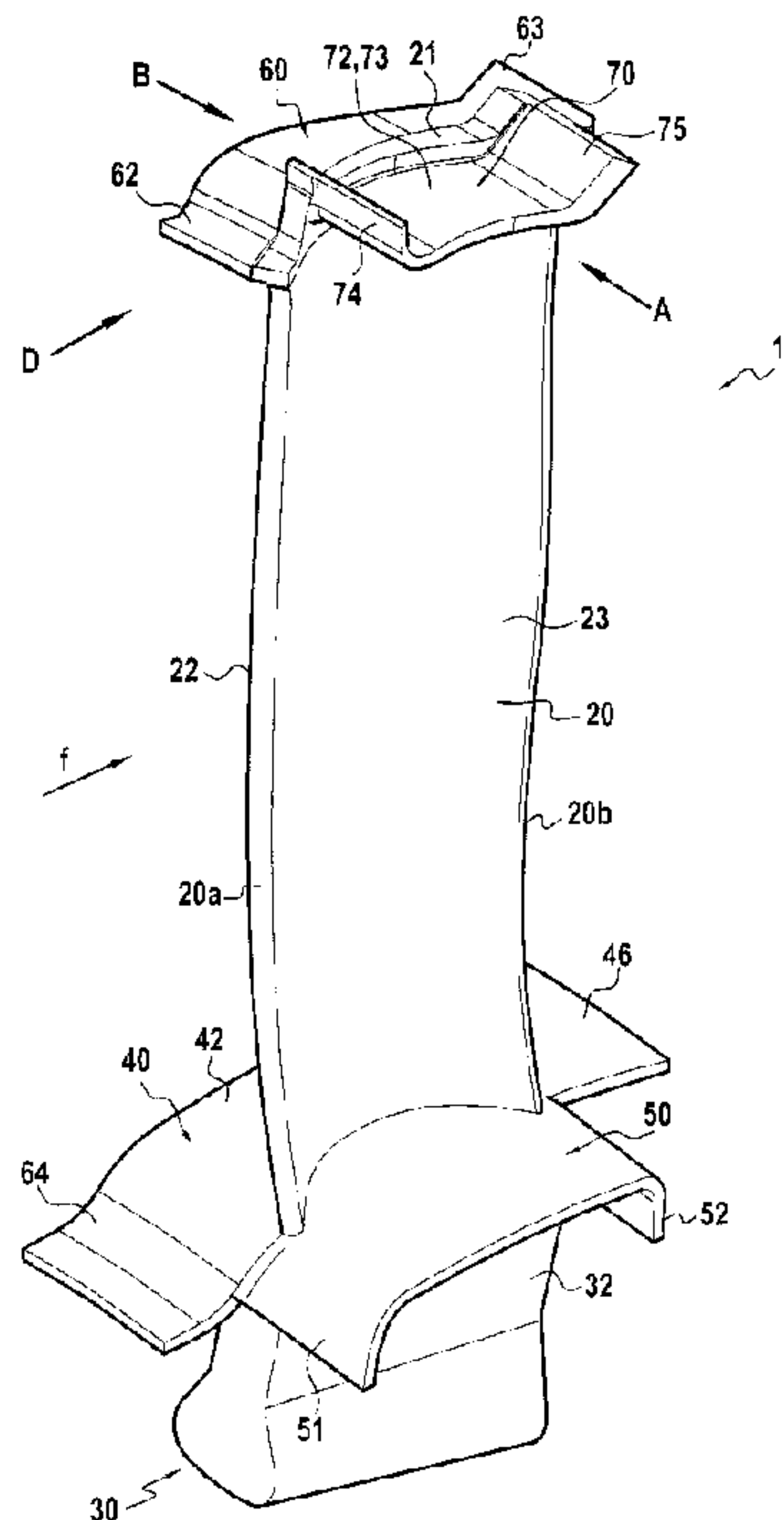




(86) Date de dépôt PCT/PCT Filing Date: 2011/06/22
(87) Date publication PCT/PCT Publication Date: 2012/01/05
(45) Date de délivrance/Issue Date: 2018/03/06
(85) Entrée phase nationale/National Entry: 2012/11/16
(86) N° demande PCT/PCT Application No.: FR 2011/051431
(87) N° publication PCT/PCT Publication No.: 2012/001269
(30) Priorité/Priority: 2010/06/28 (FR1055161)

(51) Cl.Int./Int.Cl. *B29C 70/22* (2006.01),
B29C 70/24 (2006.01), *F01D 5/14* (2006.01),
F01D 5/28 (2006.01), *D03D 25/00* (2006.01)
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(54) Titre : AUBE DE TURBOMACHINE A GEOMETRIE ASYMETRIQUE COMPLEMENTAIRE.
(54) Title: TURBOMACHINE BLADE HAVING COMPLEMENTARY ASYMMETRICAL GEOMETRY



(57) **Abrégé/Abstract:**

Turbomachine blade (10) made of composite comprising a fibre reinforcement obtained by the three-dimensional weaving of filaments and densified by a matrix, the blade comprising a first part constituting the aerofoil (20) and blade root (30), the blade aerofoil (20) having two faces (22, 23) each connecting a leading edge (20a) to a trailing edge (20b). The first part forms a single piece with at least one second part present only on one of the faces of the blade aerofoil, said second part being the constituent element of part of at least one of the following elements: the blade platform (40), the tang (50) that prevents the blade from rocking, the blade shroud spoilers (60) and blade shroud wipers (70), the fibrous reinforcing parts corresponding to the first and the second parts of the blade being at least partially imbricated in one another, with filaments of the first part of the fibrous reinforcement penetrating the second part of fibrous reinforcement.

ABSTRACT

A turbomachine blade (10) made of composite material including a fiber reinforcement obtained by three-dimensional weaving of yarns and densified by a matrix, the blade including a first portion constituting the airfoil (20) and blade root (30), the blade airfoil (20) exhibiting two faces (22, 23) each connecting a leading edge (20a) with a trailing edge (20b). The first portion forms a single piece with at least one second portion present only on one of the faces of the blade airfoil, said second portion constituting a portion of at least one of the following elements: blade inner platform (40), blade anti-tilting wall (50), blade outer platform spoilers (60) and blade outer platform wipers (70), the portions of the fiber reinforcement corresponding to the first and the second portions of the blade being at least partially mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second portion of the fiber reinforcement.

(Figure 1)

Turbomachine blade having complementary asymmetrical geometryBackground of the invention

5 The invention relates to turbomachine blades made of composite material including a fiber reinforcement densified by a matrix.

The intended field is that of gas turbine blades for aeroengines or industrial turbines.

10 The fabrication of turbomachine blades of composite material has already been proposed. Reference can be made in particular to international patent application PCT/FR2009/052309 filed jointly by SNECMA and SNECMA Propulsion Solide. This application describes the fabrication of a turbomachine blade made of composite material including a
15 fiber reinforcement densified by a matrix. More precisely, this method exhibits the feature that the fiber blank fabricated by three-dimensional weaving is shaped to obtain a one-piece fiber preform having a first portion constituting an airfoil and blade root preform and at least one second portion
20 constituting an inner platform and blade outer platform preform. Thus, after densification of the preform, it is possible to obtain a blade made of composite material having a fiber reinforcement consisting of the preform and densified by the matrix, and forming a single piece with integrated inner
25 platform and/or outer platform.

The blade obtained by such a method has the disadvantage that its outer platform cannot integrate both a function of sealing (through the presence of wipers) to the housing which surrounds the blades and an aerodynamic function
30 (by the presence of covering spoilers defining the outside of the flowpath of the gas stream in the turbine).

French patent application No. 09 58931 filed jointly by SNECMA and SNECMA Propulsion Solide, describes the fabrication of a blade made of composite material forming a
35 single piece with integrated inner platform and outer platform, the outer platform providing both the sealing function and the aerodynamic function.

However, the fabrication of such an outer platform with the method described in French patent application No. 09 58931 involves in particular shaping and molding operations with two-layer fiber structures, operations which are
5 completely feasible but which can be more complex to carry out than with single-layer structures. In addition, the blade thus fabricated does not incorporate an anti-tilting wall.

Further, in the event of damage to the outer platform of the blade fabricated according to the method described in
10 French patent application No. 09 58931, the aerodynamic function and the sealing function are both impacted because the outer platform is formed in a single piece providing both functions.

15 Object and summary of the invention

It is therefore desirable to be able to have blades available made of composite material, particularly but not necessarily of thermostructural composite material such as CMC, for turbines or compressors of turbomachinery, blades
20 that are relatively simple to fabricate and which integrate the required functions, namely the sealing, flowpath definition (aerodynamic function), and anti-tilting functions.

To this end, according to the present invention, a method is proposed for fabricating a turbomachine blade made
25 of composite material including a fiber reinforcement densified by a matrix, the method including:

- fabrication by three-dimensional weaving of a one-piece fiber blank,
- shaping of the fiber blank to obtain a one-piece
30 fiber preform having a first portion constituting an airfoil and blade root preform, the blade airfoil exhibiting two faces each connecting a leading edge and a trailing edge, and at least one second portion present only on one of the faces of the blade airfoil, said second portion constituting a preform
35 of a portion of at least one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers,

- densification of the preform by a matrix to obtain a blade made composite material having a fiber reinforcement consisting of the preform and densified by the matrix, and forming a single piece with at least a portion of one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers.

Compared with the method described in patent application No. 09 58931, the invention provides for providing each of these functions of flowpath definition, sealing, and anti-tilting by distinct portions of the blade which are fabricated from single-layer structures. The blade thus fabricated exhibits a complementary asymmetrical geometry, providing on one side of its airfoil (pressure face or suction face) the sealing function with a portion of blade outer platform wipers, the flowpath definition function with portions of an inner platform and of a blade outer platform spoiler and the anti-tilting function with a portion of an anti-tilting wall. This asymmetrical geometry allows several identical airfoils to be interleaved in order to provide the required functions on each side of their airfoil.

According to an advantageous feature of the method, in the longitudinal direction of the fiber blank corresponding to the longitudinal direction of the blade to be fabricated, the fiber blank includes a first set of several layers of yarns which are interlinked to form a first portion of the blank corresponding to the airfoil and blade root preform, and a second set of several layers of yarns which are interlinked at least locally to constitute on one of the faces of the blade airfoil at least the second portion of the blank corresponding to a preform of a portion of at least one of the following elements: blade inner platform, anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, the yarns of the first set of yarn layers not being linked to the yarns of the second set of yarn layers, and the first set of yarn layers having yarns of the second set of yarn layers crossing through it at the or each second portion of the blank.

The provision of unlinked areas allows shaping of the fiber preform without cutting linking yarns, such a cut possibly reducing the mechanical strength of the fiber reinforcement, hence of the fabricated blade.

5 According to one embodiment of the invention, in the longitudinal direction corresponding to the longitudinal direction of the fiber blank to be fabricated, the fiber blank includes:

10 - a first set of several layers of yarns which are interlinked to form a first portion of the blank corresponding to the preform of the airfoil and the blade root;

15 - a second set of several layers of yarns which are interlinked at least locally to form on one of the faces of the airfoil at least one second portion of the blank corresponding to the preform of a portion of blade inner platform and/or of blade outer platform spoilers and at least one third portion of the blank corresponding to the preform of a portion of blade anti-tilting wall and/or of blade outer platform wipers;

20 the yarns of the first set of yarn layers not being linked to the yarns of the second set of yarn layers, and

25 the first set of yarn layers having yarns from the second set of yarn layers crossing through it at the or at each second portion of the fiber blank and at the or at each third portion of the fiber blank.

30 In this case, the fiber blank is woven with a second continuous set of yarn layers and the shaping of the fiber blank includes the elimination by cutting out of portions of the second set of yarn layers outside of the or each second portion of the fiber blank and the or each third portion of the fiber blank.

35 According to another embodiment of the invention, in the longitudinal direction corresponding to the longitudinal direction of the fiber blank to be fabricated, the fiber blank includes:

- a first set of several layers of yarns which are interlinked to form a first portion of the blank corresponding to the airfoil and blade root preform;

5 - a second set of several layers of yarns which are interlinked at least locally to form on one of the surfaces of the airfoil at least one second portion of the blank corresponding to the preform of a portion of at least one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform
10 spoilers and blade outer platform wipers and a third portion of the blank corresponding to the preform of all or a portion of one of said elements other than that formed by the second portion; and

15 - a second set of several layers of yarns which are interlinked at least locally to form on one face of the airfoil at least one fourth portion of the blank corresponding to the preform of all or a portion of one of said element other than that formed by the second and third portions and a
20 fifth portion of the blank, an element corresponding to the preform of all or part of said elements other than that formed by the second, third and fourth portions;

the yarns of the first set of yarn layers not being linked to the yarns of the second and third sets of yarn layers, and

25 the first set of the yarn layers having yarns from the second and third sets of yarn layers crossing through it at second, third, fourth and fifth portions of the fiber blank.

30 In this case, the fiber blank is woven with a second and a third continuous sets of yarn layers and the shaping of the fiber blank includes the elimination by cutting out of portions of the second and third sets of yarn layers outside of the second, third, fourth and fifth portions of the fiber blank.

35 According to yet another feature of the method, in the first portion of the fiber blank and in a direction corresponding to that extending along the profile of an airfoil of variable thickness in the blade to be fabricated,

the number of yarn layers in the first set of yarn layers is constant. The yarns of the first set of yarns can then have variable weight and/or count.

Advantageously, a strip is fabricated by three-dimensional weaving that includes a succession of fiber blanks. These can then be cut out of the strip. The blanks can be woven with the longitudinal direction of the blade to be fabricated in the weft direction or in the warp direction.

According to the present invention, a turbomachine blade of composite material is also proposed including a fiber reinforcement obtained by three-dimensional weaving of yarns and densified by a matrix, the blade including a first portion constituting an airfoil and a blade root, the blade airfoil exhibiting two faces each connecting a leading edge to a trailing edge, the first portion forming a single piece with at least one second portion present only on one of the faces of the blade airfoil, the second portion constituting a portion of at least one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, the portions of the fiber reinforcement corresponding to the first and the second portions of the blade being at least partially mutually nested, with yarns of the first portion of the fiber reinforcement penetrating into the second portion of the fiber reinforcement.

According to one embodiment of the invention, the second portion constitutes a portion of one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, the first portion also forming a single piece with at least one third portion constituting a portion of at least one of said elements other than that constituted by the second portion, the third portion being present only on one face of the airfoil, the portions of the fiber reinforcement corresponding to the first, second and third portions of the blade being at least partly mutually imbricated, with yarns of the first

portion of the fiber reinforcement penetrating into the second and third portions of the fiber reinforcement.

In this case, the first portion can also form a single piece with at least one fourth portion constituting a portion
5 of at least one of said elements other than that constituted by said second and third portions, the fourth portion being present only on one face of the airfoil, the portions of the fiber reinforcement corresponding to the first, second, third and fourth portions of the blade being at least in part
10 mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second, third and fourth parts of the fiber reinforcement.

The first part can also form a single piece with at least one fifth portion constituting a portion of at least one
15 of said elements other than that constituted by said second, third, and fourth portions, said fifth portion being present only on one face of the airfoil, the portions of the fiber reinforcement corresponding to the first, second, third, fourth and fifth portions of the blade being at least in part
20 mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second, third, fourth and fifth portions of the fiber reinforcement.

According to another embodiment, the second portion
25 constitutes a portion of one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, the first portion also forming a single piece with at least one third portion constituting all or a portion of at least one of said elements
30 other than that constituted by said second portion, the portions of the fiber reinforcement corresponding to the first, second, and third portions of the blade being at least partly mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second and third
35 portions of the fiber reinforcement.

The blade can be made of a ceramic matrix composite material.

According to one feature of the blade, the yarns constituting the portion of the fiber reinforcement corresponding to the second, third, fourth and/or fifth portions of the blade cross through the portion of the fiber reinforcement corresponding to the first portion of the blade.

The blade airfoil can have a variable thickness profile along which the portion of the fiber reinforcement corresponding to the first portion of the blade has, in the longitudinal direction of the blade, a constant number of yarn layers having a variable weight and/or count, or a variable number of yarn layers.

The invention also has as its object a turbomachine rotor or disk and a turbomachine equipped with a blade as defined earlier.

Brief description of drawings

The invention will be better understood from the description given hereafter, by way of indication but without limitation, with reference to the appended drawings in which:

- Figure 1 is a perspective view of a turbomachine blade in conformity with one embodiment of the invention;

- Figures 2A through 2C are enlarged views of portions of the blade of Figure 1;

- Figure 3 illustrates very schematically the arrangement of three sets of yarn layers in a three-dimensionally woven fiber blank designed for the fabrication of a fiber preform for a blade such as that illustrated by Figure 1;

- Figures 4, 5 and 6 illustrate successive fabrication steps of a fiber preform for a blade such as that illustrated by Figure 1, starting with the fiber blank of Figure 3;

- Figure 7 is a section view showing the flattened profile of a blade airfoil such as that of Figure 1;

- Figure 8 is a section view of a set of warp yarn layers making it possible to obtain a profile such as that of Figure 7;

- Figures 9A and 9B are section views showing a method of weaving the fiber blank of Figure 3;

5 - Figures 10A and 10B are partial section views in a plane parallel to the warp and weft directions in a portion of the fiber blank of Figure 3 corresponding to the junction location between, on the one hand, the airfoil and a portion of blade anti-tilting wall and, on the other hand, between the airfoil and a portion of blade inner platform;

10 - Figure 10C is a partial weft section view in a portion of the fiber blank of Figure 2 corresponding to the junction location between the airfoil and portions of blade anti-tilting wall and of portions of blade inner platform;

15 - Figures 11A and 11B are partial section views in a plane parallel to the warp and weft directions in a portion of the fiber blank of Figure 3 corresponding to the junction location between, on the one hand, the airfoil and a portion of blade outer platform spoiler and, on the other hand, between the airfoil and a portion of blade outer platform wipers;

20 - Figure 11C is a partial weft section view in a portion of the fiber blank of Figure 2 corresponding to the junction location between the airfoil and portions of blade anti-tilting wall and a portion of blade inner platform;

25 - Figure 12A is a weft section view showing an example of arrangement of weft yarns in a portion of the fiber blank corresponding to a portion of the airfoil root;

- Figures 12B to 12D are weft section views showing warp planes for an example of three-dimensional (multilayer) weaving in the fiber blank portion of Figure 12A;

30 - Figure 13 is a partial schematic section view showing another embodiment of a portion of the blank corresponding to an airfoil root;

35 - Figures 14 and 15 illustrate very schematically two embodiments of a woven fiber strip obtained by three-dimensional weaving including a plurality of fiber blanks like that of Figure 3;

- Figure 16 indicates successive steps in an embodiment of a fabrication method for a turbomachine blade in conformity with the invention;

5 - Figure 17 indicates successive steps of another embodiment of a fabrication method for a turbomachine blade in conformity with the invention;

- Figure 18 shows the mounting onto a turbomachine rotor of a plurality of blades similar to that of Figure 1; and

10 - Figure 19 is a perspective view of a turbomachine blade in conformity with another embodiment of the invention.

Detailed description of embodiments

15 The invention is applicable to different types of turbomachine blades having integrated inner platforms and/or outer platforms, particularly compressor and turbine blades of different gas turbine spools, for example a low pressure turbine (BP) rotor blade like that illustrated by Figure 1.

20 The blade 10 of Figure 1 includes, in well-known fashion, an airfoil 20, a root 30 constituted by a portion having greater thickness, having for example a bulb-shaped section, continuing in a tang 32. The airfoil 20 extends in the longitudinal direction between its root 30 and its tip 21 and shows in cross-section a dished profile with variable
25 thickness defining two faces 22 and 23, corresponding respectively to the suction face and to the pressure face of the airfoil 20 and each connecting the leading edge 20a and the trailing edge 20b of the last mentioned.

30 The blade 10 is mounted on a turbine rotor (not illustrated) by insertion of the root 30 into a recess of matching shape provided at the periphery of the rotor.

In conformity with one embodiment of the invention, the airfoil 20 also includes four distinct elements respectively constituting a blade inner platform 40 portion, a
35 blade anti-tilting wall 50 portion, a blade outer platform spoilers 60 portion and a blade outer platform wipers 70 portion.

More precisely, at its radially inward end and on its face 22, the airfoil 20 connects to the blade inner platform 40 portion the outer (or upper) surface 42 whereof defines, radially inward, the flowpath of a gas stream f. In its upstream and downstream end portions (in the flow direction f of the gas stream), the platform 40 portion ends in covering spoilers 44 and 46. In the example illustrated, the surface 42 of the platform portion is tilted, generally forming a nonzero angle relative to the normal to the longitudinal direction of the blade. Depending on the desired profile of the inner surface of the gas stream flowpath, the angle could be zero, or the surface 42 could have a generally non-rectilinear profile, dished for example.

Still at its radially inward end but on its face 21, the blade 20 connects to the anti-tilting wall 50 portion which comprises flanks 51 and 52 at its upstream and downstream ends capable of preventing tilting of the blade when the latter is mounted on a turbine rotor.

The airfoil 20 also connects at its radially outward end and on its face 22 to the blade outer platform spoiler 60 portion which defines on its inner (lower) surface 61, radially outward, the flowpath of the gas stream f (Figures 1 and 2C). In its upstream and downstream end portions, the blade outer platform spoiler 60 portion ends in covering spoilers 62 and 63. In the example illustrated, the surface 61 of the blade outer platform spoiler 60 portion exhibits a tilted rectilinear profile generally forming a nonzero angle relative to the normal to the longitudinal direction of the blade or the surface 61 (Figure 2B). As a variant, depending on the desired profile of the outer surface of the gas stream flowpath, the surface 61 could have a generally non-rectilinear profile, dished for example, and/or extend substantially perpendicularly to the longitudinal direction of the blade.

Still at its radially outward end but on its face 21, the airfoil connects to the blade outer platform wipers 70 portion. On its outer (upper) surface 72, the blade outer

platform wipers 70 portion defines a depression or bathtub 73 (Figures 1 and 2A). Along the upstream and downstream edges of the bathtub 73, the portion 70 carries wipers 74 and 75 having a tooth-shaped profile the tips whereof can penetrate into a layer of abradable material of a turbine ring (not shown) to reduce the clearance between the blade tip and the turbine ring.

As illustrated in Figure 1, the blade inner platform 40 portion, the blade anti-tilting wall 50 portion, the blade outer platform spoilers 60 portion and the blade outer platform wipers 70 portion are respectively present only on one of the faces of the airfoil. In other words, the face of the airfoil opposite that comprising one or more of these elements lacks the or these same elements. Thus, the functions of defining (radially outside) the flowpath and of anti-tilting customarily performed by one and the same element present at the radially inward end of the airfoil are performed, in the blade of the invention, by distinct elements to wit, in the example described here, by the blade inner platform 40 portion and the blade anti-tilting wall 50 portion. Likewise, the flowpath definition and tilting seal customarily performed by one and the same element present at the radially outward end of the airfoil are performed, in the blade of the invention, by distinct elements to wit, in the example described here, by the blade outer platform spoilers 60 portion and the blade outer platform wipers 70 portion.

Figure 3 shows very schematically a fiber blank 100 starting with which a fiber blade preform can be shaped in order to obtain, after densification by a matrix and possible machining, a blade made of composite material with integrated inner platform, anti-tilting wall, blade outer platform spoilers and wipers portions like that illustrated in Figure 1.

The blank 100 includes two portions 102 and 104 obtained by three-dimensional weaving or multilayer weaving, only the envelopes of these three portions being shown in Figure 3. The portion 102 is designed, after shaping, to

constitute a portion of a fiber blade preform corresponding to an airfoil and blade root preform. The portion 104 is designed, after shaping, to constitute the portions of the fiber blade preform corresponding to preforms of the blade anti-tilting portion, the blade outer platform wiper portion, the blade inner platform portion and the blade outer platform spoilers portion.

The two portions 102 and 104 are in the form of strips extending generally in a direction X corresponding to a longitudinal direction of the blade to be fabricated. The fiber strip 102 exhibits, in its portion designed to constitute an airfoil preform, a variable thickness determined according to the thickness of the profile of the airfoil of the blade to be fabricated. In its portion designed to constitute a root preform, the fiber strip 102 exhibits an extra thickness 103 determined according to the thickness of the root of the blade to be fabricated.

The fiber strip 102 has a width l selected according to the length of the developed (flattened) profile of the airfoil and the root of the blade to be fabricated while the fiber strips 104 and 106 each have a width L greater than l selected according to developed lengths of the blade anti-tilting wall, inner platform, blade outer platform spoilers and wipers portions to be fabricated.

The fiber strip 104 has a substantially constant thickness determined according to the thicknesses of the anti-tilting wall, inner platform and outer platform spoiler and wiper portions of the blade to be fabricated. The strip 104 includes a first portion 104a, which extends along and in the vicinity of a first surface 102a of the strip 102 designed to constitute the pressure face of the airfoil, a second portion 104b, which extends along and in the vicinity of the second surface 102b of the strip 102 designed to constitute the suction face of the airfoil, and a third portion 104c which extends along and in the vicinity of the first surface 102a of the strip 102.

5 The portions 104a and 104b of the strip 104 are linked by a connecting portion 140c which extends transversely relative to the strip 102 at a location corresponding to that of the anti-tilting wall portion and the inner platform portion of the blade to be fabricated.

10 The portions 104b and 104c of the strip 104 are linked by a connecting portion 150c which extends transversely relative to the strip 102 at a location corresponding to that of the outer platform wiper portion and of the outer platform spoiler portion of the blade to be fabricated.

15 Depending on the desired geometry at the outer platform wiper portion of the blade, at the blade outer platform spoiler portion, at the anti-tilting wall portion and at the blade inner platform portion, the connecting portions 140c and 150c can cross through the strip 102, entering and/or emerging, substantially perpendicularly to the longitudinal direction X of the blank or following a curved profile as described hereafter in relation to Figures 10A, 10B, 11A and 11B. As described in more detail later, the strips 102 and 104
20 are simultaneously woven by three-dimensional weaving, with no linkage between the strip 102 and the portions 104a, 104b and 104c of the strip 104 by continuously weaving a plurality of successive blanks 100 in the X direction.

25 Figures 4 through 6 show very schematically how a fiber preform having a shape close to that of the blade to be fabricated can be obtained starting with the fiber blank 100.

30 The strip 102 is cut at one end in the extra thickness 103 and at another end slightly beyond the connecting portion 150c to obtain a strip 120 with a length corresponding to the longitudinal dimension of the blade to be fabricated with a swollen portion 130 constituted by a portion of the extra thickness 103 and situated at a location corresponding to the position of the root of the blade to be fabricated.

35 In addition, cutouts are made at the ends of the portions 104a and 104c of the strip 104 and in the portion 104b thereof so as to free independent segments 140a and 140b extending to either side of the connecting portion 140c as

well as independent segments 150a and 150b on either side of the connecting portion 150c, as shown in Figure 4.

5 The lengths of the portions 140a, 140b, 150a and 150b are determined according to the lengths of the inner platform, anti-tilting wall, outer platform spoilers and outer platform wipers portions in the blade to be fabricated.

10 Due to the absence of linkage between the strip 102 and the portions 104a, 104b and 104c of the strip 104, the portions 140a, 140b, 150a and 150b can be folded back perpendicularly to the strip 102 without cutting yarns so as to form plates as shown in Figure 5.

15 A fiber preform 200 of the blade to be fabricated is then obtained by molding with deformation of the strip 102 to reproduce the dished profile of the blade airfoil. The portions 140a and 140b are also deformed to reproduce shapes similar respectively to that of the inner platform portion of the blade (with its covering spoilers in particular) and to that of the anti-tilting wall portion of the blade. Likewise, the portions 150a and 150b are deformed to reproduce shapes
20 similar respectively to that of blade outer platform spoilers portion and to the outer platform wipers portion of the blade (see Figure 5). A preform 200 is thus obtained having an airfoil preform portion 220 including a surface 220a designed to constitute the pressure face of the airfoil and a surface 220b designed to constitute the suction face of the airfoil,
25 root preform portion 230 (with tang preform), an inner platform portion preform portion 240, an anti-tilting wall portion preform portion 250, a blade outer platform covering spoilers portion preform portion 260 and an outer platform wipers portion preform portion 270 (Figure 6).
30

As described later, the steps in fabricating a blade preform starting with a fiber blank are advantageously carried out after treatment of the fibers of the blank and its impregnation with a consolidation composition.

35 A three-dimensional weaving method for the fiber blank 100 will now be described in greater detail.

It is assumed that the weaving is carried out with warp yarns extending in the longitudinal direction X of the blank, it being specified that weaving with the weft yarns in this direction is also possible.

5 The variation in thickness of the strip 102 over its length is obtained by using warp yarns having variable weight. As a variant or a supplement it is possible to vary the count of the yarns (number of yarns per unit of length in the weft direction), a smaller count allowing greater thinning during
10 shaping of the preform by molding.

Thus, to obtain a blade airfoil profile as shown in flat projection in Figure 7, 3 layers of warp yarns can be used with variable weight and count as illustrated in Figure 8.

15 In one example of implementation, the yarns used can be silicon carbide (SiC) yarns supplied under the name "Nicalon" by the Japanese company Nippon Carbon and having a weight (number of filaments) of 0.5K (500 filaments).

 The warp is made with 0.5K SiC yarns and 1K SiC yarns
20 obtained by the combination of two 0.5K yarns, the two yarns being combined by covering. Covering is carried out advantageously with filament of a temporary nature capable of being eliminated after weaving, for example a polyvinyl alcohol (PVA) filament that can be eliminated by dissolving in
25 water.

 Table I below gives, for each column of warp yarns, the count (number of yarns/cm over the length of the profile), the number of 0.5K yarns, the number of 1K yarns and the profile thickness in mm, the latter varying between
30 approximately 1 mm and 2.5 mm:

Table I

Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Count	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	8	6
No of 0.5K yarns	3	3	3	3	3	3	3	2	1	0	0	0	0	0	0	0	2	1	3
No of 2x0.5K yarns	0	0	0	0	0	0	0	1	2	3	3	3	3	3	3	3	1	2	0
Thickness	1	1	1	1	1	1	1.2	1.5	2	2.2	2.4	2.5	2.4	2.4	2.2	2.1	1.8	1.5	1.2

5 Naturally, depending on the weights of the available yarns, different combinations of numbers of yarn layers and of variations of count and of weight can be adopted for the profile to be obtained.

Figures 9A, 9B show, in warp section, two successive plans of a weave which can be used for weaving the fiber blank 100 of Figure 3 outside the extra thickness 103.

10 The strip 102 of the fiber blank 100 includes a set of warp yarn layers, the number of layers being here for example equal to 3 (layers C_{11} , C_{12} , C_{13}). The warp yarns are linked by weft yarns t_1 by three-dimensional weaving.

15 The strip 104 also includes a set of warp yarns for example identically equal to 3 (layers C_{21} , C_{22} , C_{23}) linked by weft yarns t_2 by three-dimensional weaving, like the strip 102.

20 It is noted that the weft yarns t_1 do not extend into the layers of warp yarns of the strip 104, that the weft yarns t_2 do not extend into the layers of warp yarns of the strip 102 in order to leave them unlinked.

25 In the example illustrated, the weaving is multilayer weaving performed with a satin or multi-satin type weave. Other types of three-dimensional weaving can be used, for example multilayer weaving using a multiple plain weave or weaving with an "interlock" type weave. What is meant here by "interlock" weaving is a weave wherein each layer of weft yarns links several layers of warp yarns with all the yarns of

a given warp column having the same path in the plane of the weave.

Different methods of three-dimensional weaving are described in particular in document WO 2006/136755.

5 Figures 10A and 10B are section views parallel to the warp and weft directions at the crossing of the strip 102 respectively by the connecting portions 140c and 150c of the strip 104 of the fiber blanks of Figure 3. Figure 10A shows the entry of the warp yarns into the strip 104 on the side of
10 the surface 102a (pressure face) of the strip 102 at the connecting portion 140c. At this location, each layer of warp yarns of the strip 104 (here layers C_{21} , C_{22} , C_{23}) penetrates between the weft yarns t_1 of the strip 102 following a dished profile such as that shown in Figure 10A.

15 Figure 10B shows the emergence of the warp yarns in the strip 104 on the side of the surface 102b (suction face) of the strip 102 at the connection portion 140c. At this location, each layer of warp yarns of the strip 104 (here layers C_{21} , C_{22} , C_{23}) emerge between the weft yarns t_1 of the
20 strip 102 following a dished profile such as that shown in Figure 10B.

Naturally, depending on the desired shape of the anti-tilting wall portion and of the inner blade platform portion, the layers of warp yarns of the strip 104 can enter and emerge
25 from the strip 102 with different profiles such as rectilinear profiles for example.

The crossing of the strip 104 from one side to the other of the strip 102 is achieved, during weaving, by having each warp yarn of the strip 104 individually cross through all
30 the warp and weft yarns of the strip 102.

Figure 10C is a weft section view at the crossing of the strip 102 by the connecting portion 140c of the strip 104. It is observed that the layers of warp yarns of the strip 104 (here layers C_{21} , C_{22} , C_{23}), and of course the weft yarns t_1 of
35 the strip 104, will not re-emerge from the strip 102 at the same place as that of their entry into the strip 102. Indeed, between their entry (on the side of the face 102a) into the

strip 102 and their emergence (on the side of the face 102b), the warp yarns of the strip 104 are held within the strip 102 over a distance d_1 which makes it possible to form the offset between the portions 104a and 104b at the connecting portion 140c (Figure 3). This offset makes it possible to form, as illustrated in Figure 1, a blade inner platform portion 40 which is above the anti-tilting wall portion 50 in the direction of the airfoil 20.

Figures 11A and 11B are section views parallel to the warp and weft directions at the crossing of the strip 102 by the connecting portion 150c of the strip 104 of the fiber blank of Figure 3. Figure 11A shows the entry of the warp yarns into the strip 104 on the side of the face 102b (suction face) of the strip 102 at the connecting portion 150c. At this location, each layer of warp yarns of the strip 104 (here layers C_{21} , C_{22} , C_{23}) penetrates between the weft yarns t_1 of the strip 102 following a dished profile such as that shown in Figure 11A.

Figure 11B shows the emergence of the warp yarns in the strip 104 on the side of the face 102a (pressure face) of the strip 102 at the connecting portion 150c. At this location, each layer of warp yarns of the strip 104 (here layers C_{21} , C_{22} , C_{23}) emerge between the weft yarns t_1 of the strip 102 following a dished profile such as that shown in Figure 11B.

Of course, depending on the desired shape of the blade outer platform spoiler portion and of the blade outer platform wipers portion, the layers of warp yarns of the strip 104 can enter and emerge from the strip 102 with profiles having different shapes such as rectilinear profiles for example.

Figure 11C is a weft section view at the crossing of the strip 102 by the connecting portion 150c of the strip 104. It is observed that the warp yarn layers (here layers C_{21} , C_{22} , C_{23}) of the strip 104, and of course the weft yarns t_1 of the strip 104, will not emerge from the strip 102 at the same location as that of their entry into the strip 102. Indeed, between their entry (on the side of the face 102b) into the

strip 102 and their emergence (on the side of the face 102a), the warp yarns of the strip 104 are held within the strip 102 over a distance d_2 which allows the creation of the offset between the portions 104b and 104c at the connecting portion 150c (Figure 3). This offset makes it possible to form, as illustrated in Figure 1, a blade outer platform wipers portion 70 which is above the blade outer platform spoiler portion 60 in the direction of the airfoil 20.

The extra thickness 103 can be obtained by using warp yarns having greater weight and additional layers of weft yarns.

In Figure 12A, the number of layers of weft yarns changes in this example from 4 to 7 between a portion 102₁ of the strip 102, corresponding to the tang of the blade, and the portion 102₃ of the strip 102 having the extra thickness 103.

In addition, weft yarns t_1 , t'_1 , t''_1 having different weights are used, the yarns t_1 being for example "Nicalon" SiC yarns of 0.5K weight (500 filaments), the yarns t'_1 being obtained by the combination of two 0.5K yarns and the yarns t''_1 by the combination of three 0.5K yarns.

The weaving in the blank portion 102₃ necessitates layers of warp yarns in greater number than in the portion 102₁. This is advantageously achieved during transition between the portion 102₁ and the portion 102₃ by reducing the number of warp planes by constituting each warp plane in the portion 102₃ by combining warp yarns from two warp planes of the portion 102₁. Figures 12B and 12C show two neighboring warp planes in the portion 102₁ and Figure 12D shows a warp plane obtained in the portion 102₃ by combination of the warp planes of Figures 12B and 12C. In Figures 12B, 12C and 12D, the different weights of the warp yarns (as shown in Figure 8) or of the weft yarns are not shown for the sake of simplicity. Between Figures 12B, 12C, on the one hand, and Figure 12D, on the other hand, the dashes show how the warp yarns of the different layers in Figures 12B, 12C form the layers of warp yarns of Figure 12D.

Of course, different combinations of numbers of weft layers and of weft yarn weights can be adopted to form the extra thickness 103.

5 According to another embodiment shown schematically in Figure 13, the extra thickness 103 can be obtained by introducing an insert during weaving of the strip 102.

10 In Figure 13, the set T_1 of weft yarn layers of the portion 102₁ of the strip 102 corresponding to the tang of the blade is divided by omitting linking during weaving into two subsets T_{11} , T_{12} between which an insert 103₁ is inserted. In the example illustrated, the portion 102₁ has a greater thickness than of the portion 102₂ of the strip 102 corresponding to the blade airfoil. The transition between the 102₂ and the portion 102₁ can be made in the same manner as 15 described above for the transition between the portions 102₁ and 102₃ of Figure 12A. The crossing of the strip 102 by the strip 104 and at the connecting portion 140c of Figure 3 can optionally be performed through the thickened portion 102₁.

20 At the end of the insert 103, opposite the portion 102₁, the subsets T_{11} , T_{12} of weft yarn layers are once again reunited by weaving to form a portion 102'₁ having the same thickness as the portion 102₁, then, by thickness reduction, a portion 102'₂ having the same thickness as the portion 102₂, the portion 102'₂ forming the portion corresponding to a blade 25 airfoil for the following woven blank.

The insert 103₁ is preferably made of monolithic ceramic, preferably the same ceramic material as that of the matrix of the composite material of the blade to be fabricated. Thus, the insert 103₁ can be a block of SiC 30 obtained by sintering SiC powder.

As shown very schematically by Figure 14, a plurality of fiber blanks 100 can be obtained by weaving a strip 300 wherein are formed one or more rows of successive fiber blanks. Extra-length areas 310, 320 are provided in the warp 35 direction (warp yarns only) and in the weft direction (weft yarns only) to avoid edge effects connected with weaving, to

leave more freedom to deform during shaping of the preform and to provide transition areas between blanks 100.

Figure 15 shows a variant of implementation according to which a strip 400 is made with a row of blanks 100 woven in the weft direction perpendicularly to the longitudinal direction of the strip. Extra-length areas 410, 420 are also provided in the warp direction and, in the weft direction. Several rows of blanks 100 can be woven, the width of the strip 400 being adjusted to this end.

Successive steps of a manufacturing method for a blade made of composite material according to one embodiment of the invention are indicated in Figure 16.

At step 501, a fiber strip is woven by three-dimensional weaving having a plurality of fiber blanks, for example several rows of fiber blanks oriented in the warp direction, as shown in Figure 15. For turbomachine blades designed for use at high temperature and particularly in a corrosive environment (particularly humidity), yarns made of ceramic fibers are used for weaving, particularly silicon carbide (SiC) fibers.

At step 502, the fiber strip is treated to eliminate oiling present on the fibers and the presence of oxide on the surface of the fibers. The elimination of the oxide is obtained by acid treatment, particularly by immersion in a hydrofluoric acid bath. If the oiling cannot be eliminated by the acid treatment, a prior treatment for eliminating oiling is carried out, for example by decomposition of the oiling by a brief heat treatment.

At step 503, a thin layer of interphase coating is formed on the fibers of the fiber strip by chemical vapor infiltration or CVI. The material of the interphase coating is for example pyrolytic carbon or pyrocarbon (PyC), boron nitride (BN) or boron-doped carbon (BC, with for example 5 atom percent (%at) to 20%at B, the remainder being C). The thin layer of interphase coating has preferably a small thickness, for example equal to 100 nanometers at most, or even equal to 50 nanometers at most, so as to maintain good

deformability of the fiber blanks. Preferably, the thickness is at least equal to 10 nanometers.

At step 504, the fiber strip with the fibers coated with a thin interphase coating layer is impregnated with a
5 consolidation composition, typically a resin possibly diluted in a solvent. A carbon precursor resin can be used, for example a phenolic or furanic resin, or a ceramic precursor resin, for example a polysilazane or polysiloxane resin precursor of SiC.

10 After drying by elimination of any solvent in the resin (step 505), a pre-curing of the resin can be carried out (step 506). The pre-curing, or partial crosslinking, allows an increase in the stiffness, hence the strength, while still preserving the deformability needed for the fabrication of
15 blade preforms.

At step 507, the individual fiber blanks are cut out, as illustrated by Figures 4 and 5.

At step 508, a fiber blank thus cut out is shaped (as illustrated by Figures 5 and 6) and placed in a mold, made of
20 graphite for example, for forming of the airfoil and root preform portion and of the inner platform portion, anti-tilting wall portion, blade outer platform spoilers portion and outer platform wipers portion preform portions.

Thereafter, the crosslinking of the resin is completed
25 (step 509) and the crosslinked resin is pyrolyzed (step 510). The crosslinking and the pyrolysis can be concatenated by progressively raising the temperature in the mold.

After pyrolysis, a fiber preform consolidated by the pyrolysis residue is obtained. The quantity of consolidation
30 resin is selected so that the pyrolysis residue links the fibers of the preform sufficiently that it can be handled while retaining its shape without the assistance of tooling, it being specified that the quantity of consolidation resin is preferably chosen to be as low as possible.

35 Steps consisting of eliminating oiling, of acid treatment and of formation of interphase coating for a

substrate made of SiC fibers are known. Reference can be made to document US 5,071,679.

5 A second interphase layer is formed by CVI (step 511) in order to generally obtain a fiber-matrix interphase having sufficient thickness to provide its function of brittleness relief of the composite material. The second interphase layer can be a material selected from among PyC, BN, BC, not necessarily the same as that of the first interphase layer. The thickness of the second interphase layer is preferably at
10 least equal to 100 nanometers.

The fabrication of two-layer interphase, as indicated earlier, is preferred. It is described in French patent application No. 08 54937 by SNECMA Propulsion Solide.

15 Densification by a matrix of the consolidated preform is then carried out. For a turbomachine blade designed for use at high temperature, and particularly in a corrosive environment, the matrix is of ceramic, for example of SiC. Densification can be carried out by CVI, in which case formation of the second interphase layer and densification by
20 the matrix can be concatenated in the same furnace.

Densification can be carried out in two successive steps (steps 512 and 514) separated by a step 513 consisting of machining the blade to the desired dimensions.

25 It will be noted that a pre-machining operation can be carried out between steps 509 and 510, that is to say after crosslinking and before pyrolysis of the resin.

Successive steps of a manufacturing method of a blade made of composite material according to another embodiment of the invention are given in Figure 17.

30 Step 601 consisting of three-dimensional weaving of a fiber strip having a plurality of fiber blanks and step 602 consisting of treatment for eliminating oiling and oxide are similar to steps 501 and 502 of the embodiment of Figure 16.

35 At step 603, individual fiber blanks are cut out of the fiber strip, then each individual fiber blank is shaped in a mold or former (step 604) to obtain a fiber blade preform by forming of the airfoil and root preform portion and of the

inner platform portion, anti-tilting wall portion, blade outer platform spoilers portion and outer platform wipers portion preform portions.

At step 605, an interphase brittleness relief coating
5 is formed by CVI on the fibers of the preform held in the former. The material of the interphase coating is for example PyC, BN or BC, as previously mentioned. The thickness of the interphase coating is roughly one to a few hundred nanometers.

The preform still being held in the former,
10 consolidation of the preform by partial densification is carried out (step 606), the consolidation being carried out by formation of a ceramic deposit on the fibers by CVI.

The formation of the interphase coating by CVI and consolidation by ceramic deposit by CVI can be concatenated in
15 the same CVI furnace.

The former is preferably made of graphite and exhibits holes facilitating the passage of reactive gas phases giving the interphase deposit by CVI.

When consolidation is sufficient that the preform can
20 be handled which still retaining its shape without the assistance of holding tooling, the consolidated preform is removed from the former and densification by a ceramic matrix by CVI is carried out. The densification can be performed in two successive steps (steps 607 and 609) separated by a step
25 608 consisting of machining the blade to the desired dimensions.

In the foregoing, the fabrication of a variable thickness airfoil profile by using yarns having variable weight and/or count has been considered. It is possible, as a
30 variant, to fabricate the fiber blank portion corresponding to the airfoil preform with a certain number of layers of yarns with the same weight and with a fixed count, the variation in profile thickness being obtained during machining after the first densification step or during pre-machining of the
35 consolidated blade preform.

Further, according to the conditions of use planned for the blade, the fibers of the fiber reinforcement of the blade

can be made of a material other than ceramic, for example of carbon, and the matrix can be of a material other than ceramic, for example of carbon or of a resin, the invention being of course also applicable to the manufacture of blades
5 made of organic matrix composite material.

Figure 18 shows the mounting on a turbomachine rotor or disk 500 of a plurality of blades 510, 520, 530 and 540 exhibiting a structure similar to the blade 10 of Figure 1. The blades 510, 520, 530 and 540 are mounted on the rotor 500
10 by inserting the roots 517, 527, 537 and 547 of each blade respectively into the recesses 501, 502, 503 and 504 having matching shapes provided in the periphery of the rotor. As described before for the blade 10, the airfoil 516, respectively 526, 536 and 546, of the blade 510, respectively
15 520, 530 and 540, includes on its surface 512 (suction face), respectively 522, 532 and 542, an inner platform portion (including covering spoilers at its ends) 518, respectively 528, 538 and 548 and a blade outer platform spoiler portion 514, respectively 524, 534 and 544. In addition, on its face
20 511 (pressure face), respectively 521, 531 and 541, the airfoil 516, respectively 526, 536 and 546, includes an anti-tilting wall portion 513, respectively 523, 533 and 543 and a blade outer platform wipers portion 515, respectively 525, 535 and 545.

As shown in Figure 18, the blades nest with one another, one already-mounted blade, for example the blade 530, receiving above its anti-tilting wall portion, 533 here, the inner platform portion of the adjacent blade, here the platform portion 548 of the blade 540. Likewise, the blade 530
30 receives above its blade outer platform wipers portion 535 the blade outer platform spoilers portion 544 of the blade 540.

Once mounted together, each blade, here for example the blade 520, comprises on each side of its airfoil, here the airfoil 526, the functions customarily present at its radially
35 inward end, to wit the anti-tilting function provided here by the combination of the anti-tilting wall portions 513 and 523 and the function of defining a flowpath provided here by the

combination of the inner platform portions 528 and 538 as well as at its radially outward end, to wit the function of defining a flowpath provided by the combination of the outer platform spoiler portions 524 and 534 and the sealing function
5 provided by the combination of the outer platform wipers portions 515 and 525.

The blade 10 described earlier in relation with Figure 1 includes on the suction face of its airfoil 20 the blade platform portion 40 and the blade outer platform wipers
10 portion 70, while it includes on the pressure of its airfoil 20 the anti-tilting wall portion 50 and the blade outer platform spoilers portion 60. According to variants of implementation, the blade inner platform and blade outer platform wipers portions can be arranged on the pressure face
15 of the blade airfoil while the anti-tilting wall and blade outer platform spoilers portions can be arranged on the suction face of the blade airfoil. According to other variants of implementation, the distribution of the blade inner platform, blade outer platform wipers, anti-tilting wall and
20 blade outer platform spoilers portions over the faces of the blade airfoil can be such that the airfoil comprises on one of the faces of its airfoil only one of the portions of the blade inner platform, blade outer platform wipers, anti-tilting wall and blade outer platform spoilers portions, the three other
25 portions being arranged on the other face of the airfoil or such that these four portions are all present on the same face of the airfoil. However, for a better distribution of the masses over the blade, the blade preferably comprises two portions on one face and the two other portions on the
30 opposite face of the airfoil.

According to still other variations of implementation of the blade according to the invention, a portion of the elements of blade inner platform, of blade outer platform wipers, of anti-tilting wall and of blade outer platform
35 spoilers can be present on both faces of the airfoil while certain other of these elements are present only on one face of the airfoil as described earlier. Figure 19 illustrates

such an example of a variant of implementation with a blade 600 which comprises an inner platform 640 and complete blade outer platform spoilers 660 in that they are present on both faces 622 and 623 of the airfoil 620 while only the anti-tilting wall 650 and blade outer platform wipers 670 portions are present only respectively on the face 623 of the airfoil 620. In this case, the fiber strip designed to constitute the airfoil, such as the strip 102 described earlier, and crossed at the connecting portions, such as the portions 140c and 150c described previously, by two fiber strips such as the strip 104, in order to make it possible to have independent portions of fiber strip allowing the fabrication of an inner platform and blade outer platform spoilers together with anti-tilting wall and blade outer platform spoilers portions.

CLAIMS

1. A method of fabrication for a turbomachine blade of composite material including a fiber reinforcement densified by a matrix, the method comprising:

- fabrication by three-dimensional weaving of a one-piece fiber blank,

- shaping of the fiber blank to obtain a one-piece fiber preform having a first portion constituting an airfoil and blade root preform, the blade airfoil exhibiting two faces each connecting a leading edge with a trailing edge, and at least one second portion present only on one of the faces of the blade airfoil, said second portion constituting a preform of at least one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, and

- densification of the preform by a matrix to obtain a blade made of composite material having a fiber reinforcement consisting of the preform and densified by the matrix, and forming a single piece with at least a portion of one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, present only on one of the faces of the blade airfoil.

2. The method according to Claim 1, wherein, in the longitudinal direction of the fiber blank corresponding to the longitudinal direction of the vane to be fabricated, the fiber blank has a first set of several layers of yarns which are interlinked to constitute a first portion of the blank corresponding to the preform of the airfoil and the blade root, and a second set of several layers of yarns which are interlinked at least locally so as to constitute on one of the faces of the blade airfoil at least the second portion of the blank corresponding to a preform of one portion of at least one of the following element: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, in that the yarns of the first set of yarn layers are not linked to the yarns of the second set of yarn layers, and in that the first set of yarn layers is crossed by yarns from the second set of yarn layers at the or at each second portion of the blank.

3. The method according to Claim 1, wherein, in the longitudinal direction corresponding to the longitudinal direction of the fiber blank to be fabricated, the fiber blank includes:

- a first set of several yarn layers which are interlinked to form a first portion of the blank corresponding to the airfoil and blade root preform;

- a second set of several yarn layers which are interlinked at least locally to form on one of the faces of the airfoil at least one second portion of the blank corresponding to at least one of a preform of a blade inner platform portion and of a blade outer platform spoilers portion and at least one third portion of the blank corresponding to at least one of a preform of a blade anti-tilting wall portion and of a blade outer platform wiper portion;

the yarns of the first set of yarn layers are not linked to the yarns of the second set of yarn layers, and

the first set of yarn layers is crossed by yarns of the second set of yarn layers at the or at each second portion of the fiber blank and at the or at each third portion of the fiber blank.

4. The method according to Claim 3, wherein the fiber blank is woven with a second and a third continuous sets of yarn layers and the shaping of the fiber blank includes the elimination by cutting out of portions of the second set of yarn layers outside of the or of each second portion of the fiber blank and of the or of each third portion of the fiber blank.

5. The method according to Claim 1, wherein, in the longitudinal direction corresponding to the longitudinal direction of the fiber blank to be fabricated, the fiber blank comprises:

- a first set of several layers of yarns which are interlinked to form a first portion of the blank corresponding to the airfoil and blade root preform;

- a second set of several layers of yarns which are interlinked at least locally to form on one of the faces of the airfoil at least one second portion of the blank corresponding to the preform of a portion of a least one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers and a third portion of

the blank corresponding to the preform of all or a portion of said elements other than that constituted by the second portion; and

- a third set of several layers of yarns which are interlinked at least locally to form on one face of the airfoil at least one fourth portion of the blank corresponding to the preform of all or part of one of said elements other than that constituted by the second and third portions and a fifth portion of the blank, element corresponding to the preform of all or a portion of one of said elements other than that constituted by the second, third and fourth portions;

the yarns of the first set of yarn layers are not linked to the yarns of the second and third sets of yarn layers, and

the first set of yarn layers is crossed by yarns of the second and third sets of yarn layers at the second, third, fourth and fifth portions of the fiber blank.

6. The method according to Claim 5, wherein the fiber blank is woven with a second and a third continuous set of yarn layers and the shaping of the fiber blank includes the elimination by cutting out of portions of the second and third sets of yarn layers outside of the second, third, fourth and fifth portions of the fiber blank.

7. The method according to any one of Claims 1 to 6, wherein, in the first portion of the fiber blank and in a direction corresponding to that extending along the profile of an airfoil of variable thickness in the blade to be fabricated, the number of yarn layers in the first set of yarn layers is constant.

8. The method according to any one of Claims 1 to 7, wherein a strip is made by three-dimensional weaving, including a succession of fiber blanks.

9. A turbomachine blade made of composite material including a fiber reinforcement obtained by three-dimensional weaving of yarns and densified by a matrix, the blade including a first portion constituting an airfoil and a blade root, the blade airfoil exhibiting two faces each connecting a leading edge and a trailing edge,

wherein said first portion forms a single piece with at least one second portion present only on one of the faces of the blade airfoil, said second portion constituting a portion of at least one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers, the portions of the fiber reinforcement corresponding to the first and the second portions of the blade being at least partially mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second portion of the fiber reinforcement.

10. The blade according to Claim 9, wherein the second portion constitutes a portion of one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers and the first portion also forms a single piece with at least one third portion constituting a portion of at least one of the said elements other than that already constituted by said second portion, said third portion being present only on one face of the airfoil,

the portions of the fiber reinforcement corresponding to the first, second and third portions of the blade being at least partially mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second and third portions of the fiber reinforcement.

11. The blade according to Claim 10, wherein the first portion also forms a single piece with at least one fourth portion constituting a portion of at least one of said elements other than that constituted by said second and third portions, said fourth portion being present only on one face of the airfoil,

the portions of the fiber reinforcement corresponding to the first, second, third and fourth portions of the blade being at least partially mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second, third and fourth portions of fiber reinforcement.

12. The blade according to Claim 11, wherein the first portion also forms a single piece with at least one fifth portion constituting a portion of at least one of said elements other than

that constituted by said second, third and fourth portions, said fifth portion being present only on one face of the airfoil,

the portions of the fiber reinforcement corresponding to the first, second, third fourth and fifth portions of the blade being at least partially mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second, third, fourth and fifth portions of fiber reinforcement.

13. The blade according to Claim 9, wherein the second portion constitutes a portion of one of the following elements: blade inner platform, blade anti-tilting wall, blade outer platform spoilers and blade outer platform wipers and the first portion forms a single piece with at least one third portion constituting all or a portion of at least one of said elements other than that constituted by said second portion,

the portions of the fiber reinforcement corresponding to the first, second and third portions of the blade being at least partially mutually imbricated, with yarns of the first portion of the fiber reinforcement penetrating into the second and third portions of the fiber reinforcement.

14. A turbomachine disk including a plurality of blades according to any one of Claims 9 to 13.

15. A turbomachine equipped with a blade according to any one of Claims 9 to 13 or fabricated according to the method of any one of Claims 1 to 8.

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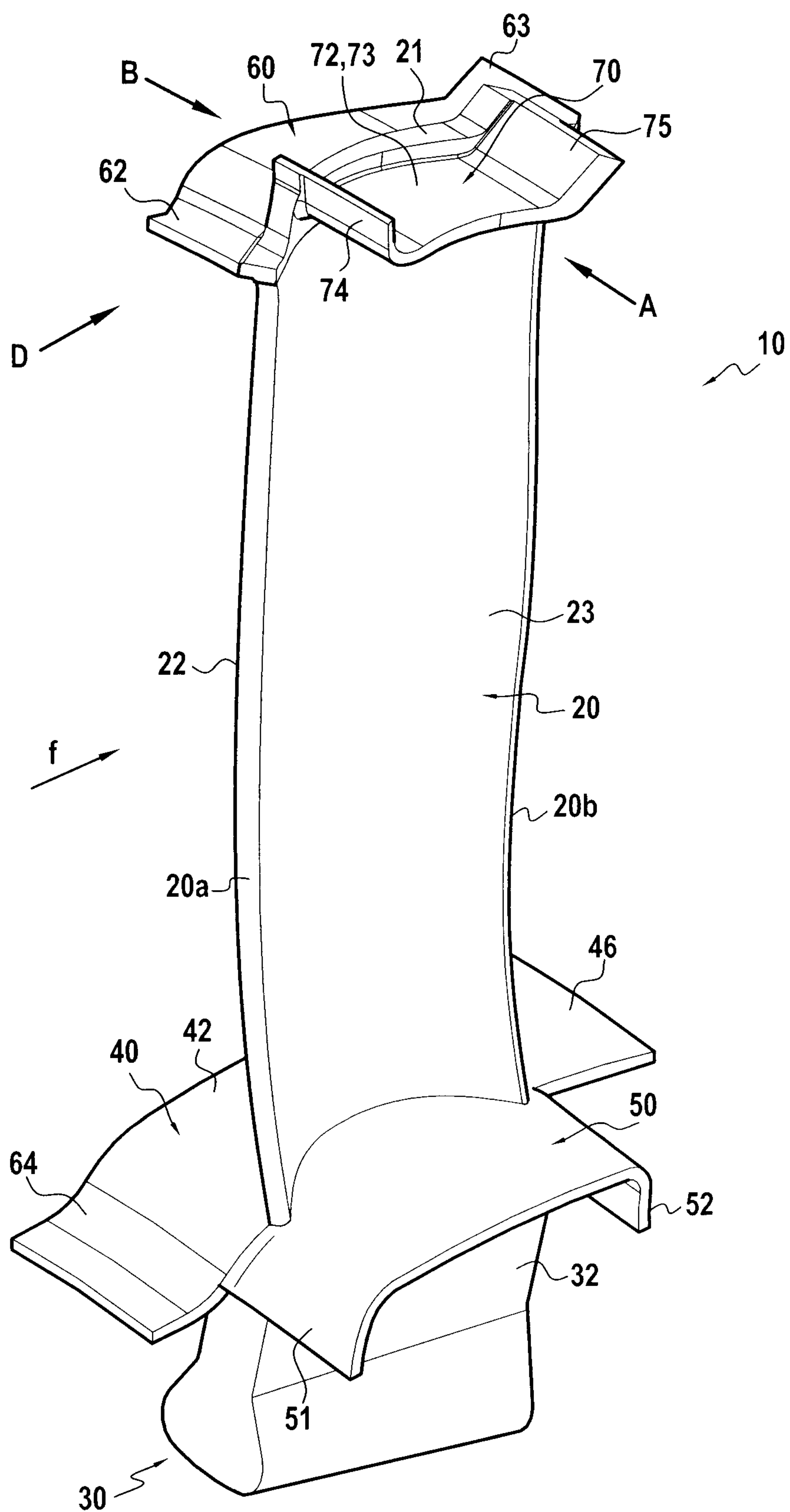


FIG.1

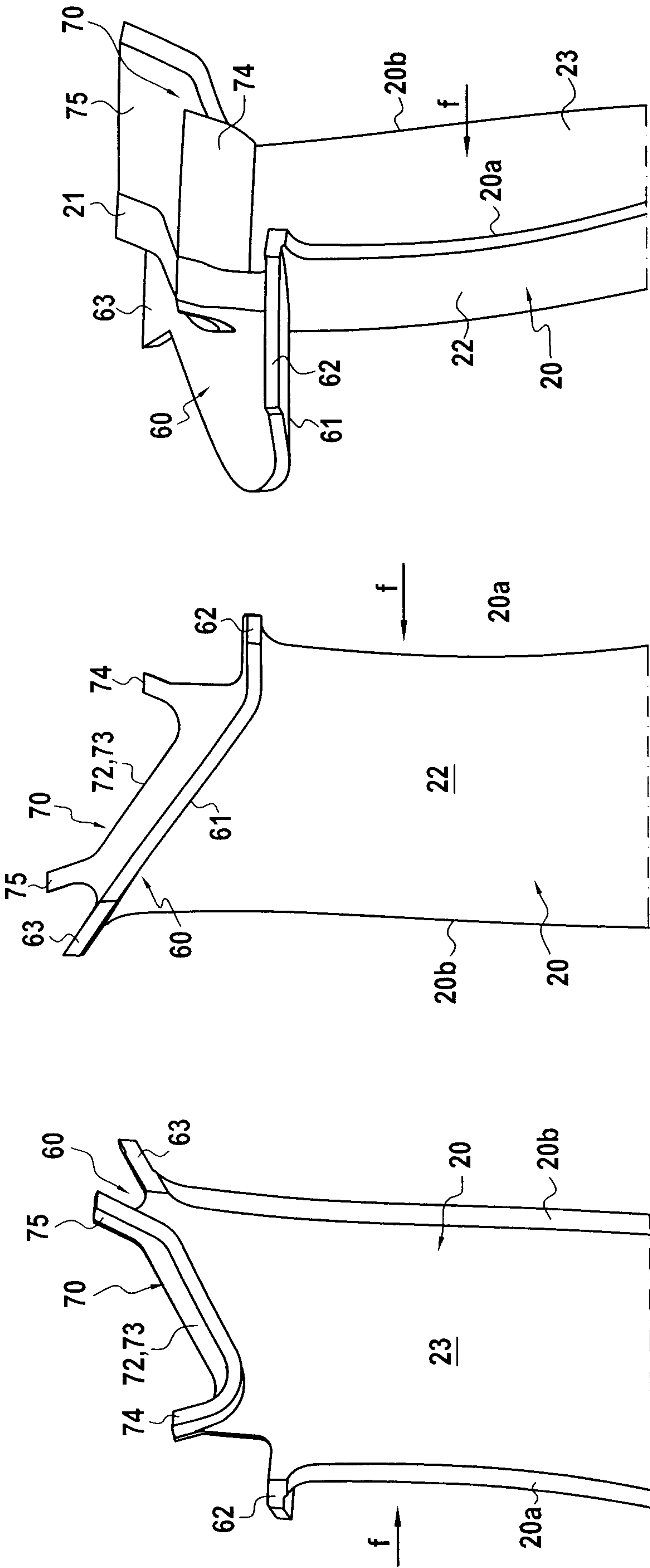


FIG.2A

FIG.2B

FIG.2C

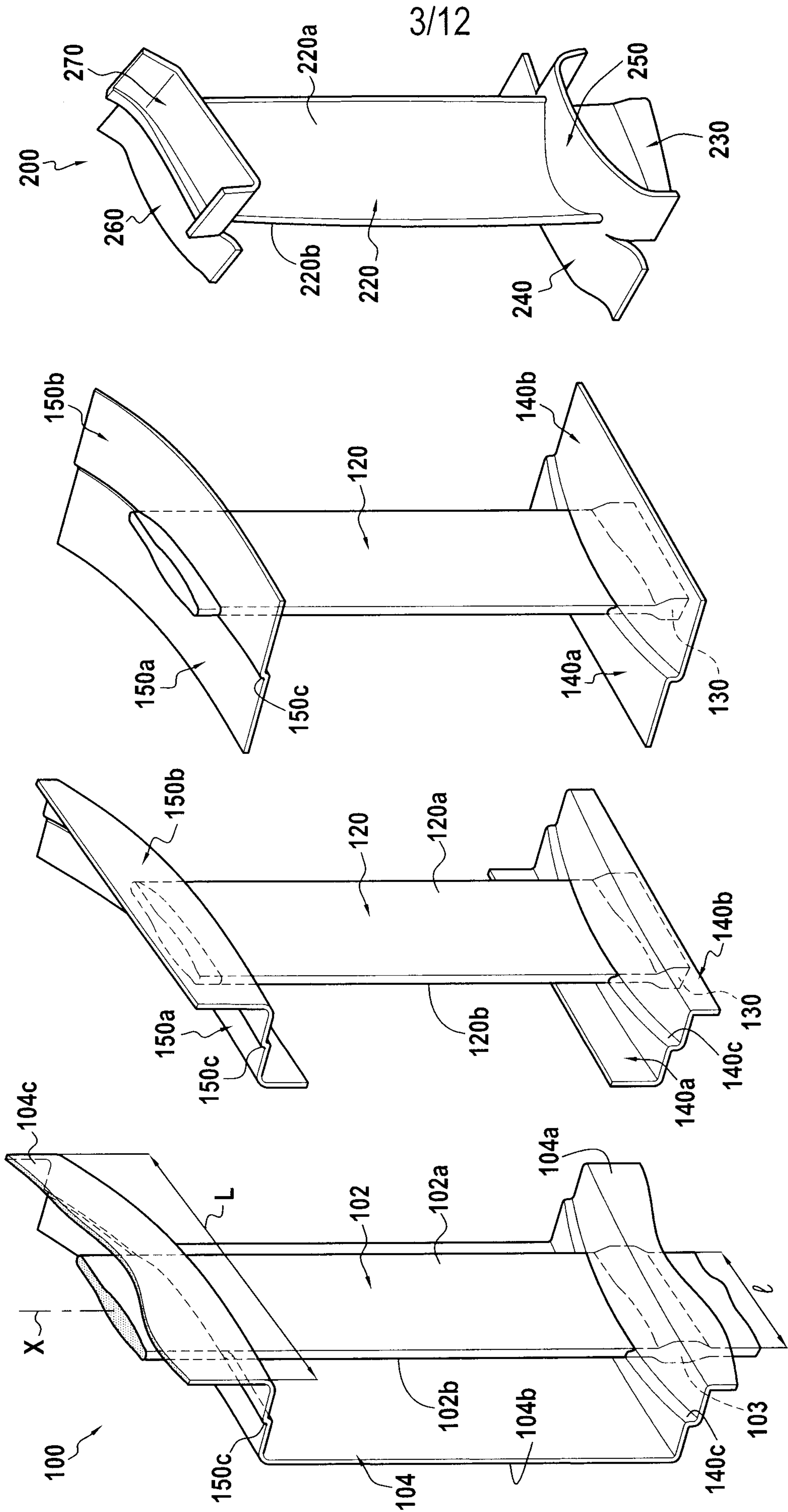
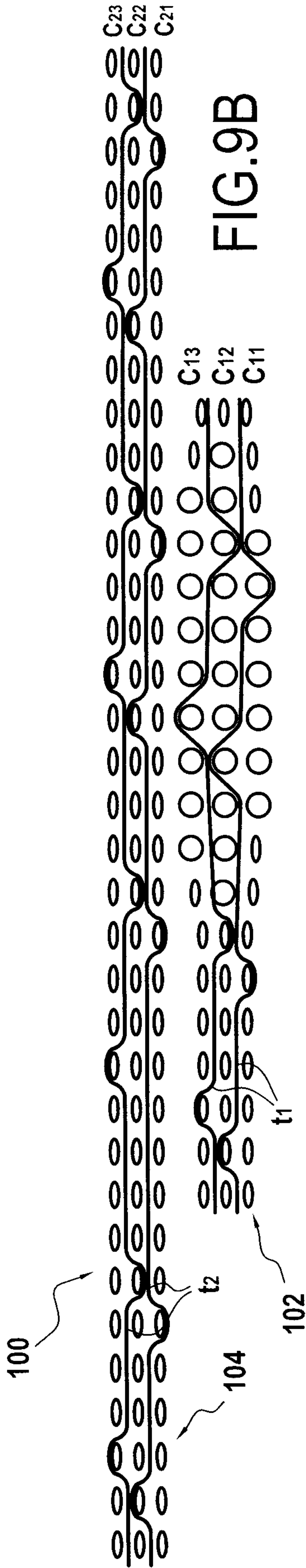
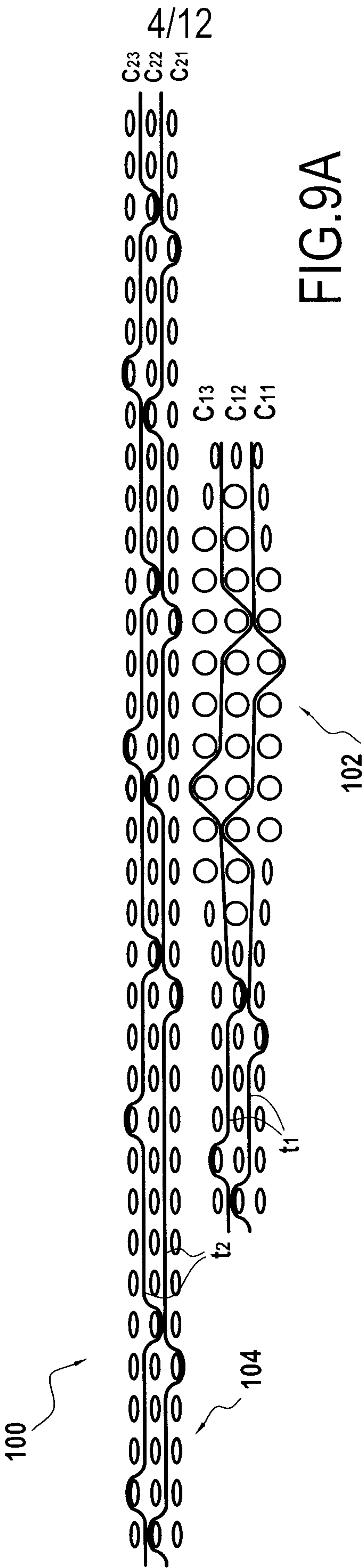


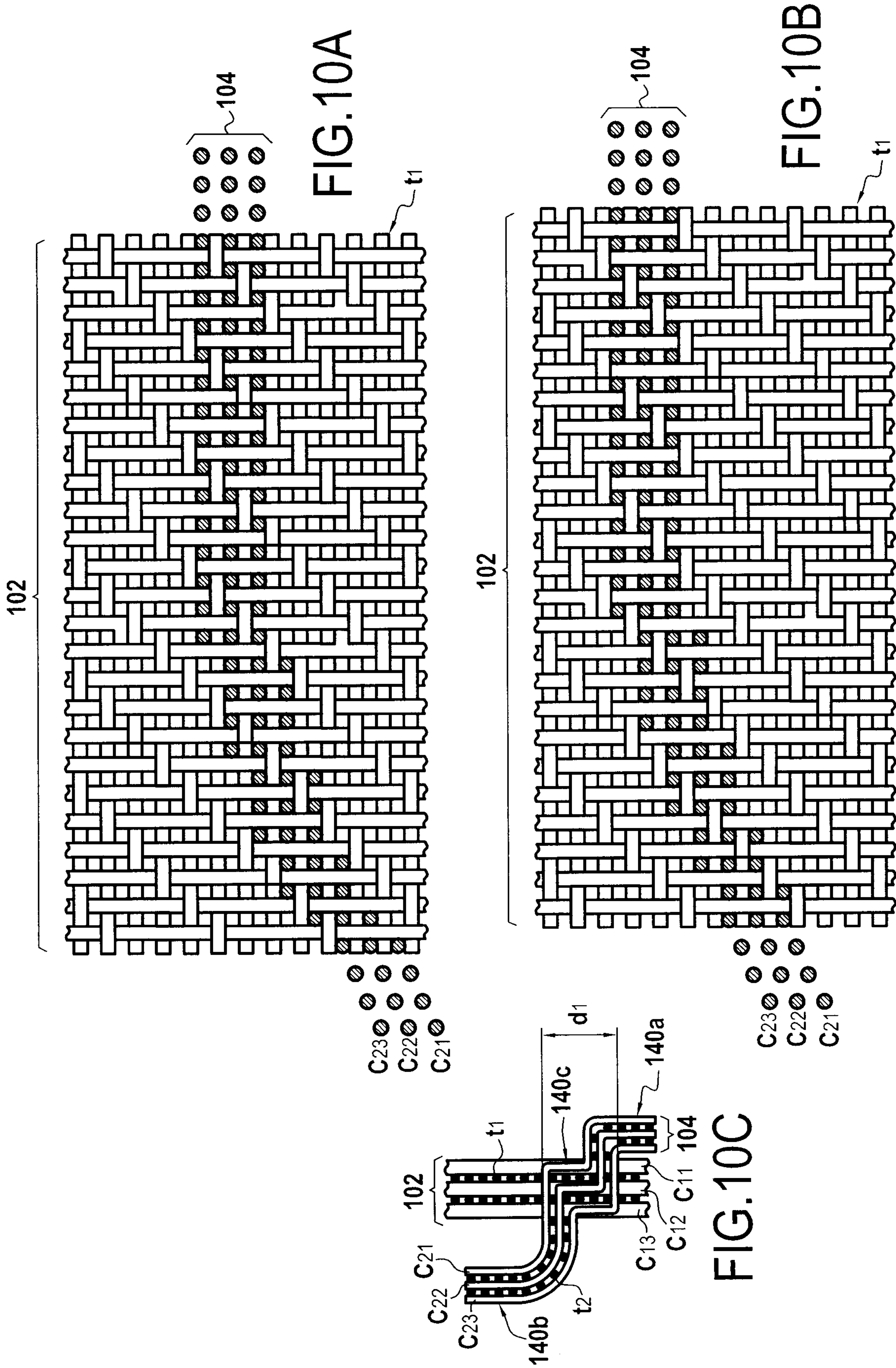
FIG.3

FIG.4

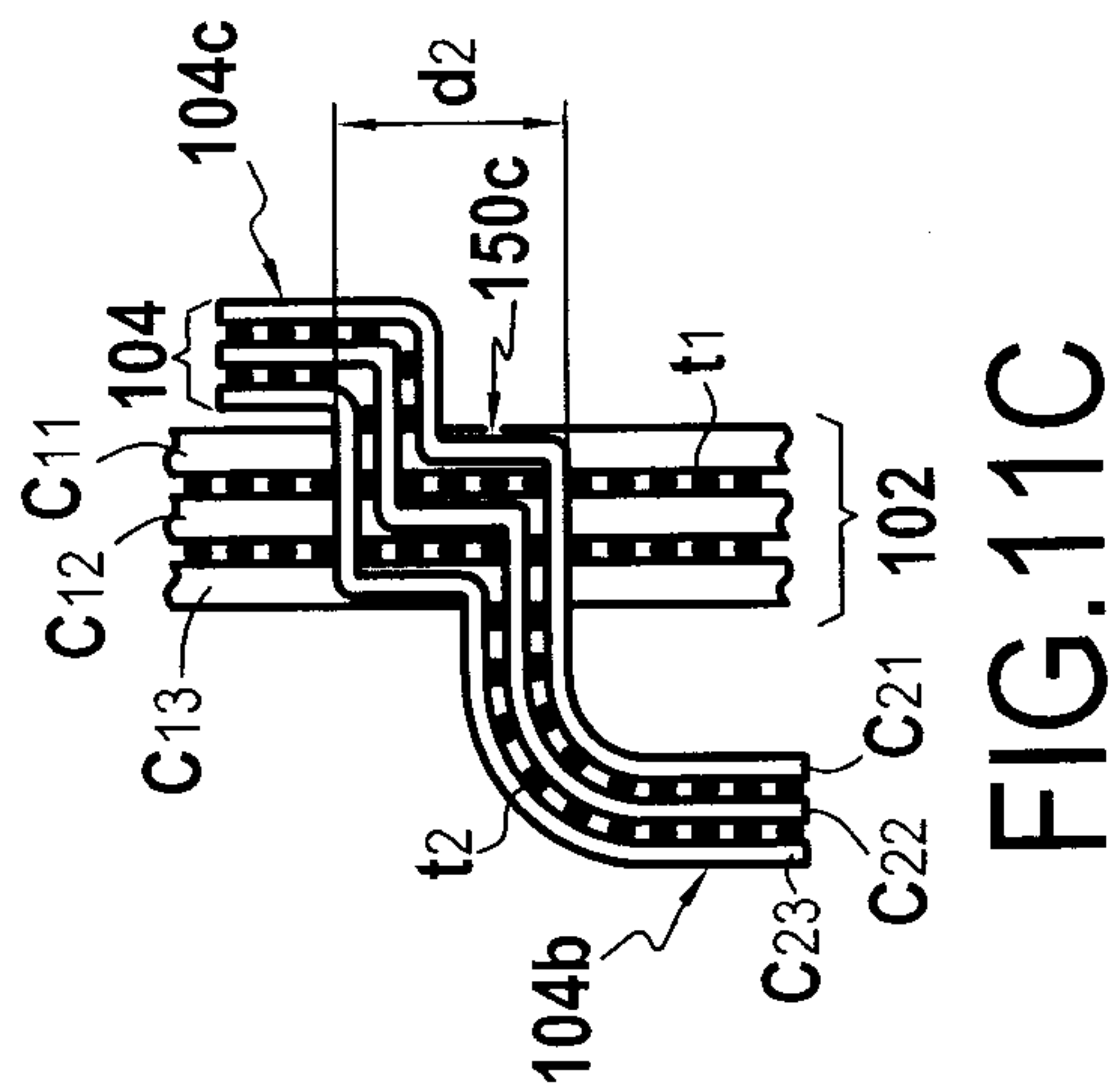
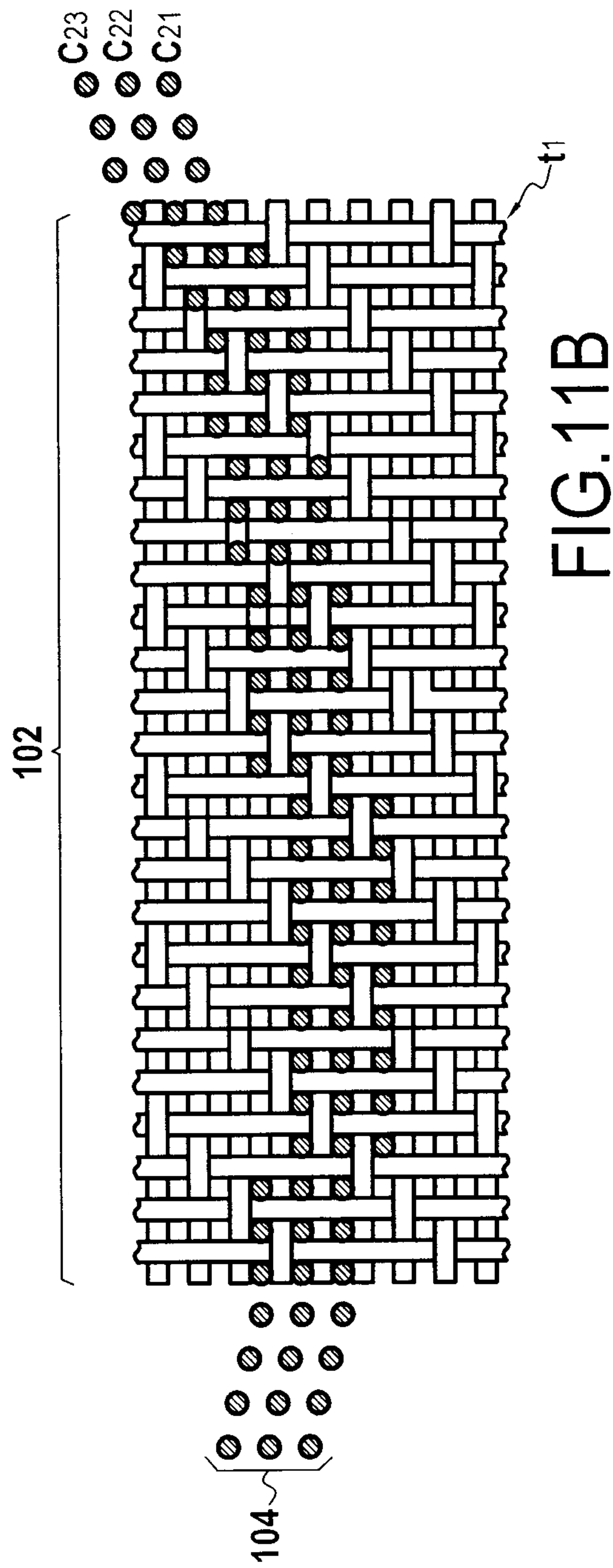
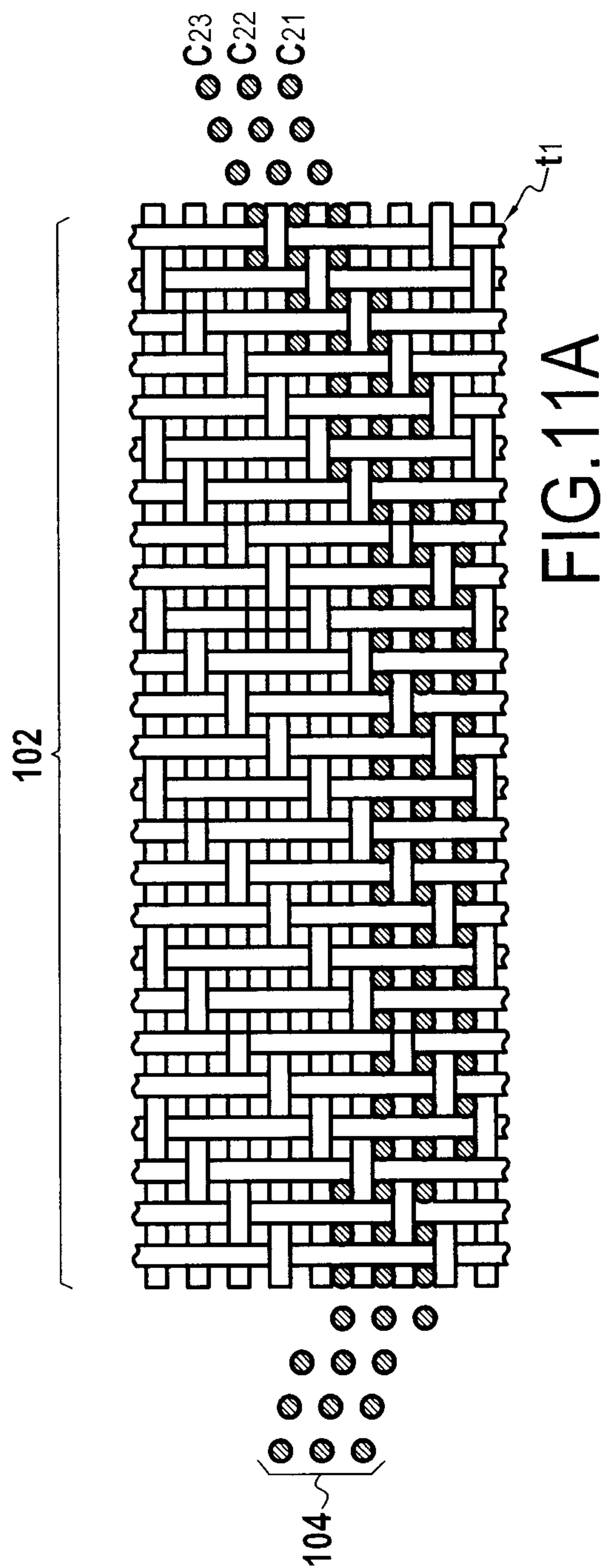
FIG.5

FIG.6





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FIG.12A

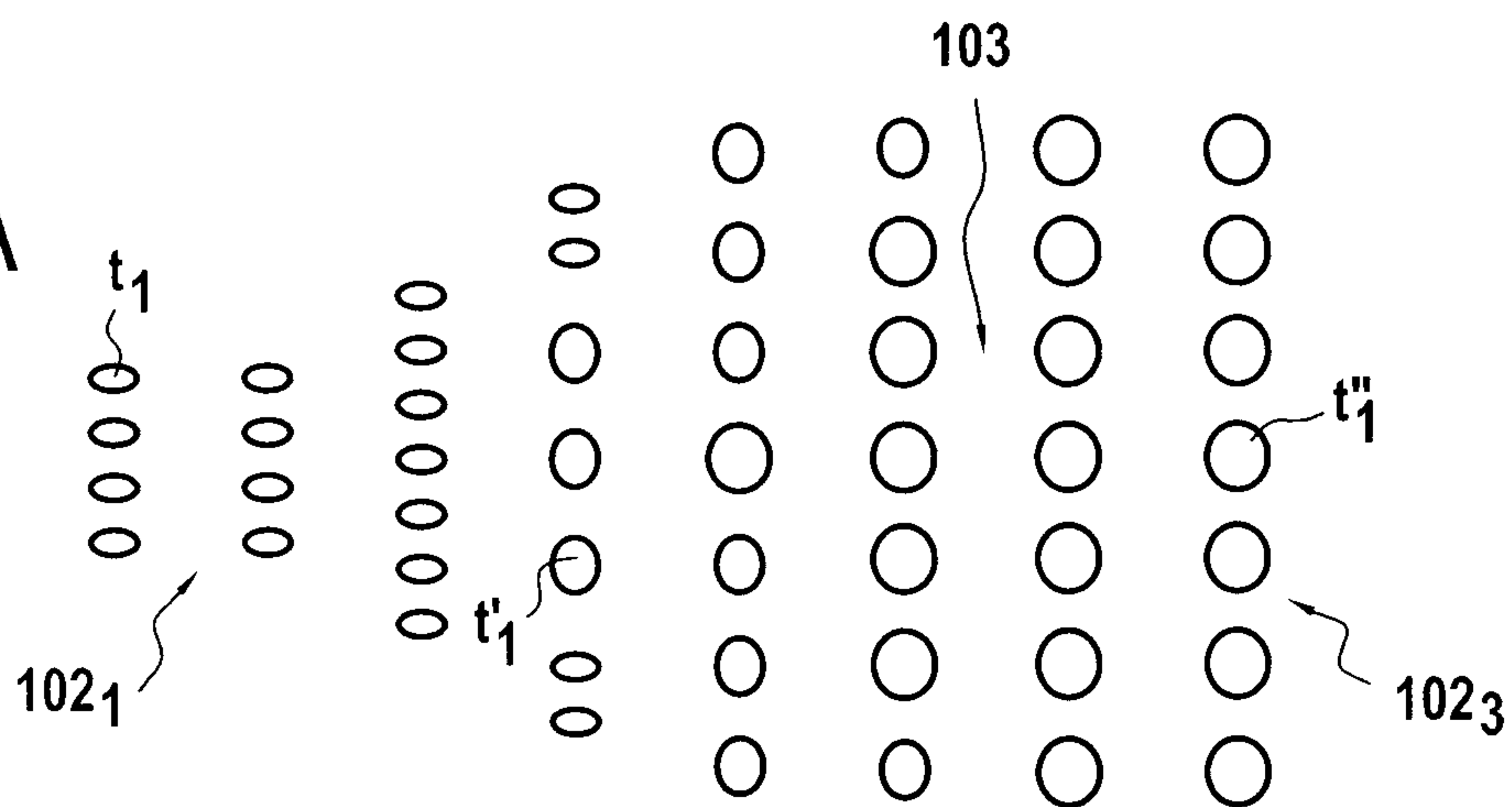


FIG.12B

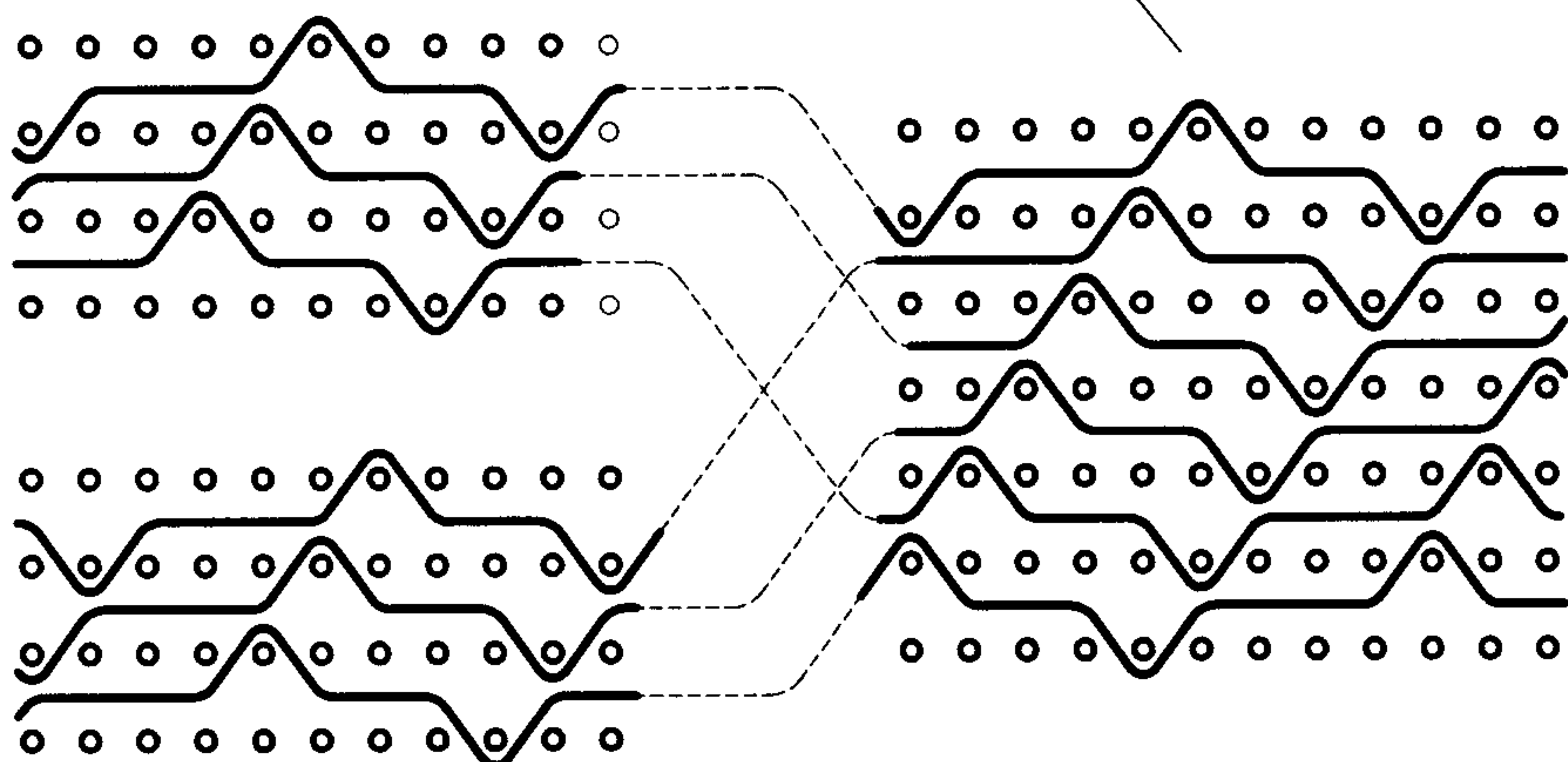


FIG.12C

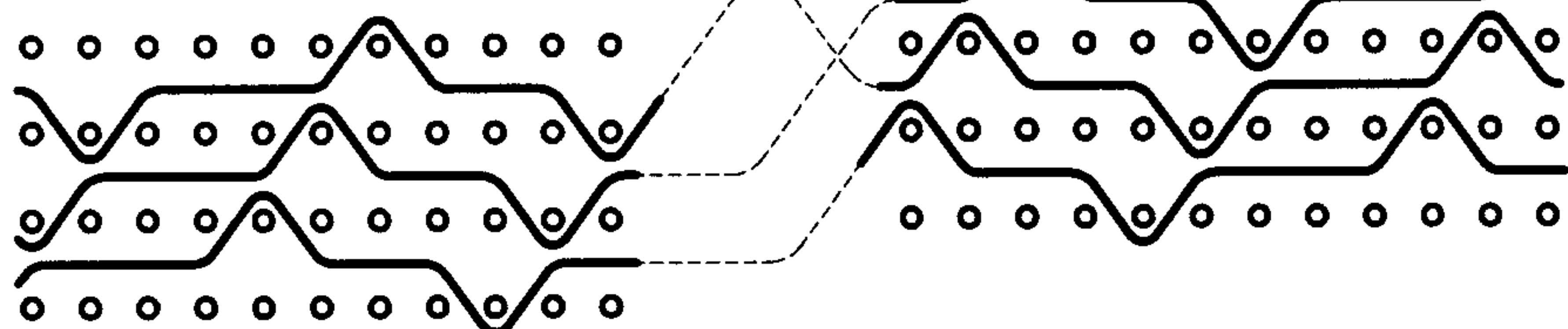


FIG.12D

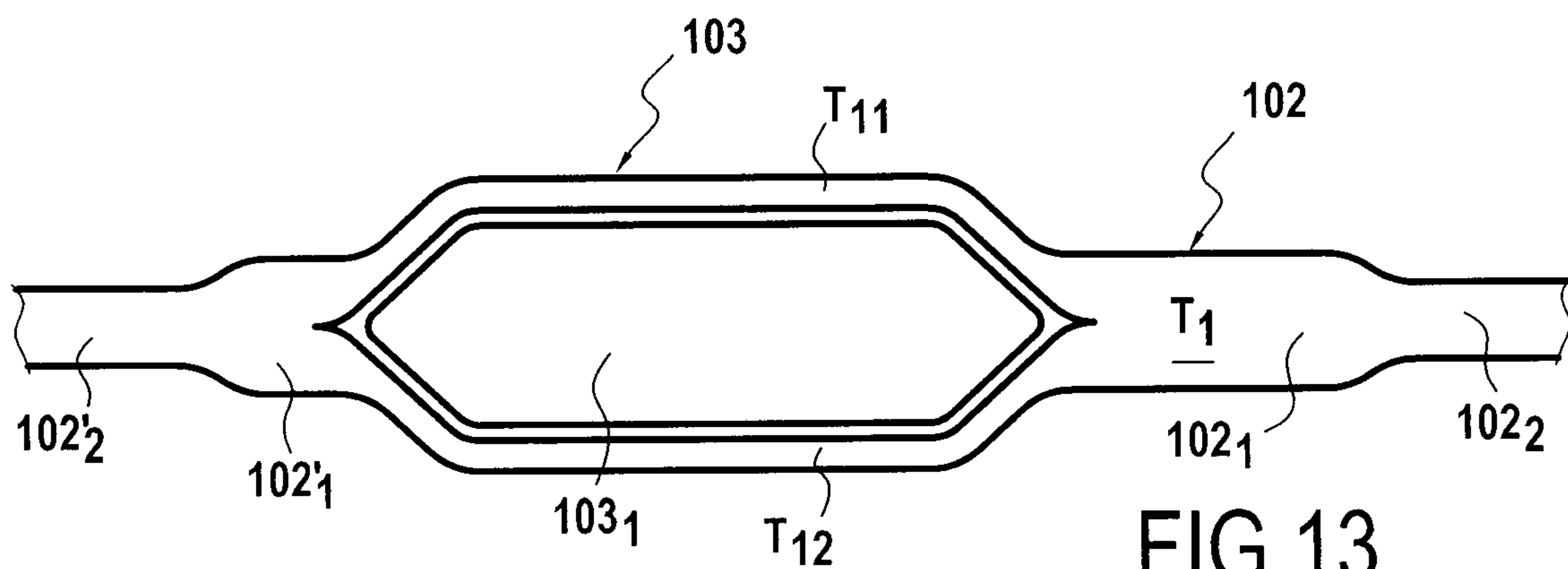


FIG.13

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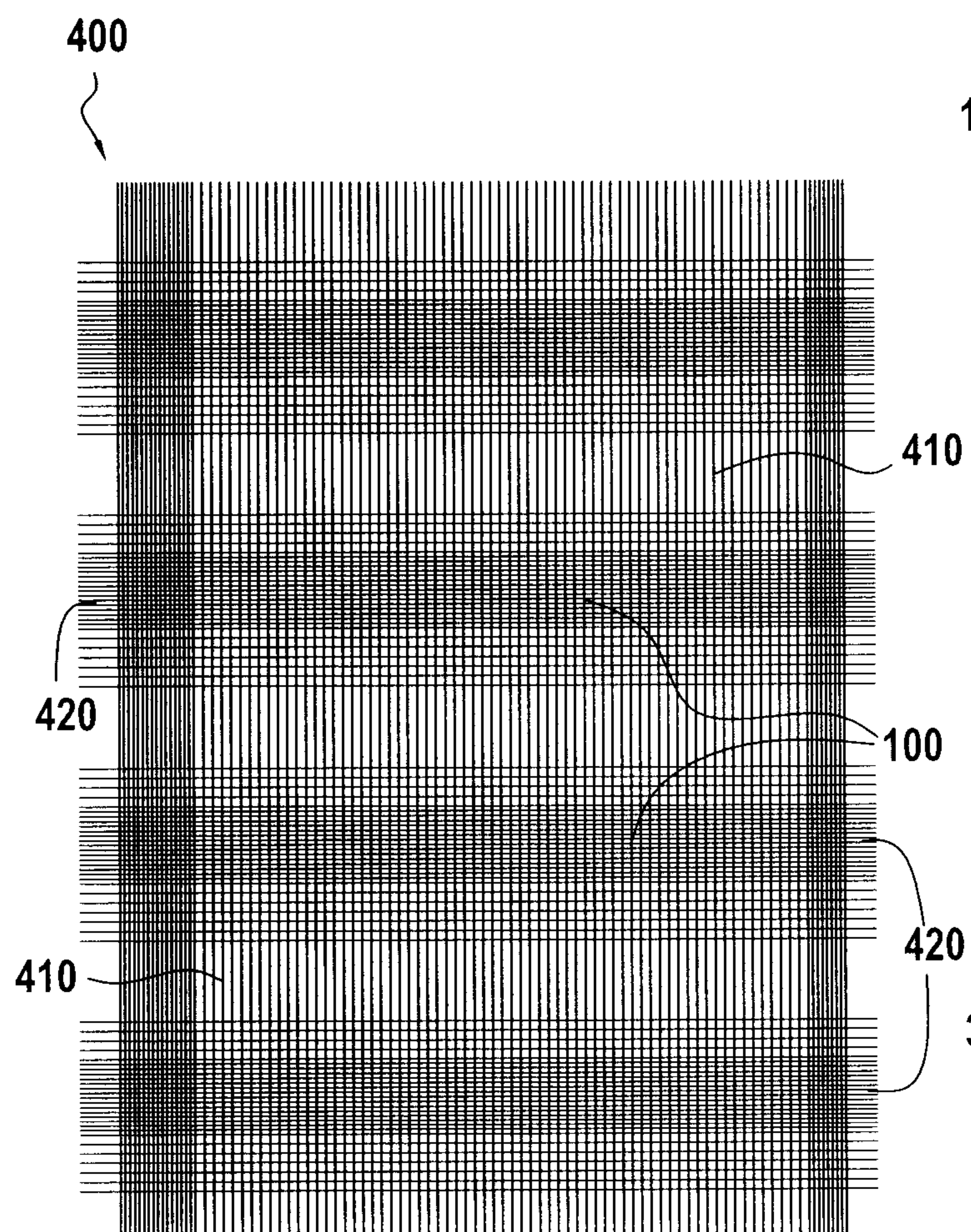


FIG.15

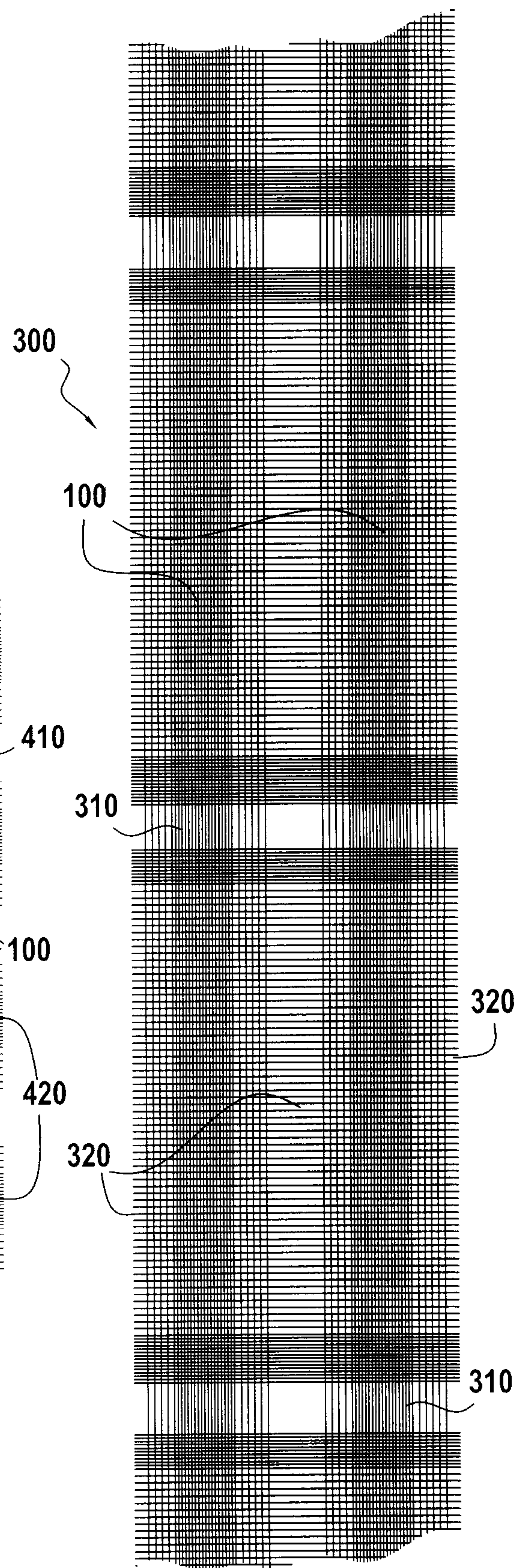


FIG.14

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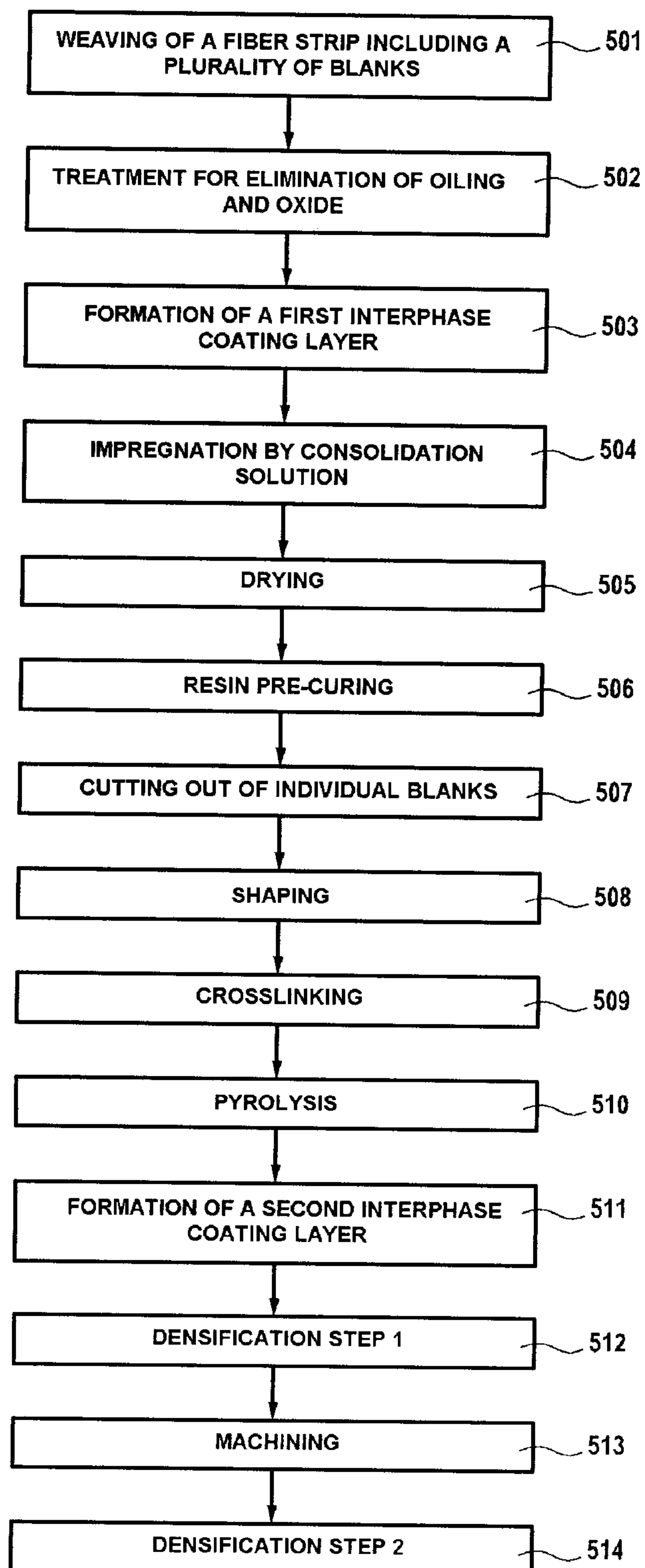


FIG.16

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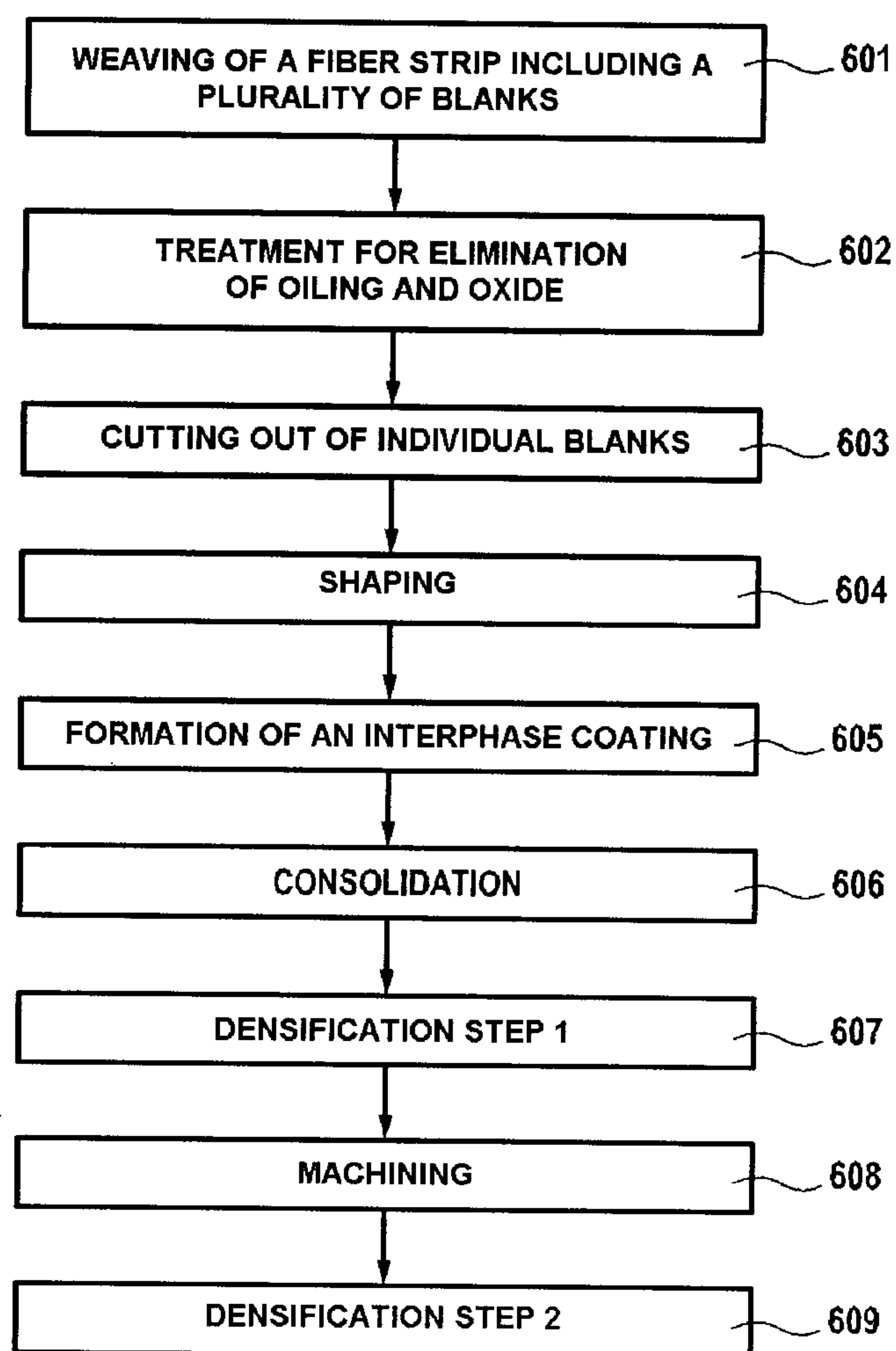
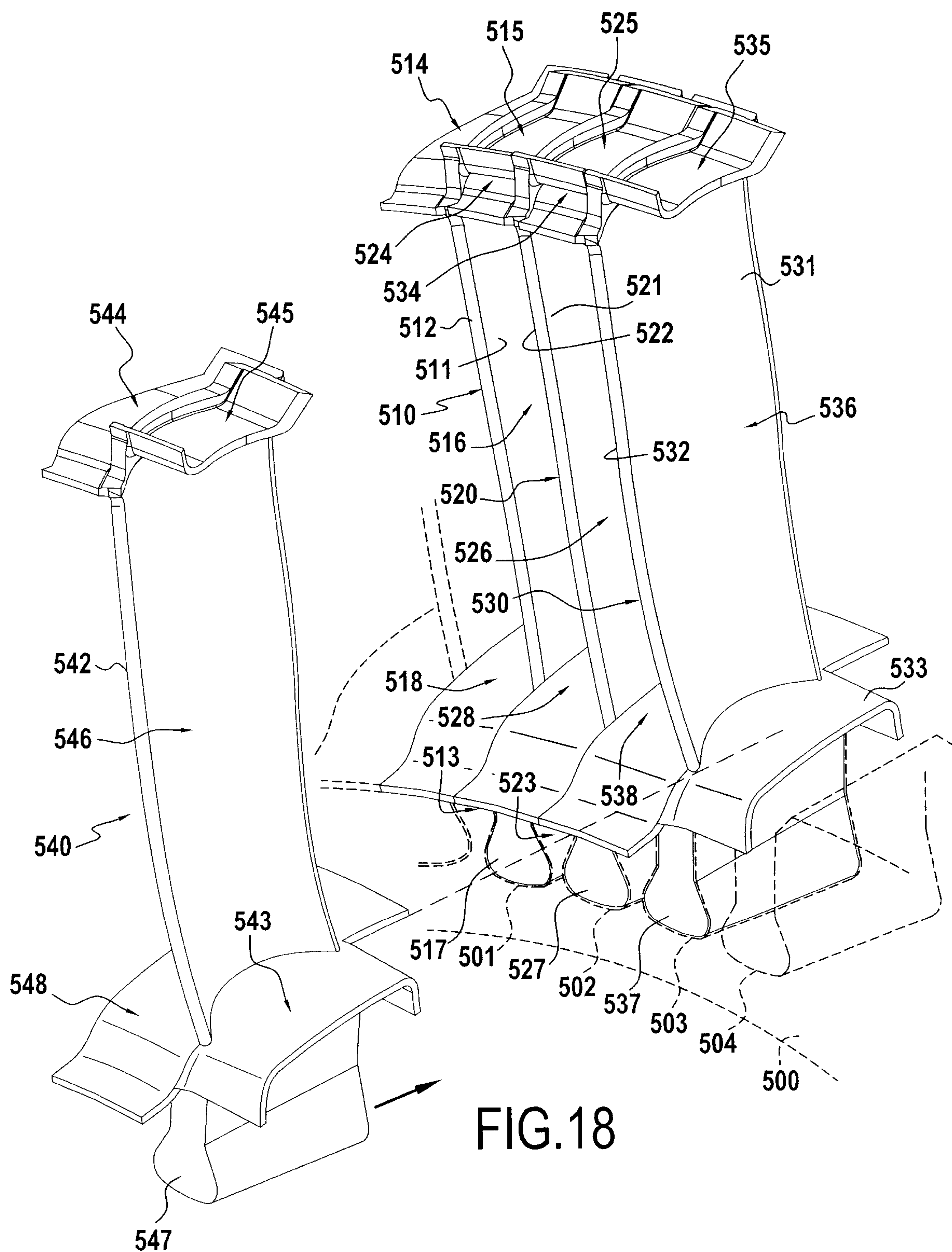


FIG.17

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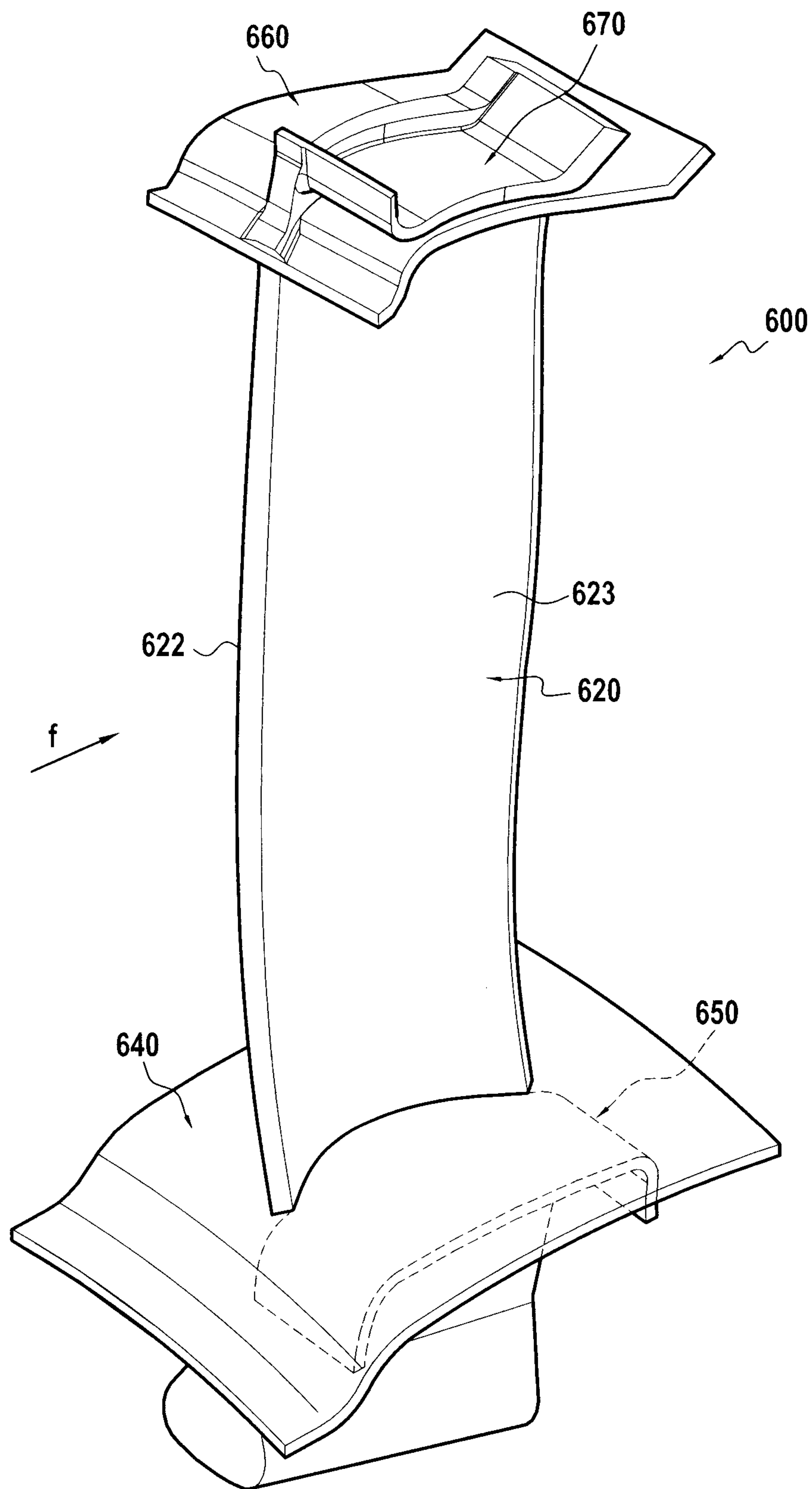


FIG.19

