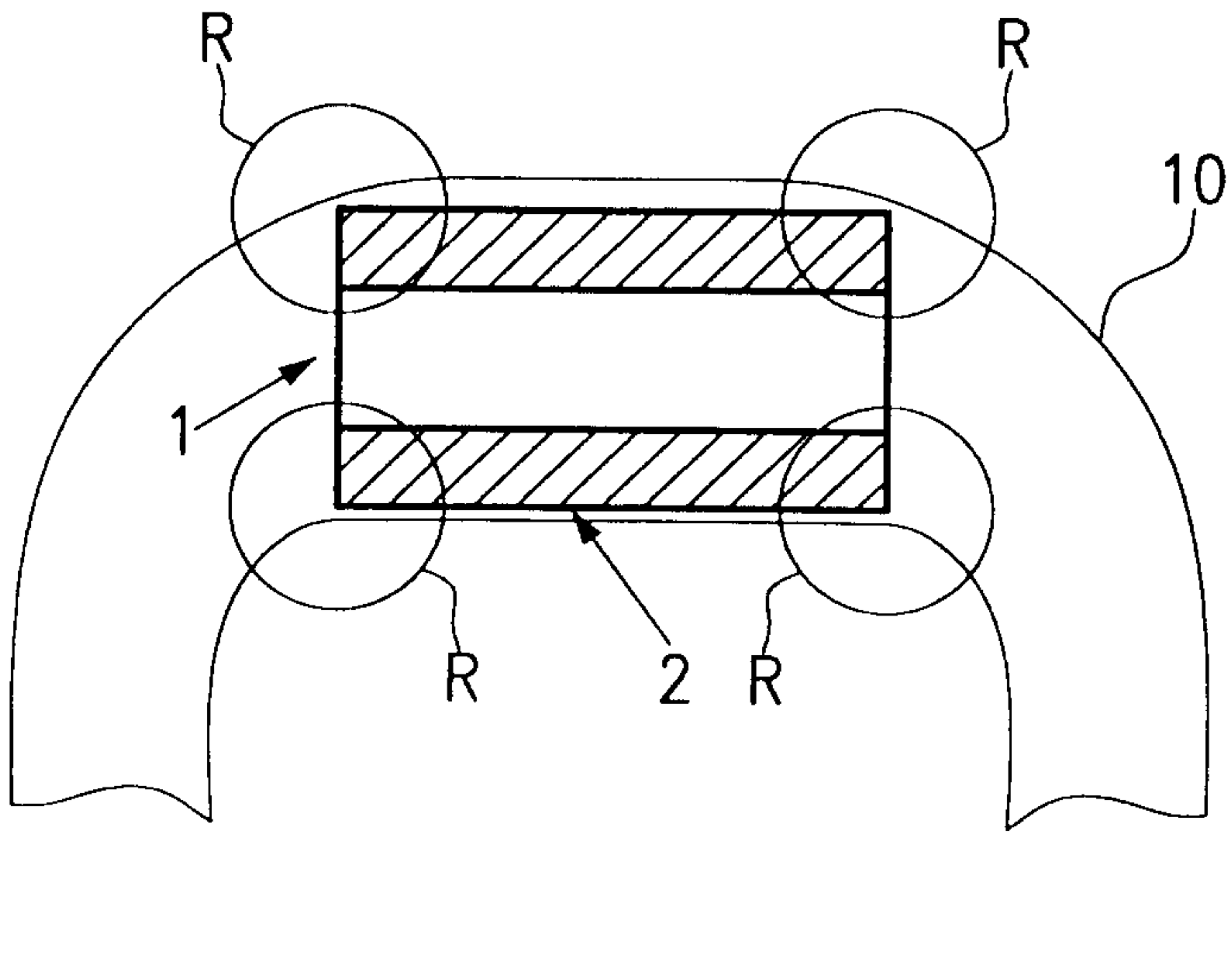
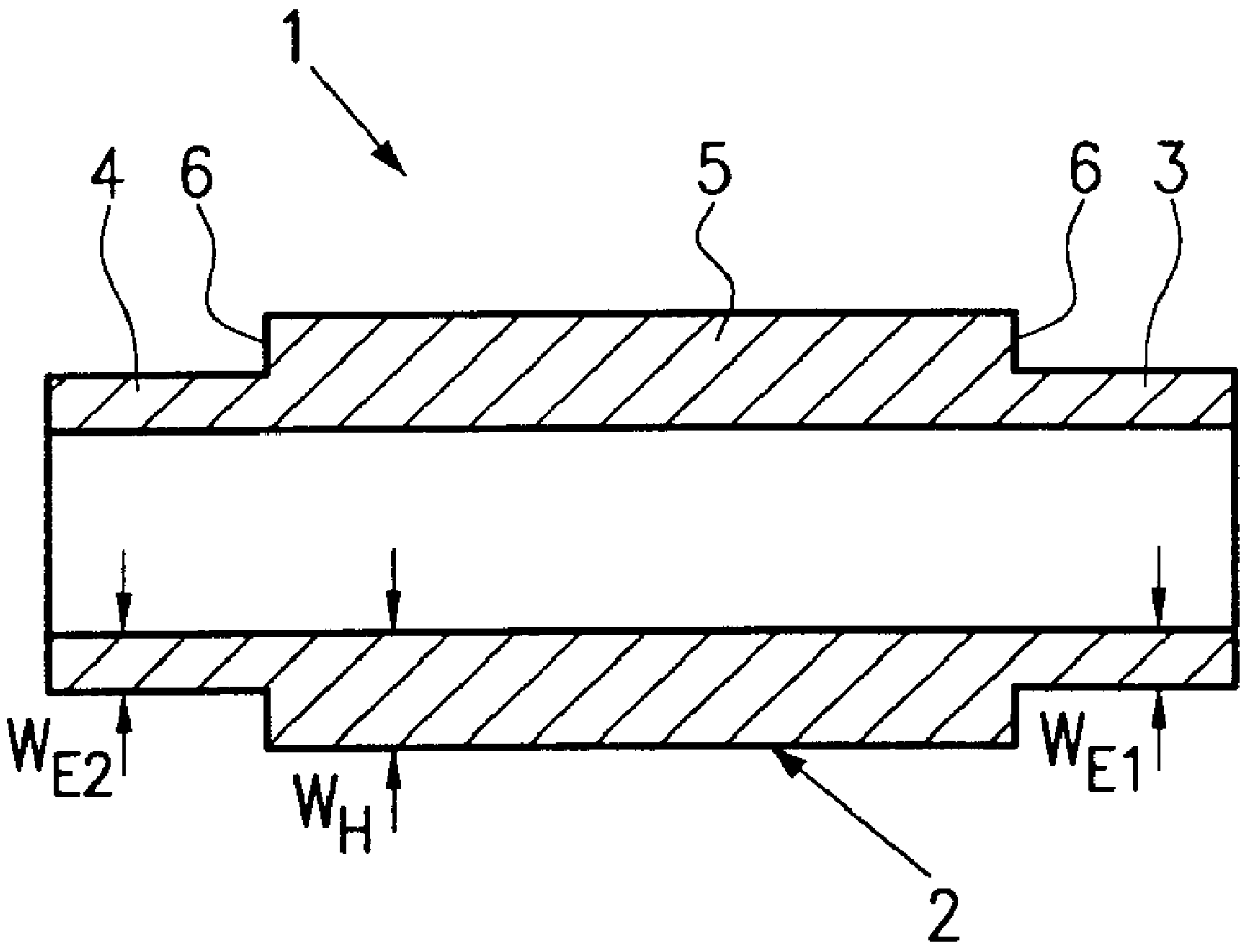


FIG.6
Prior Art




1
4
6
5
6
3
W_{E2}
W_H
2
W_{E1}