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(54) ENDOLUMINAL PROSTHESIS

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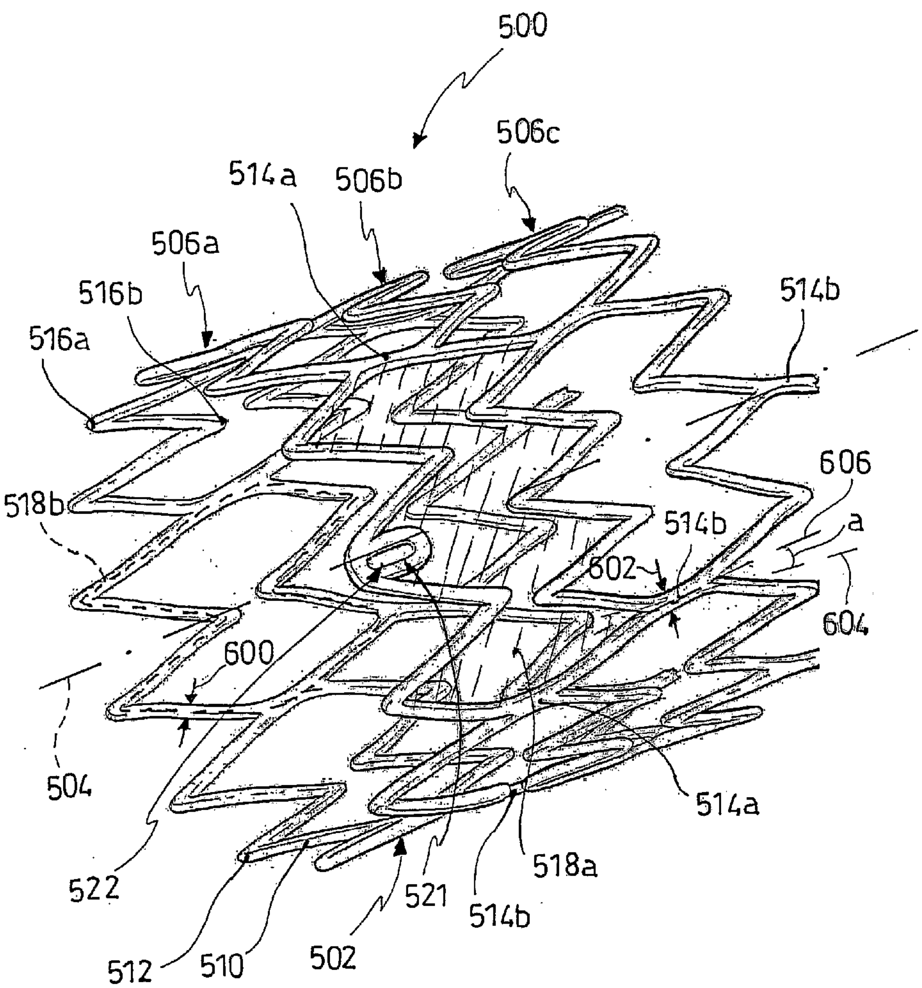
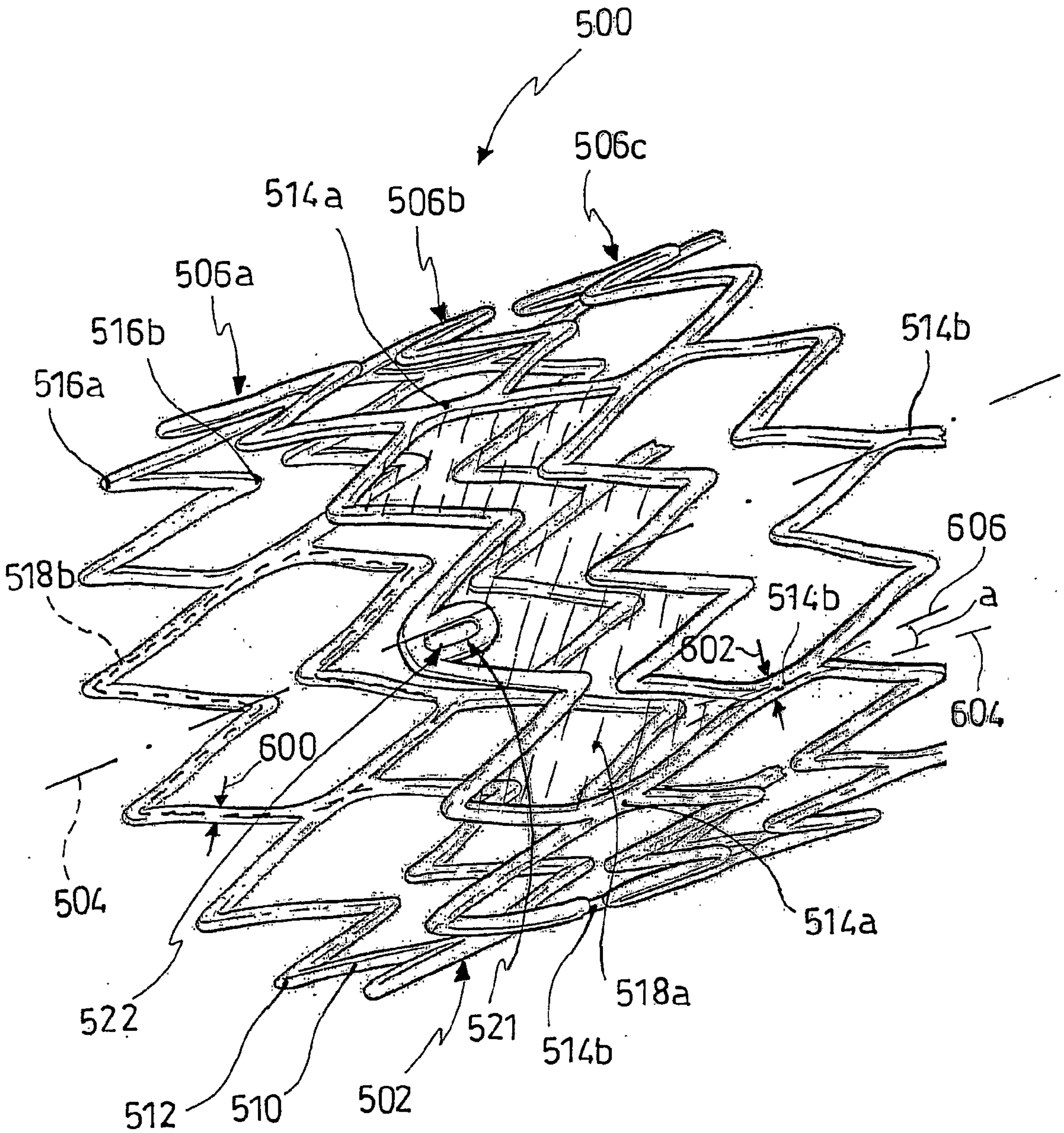
(57) ABSTRACT

An endoluminal prosthesis, comprising a tubular body, said tubular body developing along a longitudinal axis, said tubular body comprising a plurality of serpentines, which develop along a substantially circumpherential direction, each of said serpentines comprising arm portions of a preset width transversal to their main longitudinal extension, and bend portions joining two subsequent arms, at least one bridge, having a main longitudinal extension, connecting two adjacent serpentines, wherein the bends facing an adjacent serpentine are circumpherentially staggered relative to the opposite bends of the adjoining serpentine, both when the prosthesis is collapsed and when the prosthesis is expanded or partially expanded, wherein the at least one bridge connecting adjacent serpentines extends substantially straight, and wherein the at least one bridge has a width transversal to its main longitudinal direction of a greater value than the arm width.




500
506c
514a
506b
506a
516b
516a
514b
606
518b
514b
a
602
604
600
504
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522
521
518a
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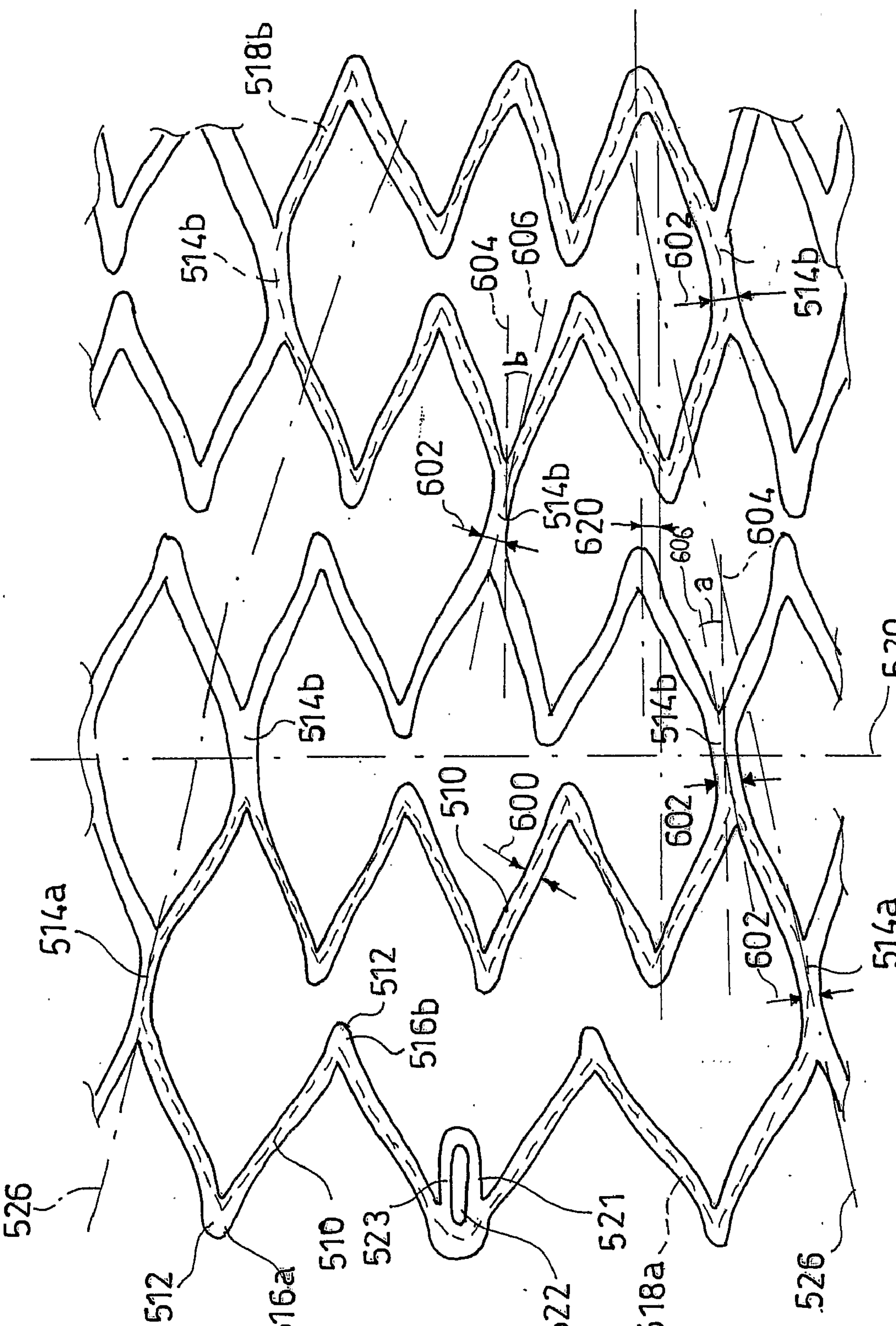
512
510
502

FIG.1


518b
514b
604
606
602
514b
602
514b
620
606
604
a
b
520
514b
514b
510
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514a
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516b
526
512
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510
523
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521
518a
526

FIG. 2

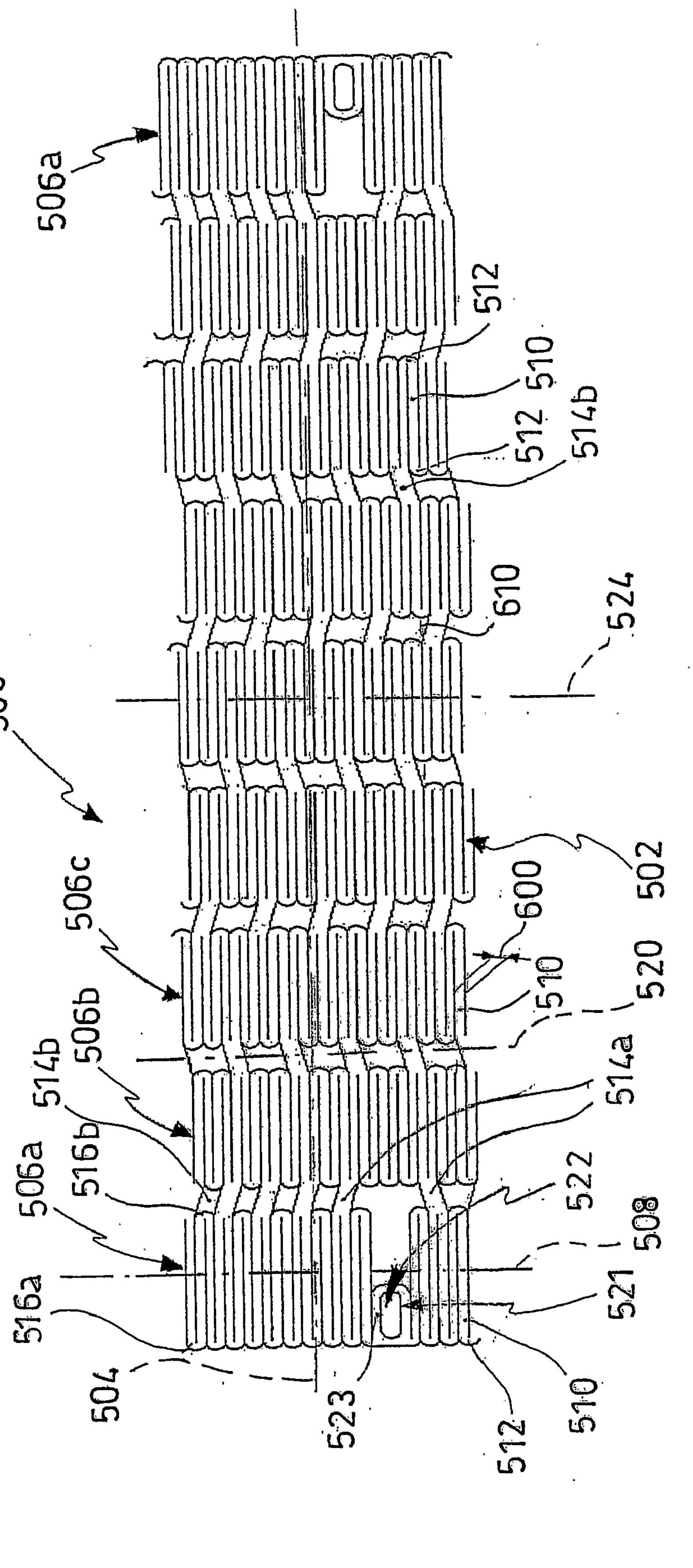

500
502
504
506a
506b
506c
508
510
512
514a
514b
516a
516b
520
521
522
523
524
600
610

FIG. 3

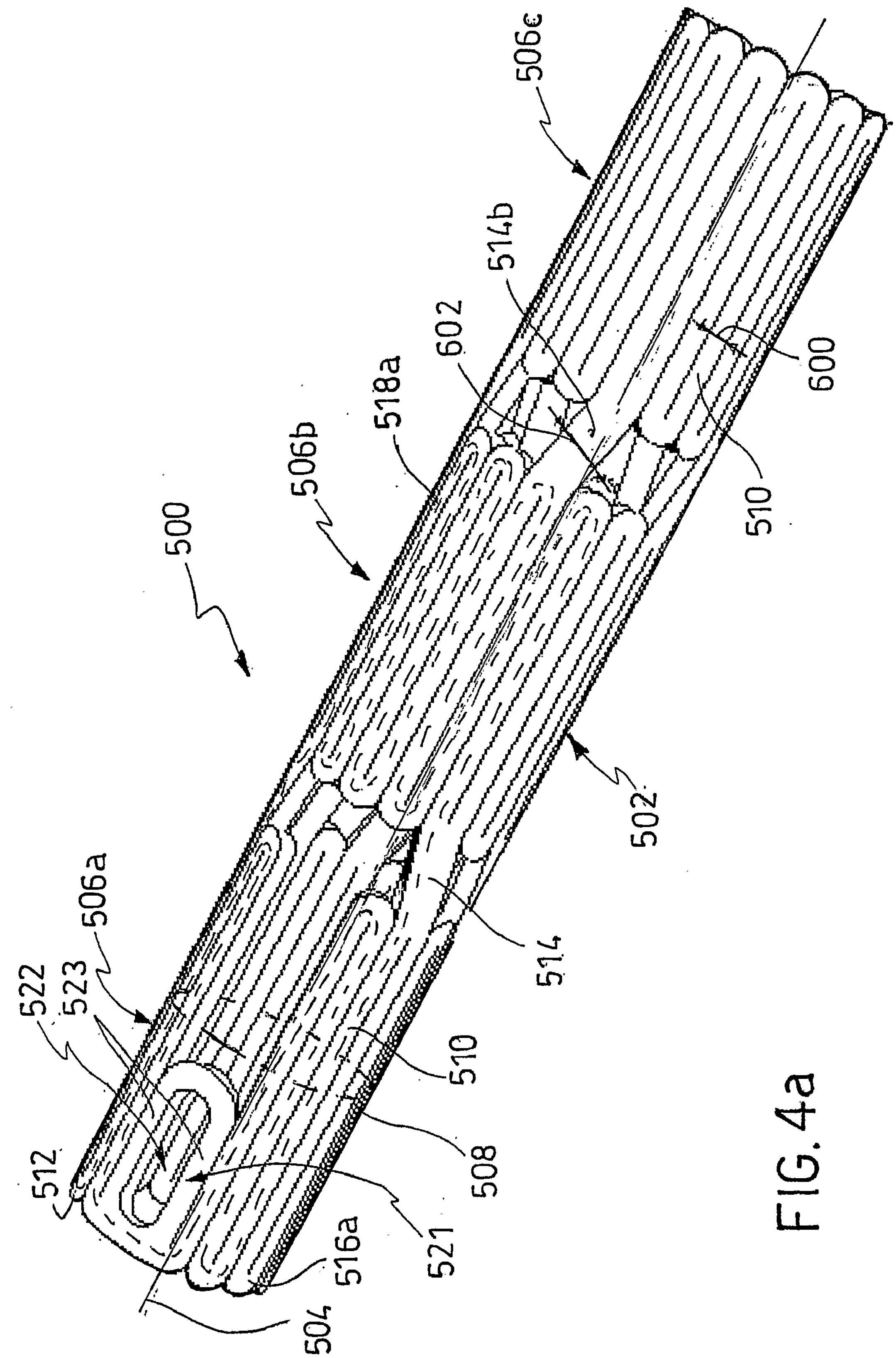

500
502
504
506a
506b
506c
508
510
510
512
514
514b
516a
518a
521
522
523
600
602

FIG. 4a

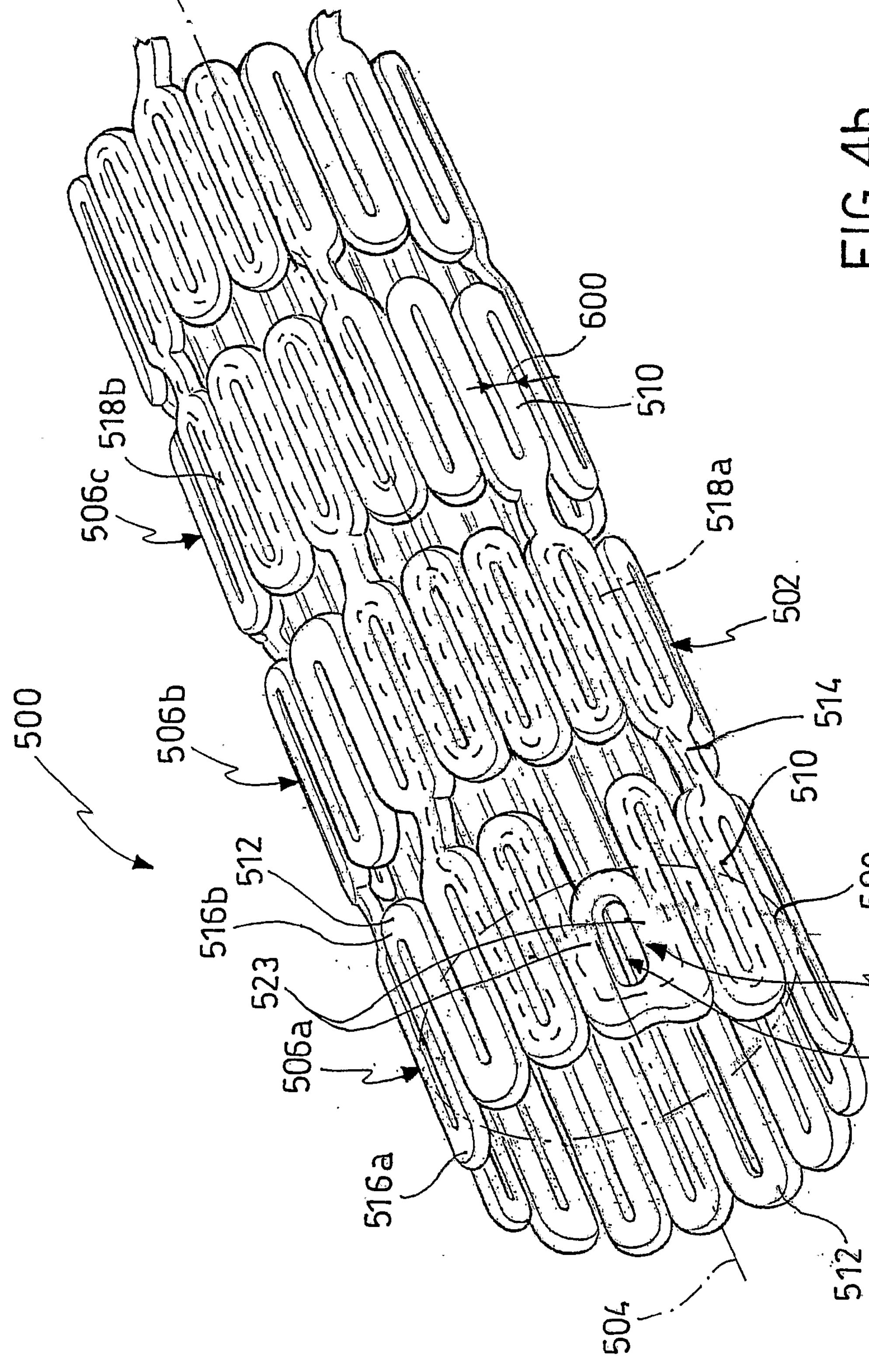

500
506b
506c
518b
600
510
518a
502
514
510
508
521
522
523
506a
516b
512
516a
504
512

FIG. 4b

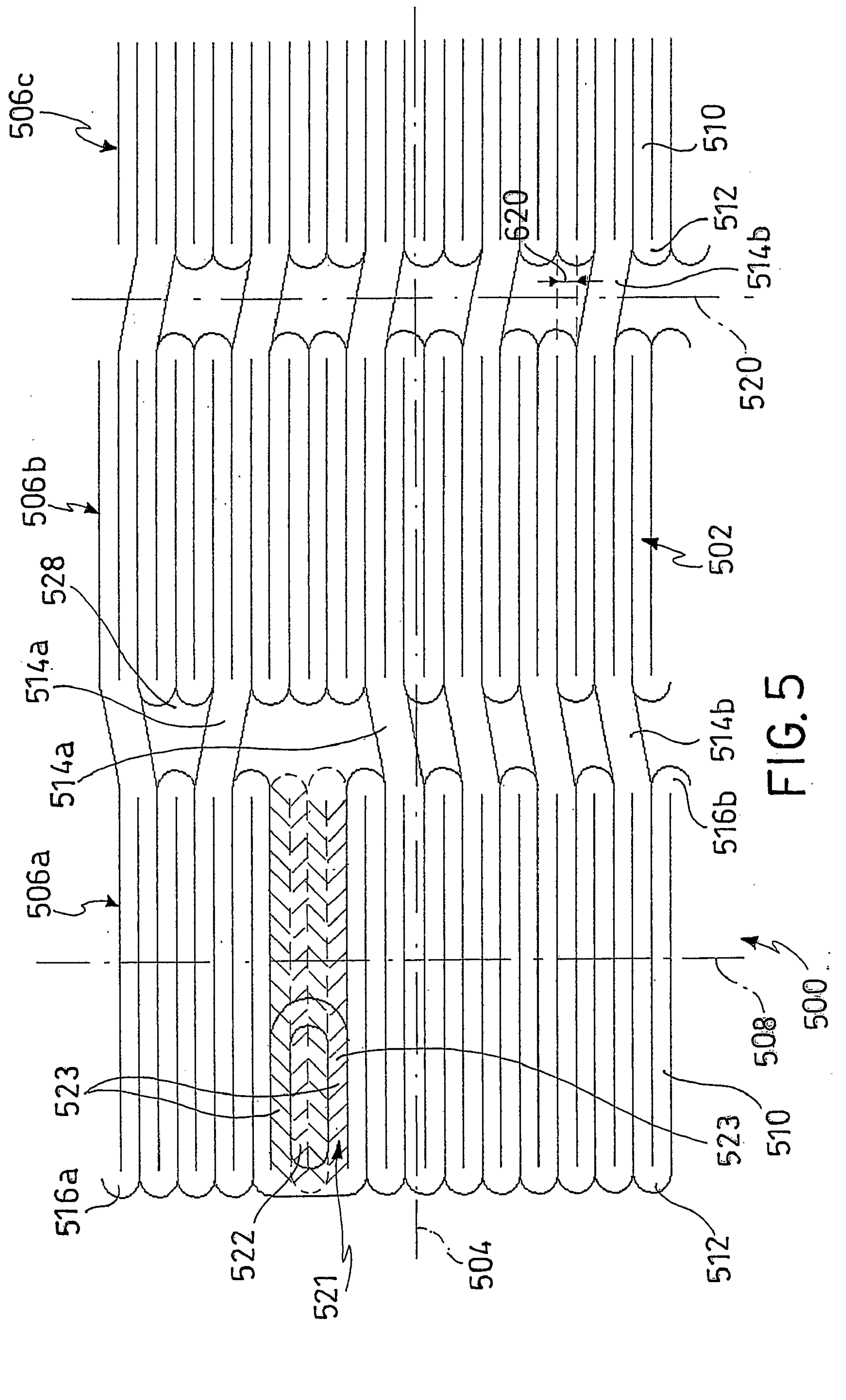

506c
510
512
620
514b
520
506b
502
528
514a
514a
514b
516b
506a
500
508
510
523
523
516a
522
521
504
512

FIG. 5

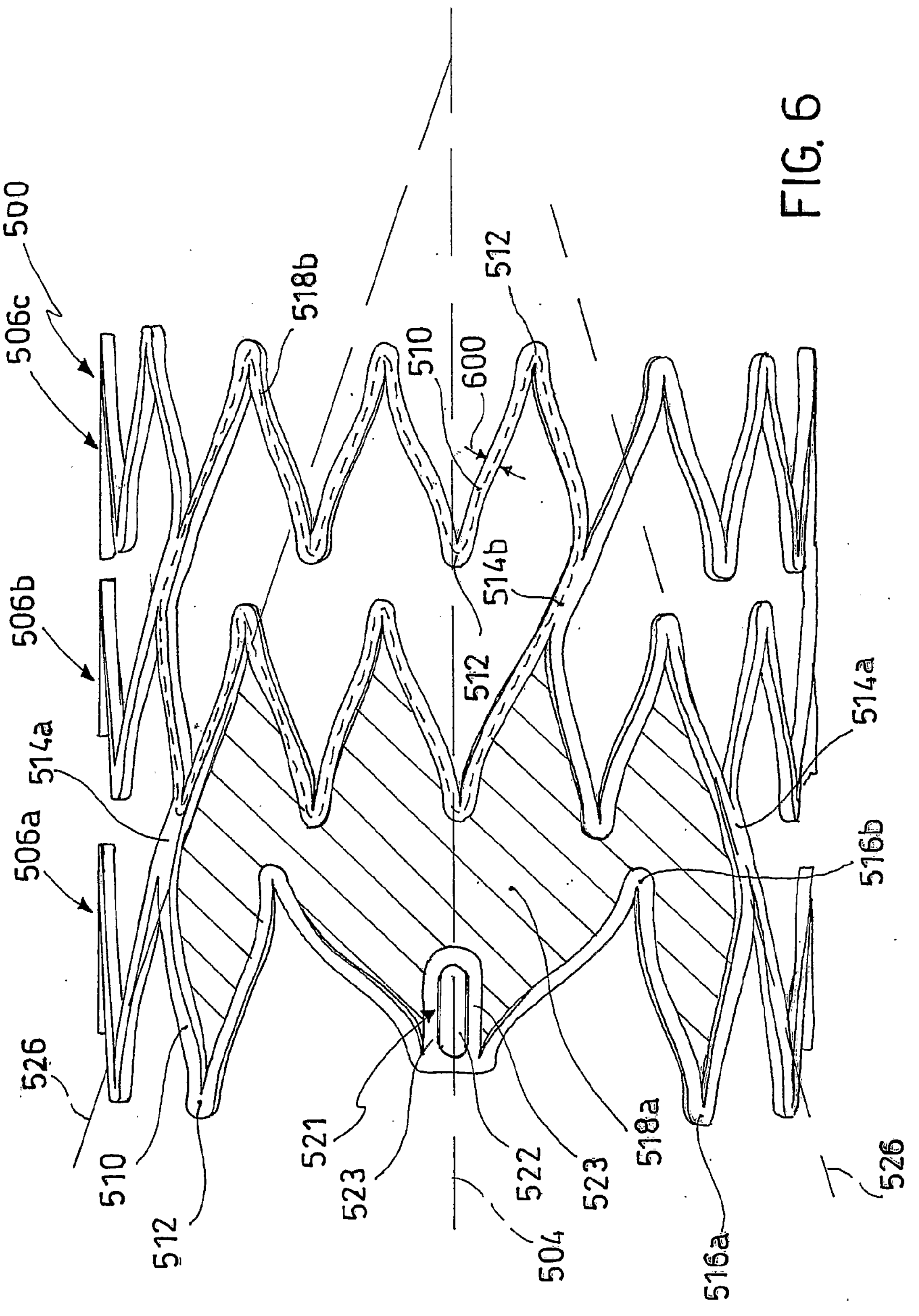

500
506c
506b
506a
510
512
514a
514b
516a
516b
518a
518b
521
522
523
526
504
600

FIG. 6

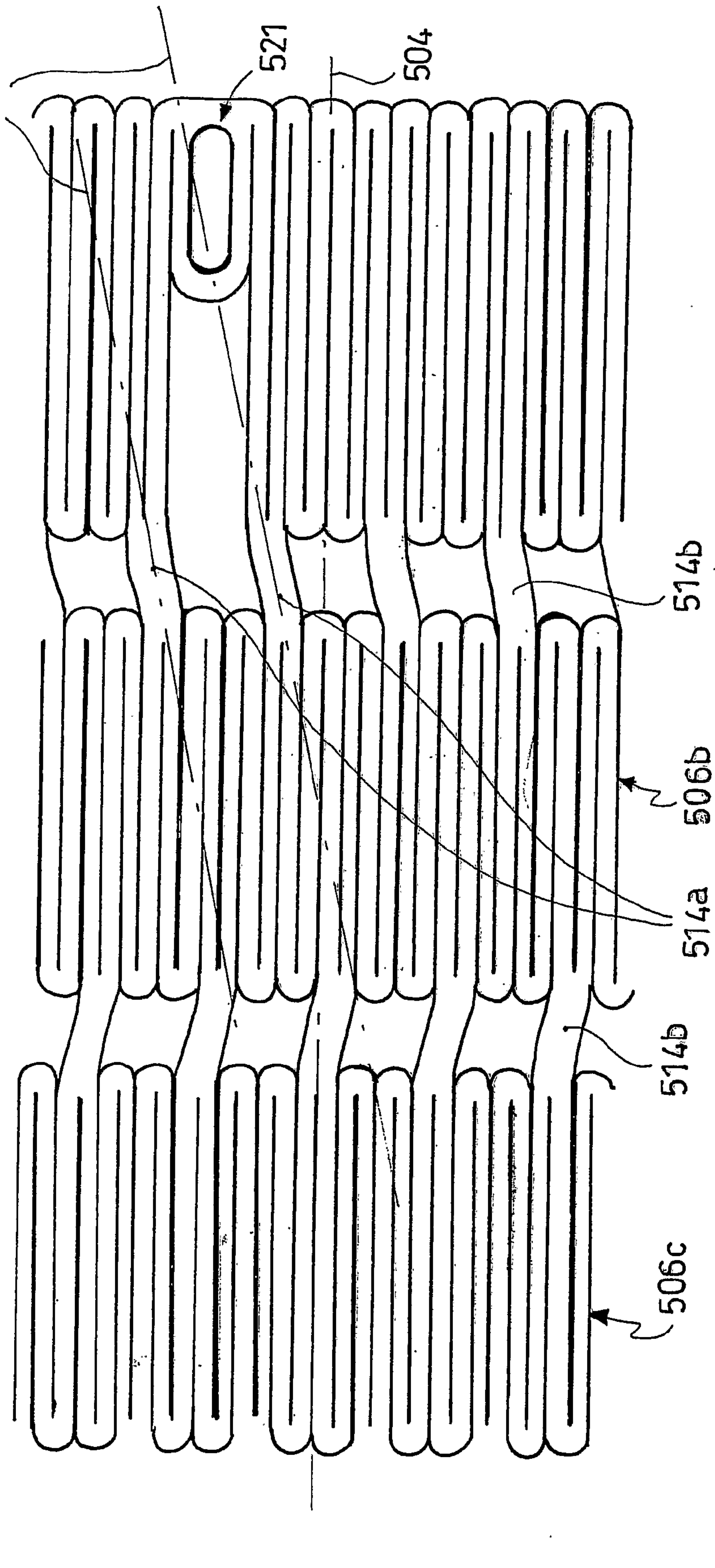
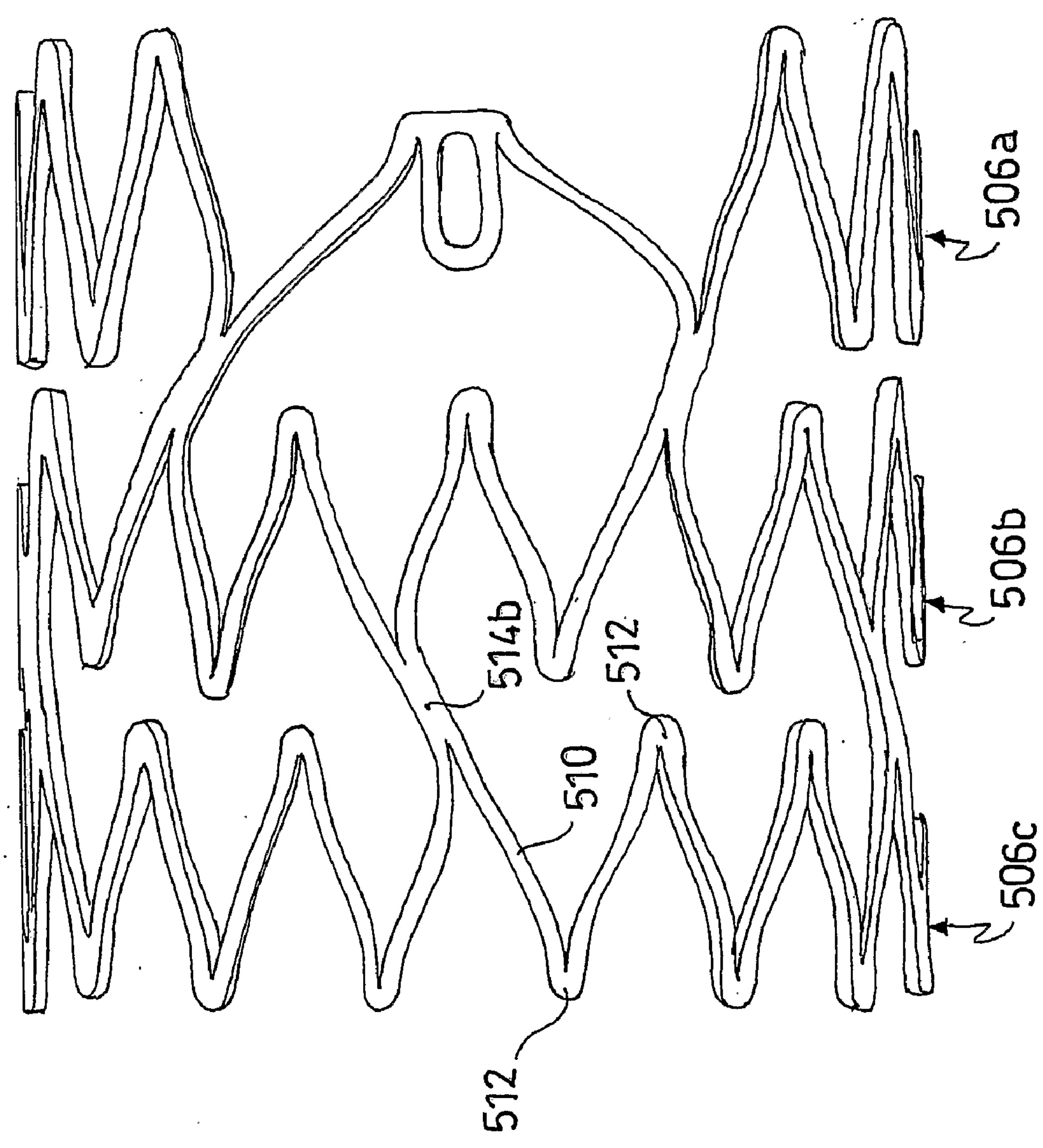


FIG. 7

FIG.8



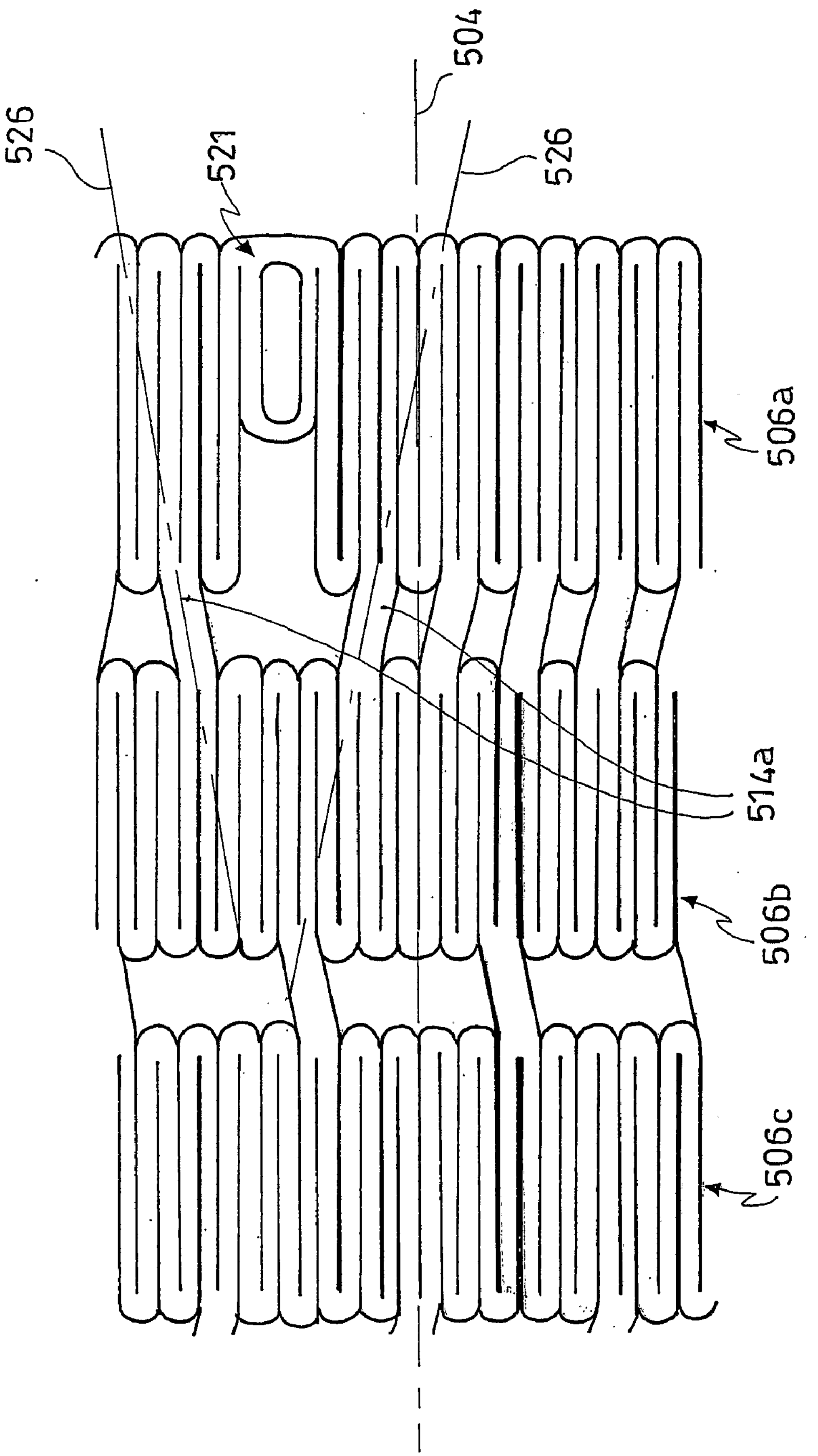


FIG.9

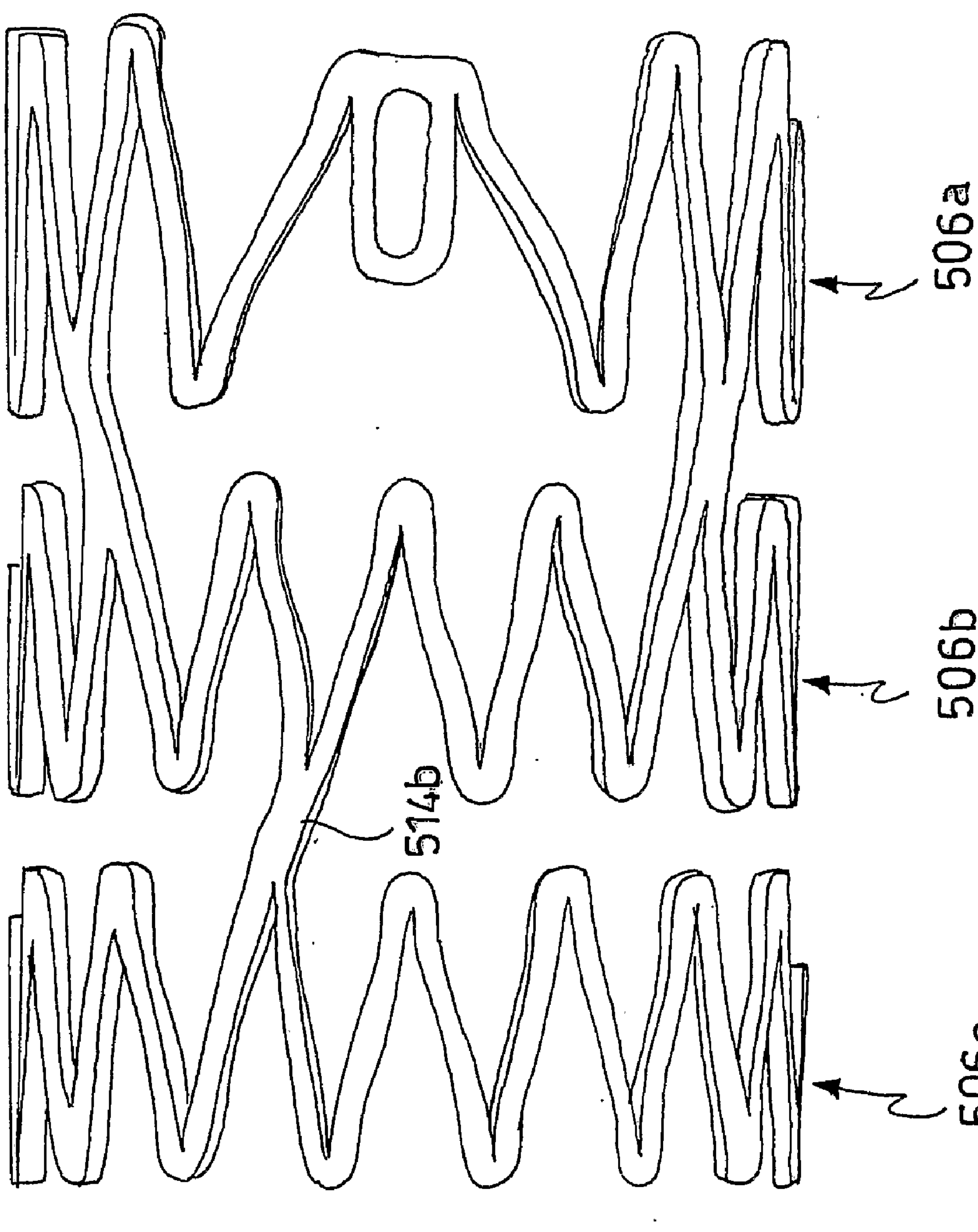


FIG.10

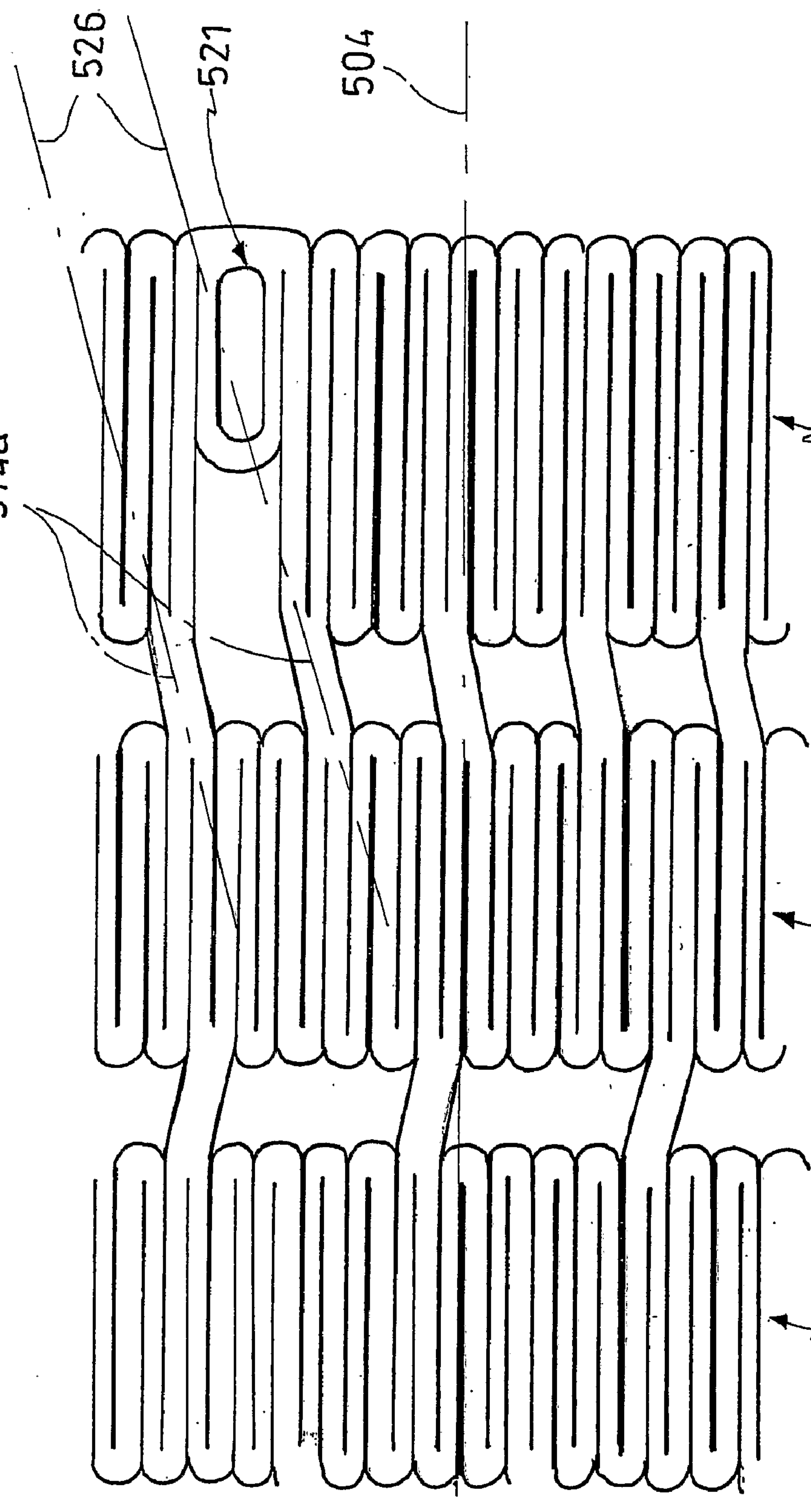


FIG. 11

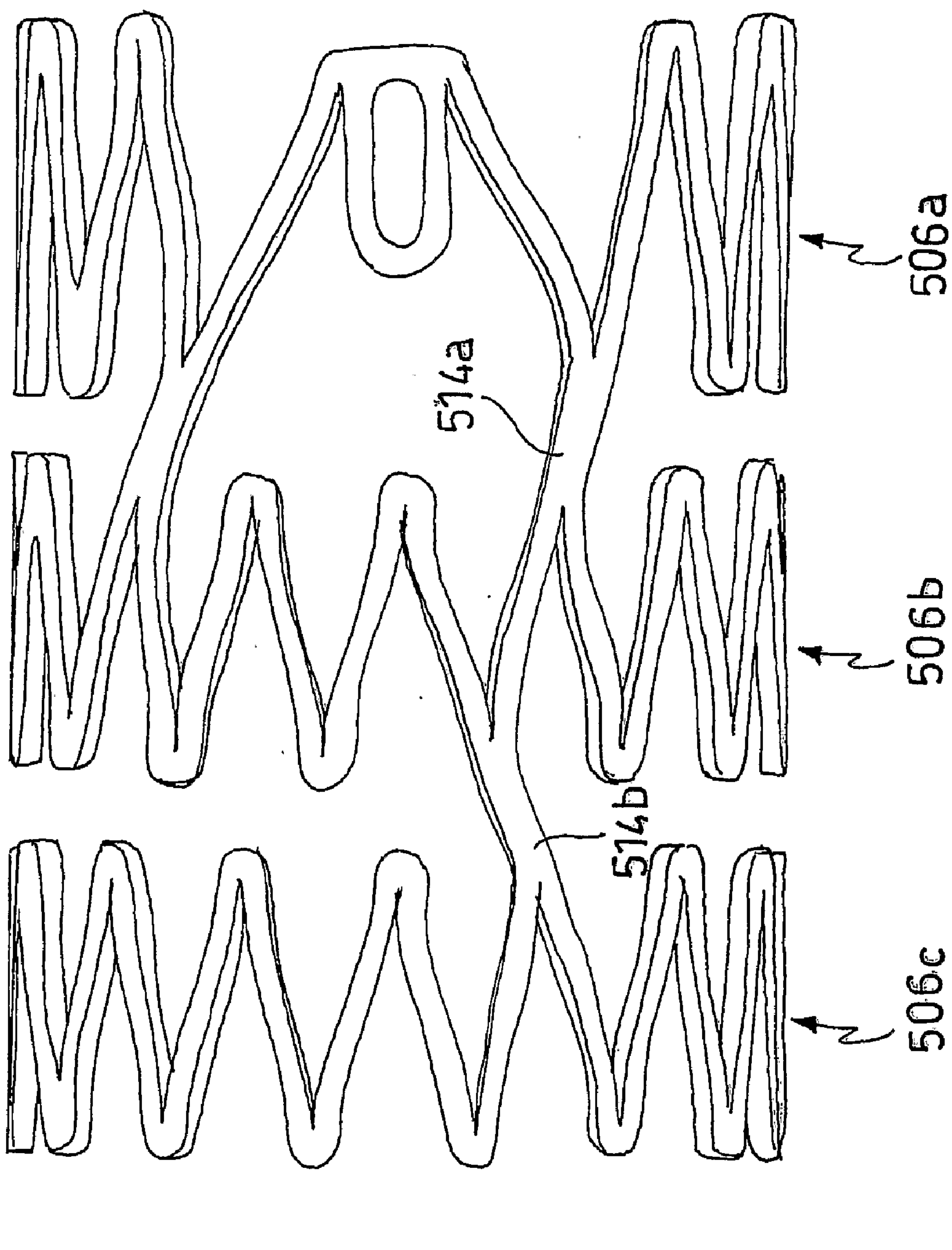


FIG.12

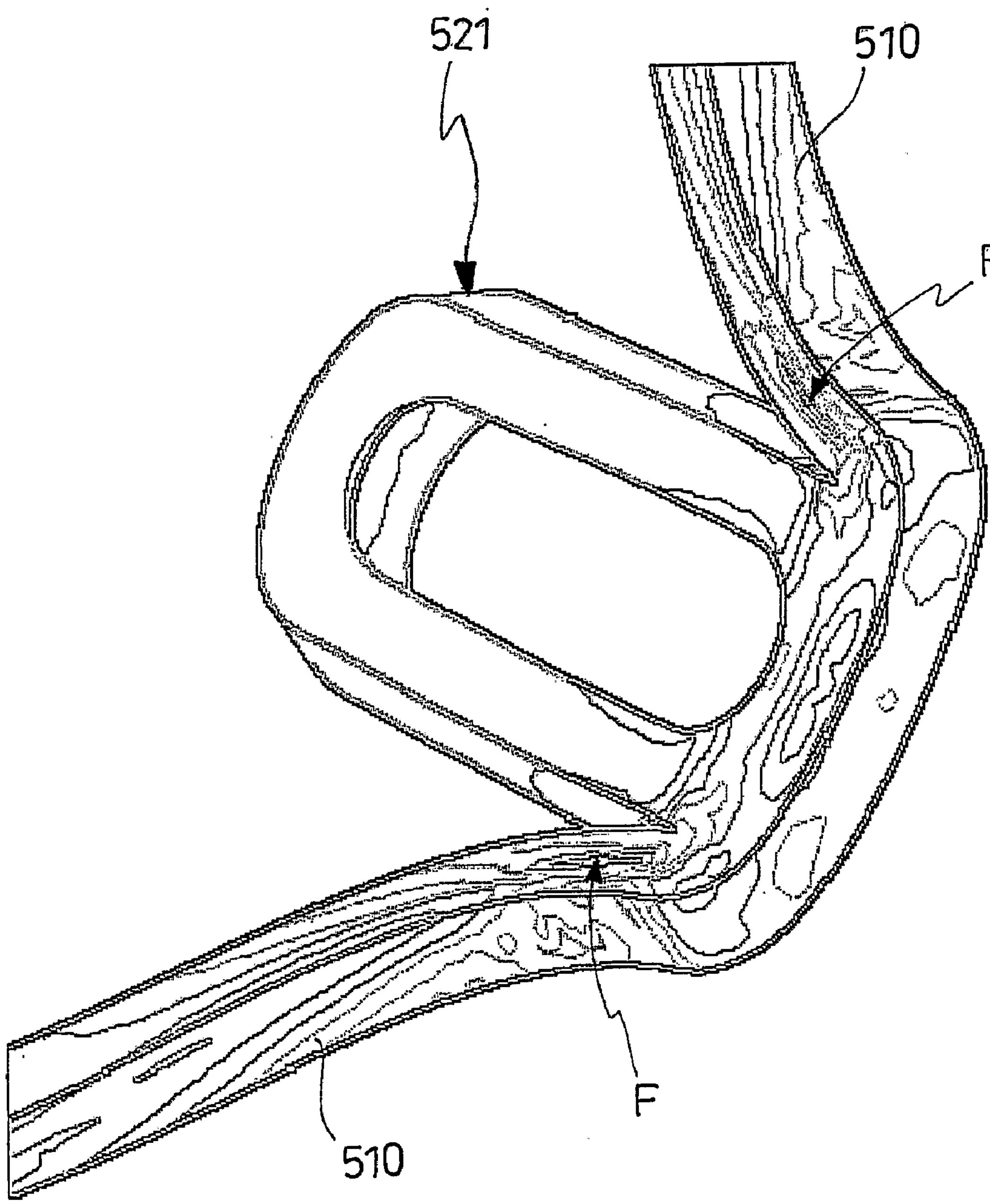


FIG. 13

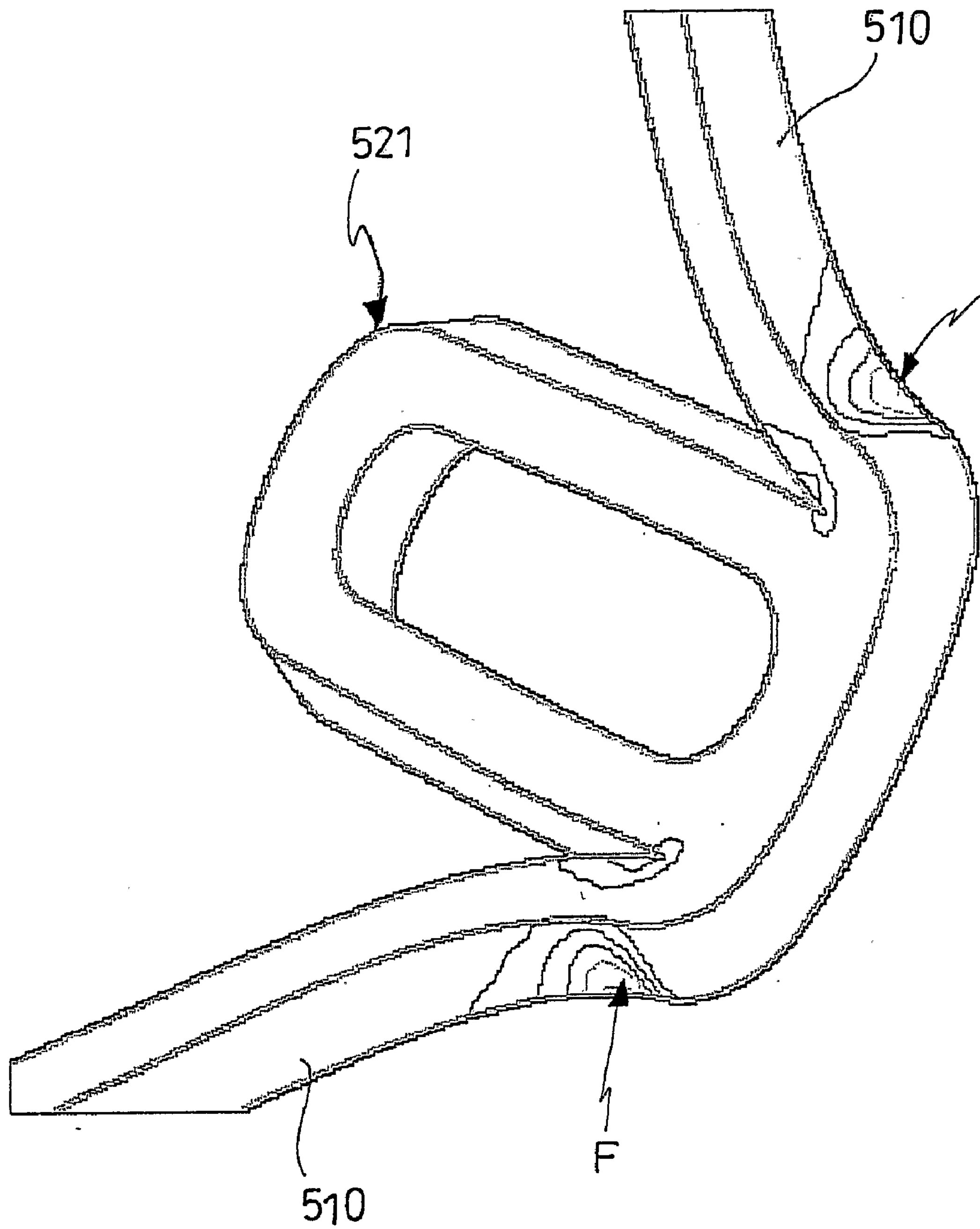


FIG.14

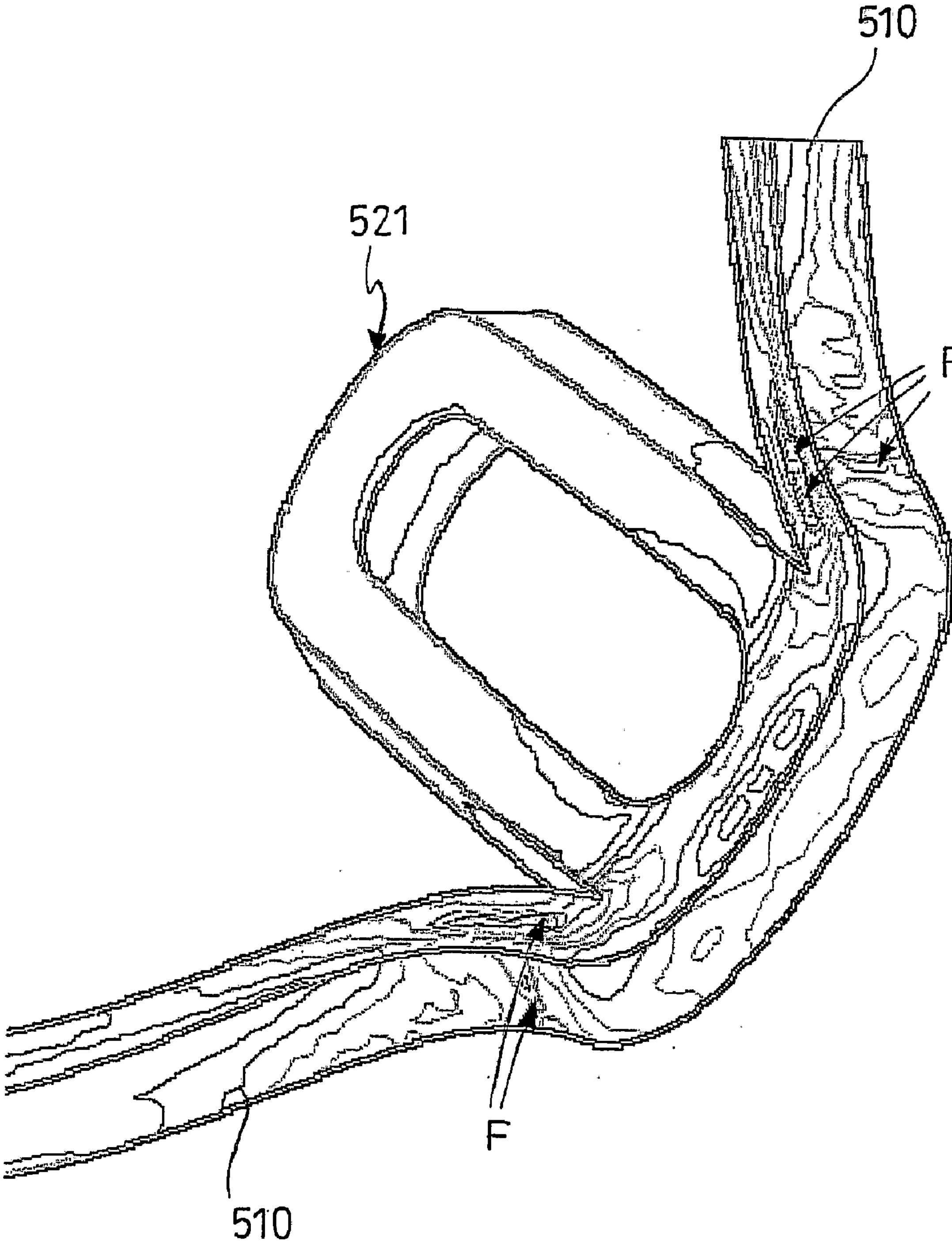


FIG.15

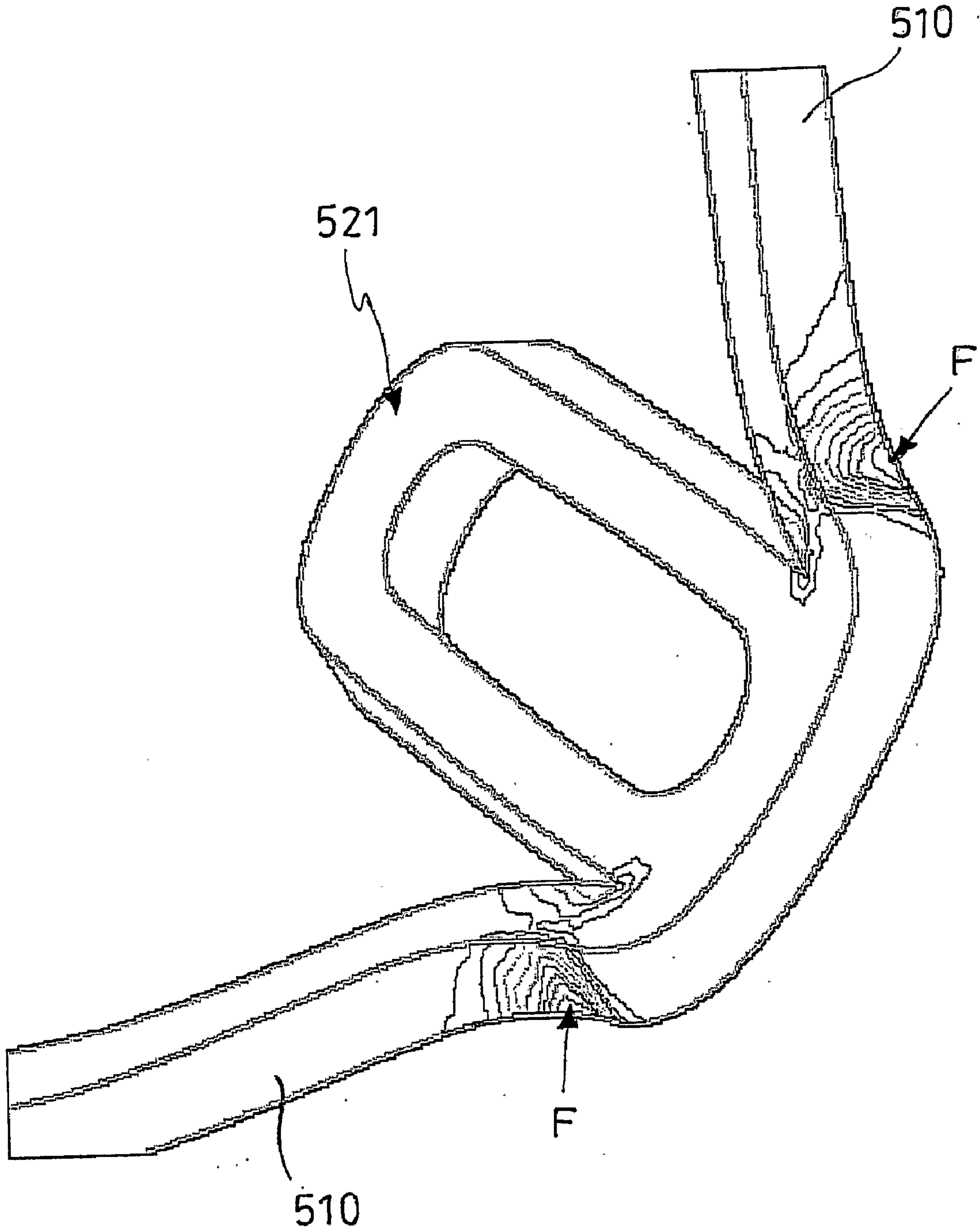


FIG. 16

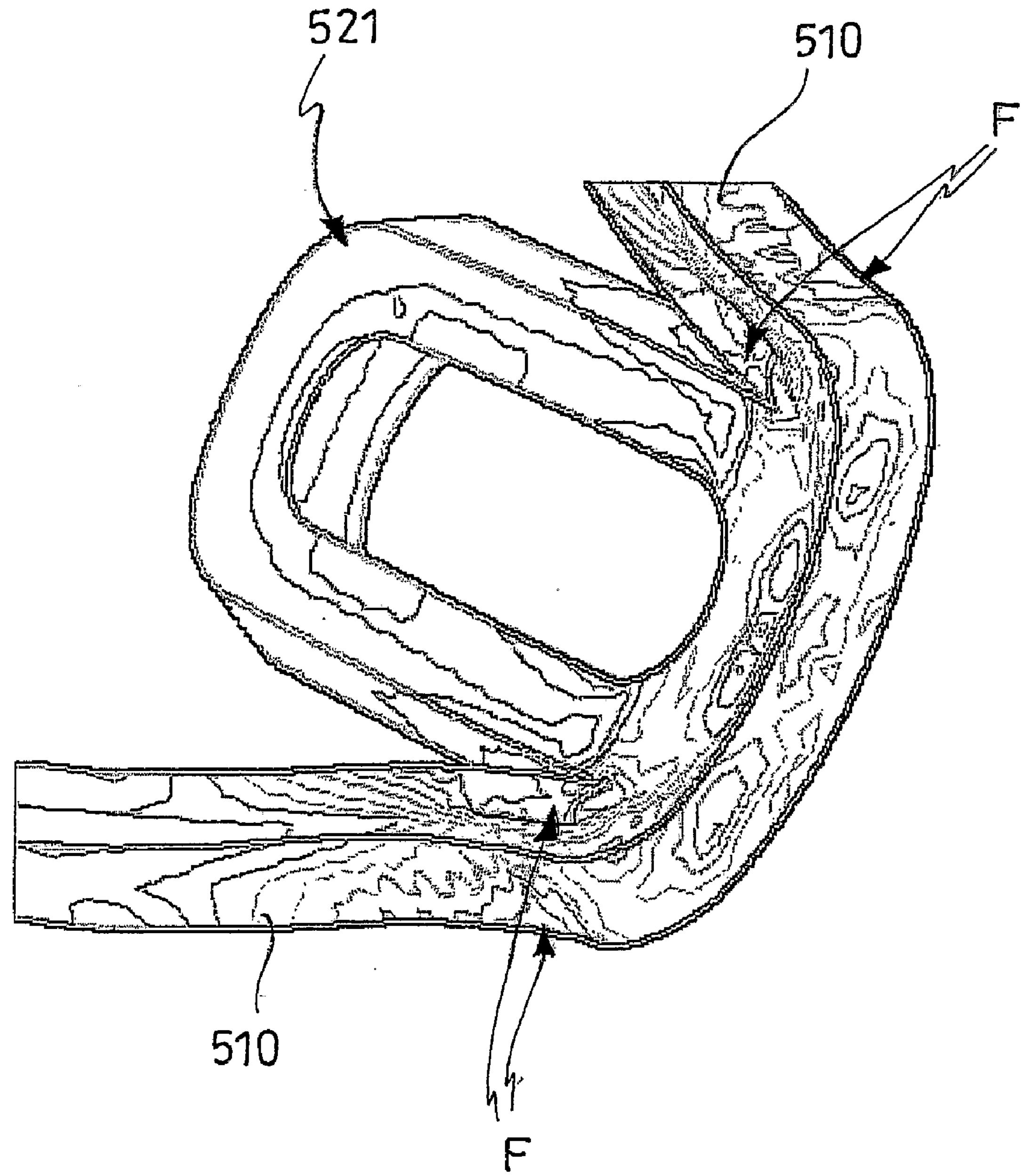


FIG.17

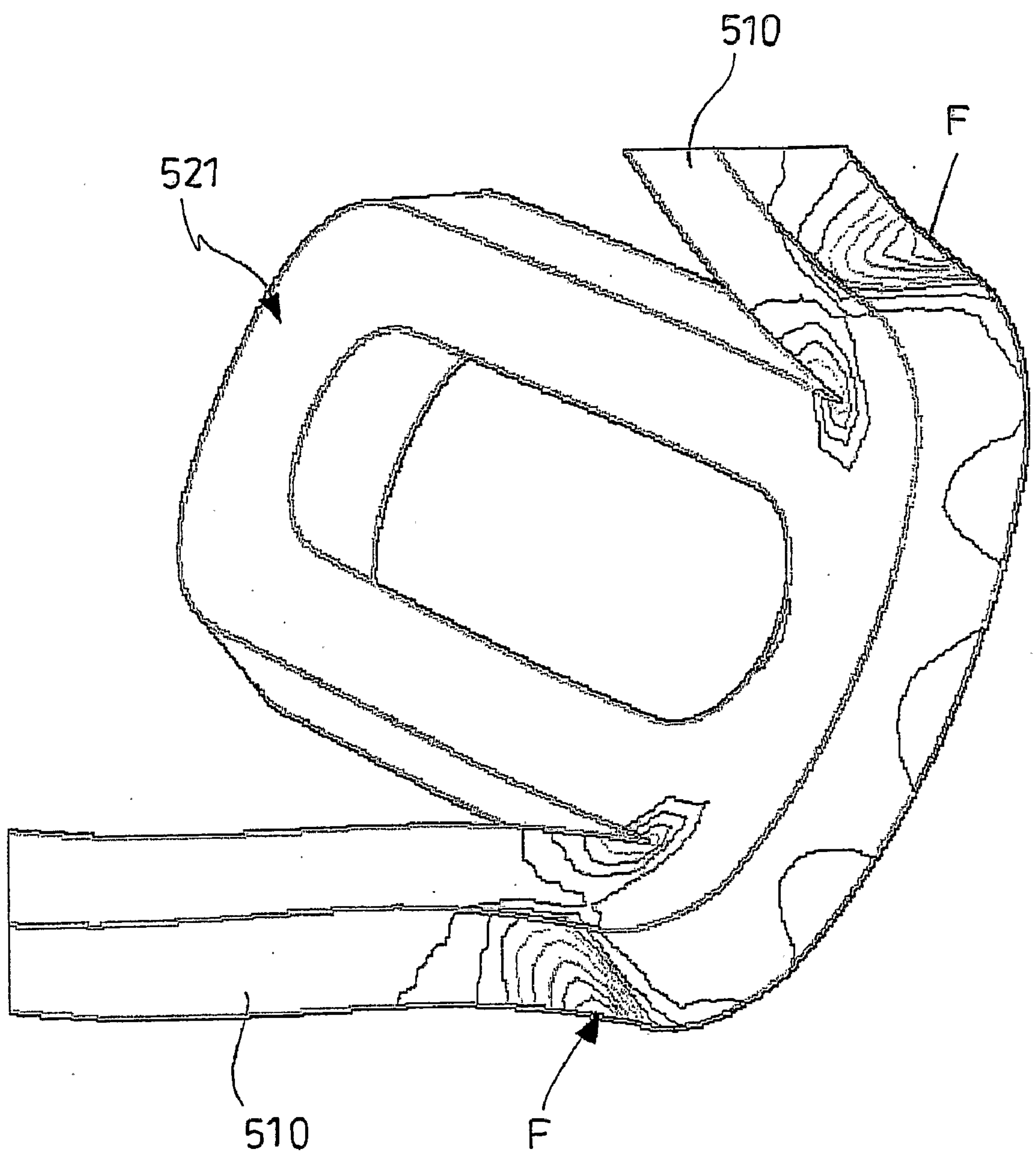


FIG. 18

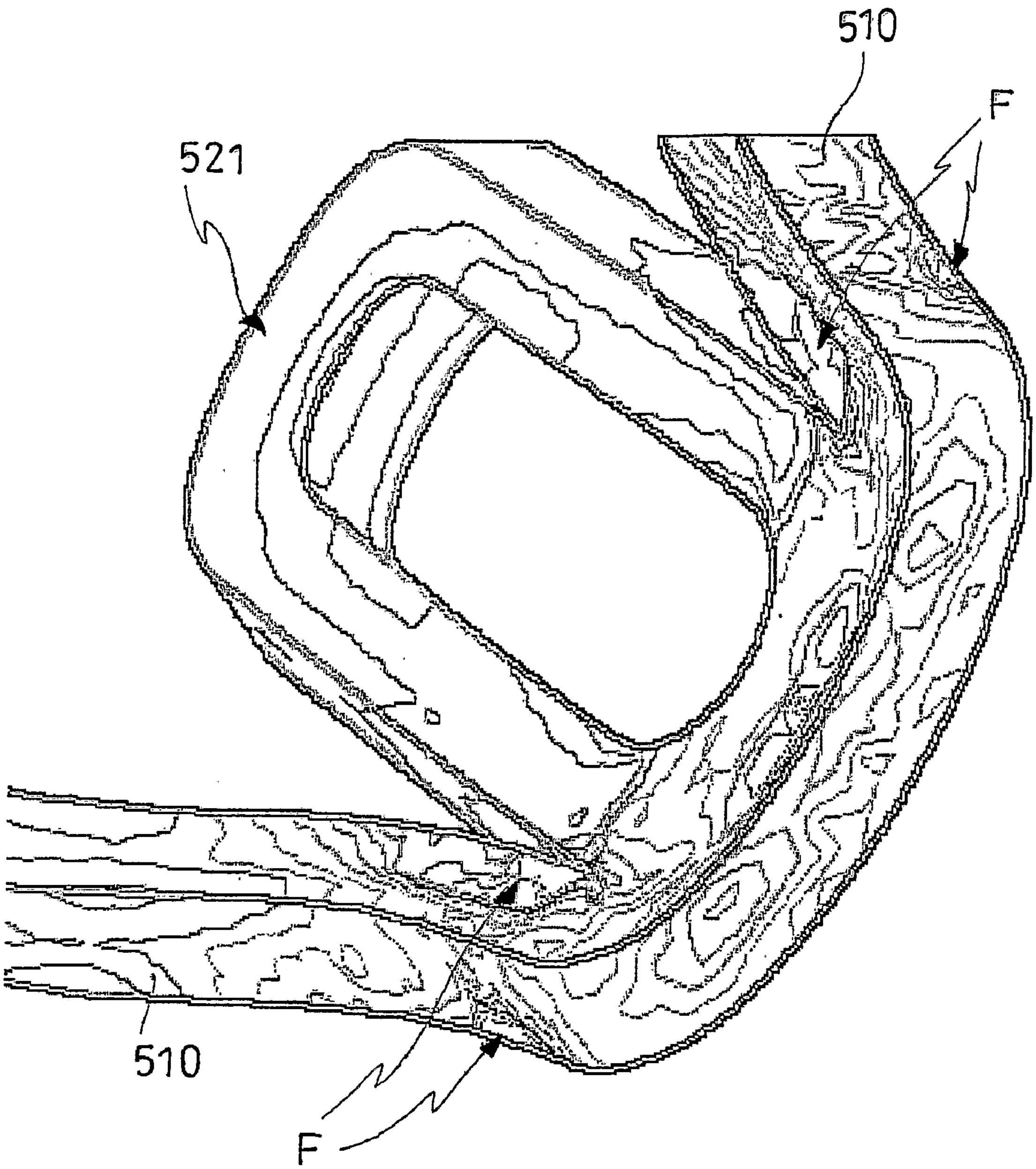


FIG. 19

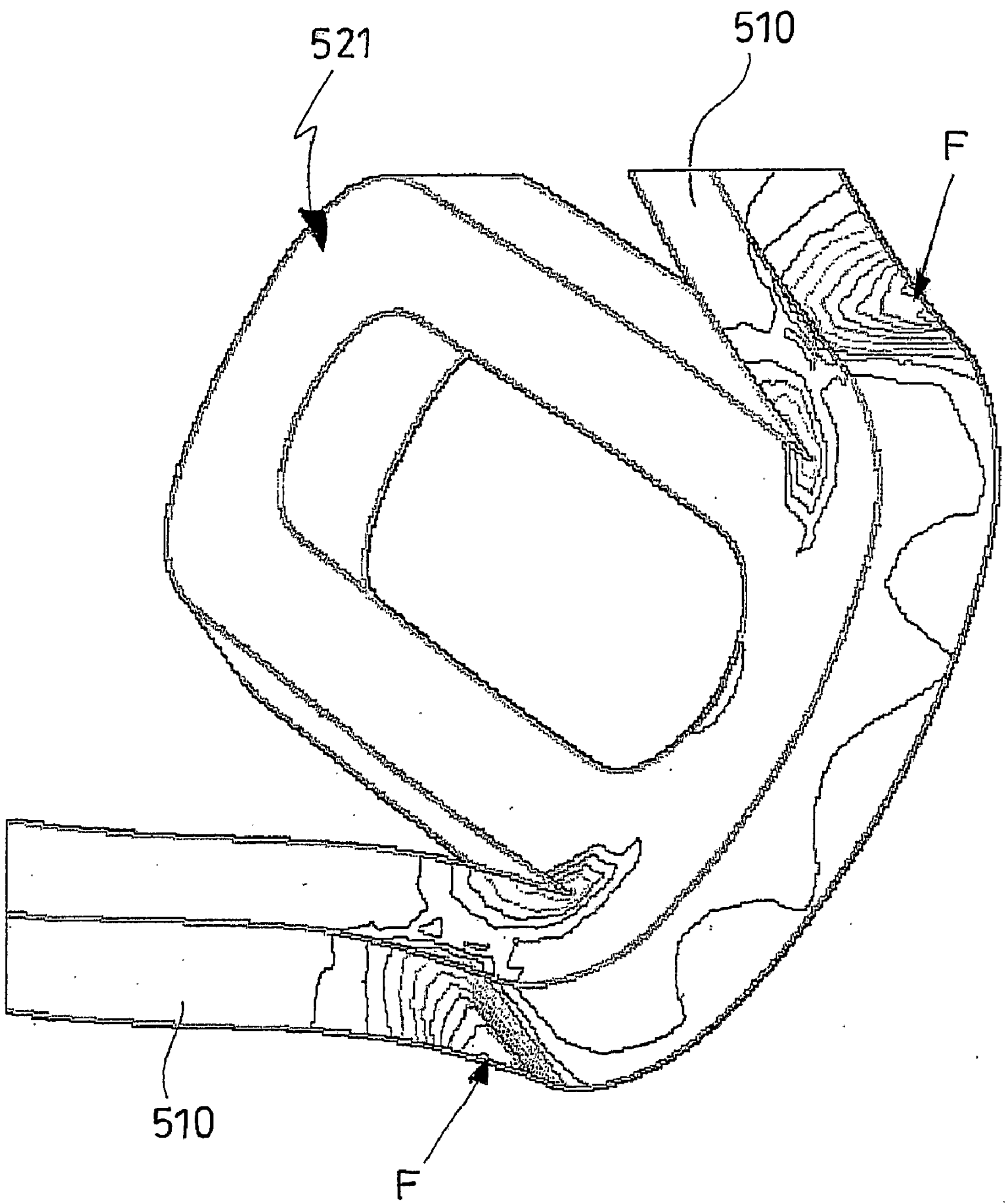


FIG. 20

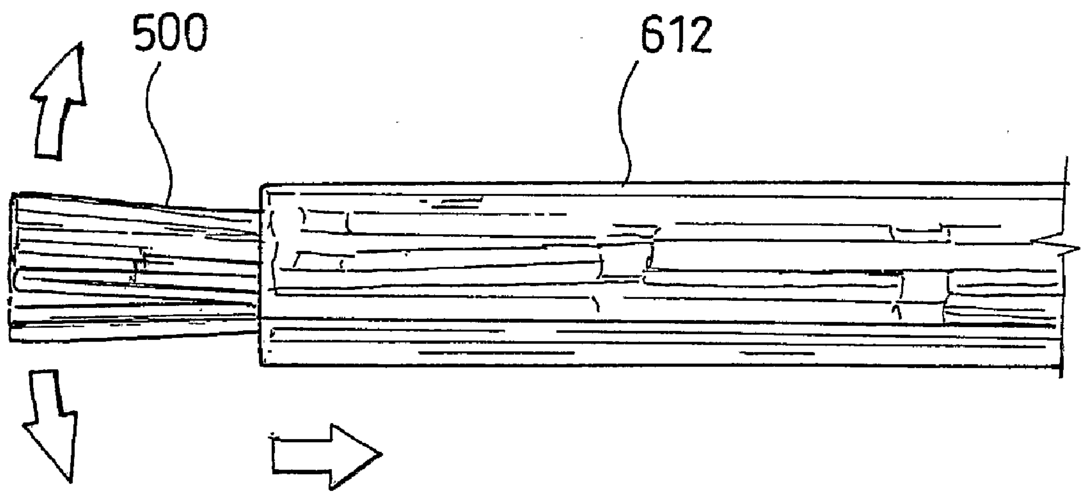


FIG. 21

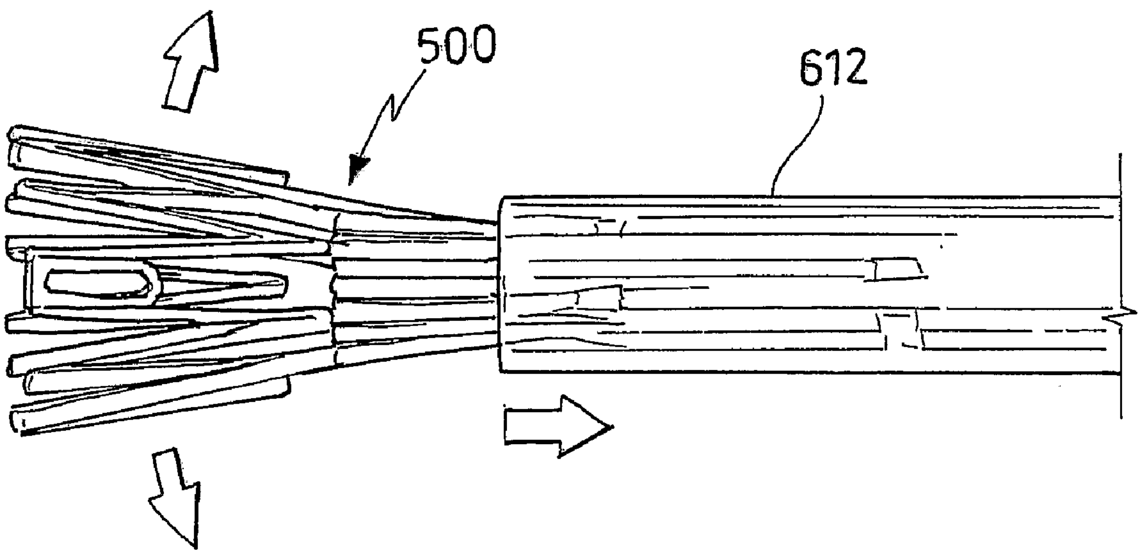


FIG. 22

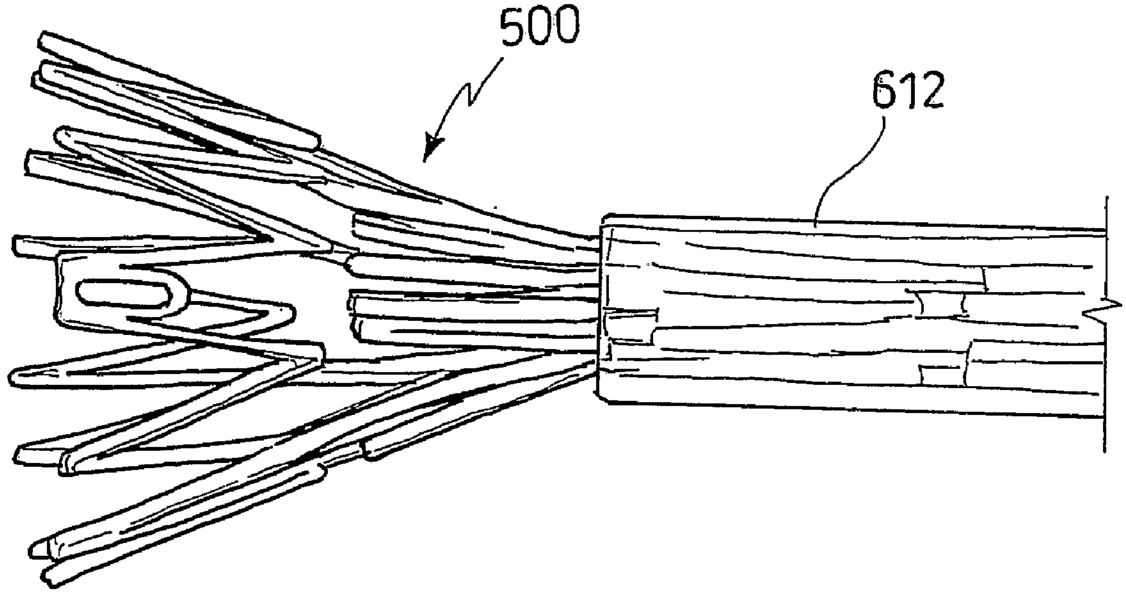


FIG. 23

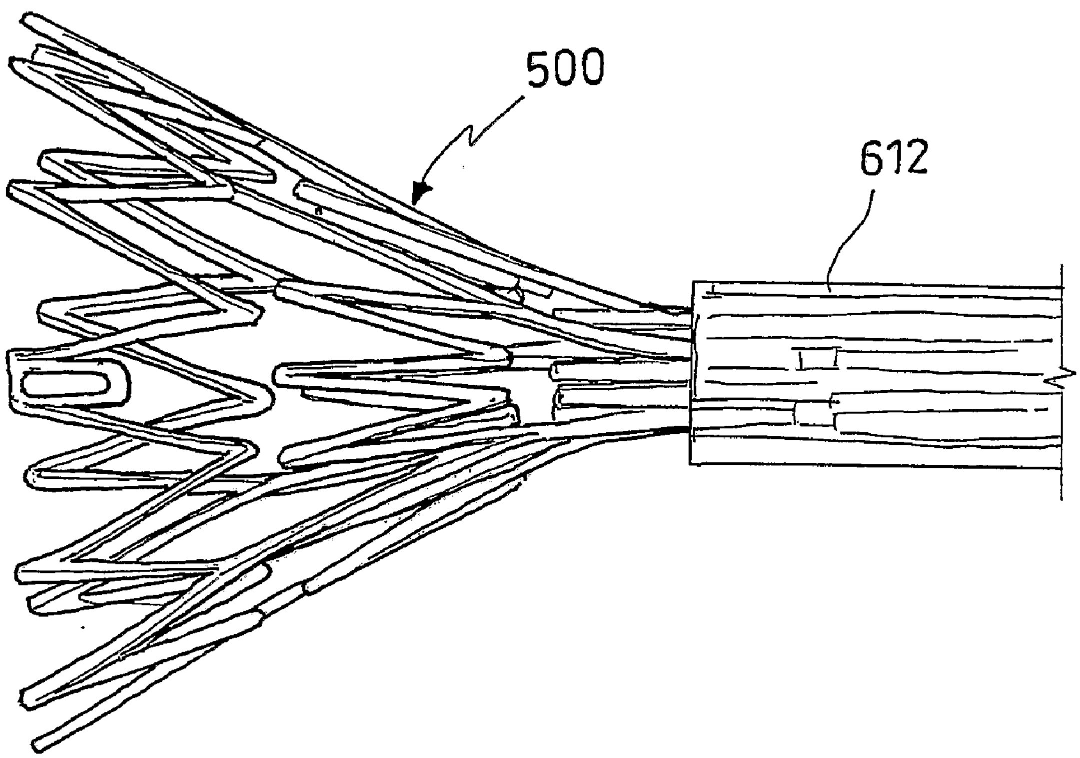


FIG. 24

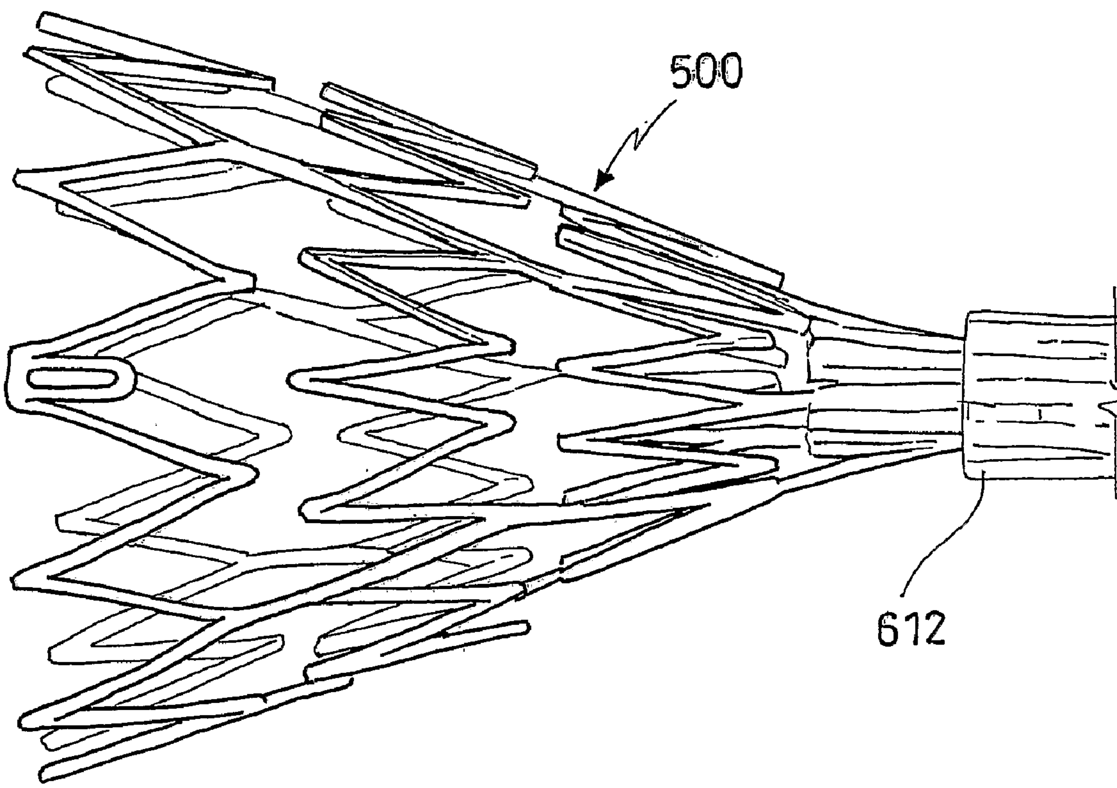


FIG. 25

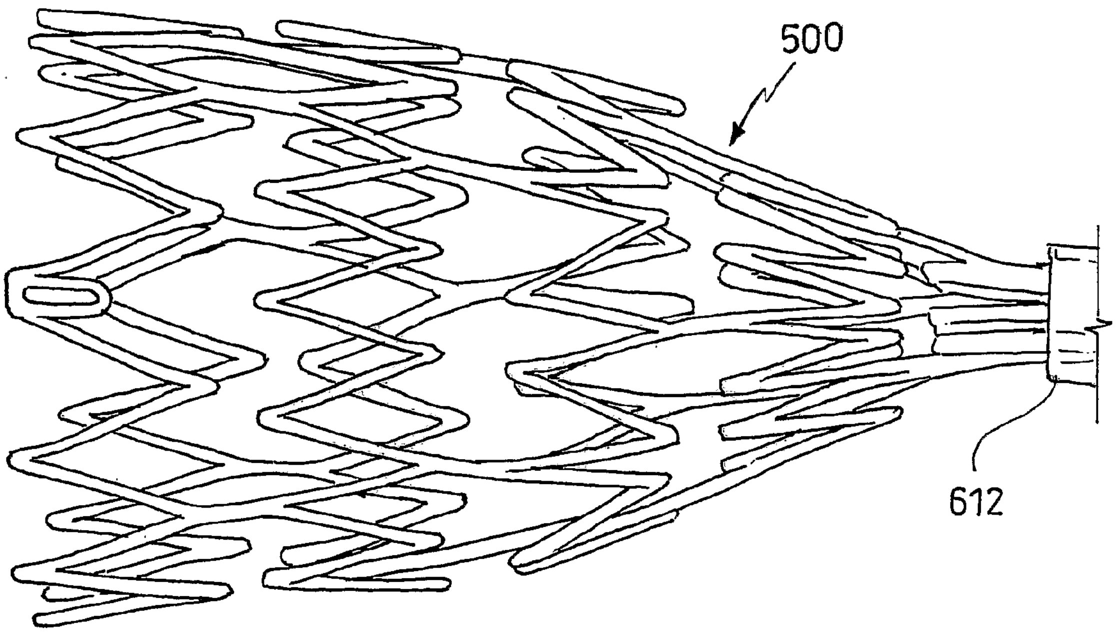


FIG. 26

ENDOLUMINAL PROSTHESIS

[0001] The object of the present invention is an endoluminal prosthesis to be used in passages or ducts of a human body, such as to restore the passage in blood vessels narrowed or occluded by diseases such as a stenosis, in bile ducts or other similar organs of living bodies.

[0002] The present invention also relates to such type of endoluminal prosthesis which are self-expanding, e.g. made of superelastic or shape memory materials such as Nitinol.

[0003] The present invention also relates to an endoluminal prosthesis provided with means for a prompt location thereof, e.g. by radioscopy.

[0004] Endoluminal prosthesis, i.e. stents, particularly of the self-expanding type, are known for example by U.S. Pat. No. 4,665,771, U.S. Pat. No. 4,665,905, U.S. Pat. No. 4,925, 445 or EP-A-0928606.

[0005] These endoluminal prosthesis, though being acceptable in many respects, particularly for their great flexibility and resilience, which enable them to be easily positioned in narrow and tortuous passages in their collapsed state, in some cases they are not sufficiently suitable, when expanded, to support the vessel walls, in order to maintain a proper free lumen for blood to pass therethrough.

[0006] Furthermore, in some cases the complex geometry of such known stents may be harmful, since it can hang up to or pinch the vessel wall, thus favouring the re-forming of obstructions, such as plaques and stenosis.

[0007] The problem at the heart of the present invention is to provide an endoluminal prosthesis, having such structural and functional characteristics to overcome the drawbacks mentioned with reference to the prior art.

[0008] This problem is resolved by means of an endoluminal prosthesis of the type described in claims **1** or **68**.

[0009] Further embodiments are described in the secondary claims.

[0010] Further characteristics and the advantages of the prosthesis according to the invention will become apparent from the description given below of the preferred embodiments thereof, being merely illustrative and non-limiting, with reference to the annexed figures, where:

[0011] FIG. **1** is a perspective view of an expanded endoluminal prosthesis portion, in accordance with a first embodiment;

[0012] FIG. **2** is a plane development of a portion of the prosthesis from FIG. **1**;

[0013] FIG. **3** is a plane development of the prosthesis from FIG. **1** in the collapsed state;

[0014] FIG. **4*a*** is a perspective view of a portion of the prosthesis from FIG. **1** in the collapsed state;

[0015] FIG. **4*b*** is a perspective view of the collapsed prosthesis in accordance with a further embodiment;

[0016] FIG. **5** illustrates a detail of the plane development of the prosthesis from FIG. **1** when collapsed;

[0017] FIG. **6** is a view of a detail of the prosthesis from FIG. **1** when expanded;

[0018] FIG. **7** illustrates a detail of a plane development of a collapsed endoluminal prosthesis according to a further embodiment;

[0019] FIG. **8** is a view of a detail of the prosthesis from FIG. **7** when expanded;

[0020] FIG. **9** illustrates a detail of a plane development of a collapsed endoluminal prosthesis according to a still further embodiment;

[0021] FIG. **10** is a view of a detail of the prosthesis from FIG. **9** when expanded;

[0022] FIG. **11** illustrates a detail of a plane development of a collapsed endoluminal prosthesis according to a further embodiment;

[0023] FIG. **12** is a view of a detail of the prosthesis from FIG. **11**, when expanded;

[0024] FIGS. **13** and **14** are perspective views of a detail of the prosthesis from FIG. **1** when expanded, wherein the stress condition and the corresponding strain condition are highlighted;

[0025] FIGS. **15** and **16** are perspective views of a detail of the prosthesis from FIG. **7** when expanded, wherein the stress condition and the corresponding strain condition are highlighted;

[0026] FIGS. **17** and **18** are perspective views of a detail of the prosthesis from FIG. **9** when expanded, wherein the stress condition and the corresponding strain condition are highlighted;

[0027] FIGS. **19** and **20** are a perspective view of a detail of the prosthesis from FIG. **11** when expanded, wherein the stress condition and the corresponding strain condition are highlighted;

[0028] FIGS. **21** to **26** are views of six expansion steps of the prosthesis from FIG. **1**.

[0029] With reference to the above mentioned figures, with **500** has been indicated an endoluminal prosthesis as a whole, such as a prosthesis of the self-expanding type for ducts or vessels of living bodies, such as blood vessels and bile ducts or gastro-intestinal ducts or similar.

[0030] In accordance with a general embodiment of the present invention, the endoluminal prosthesis comprises a tubular body **502** suitable to turn from a collapsed condition to an expanded or partially expanded condition.

[0031] By "collapsed condition" is meant a state of the prosthesis as being contracted such as to have a smaller bulk than in an operating use condition, e.g. a condition where the tubular body **502** has a smaller size or outer diameter than in an operating use condition. For example, the prosthesis is arranged in a collapsed condition when it is either accommodated or arranged on a transport and delivery device suitable to travel along a duct or vessel to the area to be treated. For example, in the case of a self-expanding prosthesis, this is accommodated in a sheath such as to be maintained in the collapsed condition (FIGS. **4** and **21**).

[0032] By "expanded or partially expanded condition" is meant a condition where the prosthesis is free from restrictions or an operating use condition with the prosthesis being widened upon pressure contact against the inner surfaces of a duct or vessel walls (FIGS. **1**,**6** and **26** where it is illustrated with an expanded and a partially expanded length).

[0033] The tubular body **502** develops along a longitudinal axis **504**.

[0034] By "longitudinal axis" is meant for example either a symmetry axis of a cylindrical body or the stretch axial direction of a tubular body.

[0035] The tubular body **502** comprises a plurality of serpentines **506*a***, **506*b***, **506*c***, or closed meander paths, developing along a substantially circumpherential direction.

[0036] By "serpentine" is meant a zig-zag/to-and-fro developing element around a main direction of stretching.

[0037] Each of these serpentines comprising either arm portions or arms **510** of predetermined length **600** transversal to their main longitudinal stretch.

[0038] Each of said serpentines **506***a*, **506***b*, **506***c* comprises either bended portions or bends **512**, which join two subsequent arms **510** to form said meander path.

[0039] Advantageously, at least a bridge **514***a*, **514***b* of a main longitudinal stretch connects two adjacent serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b*.

[0040] With further advantage, the bends **512** facing an adjacent serpentine **506***b* or **506***c* are circumpherentially staggered **620** relative to the opposite bends **512** of the adjoining serpentine **506***b* or **506***c*, both when the prosthesis is collapsed and when the prosthesis is expanded or partially expanded.

[0041] Preferably, the at least one bridge **514***a* and **514***b* connecting adjacent serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b* stretches substantially straight.

[0042] Advantageously, the at least one bridge **514***a* and **514***b* has a length **602** transversal to its main longitudinal direction which has a greater value than the length **600** of arms **510**.

[0043] According to a possible embodiment, an endoluminal prosthesis **500** comprises a tubular body **502** developing along a longitudinal axis **504**. The tubular body comprises a plurality of serpentines or meander paths **506***a*, **506***b*, **506***c* preferably closed, which develop according to a circumpherential direction **508** relative to the direction of the longitudinal axis of the endoluminal prosthesis. The circumpherential direction **508** is illustrated in FIG. **4***a* with reference to the perspective view of the prosthesis in a closed configuration and in FIGS. **3** and **5** with reference to the plane development of the tubular body **502** of the prosthesis in a closed configuration.

[0044] A serpentine comprises arms **510** connected by bends **512**. According to a possible embodiment, the arms are substantially straight.

[0045] In accordance with a possible embodiment, the arms are connected by bends such as to form a sequence of peaks and valleys along the circumpherential direction of the corresponding serpentines. With reference to an end portion of a prosthesis such as illustrated in FIG. **1** or **5**, for simplicity of exposition those bends being convex towards the outside of the prosthesis will be identified as peaks **516***a* and those bends being concave towards the outside of the prosthesis, i.e. moving away from a middle axis **524**, will be identified as valleys **516***b*.

[0046] Two adjacent serpentines are connected by at least one bridge **514***a*, **514***b* thus forming at least two cells between both adjacent serpentines. With "cell" is meant a closed periphery defined by a length of a first serpentine, a first connecting bridge, a length of a second serpentine adjacent to the first one (with the path developing in the opposite way along the circumpherential direction) and a second connecting bridge immediately next to the first one.

[0047] With references **518***a* and **518***b* there have been represented two different cells and the perimeters or areas thereof have been outlined.

[0048] According to a possible embodiment, the plurality of serpentines comprise a first serpentine **506***a*, a second serpentine **506***b* and a third serpentine, **506***c*. Preferably, the second serpentine **506***b* and the third serpentine **506***c* repeat alternatively along the longitudinal axis. Still more preferably, the second serpentine and the third serpentine are substantially identical. Furthermore, they can be arranged specularly relative to a circumpherential direction **520** intermediate between both serpentines. With reference to the embodiment illustrated in the figures, the second and third serpentines can be arranged specularly relative to a circumpherential direction **520** intermediate between both serpentines and staggered to one another along the circumpherential direction.

[0049] In accordance with one embodiment, said at least one bridge **514** is joined with a bend **512** of a serpentine **506***a* or **506***b* or **506***c* and with a bend **512** of an opposite serpentine **506***b* or **506***c* or **506***a*.

[0050] Advantageously, the at least one bridge **514***a* and **514***b* has a substantially constant width **602** all along its longitudinal stretch. Preferably, the at least one bridge **514***a*, **514***b* has a width **602** substantially equal to twice the width **600** of arms **510**. With a further advantage, the at least one bridge **514***a* and **514***b* has substantially straight edges. In other words, a bridge **514***a*, **514***b* extends without forming any bend, or folds, between a connecting or joint portion thereof to a first serpentine and a second connecting or joint portion thereof to a second serpentine.

[0051] In accordance with one embodiment, at least one bridge **514***a*, **514***b* is comprised between all the adjacent serpentines **506***a*, **506***b* and **506***c*.

[0052] Advantageously, a plurality of bridges **514***a*, **514***b* is comprised between adjacent serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b*.

[0053] In accordance with one embodiment, between at least two adjacent serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b* a bridge **514***b* is provided every four bends **512** as counted along the path of each serpentine.

[0054] In accordance with a further embodiment, between at least two adjacent serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b* a bridge **514***b* is provided every six bends **510** as counted along the path of each serpentine.

[0055] In accordance with a still further embodiment, between at least two adjacent serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b* a bridge **514***b* is provided every ten bends **510** as counted along the path of each serpentine.

[0056] Advantageously, the at least one bridge **514***a* and **514***b* develops according to a direction **606** tangential to the tubular body **502** and biased relative to an axis **604** parallel to the longitudinal axis **504** of said body (for example by an angle designated with the reference a or b).

[0057] Preferably, all the bridges **514***b* between at least two adjacent serpentines **506***b* and **506***c* are parallel to one another.

[0058] In accordance with one embodiment, by going through the prosthesis **500** in a longitudinal way, e.g. from a first proximal end to a second distal end of the prosthesis, one encounter bridges **514***b* alternating with one another with opposite way direction biases (a and b) relative to an axis **604** parallel to the longitudinal axis of the tubular body.

[0059] Advantageously, by going through the prosthesis **500** in a longitudinal way, one encounters the bridges **514***b* alternating with one another with direction biases a, b of opposite value ("a" having the same value as and opposite way to "b") relative to an axis **604** parallel to the longitudinal axis of the tubular body.

[0060] In accordance with one embodiment, the prosthesis comprises a cell **518***a*, **518***b* comprising opposite lengths of two adjoining serpentines **506***a* and **506***b* or **506***b* and **506***c* or **506***c* and **506***b* comprised between two subsequent bridges

514*a*, **514***b*, and said subsequent bridges **514***a* and **514***b* forming a closed path (such as indicated by dotted line **518***b* in FIG. **2**).

[0061] In accordance with one embodiment, the arms **510** are substantially straight. In other words, an arm extends without forming any bend, or fold, between a connecting or joint portion thereof to a first bend **512** and a second connecting or joint portion thereof to a second bend **512**.

[0062] Advantageously, the arms **510** comprise substantially straight edges.

[0063] In accordance with one embodiment, at least one cell **518***b* comprises six complete bends **512**.

[0064] In accordance with a further embodiment, at least one cell **518***b* comprises ten complete bends **512**.

[0065] In accordance with a still further embodiment, at least one cell **518***b* comprises eighteen complete bends **512**.

[0066] Advantageously, according to one embodiment, at least one prosthesis **500** length, when being in a collapsed state, comprises a plurality of serpentines **506***b* and **506***c* equal to one another, having corresponding bends **512**, facing the same end as the prosthesis **500**, such as the proximal end, either circumpherentially aligned with one another, or on the same axis **610** parallel to longitudinal axis **504** of tubular body **502**. With further advantage, said at least one length of prosthesis is an intermediate portion of the prosthesis or, preferably, a middle length of the prosthesis **500**.

[0067] In accordance with one embodiment, said prosthesis **500** is a unique body. For example, said body **502** is obtained by cutting a tubular element, preferably by laser cutting.

[0068] Advantageously, said body is made of a superelastic material. In accordance with a different embodiment, said body is made of a strain hardened pseudoelastic material. In other words, a material being in the austenitic state at room temperature (Af<15° C.) when annealed can be used, to which is then applied a sufficient strain hardening, such as greater than 30%, which allows to get 3%-4% elastic recovery after deformation or greater. Preferably, 50% strain hardening is applied.

[0069] In accordance with an embodiment, said body **502** is made of a shape memory material.

[0070] Advantageously, said body is made of Nitinol, or a Ni and Ti based alloy, such as with Nickel nominal weight percentage of 55.8%.

[0071] For example, a material with Austenite-to-Martensite phase transition can be used that, when being in the annealed or stress-relieved state, during a heating of the same the higher temperature of the end of austenite transformation, or Af, is lower than 15° C.

[0072] In accordance with one embodiment, the first serpentine **506***a* comprises at least one frame **521** defining a slot or housing **522**. The frame **521** is arranged at a bend between two arms. Particularly, the frame **521** and the slot **522** can be arranged in place of at least two arms and one bend relative to the second or third serpentines.

[0073] According to a possible embodiment, the second serpentine and the third serpentine comprise the same number of arms and the same number of bends.

[0074] Preferably the frame **521** and the slot **522** are arranged at the bend between two arms in place of four arms and three bends relative to the second or third serpentines. In FIG. **5** the arms and the bends replaced by the slot have been illustrated with a dotted line.

[0075] Advantageously the frame **521** occupies the whole length left free by the replaced arms and bends, as measured along the circumpherential direction and when the endoluminal prosthesis is in the collapsed condition.

[0076] In accordance with a possible embodiment, the slot or housing **522** passes all through the thickness of the tubular body **502**.

[0077] Advantageously the frame **521** is arranged in the concave part of the bend between both arms directly connected to the frame **521**.

[0078] According to a possible embodiment, the prosthesis is formed as a unique body from a tubular body **502** by cutting, such as laser cutting of a cylindrical wall thereof.

[0079] Advantageously, the frame **521** is formed as a unique body in the tubular body **502** obtained by laser cutting of a cylindrical wall.

[0080] In accordance with a possible embodiment, the slot **522** has an elongated shape in the direction of the longitudinal axis of the prosthesis, preferably elliptical or rectangular with short rounded sides. Advantageously, the frame **522** has an elongated shape in the direction of the longitudinal axis of the prosthesis. Preferably the short side of frame **521** corresponding to the bend between both arms directly connected to the frame itself is substantially straight along the circumpherential direction, when considered in a plane development of the prosthesis.

[0081] Advantageously both arms directly connected to the frame **521** join to the frame itself at end points.

[0082] Advantageously the frame **521** comprises two elongated sides **523** having substantially the same width as the arms **510** of the prosthesis, as measured along the circumpherential direction **508**, and a shorter length than the arms **510** of the prosthesis, as measured along the longitudinal direction **504** thereof.

[0083] Advantageously, a radiopaque material is provided within the slot **522**, preferably melted within the slot. The radiopaque material may be any material having a greater visibility to X-rays than the material used for the prosthesis.

[0084] In the case where the prosthesis is made of a superelastic or shape memory material, such as Nitinol (or an alloy with Ni and Ti as the main part), the radiopaque material can be selected from Tantalum, Gold, Platinum, Tungsten or other materials suitable for the purpose.

[0085] According to a possible embodiment, the first serpentine **506***a* housing the frame **521** is an end serpentine of the prosthesis. Advantageously, both end serpentines of the prosthesis, i.e. the first and last serpentines, comprise at least one frame **521**, respectively. In other words, in a possible embodiment of the prosthesis according to the present invention, by going through the prosthesis along the longitudinal axis **504** starting from an end of the prosthesis itself, such as a proximal end, one encounters a first serpentine or end serpentine, a sequence of alternated second and third serpentines and a last serpentine or further end serpentine, or distal end serpentine. In accordance with a possible embodiment, the last serpentine or further end serpentine specularly reproduces the first serpentine relative to a middle axis **524** of the prosthesis, possibly staggered along the circumpherential direction.

[0086] In accordance with an advantageous embodiment, the frame **522** is arranged at an end bend, i.e. a bend belonging to the end serpentine and with its concavity facing the inside of the prosthesis, i.e. the middle axis **524**. In other words, the frame **521** is arranged at or in place of a peak **516***a*, preferably within the concavity thereof.

[0087] Considering a cell **518***a* comprising the frame **521** and defined between a length of the end serpentine **506***a* and a length of the second serpentine **506***b*, the frame **521** is advantageously arranged inside the respective cell.

[0088] In accordance with a possible embodiment, the frame **521** has an elongated shape in the direction of the longitudinal axis of the prosthesis and develops from the end bend towards a middle axis **524** of the endoluminal prosthesis.

[0089] By designating with **518***a* the cell defined between the first and the second serpentines and comprising the frame **521**, this cell comprises two bridges **514***a* developing along directions **526** tangential to the tubular body. Both bridges **514***a* may be advantageously arranged along directions **526** substantially parallel to one another and further parallel to the development directions of the remaining bridges **514***b* between the first and the second serpentines. Still more advantageously, both bridges **514***a* may be arranged along directions **526** incident to one another, both in a closed configuration and in an expanded configuration of the prosthesis (FIGS. **2**, **3**).

[0090] In accordance with a possible embodiment, the bridges **514***a* belonging to the cell **518***a* comprising the frame **521** develop along directions **526** converging from the end of the prosthesis towards a middle axis **524** of the prosthesis itself.

[0091] In accordance with an embodiment, the bridges **514***a* develop according to directions **526** tangential to the tubular body and biased relative to an axis parallel to the longitudinal axis **504** of the endoluminal prosthesis.

[0092] Advantageously, the bridges **514***a* of cell **518***a* comprising the frame **521** develop along directions **526** tangential to the tubular body and biased relative to the longitudinal axis **504** of the endoluminal prosthesis.

[0093] In accordance with a possible embodiment, by designating with **514***b* the bridges connecting the first and the second serpentines which do not belong to cell **518***a* comprising the frame **521**, these bridges **514***b* are substantially parallel to at least one of the bridges **514***a* belonging to the cell **518***a* comprising the slot **522**.

[0094] Advantageously, in the cell **518***a* comprising the frame **521**, the number of arms and bends of the first serpentine length is lower than the number of arms and bends of the second serpentine length. For example in the cell **518***a* comprising the frame **521**, the length belonging to the first serpentine may comprise at least two arms and two bends less than the arms and bends of the length belonging to the second serpentine, as specularly counted between both serpentines. In the example from FIG. **2**, starting from one of the bridges **514***a*, the length of the first serpentine belonging to the cell **518***a* containing the slot comprises six arms and five bends while the length of second serpentine belonging to the cell **518** containing the frame **521** comprises eight arms and seven bends.

[0095] In FIG. **5** is shown a plane development of a possible embodiment of the endoluminal prosthesis according to the present invention.

[0096] According to a possible embodiment, such as illustrated in FIG. **5**, with **528** has been designated a further cell of a different shape than the cell **518***a* containing the frame **521** and the remaining cells **518***b* of the endoluminal prosthesis. For simplicity of description the further cell **528** will be indicated as the "anomalous" cell.

[0097] The anomalous cell **528** is defined between the first and second serpentines and preferably adjacent to the cell **518***a* containing the slot. Advantageously the anomalous cell **528** shares a bridge **514***a* with cell **518***a* containing the slot and preferably shares that bridge which develops along a direction tangential to the tubular body incident to the development directions of the remaining bridges provided between the first and the second serpentines. The "anomalous" cell comprises two arms and two bends more than the remaining cells **518***b* of the prosthesis. For example, the anomalous cell comprises six arms and five bends on the length relative to the second serpentine while the remaining cells **518***b* of the prosthesis comprise four arms and three bends, with reference to a length relative to a serpentine.

[0098] From what has been discussed above, it should be appreciated that providing an endoluminal prosthesis according to the present invention allows to meet the requirement of visibility to X-rays, or however to radioscopy, of the prosthesis itself while maintaining its structure solid and avoiding that parts may protrude outside the prosthesis.

[0099] The original provision of replacing some arms and bends of the serpentine to insert the slot and the radiopaque material enables the prosthesis to deploy evenly all along the longitudinal development thereof, simplifying at the same time the manufacturing steps of the prosthesis itself.

[0100] By providing the cell comprising the frame with arms developing along directions tangential to the tubular body which are incident to one another, local distortions due to the difference in arms and bends between the serpentines can be prevented. This aspect is enhanced by the presence of the anomalous cell adjacent to the cell containing the slot.

[0101] FIG. **6** illustrates a partial perspective view of the above prosthesis in a deformed configuration with reference to the end comprising the frame **521**.

[0102] FIGS. **7**, **9**, **11** illustrate the plane development of respective three possible embodiments of the prosthesis according to the present invention. FIG. **7** represents an embodiment similar to that of FIG. **3** or **5** wherein the bridges **514***a* corresponding to the cell comprising the frame **521** develop along directions **526** tangential to the tubular body, biased relative to the longitudinal axis **504** and parallel to one another. These directions are further parallel to the tangential directions along which the other bridges **514***b* develop between the first and second serpentines. FIGS. **9** and **11** represent two types of prosthesis where the cells defined between the second and third serpentines are of a different configuration compared to that of the cells between the second and third serpentines of the embodiments from FIG. **3**, **5** or **7**. Furthermore, the prosthesis from FIG. **9** has the bridges of cell **518***a* containing the frame **521** that develop along directions **526** tangential to the tubular body and biased relative to the longitudinal axis and incident to one another. On the other hand, in the prosthesis from FIG. **11** the bridges of the cell **518***a* containing the frame **521** develop along directions **526** tangential to the tubular body and biased relative to the longitudinal axis and parallel to one another.

[0103] FIGS. **8**, **10**, **12** illustrate the prosthesis from FIGS. **7**, **9**, **11** respectively, in an expanded or widened configuration.

[0104] FIGS. **13**, **14** illustrate the stresses and strains at the frame **521** in the prosthesis from FIGS. **3**, **5**, respectively. FIGS. **15**, **16** illustrate the stresses and strains at the frame **521** in the prosthesis from FIGS. **7**, **8**, respectively. FIGS. **17**, **18** illustrate the stresses and strains at the frame **521** in the prosthesis from FIGS. **9**, **10**, respectively. FIGS. **19**, **20** illustrate the stresses and strains at the frame **521** in the prosthesis from FIG. **11**, **12**, respectively. Arrow F designates the greatest stress-strain area. The prosthesis illustrated in FIGS. **3**, **5** allows to achieve a very low stress-strain peak value, and however a more constant distribution or gradual variation of the stress state.

[0105] The above has been achieved both by the advantageous embodiment of the frame **521** to accommodate the radiopaque material and by the overall synergy between the frame **521** and the overall geometry of the prosthesis.

[0106] Thanks to the prosthesis thus provided, it is possible to carry out endoluminal operations in tortuous vessels or ducts, and at the same time, an optimum and constant support of the treated vessel wall can also be ensured with the prosthesis being in the expanded state.

[0107] FIGS. **21** to **26** illustrate six release steps from a sheath **612** of a self-expanding endoluminal prosthesis **500**. This procedure is, for example, carried out by withdrawing the sheath such that the prosthesis is left free to expand, such as from a housing where it is accommodated as provided in a transport and release device, such as a catheter (not shown herein).

[0108] It should be understood that variants and/or additions may be provided to what has been described and illustrated above.

[0109] The slot can be of any shape other than that illustrated in the figures. Furthermore, it could be provided in a serpentine different from the serpentine end, or in a bend corresponding to a valley with reference to the meaning of the term "valley" such as discussed above.

[0110] The number of serpentines, arms or bends may be changed from what has been described or illustrated. The shape of the serpentines may also be changed, particularly the alternate repetition between the second and third serpentines. For example, the second and third serpentines may be either equal, or perfectly specular without resulting staggered in the circumpherential direction.

[0111] Generally all the embodiments which have been described as possible above, can be made as such, in the absence of those characteristics described as belonging to other possible embodiments.

[0112] To the above preferred embodiments of the endoluminal prosthesis, those skilled in the art, aiming at satisfying contingent and specific needs, may carry out a number of modifications, variants and replacements of elements with others functionally equivalent, without departing from the scope of the claims below.

1. Endoluminal prosthesis, comprising a tubular body suitable to turn from a collapsed state to an expanded or partially expanded state,

said body developing along a longitudinal axis,

said tubular body comprising a plurality of serpentines, or closed meander paths, developing along a substantially circumferential direction,

each of said serpentines comprising arm portions, or arms, of a preset width transversal to the main longitudinal extension thereof,

each of said serpentines comprising bend portions, or bends, joining two subsequent arms to form said meander path,

at least one bridge having a main longitudinal extension, connecting two adjacent serpentines, wherein

the bends facing an adjacent serpentine are circumferentially staggered relative to the opposite bends of the contiguous serpentine, both when the prosthesis is collapsed and when the prosthesis is expanded or partially expanded, wherein

the at least one bridge connecting adjacent serpentines extends substantially straight, and wherein

the at least one bridge has a width transversal to its main longitudinal extension of a greater value than the arm width.

2. Endoluminal prosthesis according to claim **1**, wherein said at least one bridge joins with a bend of a serpentine and with a bend of an opposite serpentine.

3. Endoluminal prosthesis according to claim **1**, wherein the at least one bridge has a substantially constant length all along the longitudinal extension thereof.

4. Endoluminal prosthesis according to claim **1**, wherein the at least one bridge has a length substantially equal to twice the length of the arms.

5. Endoluminal prosthesis according to claim **1**, wherein the at least one bridge has substantially straight edges.

6. Endoluminal prosthesis according to claim **1**, wherein at least one bridge is comprised between all the adjacent serpentines.

7. Endoluminal prosthesis according to claim **1**, wherein a plurality of bridges is comprised between adjacent serpentines.

8. Endoluminal prosthesis according to claim **1**, wherein between at least two adjacent serpentines a bridge is provided every four bends as counted along the path of each serpentine.

9. Endoluminal prosthesis according to claim **1**, wherein between at least two adjacent serpentines a bridge is provided every six bends as counted along the path of each serpentine.

10. Endoluminal prosthesis according to claim **1**, wherein between at least two adjacent serpentines a bridge is provided every ten bends as counted along the path of each serpentine.

11. Endoluminal prosthesis according to claim **1**, wherein the at least one bridge develops along a direction tangential to the tubular body and biased relative to an axis parallel to the longitudinal axis of said body.

12. Endoluminal prosthesis according to claim **1**, wherein all the bridges between at least two adjacent serpentines are parallel to one another.

13. Endoluminal prosthesis according to claim **1**, wherein by going through the prosthesis in a longitudinal way one encounters bridges which alternate with opposite way direction biases compared to an axis parallel to the longitudinal axis of the tubular body.

14. Endoluminal prosthesis according to claim **1**, wherein by going through the prosthesis in a longitudinal way one encounters bridges alternating with direction biases of opposite value to that of an axis parallel to the longitudinal axis of the tubular body.

15. Endoluminal prosthesis according to claim **1**, wherein a cell is comprised which comprises opposite lengths of two contiguous serpentines comprised between two subsequent bridges and said subsequent bridges to form a closed path.

16. Endoluminal prosthesis according to claim **1**, wherein said arms are substantially straight.

17. Endoluminal prosthesis according to claim **1**, wherein said arms comprise substantially straight edges.

18. Endoluminal prosthesis according to claim **15**, wherein at least one cell comprises six complete bends.

19. Endoluminal prosthesis according to claim **15**, wherein at least one cell comprises ten complete bends.

20. Endoluminal prosthesis according to claim **15**, wherein at least one cell comprises eighteen complete bends.

21. Endoluminal prosthesis according to claim **1**, wherein at least one prosthesis length in the collapsed state comprises a plurality of serpentines equal to one another with corresponding bends, facing the same prosthesis end, aligned with one another.

22. Endoluminal prosthesis according to claim **21**, wherein said at least one prosthesis length is an intermediate portion of the prosthesis.

23. Endoluminal prosthesis according to claim **21**, wherein said at least one prosthesis length is a middle length of the prosthesis.

24. Endoluminal prosthesis according to claim **1**, wherein said prosthesis is a unique body.

25. Endoluminal prosthesis according to claim **1**, wherein said body is obtained by cutting a tubular element.

26. Endoluminal prosthesis according to claim **1**, wherein said body is obtained by laser cutting.

27. Endoluminal prosthesis according to claim **1**, wherein said body is made of a superelastic material.

28. Endoluminal prosthesis according to claim **1**, wherein said body is of a strain hardened pseudoelastic material.

29. Endoluminal prosthesis according to claim **1**, wherein said body is of a shape memory material.

30. Endoluminal prosthesis according to claim **1**, wherein said body is Nitinol.

31. Endoluminal prosthesis according to claim **1**, comprising a tubular body developing along a longitudinal axis, said tubular body comprising a plurality of serpentines or meander paths developing along a substantially circumferential direction relative to the direction of the longitudinal axis of the endoluminal prosthesis, said serpentines comprising arms connected by bends, wherein two adjacent serpentines are connected by at least one bridge thus forming at least two cells between said two adjacent serpentines, wherein at least one serpentine comprises at least one frame defining a slot located at the bend between two arms in place of at least two arms and one bend compared to the second serpentine, a radiopaque material being provided within said slot.

32. Prosthesis according to claim **1**, wherein said plurality of serpentines comprises a first serpentine and a second serpentine, said first serpentine forming only end lengths of said prosthesis.

33. Prosthesis according to claim **1**, wherein said plurality of serpentines comprises a first serpentine, a second serpentine and a third serpentine, said second and third serpentines repeating alternatively along said longitudinal axis.

34. Endoluminal prosthesis according to claim **1**, wherein said at least one serpentine is a first serpentine.

35. Endoluminal prosthesis according to claim **31**, wherein said frame is located at the bend between two arms in place of four arms and three bends relative to the second or third serpentines.

36. Endoluminal prosthesis according to claim **31**, wherein said frame is located in the concave part of the bend.

37. Endoluminal prosthesis according to claim **32**, wherein said first serpentine is a prosthesis end serpentine.

38. Endoluminal prosthesis according to claim **31**, wherein said frame is arranged at an end bend or peak of the serpentine.

39. Endoluminal prosthesis according to claim **31**, wherein said frame is arranged within the corresponding cell as defined between the first serpentine and the second serpentine.

40. Endoluminal prosthesis according to claim **31**, wherein said frame has an elongated shape in the direction of the prosthesis longitudinal axis.

41. Endoluminal prosthesis according to claim **31**, wherein said frame develops from the end bend towards a middle axis of the endoluminal prosthesis.

42. Endoluminal prosthesis according to claim **31**, wherein a cell comprising said frame is defined between the first and second serpentines, said cell comprising two bridges developing along two directions tangential to the tubular body which are incident to one another.

43. Endoluminal prosthesis according to claim **32**, wherein between the first and second serpentines is defined a cell comprising said frame, said cell comprising two bridges developing along directions tangential to the tubular body, which are parallel to one another.

44. Endoluminal prosthesis according to claim **31**, wherein the bridges of the cell comprising said frame develop along directions tangential to the tubular body converging from the end to a middle axis of the prosthesis.

45. Endoluminal prosthesis according to claim **31**, wherein the bridges of the cell comprising said frame develop according to directions tangential to the tubular body which are biased relative to the longitudinal axis of the endoluminal prosthesis.

46. Endoluminal prosthesis according to claim **32**, wherein the bridges connecting the first and second serpentines which do not belong to the cell comprising said frame are substantially parallel to one of both bridges belonging to the cell comprising said slot.

47. Endoluminal prosthesis according to claim **32**, wherein in the cell comprising said frame the number of arms and bends of the first serpentine is smaller than the number of arms and bends of the second serpentine.

48. Endoluminal prosthesis according to claim **32**, wherein in the cell comprising said frame the length belonging to the first serpentine comprises two arms and two bends less than the arms and bends belonging to the length belonging to the second serpentine, as symmetrically counted between both serpentines starting from the joining bridges.

49. Endoluminal prosthesis according to claim **32**, wherein in the cell comprising said frame the length belonging to the first serpentine comprises six arms and five bends, whereas the length belonging to the second serpentine comprises eight arms and seven bends.

50. Endoluminal prosthesis according to claim **31**, wherein said slot passes all through the thickness of the tubular body.

51. Endoluminal prosthesis according to claim **31**, wherein said radiopaque material is either melted or welded within the slot.

52. Endoluminal prosthesis according to claim **33**, wherein said second and third serpentines are symmetrical relative to a circumferential direction intermediate between both serpentines and staggered relative to one another.

53. Endoluminal prosthesis according to claim **1**, wherein two frames are provided which are arranged in end serpentines of the prosthesis, respectively.

54. Endoluminal prosthesis according to claim **1**, wherein the end serpentines are symmetrical to one another relative to a middle axis of the prosthesis.

55. Endoluminal prosthesis according to claim **1**, wherein the end serpentines are symmetrical to one another relative to a middle axis of the prosthesis and staggered in the circumferential direction.

56. Endoluminal prosthesis according to claim **32**, wherein at least an anomalous cell is provided being defined between the first and second serpentines, said anomalous cell being different from both the cell containing said frame and the remaining cells of the prosthesis.

57. Endoluminal prosthesis according to claim **56**, wherein said anomalous cell is adjacent to the cell containing said frame, and shares a connecting bridge with it.

58. Endoluminal prosthesis according to claim **56**, wherein the anomalous cell shares with the cell containing the frame the bridge developing along a direction tangential to the tubular body which is incident to the directions of development of the remaining bridges provided between the first and second serpentines.

59. Endoluminal prosthesis according to claim **56**, wherein the anomalous cell comprises two arms and two bends more than the remaining cells of the prosthesis which do not contain the frame.

60. Endoluminal prosthesis according to claim **56**, wherein the anomalous cell comprises six arms and five bends on the length corresponding to the second serpentine whereas the remaining cells of the prosthesis comprise, with reference to a length corresponding to a serpentine, four arms and three bends.

61. Endoluminal prosthesis according to claim **31**, wherein said frame occupies the entire width which has been left free by the replaced arms and bends, as measured along the circumferential direction.

62. Endoluminal prosthesis according to claim **31**, wherein said frame is formed as a unique body in the tubular body by laser cutting a cylindrical wall.

63. Endoluminal prosthesis according to claim **31**, wherein said slot has an elongated shape along the direction of the prosthesis longitudinal axis.

64. Endoluminal prosthesis according to claim **31**, wherein an end side of the frame is substantially straight along the circumferential direction, in a plane development of the prosthesis.

65. Endoluminal prosthesis according claim **31**, wherein those arms directly connected to the frame join thereto at end points of the frame itself.

66. Endoluminal prosthesis according to claim **31**, wherein said frame comprises elongated sides of substantially the same width as the prosthesis arms, as measured along the circumferential direction, and a shorter length of the prosthesis arms, as measured along the longitudinal direction.

67. Endoluminal prosthesis according to claim **1**, wherein a serpentine is closed along the circumferential direction relative to the prosthesis.

68. Endoluminal prosthesis comprising:

a tubular body developing along a longitudinal axis,

said tubular body comprising a plurality of serpentines or meander paths developing along a substantially circumferential direction relative to the direction of the longitudinal axis of the endoluminal prosthesis, said serpentines comprising arms connected by bends,

wherein two adjacent serpentines are connected by at least one bridge thus forming at least two cells between said two adjacent serpentines,

wherein at least one serpentine comprises at least one frame defining a slot arranged at the bend between two arms in place of at least two arms and one bend compared to the second serpentine,

a radiopaque material being provided within said slot.

69. Prosthesis according to claim **68**, wherein said plurality of serpentines comprises a first serpentine and a second serpentine, said first serpentine forming only end lengths of said prosthesis.

70. Prosthesis according to claim **68**, wherein said plurality of serpentines comprises a first serpentine, a second serpentine and a third serpentine, said second and third serpentines alternatively repeating along said longitudinal axis.

71. Endoluminal prosthesis according to claim **68**, wherein said at least one serpentine is a first serpentine.

72. Endoluminal prosthesis according to claim **68** wherein said frame is arranged at the bend between both arms in place of four arms and three bends relative to second or third serpentines.

73. Endoluminal prosthesis according to claim **68**, wherein said frame is arranged on the concave part of the bend.

74. Endoluminal prosthesis according to claim **69**, wherein said first serpentine is an end serpentine of the prosthesis.

75. Endoluminal prosthesis according to claim **74**, wherein said frame is arranged at an end bend or peak of the serpentine.

76. Endoluminal prosthesis according to claim **75**, wherein said frame is arranged within the corresponding cell as defined between the first and the second serpentines.

77. Endoluminal prosthesis according to claim **68**, wherein said frame has an elongated shape in the direction of the longitudinal axis of the prosthesis.

78. Endoluminal prosthesis according to claim **77** when dependent from claims **5**, wherein said frame develops from the end bend towards a middle axis of the endoluminal prosthesis.

79. Endoluminal prosthesis according to claim **68**, wherein between the first and second serpentines a cell is defined which comprises said frame, said cell comprising two bridges developing along directions tangential to the tubular body, which are incident to one another.

80. Endoluminal prosthesis according to claim **68**, wherein between the first and the second serpentine a cell is defined which comprises said frame, said cell comprising two bridges developing along directions tangential to the tubular body, which are parallel to one another.

81. Endoluminal prosthesis according to claim **79**, wherein the bridges of the cell comprising said frame develop along directions tangential to the tubular body converging from the end to a middle axis of the prosthesis.

82. Endoluminal prosthesis according to claim **79**, wherein the bridges of the cell comprising said frame develop according to directions tangential to the tubular body which are biased relative to the longitudinal axis of the endoluminal prosthesis.

83. Endoluminal prosthesis according to claim **79**, wherein the connecting bridges between the first and second serpentines that do not belong to the cell comprising said frame are substantially parallel to one of those bridges belonging to the cell comprising said slot.

84. Endoluminal prosthesis according to claim **79**, wherein in the cell comprising said frame the number of arms and bends of the first serpentine is lower than the number of arms and bends of the second serpentine.

85. Endoluminal prosthesis according to claim **84**, wherein in the cell comprising said frame the length belonging to the first serpentine comprises two arms and two bends less than the arms and bends of the length belonging to the second serpentine, as symmetrically counted between both serpentines starting from junction points.

86. Endoluminal prosthesis according to claim **85**, wherein in the cell comprising said frame the length belonging to the first serpentine comprises six arms and five bends whereas the length belonging to the second serpentine comprises eight arms and seven bends.

87. Endoluminal prosthesis according to claim **68**, wherein said slot passes all through the thickness of the tubular body.

88. Endoluminal prosthesis according to claim **68**, wherein said radiopaque material is either melted or welded within the slot.

89. Endoluminal prosthesis according to claim **70**, wherein said second and third serpentines are symmetrical relative to a circumferential direction intermediate between both serpentines and staggered to one another.

90. Endoluminal prosthesis according to claim **68**, wherein two frames are provided arranged in end serpentines of the prosthesis, respectively.

91. Endoluminal prosthesis according to claim **90**, wherein the end serpentines are symmetrical to one another relative to a middle axis of the prosthesis.

92. Endoluminal prosthesis according to claim **91**, wherein the end serpentines are symmetrical to one another relative to a middle axis of the prosthesis and staggered in the circumferential direction.

93. Endoluminal prosthesis according to claim **68**, wherein at least one anomalous cell is provided being defined between the first and second serpentines, said anomalous cell being different both from the cell containing said frame and the remaining cells of the prosthesis.

94. Endoluminal prosthesis according to claim **93**, wherein said anomalous cell is adjacent to the cell containing said frame, sharing a connecting bridge therewith.

95. Endoluminal prosthesis according to claim **94**, wherein the anomalous cell shares with the cell containing the frame the bridge developing along a direction tangential to the tubular body incident to the directions of development of the remaining bridges provided between the first and second serpentines.

96. Endoluminal prosthesis according to claim **93**, wherein the anomalous cell comprises two arms and two bends more than the remaining cells of the prosthesis which do not contain the frame.

97. Endoluminal prosthesis according to claim **96**, wherein the anomalous cell comprises on the length corresponding to the second serpentine six arms and five bends, whereas the remaining cells of the prosthesis comprise, with reference to a length corresponding to a serpentine, four arms and three bends.

98. Endoluminal prosthesis according to claim **68**, wherein said frame occupies the whole width which has been left free by the replaced arms and bends, as measured along the circumferential direction.

99. Endoluminal prosthesis according to claim **68**, wherein said frame is formed as a unique body in the tubular body by laser cutting a cylindrical wall.

100. Endoluminal prosthesis according to claim **68**, wherein said slot has an elongated shape along the direction of the longitudinal axis of the prosthesis.

101. Endoluminal prosthesis according to claim **68**, wherein an end side of the frame is substantially straight along the circumferential direction, in a plane development of the prosthesis.

102. Endoluminal prosthesis according to claim **68**, wherein the arms directly connected to the frame join thereto at end points of the frame itself.

103. Endoluminal prosthesis according to claim **68**, wherein said frame comprises elongated sides having substantially the same width as the prosthesis arms, as measured along the circumferential direction, and the length being shorter than the prosthesis arms, as measured along the longitudinal direction.

104. Endoluminal prosthesis according to claim **68**, wherein a serpentine is closed along the circumferential direction of the prosthesis.

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