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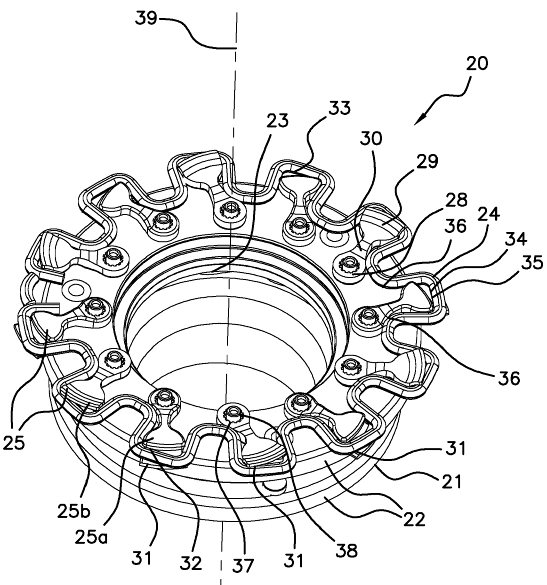
(54) **METHOD OF MANUFACTURING A RING FOR CONTROLLING THE ANGULAR POSITION OF BLADES OF A STATIONARY TURBOMACHINE BLADE ASSEMBLY**

(57) The invention relates to a method of manufacturing a ring, named control ring (33), of a mechanism (24) for controlling the angular position of blades of a blade assembly, named stationary blade assembly (21), of a turbomachine,
- a stationary blade assembly (21), comprising:
◦ two rings (22) coaxial along an axis, named main axis (39),
◦ a plurality of blades (23), each blade (23) is mounted to pivot with respect to the two rings (22) of the stationary blade assembly,

- the mechanism (24) for controlling the angular position of the blades of the stationary blade assembly comprising:
◦ a plurality of levers (25) including at least one lever, named driving lever,
◦ said control ring (33) being able to be rotationally driven about the main axis and defining at least one housing (34) for receiving a driving lever, characterised in that the control ring (33) and each receiving housing (34) are formed by bending a metal strip which is plastically deformable under bending.

Fig 1



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Description

[0001] The invention relates to a method of manufacturing a ring, named control ring, for controlling the angular position of blades of a blade assembly, named stationary blade assembly, fixedly attached to a turbomachine stator of a turbomachine. The invention also relates to a control ring manufactured by such a manufacturing method and a turbomachine fluid guiding stator device comprising such a control ring.

[0002] Throughout the text, "turbomachine" is intended to mean, as is usual, any machine through which a fluid passes and which receives (turbine) and/or generates (compressor, blower, fan, pumps) fluidic energy, comprising a stator and at least one wheel mounted to rotate with respect to the stator about a main axis of the machine. Each wheel is provided with a blade assembly (assembly of a plurality of blades), named mobile blade assembly, and is in fluid communication with a fluid guiding stator device comprising a blade assembly, named stationary blade assembly, fixedly attached to the stator. Depending upon the applications, a turbomachine may be: axial or radial; with incompressible fluid (liquid) or with compressible fluid (air, gas, vapours ...).

[0003] In particular, a turbine is a turbomachine receiving fluidic energy comprising a stator and at least one wheel mounted to rotate with respect to the stator about a main axis of the turbine. Each wheel of the turbine is provided with a mobile blade assembly supplied with fluid from a fluid guiding stator device, named distributor, comprising a stationary blade assembly fixedly attached to the stator. Similarly, a compressor is a turbomachine generating fluidic energy comprising a stator and at least one wheel mounted to rotate with respect to the stator about a main axis of the compressor. Each wheel of the compressor is provided with a mobile blade assembly delivering the fluid into a fluid guiding stator device, named diffusor, comprising a stationary blade assembly fixedly attached to the stator. A turbomachine can also be a turbocompressor, i.e. a machine which combines the functions of a turbine and compressor and thus has a distributor for the turbine and a diffusor for the compressor.

[0004] Therefore, a turbomachine fluid guiding stator device is a device adapted to guide a flow of fluid, in particular to a turbine or even for guiding a flow of fluid from a compressor.

[0005] Some fluid guiding devices comprise a stationary blade assembly having a variable cross-section, i.e. a blade assembly comprising a plurality of blades interposed between two coaxial rings along a main axis defining a passage, named fluid passage:

- the blades of said plurality of blades being arranged so as to form, in the fluid passage between every two blades and between the rings of the blade assembly, a plurality of channels,
- each blade of said plurality of blades being mounted to rotate on an axis of rotation secant to the guiding faces, such that a modification of the angular position of the blade results in a modification of the geometric characteristics of each channel delimited by this blade.

[0006] Furthermore, a control mechanism is provided to modify the angular position of the blades.

[0007] Such a guide stator device with a stationary blade assembly having a variable cross-section is adapted to adjust a flow rate and a direction of a flow of fluid passing through said fluid passage depending upon operating conditions of the turbomachine, e.g. based on the state of the turbomachine.

[0008] Numerous mechanisms are known for controlling the angular position of the blades of a stationary blade assembly having a variable cross-section of a turbomachine fluid guiding stator device. In particular, such a known mechanism for controlling the angular position of blades can comprise:

- a control ring coaxial with respect to the rings of the stationary blade assembly with a variable cross-section, the control ring being able to be rotationally driven about the main axis with respect to the stationary blade assembly,
- a plurality of levers rotationally coupled to the blades of said plurality of blades of the stationary blade assembly with a variable cross-section, at least some of these levers co-operating, in rotation, with said control ring.

[0009] Rotationally driving the control ring about the main axis thus allows the levers of said plurality of levers to be rotationally guided so as to modify the angular position of the blades of the stationary blade assembly.

[0010] More particularly, the control ring can have a plurality of radial housings, named receiving housings, adapted to receive said plurality of levers, each lever of said plurality of levers having a proximal end rotationally coupled to a blade of said plurality of blades and a distal end, named head, arranged in a receiving housing of the control ring.

[0011] Numerous turbomachine fluid guiding devices are known for which the control ring is manufactured by a die-cutting process from a metal plate. In particular, the main circular shape of the control ring and the receiving housings of the control ring are cut from a metal plate. Therefore, in such a method of manufacturing the control ring, only a zone cut from said metal plate is used to form said guide ring. Such a manufacturing method is expensive because the zones of the metal plate not forming the metal ring may not subsequently be used and discarded.

[0012] The invention aims to overcome these disadvantages.

[0013] The invention thus aims to propose a method of manufacturing a ring for controlling the angular position of the blades of a stationary blade assembly of a turbomachine which is inexpensive.

[0014] The invention aims more particularly to propose such a manufacturing method which allows any waste to be avoided.

[0015] The invention also aims to propose such a manufacturing method which is simple and quick to implement.

[0016] To this end, the invention relates to a method of manufacturing a ring, named control ring, of a mechanism for controlling the angular position of blades of a blade assembly, named stationary blade assembly, of a turbomachine,

- the stationary blade assembly being fixedly attached to a turbomachine stator, and comprising:

    ◦ two rings coaxial along an axis, named main axis,
    ◦ a plurality of blades held between the coaxial rings of the stationary blade assembly and disposed around said main axis, each blade being mounted to pivot with respect to the two rings of the stationary blade assembly, said plurality of blades comprising at least one blade, named driven blade,

- the mechanism for controlling the angular position of the blades of the stationary blade assembly comprising:

    ◦ a plurality of levers including at least one lever, named driving lever, each driving lever being rotationally coupled with a single driven blade and each driven blade being coupled with a single driving lever,
    ◦ said control ring being coaxial with the two rings of the stationary blade assembly and being able to be rotationally driven about the main axis with respect to the two rings of the stationary blade assembly and defining at least one housing for receiving a driving lever, said driving lever being placed in this receiving housing so as to co-operate, in rotation, with the control ring,

    characterised in that the control ring and each receiving housing are formed by bending at least one metal strip, named initial strip, which is plastically deformable under bending.

[0017] Therefore, the invention aims to obtain, for the first time, a method in accordance with the invention for manufacturing a control ring allowing any machining which may produce waste to be avoided. In fact, forming receiving housings does not require any cutting from said initial strip because the receiving housings are formed by bending said initial strip.

[0018] The absence of waste during the manufacture of the control ring allows a reduction in the quantity of material used for manufacturing a control ring of a mechanism for controlling the angular position of blades of a stationary blade assembly of a turbomachine, and thus a reduction in the costs for producing this control ring. A manufacturing method in accordance with the invention is therefore inexpensive. Furthermore, a manufacturing method in accordance with the invention is simple and quick to implement.

[0019] In some advantageous embodiments, the control ring and each receiving housing are formed by bending only one initial strip. However, there is nothing to prevent the provision of a control ring formed by bending a plurality of initial strip and by joining them together.

[0020] Preferably, said initial strip is bent by a bending machine or a corresponding set of bending tools.

[0021] More particularly, in a method in accordance with the invention:

- in a first step, each initial strip which is plastically deformable under bending is chosen,
- each initial strip is shaped by bending by plastic deformation thereof to impart the shape of a control ring thereto, defining each receiving housing,
- each initial strip having two portions, named assembly portions, and each assembly portion is assembled with another assembly portion in order to form said control ring.

[0022] Therefore, in a manufacturing method in accordance with the invention, each initial strip is bent to impart a wavy shape thereto so as to define each receiving housing and said assembly portions are connected so as to form the control ring.

[0023] More particularly, in some embodiments in which said control ring is made from only one initial strip, the initial strip has two assembly portions which are assembled together in order to form said control ring.

[0024] In particular, in some advantageous embodiments, the initial strip has a uniform cross-section over its length. However, there is nothing to prevent the provision of an initial strip having a non-uniform cross-section over its length. For example, said initial strip can have a variable thickness over its length. Therefore, said initial strip can be provided with sections which are thicker than other sections of said initial strip. These thicker sections can be arranged on said initial strip depending upon the position of zones of the control ring which may be subjected most to mechanical stresses.

[0025] Any cross-sectional shape of said initial strip can be provided. For example, the shape of the cross-section of said initial strip can be selected from a rectangular shape, circular shape and hexagonal shape. Nevertheless, in some preferred embodiments in accordance with the invention, a wire having a circular cross-section is used as the initial strip.

[0026] The use of a metal wire having a circular cross-section allows the manufacture of the control ring to be facilitated, the metal wire being able to be bent in any transverse direction. Furthermore, the use of a metal wire allows the weight of the control ring to be reduced overall.

[0027] In some advantageous embodiments in accordance with the invention, said initial strip is manufactured from a material selected from steel, copper and brass. Preferably, said initial strip is made from steel.

[0028] In some advantageous embodiments in accordance with the invention, each initial strip to be formed is cut at a predetermined length *d* in a strip, named raw strip, which is made of metal and plastically deformable under bending and has a length *D* greater than *d.* Said raw strip can thus be used to manufacture a plurality of control rings. Therefore, said raw strip preferably has a length *D* greater than or equal to 2*d*.

[0029] Said initial strip is preferably cut in said raw strip after said initial strip has been bent. Nevertheless, there is nothing to prevent a manufacturing method being provided in which said initial strip is cut from said raw strip prior to bending said initial strip..

[0030] Preferably, a straight initial strip is used as the starting point. The initial strip is then bent to obtain a circular shape. In some embodiments, the initial strip is bent to have a circular shape after each receiving housing has been formed. In some other embodiments, in particular when the control ring has to have a plurality of receiving housings, the circular shape of the control ring is obtained whilst forming said receiving housings.

[0031] Preferably, in order to form a receiving housing, said initial strip is bent at least once in a first direction and then at least once in a second direction opposite to said first direction and then at least once in said first direction.

[0032] Preferably, each receiving housing is delimited by a surface, named drive surface, of said initial strip defining a base of this receiving housing and extending at least substantially in a plane in parallel with said main axis and with a tangent to the control ring at this receiving housing. In order to form such a drive surface which is at least substantially flat, said initial strip is bent at least once in a first direction and then twice at two separate points in a second direction opposite to said first direction and then at least once in said first direction. Therefore, the drive surface is formed between said two separate points.

[0033] The use of a lever having a radial support which can be placed in contact with such a drive surface so that the control ring can rotationally drive this lever allows slide-free rolling of this lever against said control ring to be achieved.

[0034] Furthermore, said assembly portions are spaced apart from each other by a distance at least substantially equal to the perimeter of the control ring.

[0035] In some advantageous embodiments, said assembly portions are longitudinal ends of said initial strip.

[0036] Nevertheless, as a variant, provision can be made to have said assembly portions between said longitudinal ends of said initial strip and to cut, after assembly, said protruding portions which do not form the control ring between the assembly portions and said longitudinal ends.

[0037] In some advantageous embodiments in accordance with the invention, said assembly portions are assembled by welding.

[0038] Nevertheless, other types of assembly can be provided. For example, it is possible to provide two longitudinal ends of said initial strip, in particular when it has a rectangular cross-section, having conjugate shapes so as to provide for their assembly by nesting.

[0039] In some embodiments, each assembly portion is formed by an edge of an end of an initial strip.

[0040] More particularly, in some embodiments in which said control ring is formed by only one initial strip, said initial strip comprises two ends each having an edge, in particular a flat edge. Therefore, in some preferred embodiments, the edges of the two ends of said initial strip are assembled together to form the control ring. The edges of the two ends thus face one another.

[0041] In other embodiments in which said control ring is formed by a plurality of initial strips, the edges of the ends of said initial strips are joined together to form said control ring.

[0042] Furthermore, said assembly portions each have a boundary. In some embodiments, said assembly portions are assembled on their boundary.

[0043] In other embodiments, said assembly portions are assembled by welding, to said assembly portions, a metal strip, named junction strip, interposed between said assembly portions. The longitudinal ends of said junction strip are preferably welded to said assembly portions. Said junction strip can be cut from said raw strip.

[0044] The invention relates to a ring, named control ring, of a mechanism for controlling the angular position of blades of a blade assembly, named stationary blade assembly, of a turbomachine,

- the stationary blade assembly being fixedly attached to a turbomachine stator, and comprising:
    - two rings coaxial along an axis, named main axis,
    - a plurality of blades held between the coaxial rings of the stationary blade assembly and disposed around said main axis, each blade being mounted to pivot with respect to the two rings of the stationary blade assembly, said plurality of blades comprising at least one blade, named driven blade,
- the mechanism for controlling the angular position of the blades of the stationary blade assembly comprising:
    - a plurality of levers including at least one lever, named driving lever, each driving lever being rotationally coupled with a single driven blade

and each driven blade being coupled with a single driving lever,

◦ said control ring being coaxial with the two rings of the stationary blade assembly and being able to be rotationally driven about the main axis with respect to the two rings of the stationary blade assembly and defining at least one receiving housing of a driving lever, said driving lever being placed in said receiving housing so as to cooperate, in rotation, with the control ring,

characterised in that the control ring and each receiving housing are formed by at least one metal strip, named initial strip, which is plastically bent.

[0045] In particular, such a control ring is manufactured as per a manufacturing method in accordance with the invention.

[0046] The invention also relates to a fluid guiding stator device comprising a turbomachine fluid guiding stator device, comprising:

- a blade assembly, named stationary blade assembly, comprising:

  ◦ two rings coaxial along an axis, named main axis,

  ◦ a plurality of blades held between the coaxial rings of the stationary blade assembly and disposed around said main axis, each blade being mounted to pivot with respect to the two rings of the stationary blade assembly, said plurality of blades comprising at least one blade, named driven blade,

- a mechanism for controlling the angular position of the blades of the stationary blade assembly, comprising:

  ◦ a plurality of levers including at least one lever, named driving lever, each driving lever being rotationally coupled with a single driven blade and each driven blade being coupled with a single driving lever,

  ◦ said control ring being coaxial with the two rings of the stationary blade assembly and being able to be rotationally driven about the main axis with respect to the two rings of the stationary blade assembly and defining at least one receiving housing of a driving lever, said driving lever being placed in said receiving housing so as to cooperate, in rotation, with the control ring,

characterised in that the control ring and each receiving housing are formed by at least one metal strip, named initial strip, which is plastically bent.

[0047] In particular, a control ring of such a stator guide device is manufactured as per a manufacturing method in accordance with the invention.

[0048] More particularly, in some embodiments, one of the two rings of the stationary blade assembly is formed in the stator of the turbomachine. Nevertheless, in some other embodiments, both of the rings of the stationary blade assembly are formed in two pieces which are distinct from the stator.

[0049] In some advantageous embodiments in accordance with the invention, the control ring is bent to form stops delimiting the end rotational positions of said levers.

[0050] Preferably, said stops delimiting the end rotational positions of the lever are formed on sections of the control ring between said receiving housings.

[0051] Nevertheless, as a variant or in combination, there is nothing to prevent the provision of a fluid guiding stator device in which the end rotational positions of at least one lever are defined by stops connected to a ring of the stationary blade assembly, in particular the ring facing the control ring.

[0052] In some preferred embodiments, at least three levers, named radial holding levers, of said plurality of levers form radial stops against the control ring such that the control ring is radially held exclusively by said radial holding levers.

[0053] Therefore, the control ring is radially held only by said radial holding levers.

[0054] Preferably, each radial holding lever is a driving lever coupled to a driven blade of the stationary blade assembly.

[0055] Furthermore, in some advantageous embodiments in accordance with the invention, each radial holding lever comprises a support portion, named radial support, forming a radial stop against the control ring so as to prevent any movement of the control ring towards said main axis.

[0056] In particular, the radial support of each radial holding lever allows this lever to be rotationally guided about its axis of rotation, i.e. about the pivoting axis of the blade to which it is coupled, by the control ring so as to be able to rotationally drive the blade of the stationary blade assembly to which this lever is coupled.

[0057] In some advantageous embodiments in accordance with the invention, each lever of said plurality of levers has a proximal end rotationally coupled to a blade of said plurality of blades, and a distal end, named head.

[0058] In a preferred embodiment in accordance with the invention, the head of each radial holding lever forms said radial support of this lever.

[0059] Furthermore, advantageously and in accordance with the invention, said radial support of each radial holding lever and said control ring have conjugate shapes able to allow said radial support of each radial holding lever to roll, without sliding, against said control ring.

[0060] Therefore, the radial holding levers can be displaced by the control ring, reducing the stresses exerted on these levers by the control ring so as to improve the control of the angular position of the blades of the stationary blade assembly and to reduce the risk of breakdown (breaking of the levers ...).

[0061] More particularly, the head of a radial holding lever can comprise edges which can slide against the control ring during the rotation of this radial holding lever.

[0062] In particular, in some embodiments said radial support of each radial holding lever has a convex shape and each receiving housing has a surface, named drive surface, in contact with this radial support, and extending at least substantially in a plane in parallel with said main axis and with a tangent to the control ring at this receiving housing.

[0063] Therefore, said radial support of each radial holding lever is in point-wise contact, in any angular position, with said drive surface of the receiving housing receiving this lever so as to permit slide-free rolling of the radial support of each radial holding lever against said control ring.

[0064] In particular, the drive surface of a receiving housing of the control ring defines a base of this receiving housing.

[0065] Furthermore, in some embodiments of a stator guide device in accordance with the invention, at least two levers, named axial holding levers, of said plurality of levers - in particular the set of levers of said plurality of levers - can be adapted to axially hold the control ring along said main axis. In particular, the axial holding levers form axial stops along said main axis against the control ring such that the control ring is axially held along the main axis exclusively by said axial holding levers - in particular by the set of levers of said plurality of levers.

[0066] Preferably, each axial holding lever is a driving lever coupled to a driven blade of the stationary blade assembly.

[0067] In particular, in some advantageous embodiments in accordance with the invention the control ring extends in a main plane, and in that each axial holding lever comprises a support portion, named axial support, the axial support of each internal lever extending from a first side with respect to said main plane and forming a first axial stop against the control ring, and the axial support of each external lever extending from a second side, opposite to said first side, with respect to said main plane and forming a second axial stop against the control ring.

[0068] Each internal lever and each external lever thus each have a single axial support.

[0069] More particularly, the axial support of each internal lever is in abutment against a surface, named first surface, of the control ring and the axial support of each external lever is in abutment against a surface of the control ring opposite to said first surface with respect to said main plane.

[0070] In some advantageous embodiments in accordance with the invention, some radial holding levers are also axial holding levers. Therefore, in these embodiments, at least two axial holding levers form radial stops against the control ring such that the control ring is radially held exclusively by said at least two axial holding levers. Preferably, each radial holding lever is an axial holding lever. Advantageously, each axial holding lever is likewise a radial holding lever. In some embodiments, each lever of said plurality of levers is an axial holding lever and a radial holding lever.

[0071] Preferably, when each radial holding lever is likewise an axial holding lever, for each head of a radial holding lever, said radial support is arranged at least substantially orthogonally to said axial support of this lever.

[0072] In some of these embodiments, when each radial holding lever is likewise an axial holding lever, the head of each radial holding lever has a recess between said axial support and said radial support of this lever.

[0073] This recess allows the contact surface between the axial/radial holding lever and the control ring to be reduced. Therefore, the recesses allow a reduction in the friction between the axial/radial holding levers and the control ring when the control ring is rotationally driven about said main axis.

[0074] The invention can be applied equally to a radial turbomachine stationary blade assembly and to an axial turbomachine stationary blade assembly.

[0075] Therefore, advantageously and in accordance with the invention, since the turbomachine is a radial turbomachine comprising at least one blade assembly mobile about an axis of rotation, said guiding faces of the stationary blade assembly of the guide stator device are thus planar faces radial with respect to the axis of rotation of the turbomachine.

[0076] The invention also relates to a method for manufacturing control ring, a control ring and a turbomachine fluid guiding device, which are characterised in combination by all or some of the features mentioned above or below.

[0077] Other aims, features and advantages of the invention will become apparent upon reading the following description given by way of nonlimiting example and which makes reference to the attached figures in which:

- figure 1 is a perspective view of a fluid guiding device in accordance with one embodiment of the invention,
- figures 2 and 3 are two perspective views of a lever of a fluid guiding stator device in accordance with one embodiment and in accordance with the invention,
- figures 4 to 6 are perspective views of a guide ring in accordance with several embodiments of the invention.

[0078] Figure 1 shows a fluid guiding stator device 20 comprising a control ring 33 manufactured as per a manufacturing method in accordance with one embodiment of the invention. This device 20 is a fluid guiding stator device for a radial turbomachine (not shown).

[0079] The fluid guiding stator device 20 comprises a stationary blade assembly 21. The stationary blade assembly 21 comprises two rings 22 coaxial along an axis, named main axis 39, which are spaced apart from each other so as to form a passage, named fluid passage, which a fluid can pass through. More particularly, the fluid passage is delimited by faces, named guiding faces, facing each other of the two coaxial rings 22 of the stationary blade assembly 21. Said guiding faces are planar and extend radially.

[0080] The stationary blade assembly 21 also comprises a plurality of blades 23 arranged about said main axis 39 and held in said fluid passage between the coaxial rings 22. Furthermore, the blades 23 of said plurality of blades 23 are arranged so as to form, in the fluid passage between every two blades and between the rings 22 of the stationary blade assembly 21, a plurality of channels. Each blade 23 is mounted to pivot with respect to the two rings 22 of the stationary blade assembly 21. In particular, in the illustrated embodiments, each blade 23 is mounted to pivot on a theoretical axis, named pivoting axis, in parallel with said main axis 39 and orthogonally to the two guiding faces.

[0081] Each blade 23 can thus be pivoted between two end angular positions. The angle between a longitudinal axis of a blade 23 and a diametral plane of the stationary blade assembly 21 passing through the pivoting axis of this blade 23 is the same for all the blades 23. A modification of the angular position of a blade 23 results in a modification of the geometric characteristics of each channel delimited by this blade 23, and consequently of the fluid passage.

[0082] A first end angular position of the blades 23 defines a minimum opening of the fluid passage of the stationary blade assembly 21. The minimum opening preferably allows the fluid passage of the stationary blade assembly 21 to be blocked. A second end angular position defines a maximum opening of the fluid passage of the stationary blade assembly 21.

[0083] The fluid passage of the stationary blade assembly 21 thus has a variable cross-section. The guide stator device 20 with a stationary blade assembly 21 having a variable cross-section thus allows the adjustment of a flow rate and a direction of a flow of fluid passing through said fluid passage depending upon an operating state of the turbomachine.

[0084] Each blade 23 comprises a transmission shaft 38 extending along said pivoting axis of this blade 23. A ring 22 of the stationary blade assembly 21 comprises a plurality of bearings for receiving the transmission shafts 38 of the blades 23. Each transmission shaft 38 passes through a bearing of said ring 22 of the stationary blade assembly 21.

[0085] Furthermore, the guide stator device 20 comprises a mechanism 24 for controlling the angular position of the blades 23 of the stationary blade assembly 21. The control mechanism 24 is thus able to cause the blades 23 of the stationary blade assembly 21 to pivot.

[0086] More particularly, the control mechanism 24 comprises a plurality of levers 25 arranged about the main axis 39 and said control ring 33 manufactured in accordance with one embodiment of a manufacturing method in accordance with the invention. Said control ring 33 is coaxial with respect to the rings 22 of the stationary blade assembly 21. The control ring 33 extends in a plane, named main plane, in parallel with the guiding faces of the rings 22 of the stationary blade assembly 21.

[0087] Each lever 25 is rotationally coupled with a blade 23 of the stationary blade assembly 21, each blade 23 of the stationary blade assembly 21 being rotationally coupled with a lever 25 of said plurality of levers 25. Therefore, each lever 25 allows the blade 23 to which it is coupled to be rotationally driven so as to modify its angular position.

[0088] Furthermore, each lever 25 of said plurality of levers 25 cooperates, in rotation, with said control ring 33. Therefore, rotational driving about the main axis 39 of said control ring 33 allows each lever 25 to be rotationally driven about the pivoting axis of the blade 23 to which it is connected.

[0089] As shown in figures 2 and 3, each lever 25 extends longitudinally between a proximal end 28 and a distal end, named head 29. Furthermore, as shown in figure 1, in the fluid guiding stator device 20, each lever 25 extends longitudinally orthogonally to said main axis 39.

[0090] The proximal end 28 of each lever 25 is adapted to be rotationally coupled with a blade 23 of the stationary blade assembly 21, in particular with the transmission shaft 38 of this blade 23. The proximal end 28 of each lever 25 comprises a through-orifice 37 having at least one rotationally cylindrical section extending along said pivoting axis of the blade 23 to which the lever 25 is coupled. The orifice 37 of each lever 25 is coupled to an end of a transmission shaft 38 of a blade 23, the transmission shaft 38 passing through the bearings of the ring 22 of the stationary blade assembly 21 facing the control ring 33 as far as this coupled end. Therefore, each blade 23 is rotationally guided by a lever 25 via the transmission shaft 38 of this blade 23.

[0091] In the embodiment illustrated in figure 2, the orifice 37 of each lever 25 has a plurality of ribs allowing the coupling by riveting between the transmission shaft 38 and the orifice 37 of the lever 25 to be facilitated. The coupling between the transmission shaft 38 and the orifice 37 of the lever can be done by riveting or by welding for example.

[0092] The head 29 of each lever 25 is adapted to cooperate, in rotation, with the control ring 33. In particular, the shape of the control ring 33 defines a plurality of radial housings, named receiving housings 34, extending away from the main axis 39 and arranged about said main axis 39. The control ring 33 thus has a wavy shape. More particularly, the control ring 33 is manufactured as per a manufacturing method in accordance with the invention as described below. Each receiving housing 34 is adapted to receive a head 29 of the lever 25. The head 29 of each lever 25 has a support portion, named radial support 32, forming a radial stop against the receiving housing

34 receiving the head 29 of this lever 25. Therefore, the heads 29 of the levers 25 make it possible to prevent any movement of the control ring 33 towards the main axis 39. In the embodiment illustrated in figure 1, each lever is thus a radial holding lever. Furthermore, the contact between the radial supports 32 and the receiving housings 34 of the control ring 33 allows the levers 25 to be able to be rotationally driven when the control ring 33 is rotationally driven. More particularly, each receiving housing 34 comprises a base 35 formed by a surface, named drive surface 40, of the control ring 33 at least substantially in a plane in parallel with the main axis 39 and with a tangent to the control ring 33 at this receiving housing 34. Furthermore, each radial support 32 has a convex shape such that only one point of said radial support 32 is in contact with said drive surface 40 such that each lever 25 of said plurality of levers 25 can roll, without sliding, against said control ring 33.

[0093] Therefore, the levers 25 can be displaced by the control ring 33, reducing the stresses exerted on these levers 25 by the control ring 33 so as to improve the control of the angular position of the blades 23 of the stationary blade assembly 21 and to reduce the risk of breakdown (breaking of the levers 25...).

[0094] Therefore, rotationally displacing the control ring 33 about the main axis 39 thus allows the set of levers 25 of the control mechanism 24 to be simultaneously rotationally driven so as to modify the angular position of the set of blades 23 of the stationary blade assembly 21.

[0095] Furthermore, the control ring 33 is arranged so as to form stops delimiting the end rotational positions of said levers 25. Said stops 36 delimiting the end rotational positions of the lever 25 are formed on sections of the control ring 33 between said receiving housings 34. In particular, the stops 36 of the control ring 33 delimiting the end rotational positions of the lever 25 are arranged at least substantially over a single theoretical circular line of diameter *d1*. Furthermore, the base 35 of each receiving housing 34 of the control ring 33 is arranged at least substantially over a single theoretical circular line of diameter *d2* greater than *d1*.

[0096] Furthermore, each head 29 of the lever 25 comprises a support portion, named axial support 31, forming an axial stop along the main axis 39 against the control ring 33. Therefore, in the embodiment illustrated in figure 1, each lever is an axial holding lever. In particular, said head 29 of a lever 25 has a section protruding from said radial support 32. Said protruding section has a distal ridge forming said axial support 31.

[0097] In particular, some levers 25, named internal levers 25a, of said plurality of levers 25 are arranged in the fluid guiding stator device 20 so as to prevent any axial movement of the control ring 33 towards the stationary blade assembly 21 along the main axis 39.

[0098] Other levers 25, named external levers 25b, of said plurality of levers 25 are arranged in the fluid guiding stator device 20 so as to prevent any axial movement of the control ring 33 in a direction away from the stationary blade assembly 21 along the main axis 39.

[0099] In the illustrated embodiments, the internal levers 25a and the external levers 25b are arranged alternately about the main axis 39. This arrangement of internal levers 25a and external levers 25b allows the control ring 33 to be held axially in a uniform manner.

[0100] More particularly, the axial support 31 of each internal lever 25a extends from a first side with respect to said main plane and forms a first axial stop against the control ring 33. The axial support 31 of each external lever 25b extends from a second side, opposite said first side, with respect to said main plane and forms a second axial stop against the control ring 33.

[0101] The levers 25 of said plurality of levers 25 by themselves make it possible to support and hold the control ring 33.

[0102] Furthermore, each lever 25 comprises an intermediate section 30 connecting said proximal end 28 of the lever 25 and said head 29 of the lever 25. This intermediate section 30 has an offset forming a difference in level between said head 29 of the lever 25 and said proximal end 28 of the lever 25. This difference in level allows the control ring 33 to be raised with respect to the stationary blade assembly 21 such that the section of the head 29 of the internal levers 25a supporting said axial support 31 can be arranged between the stationary blade assembly 21 and the control ring 33. Furthermore, the difference in level allows the head 29 of each lever 25 to be raised with respect to the proximal end 28 of each lever 25 so as to avoid the head 29 of this lever 25 being in contact with the ring 22 of the stationary blade assembly 21 facing the control ring 33. Furthermore, said intermediate portion 30 of a lever 25 is placed against a stop 36 of the control ring 33 delimiting an end rotational position when this lever 25 has reached this end rotational position.

[0103] The section of the head 29 of each lever 25 protruding from said radial support of this lever 25 comprises a recess between said radial support and said axial support so as to reduce the contact surface between the control ring 33 and the head 29 of the lever 25. The recesses of the heads 29 of the lever 25 thus allow a reduction in the friction between the levers 25 and the control ring 33 when the control ring 33 is rotationally driven about said main axis 39.

[0104] Since the control ring 33 is held axially only by the levers 25 of the control mechanism 24, it is not necessary to provide any additional part in the guide stator device 20 to perform this technical function.

[0105] The levers 25 of the control mechanism 24 can be obtained by lost-wax moulding, injection moulding of metal powder, stamping and by cold-forming.

[0106] In a method in accordance with the invention for manufacturing a control ring 33, a strip, named initial strip, which is metal and plastically deformable under bending is used as the starting point. Said initial strip has a predetermined length d greater than or equal to the perimeter of the control ring 33.

[0107] More particularly, a strip, named raw strip, which is made of metal and plastically deformable under bending and has a length D greater than or equal to d can be used as the starting point. Then, said initial strip is cut from said raw strip. Said raw strip can thus be used to produce a plurality of initial strips to manufacture a plurality of control rings. Therefore, said raw strip preferably has a length D greater than or equal to 2*d*.

[0108] Preferably, and as shown in the figures, a metal wire having a circular cross-section is used as the initial strip and the raw strip. Furthermore, the diameter of said metal wire is preferably constant over the length of said initial strip and of the raw strip. The use of a metal wire having a circular cross-section allows the manufacture of the control ring 33 to be facilitated, the metal wire being able to be bent in any transverse direction. Furthermore, the use of a metal wire allows the weight of the control ring 33 to be reduced overall.

[0109] Said initial strip is manufactured from a material selected from steel, copper and brass, in particular preferably steel.

[0110] Then said initial strip is formed by bending it under plastic deformation to impart the shape of the control ring 33 thereto. In particular, said initial strip is bent so as to define each receiving housing 34. Said initial strip is bent by a bending machine or a corresponding set of bending tools.

[0111] In a manufacturing method in accordance with the invention, said initial strip is bent to impart a wavy shape thereto so as to define each receiving housing 34 and said assembly portions are connected so as to form the control ring 33.

[0112] Preferably, a straight initial strip is used as the starting point. The initial strip is then bent to obtain a circular shape. Advantageously, said initial strip is bent to have a circular shape after each receiving housing 34 has been formed. As a variant, the circular shape of the control ring 33 can be obtained whilst forming said receiving housings 34.

[0113] In order to form a receiving housing 34 having said drive surface 40, said initial strip is bent at least once in a first direction and then twice at two separate points in a second direction opposite to the first direction and then at least once in said first direction. The drive surface 40 is thus formed between said two separate points.

[0114] After said initial strip has been bent to form said receiving housings 34, two portions, named assembly portions, of said initial strip are assembled together in order to form said control ring 33. Said assembly portions are spaced apart from each other by a distance at least substantially equal to the perimeter of the control ring 33 such that the control ring 33 is formed between these two assembly portions after said initial strip has been bent.

[0115] Advantageously, said assembly portions are longitudinal ends of said initial strip. Nevertheless, as a variant, it is possible to select assembly portions between said longitudinal ends of said initial strip and to cut, after assembly, said protruding portions which do not form the control ring 33 between each assembly portion and the longitudinal end closest to this assembly portion.

[0116] Said longitudinal ends each have an edge, in particular a flat edge. Furthermore, said assembly portions each have a boundary.

[0117] In a first embodiment illustrated in figure 4, the edges of the two ends of said initial strip are assembled together by welding to form the control ring 33. The edges of the two ends thus face one another.

[0118] In a second embodiment illustrated in figure 5, said assembly portions are assembled on their boundary by welding.

[0119] In a third embodiment illustrated in figure 6, said assembly portions are assembled by welding, to said assembly portions, a metal strip, named junction strip, interposed between said assembly portions. The longitudinal ends of said junction strip are preferably welded to said assembly portions. Said junction strip can be cut from said raw strip.

[0120] The invention thus relates to a method of manufacturing a control ring 33 of a mechanism for controlling the angular position of blades of a turbomachine stationary blade assembly in which a metal strip which is plastically deformable under bending is bent to form said control ring 33. Such a method of manufacturing a control ring 33 does not produce any waste because no cutting from the initial strip is performed. Furthermore, said raw strip can be completely used to form a plurality of initial strips to form a plurality of control rings. Furthermore, such a method allows a control ring 33 to be manufactured simply and quickly. A method in accordance with the invention is also inexpensive (reduction in the amount of material used compared with manufacturing a control ring 33 by cutting from a metal plate). The invention thus also relates to a control ring 33 manufactured by such a manufacturing method and a turbomachine fluid guiding stator device 20 comprising such a control ring 33.

[0121] The invention can be varied in many ways with respect to the embodiments described above and illustrated in the figures. In particular, the initial strip can have a cross-section which is non-uniform over its length. For example, said initial strip can have a thickness which varies over its length. Therefore, said initial strip can be provided with sections which are thicker than other sections of said initial strip. These thicker sections can be arranged on said initial strip depending upon the position of zones of the control ring 33 which may be subjected to the greatest mechanical stresses. Furthermore, other types of assembly can be provided. For example, it is possible to provide two longitudinal ends of said initial strip having conjugate shapes so as to provide for their assembly by nesting.

[0122] A method in accordance with the invention is adapted for manufacturing a control ring 33 of a mechanism for controlling the angular position of blades of a stationary blade assembly of a turbomachine fluid guiding stator device. The fluid guiding stator device can be used as a distributor for a turbine or as a diffusor for a compressor.

Claims

1. Method of manufacturing a ring, named control ring (33), of a mechanism (24) for controlling the angular position of blades of a blade assembly, named stationary blade assembly (21), of a turbomachine,

   - the stationary blade assembly (21) being fixedly attached to a turbomachine stator, and comprising:

     ◦ two rings (22) coaxial along an axis, named main axis (39),
     ◦ a plurality of blades (23) held between the coaxial rings of the stationary blade assembly and disposed around said main axis, each blade (23) being mounted to pivot with respect to the two rings (22) of the stationary blade assembly, said plurality of blades (23) comprising at least one blade, named driven blade,

   - the mechanism (24) for controlling the angular position of the blades of the stationary blade assembly comprising:

     ◦ a plurality of levers (25) including at least one lever, named driving lever, each driving lever being rotationally coupled with a single driven blade and each driven blade being coupled with a single driving lever,
     ◦ said control ring (33) being coaxial with the two rings of the stationary blade assembly and being able to be rotationally driven about the main axis with respect to the two rings (22) of the stationary blade assembly and defining at least one housing (34) for receiving a driving lever, said driving lever being placed in this receiving housing (34) so as to co-operate, in rotation, with the control ring, **characterised in that** the control ring (33) and each receiving housing (34) are formed by bending at least one metal strip, named initial strip, which is plastically deformable under bending.

2. Method according to claim 1, **characterised in that**:

   - in a first step, each initial strip which is plastically deformable under bending is chosen,
   - each initial strip is shaped by bending by plastic deformation thereof to impart the shape of a control ring (33) thereto, defining each receiving housing (34),
   - each initial strip having two portions, named assembly portions (43), and each assembly portion (43) is assembled with another assembly portion (43) in order to form said control ring (33).

3. Method according to any one of claims 1 or 2, **characterised in that** each initial strip to be formed is cut at a predetermined length d from a strip, named raw strip, which is made of metal and plastically deformable under bending and has a length D greater than *d*.

4. Method according to any one of claims 2 or 3, **characterised in that** each assembly portion (43) is formed by an edge of an end of an initial strip.

5. Method according to any one of claims 2 to 3, **characterised in that** said assembly portions (43) each have a boundary, and **in that** said assembly portions are assembled on their boundary.

6. Method according to any one of claims 2 to 3, **characterised in that** said assembly portions (43) are assembled by welding, to said assembly portions, a metal strip, named junction strip (44), interposed between said assembly portions.

7. Method according to any one of claims 2 to 5, **characterised in that** said assembly portions (43) are assembled by welding.

8. Method according to any one of claims 1 to 7, **characterised in that** a wire having a circular cross-section is used as the initial strip.

9. Method according to any one of claims 1 to 7, **characterised in that** said initial strip is manufactured from a material selected from the group formed of steel, copper and brass.

10. Ring (33) of a mechanism (24) for controlling the angular position of blades (23) of a blade assembly, named stationary blade assembly (21), of a turbomachine,

    - the stationary blade assembly (21) being fixedly attached to a turbomachine stator, and comprising:

      ◦ two rings (22) coaxial along an axis, named main axis (39),
      ◦ a plurality of blades (23) held between the coaxial rings (22) of the stationary blade assembly (21) and disposed around said main axis, each blade being mounted to pivot with respect to the two rings (22) of the stationary blade assembly (21), said plurality of blades (23) comprising at least one blade, named

driven blade,

- the mechanism (24) for controlling the angular position of the blades (23) of the stationary blade assembly (21) comprising:

◦ a plurality of levers (25) including at least one lever, named driving lever, each driving lever being rotationally coupled with a single driven blade and each driven blade being coupled with a single driving lever,
◦ said control ring (33) being coaxial with the two rings (22) of the stationary blade assembly (21) and being able to be rotationally driven about the main axis with respect to the two rings of the stationary blade assembly and defining at least one housing (34) for receiving a driving lever, said driving lever being placed in said receiving housing (34) so as to co-operate, in rotation, with the control ring,

characterised in that the control ring (33) and each receiving housing (34) are formed by at least one metal strip, named initial strip, which is plastically bent.

11. Fluid guiding stator device comprising a turbomachine fluid guiding stator device, comprising:

- a blade assembly, named stationary blade assembly (21), comprising:

◦ two rings (22) coaxial along an axis, named main axis (39),
◦ a plurality of blades (23) held between the coaxial rings (22) of the stationary blade assembly (21) and disposed around said main axis, each blade being mounted to pivot with respect to the two rings (22) of the stationary blade assembly (21), said plurality of blades (23) comprising at least one blade, named driven blade,

- a mechanism (24) for controlling the angular position of the blades (23) of the stationary blade assembly (21) comprising:

◦ a plurality of levers (25) including at least one lever, named driving lever, each driving lever being rotationally coupled with a single driven blade and each driven blade being coupled with a single driving lever,
◦ said control ring (33) being coaxial with the two rings (22) of the stationary blade assembly (21) and being able to be rotationally driven about the main axis (39) with respect to the two rings (22) of the stationary blade assembly (21) and defining at least one housing (34) for receiving a driving lever, said driving lever being placed in said receiving housing (34) so as to co-operate, in rotation, with the control ring (21),

characterised in that the control ring (33) and each receiving housing (34) are formed by at least one metal strip, named initial strip, which is plastically bent.

Fig 1

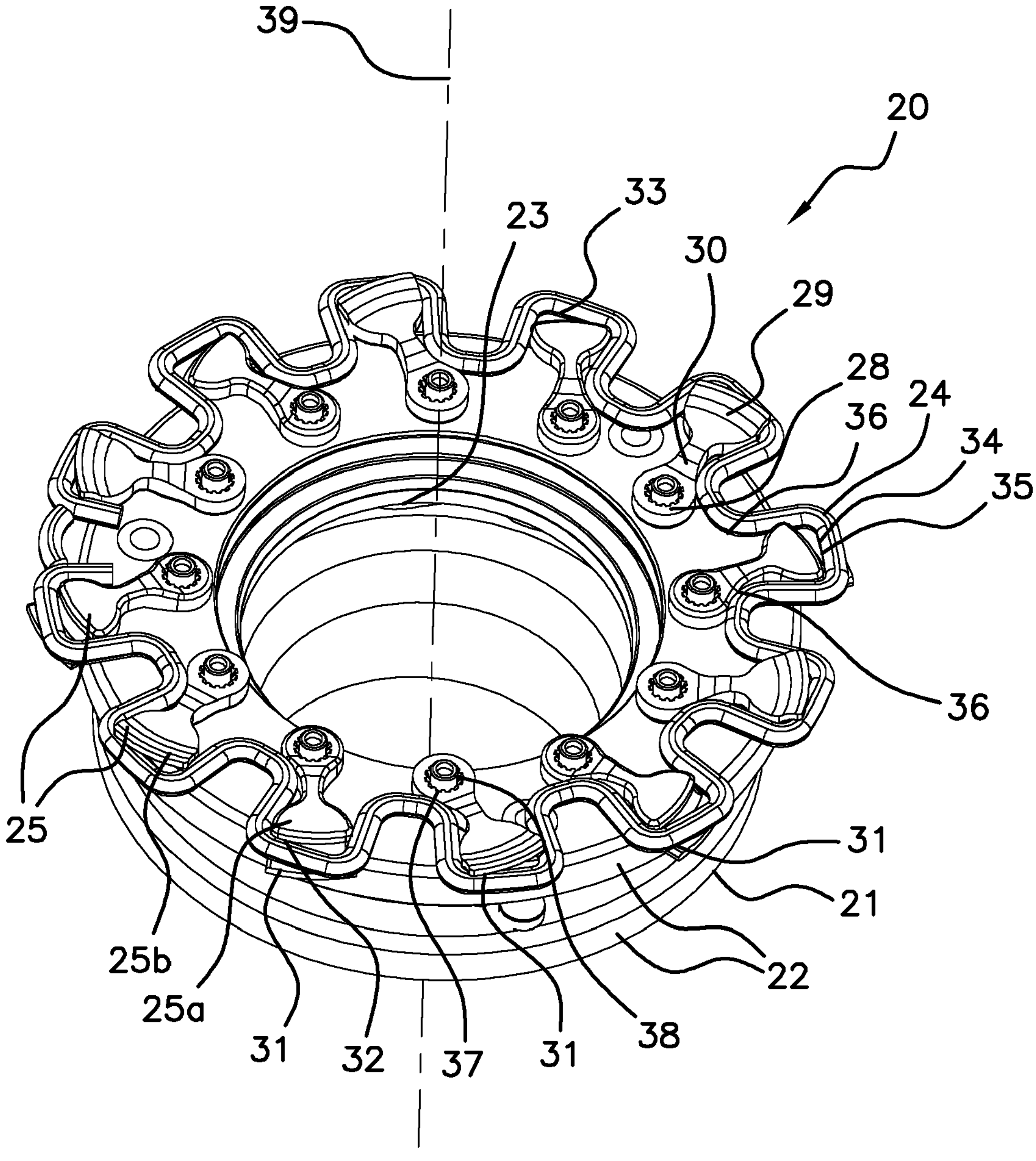


Fig 2

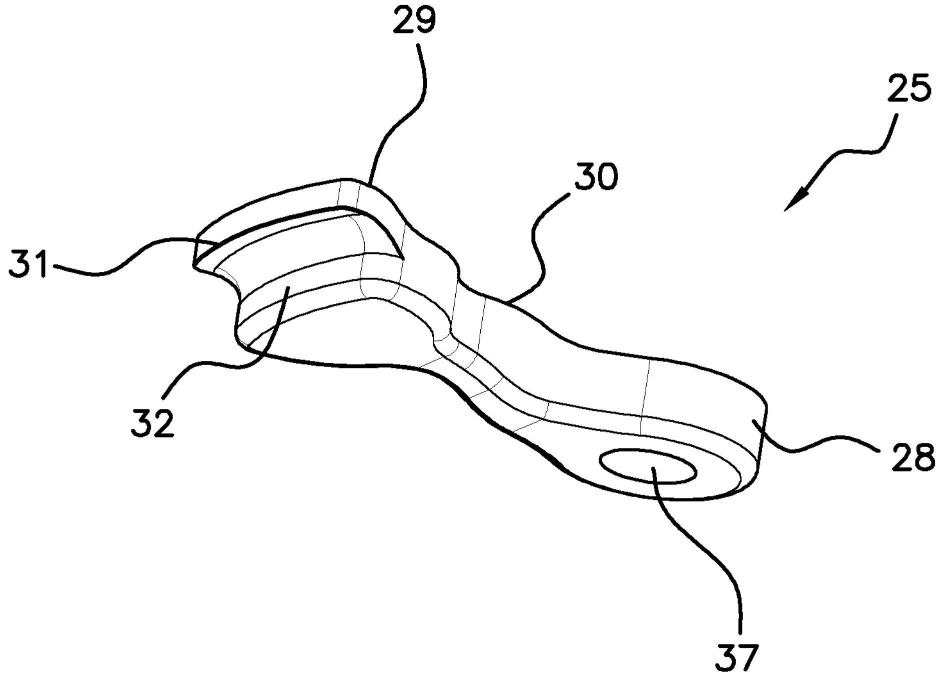


Fig 3

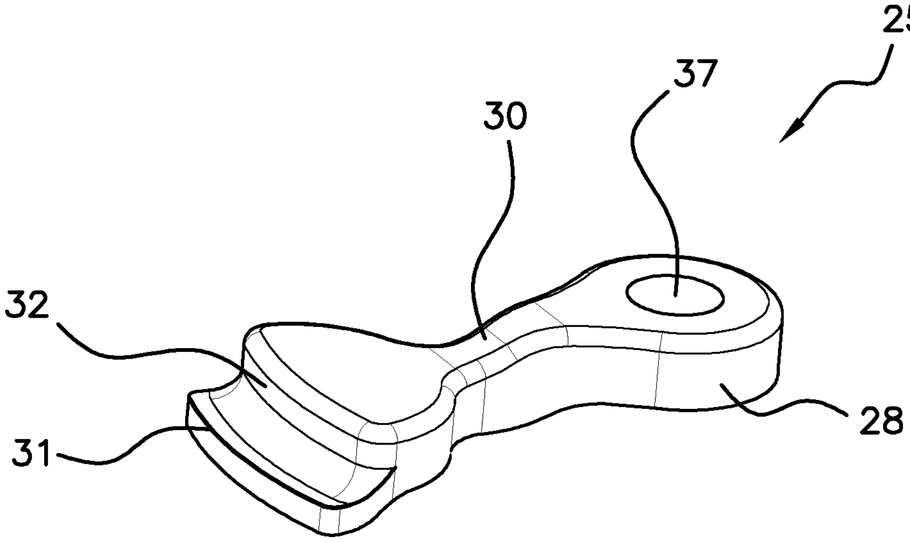


Fig 4

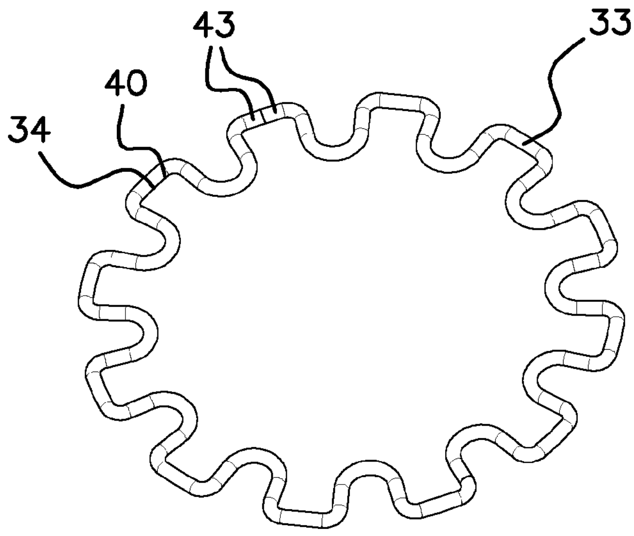


Fig 5

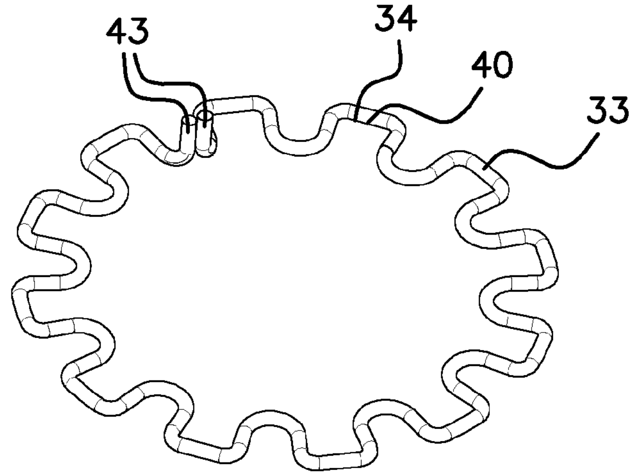
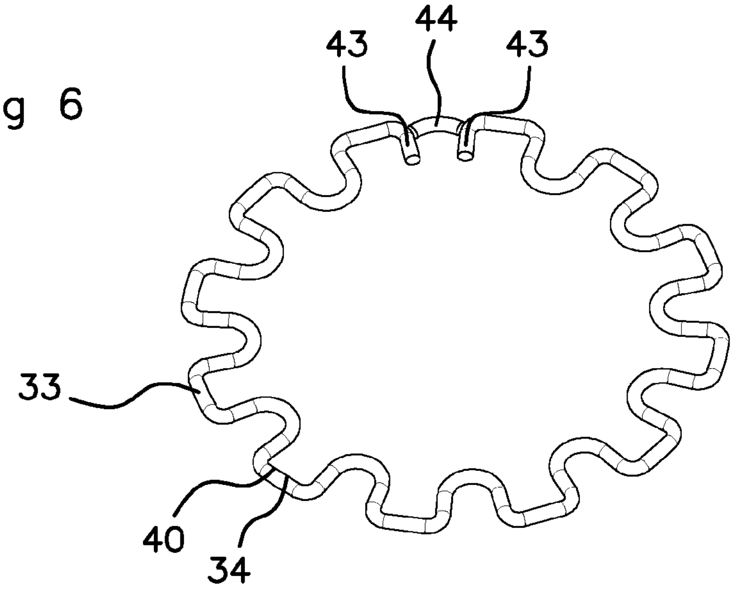


Fig 6



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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 8576

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	30 May 2018	Teissier, Damien

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