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Description

The present invention relates to a synchronous generator, in particular a multipole synchronous ring generator of a gearless wind turbine. Moreover, the present invention relates to a method for producing a synchronous generator
5 of this kind.

Wind turbines are widely known and they generate electric current from wind by means of a generator. Modern gearless wind turbines often have a multipole synchronous ring generator with a large air gap diameter. In this case, the diameter of the air gap is at least 4 m and generally extends to almost 5 m.
10 Composite synchronous generators can even have an air gap diameter of about 10 m.

During the operation of the wind turbine, i.e. of the synchronous generator concerned, noise is generated by vibration, and, owing to the large construction, this vibration is also transmitted to large resonant bodies, e.g. the nacelle cowl-
15 ing of a wind turbine, thus amplifying this noise even more. By virtue of the way they function, such synchronous generators of a gearless wind turbine are very slowly rotating generators, rotating at a typical speed of about 5 to 35 rpm. This slow speed can also contribute to promoting specific noises, especially in comparison with generators which rotate at high speeds of revolution, e.g. 1500 or
20 3000 rpm.

Because they are in continuous operation, such synchronous generators of gearless wind turbines and therefore also the wind turbines themselves can give rise to a continuous source of troublesome noise. Nowadays, particularly large, modern wind turbines are increasingly being set up and operated at a
25 relatively large distance from residential areas, and any noise from the wind turbine is therefore also perceived to be less troublesome.

To reduce this noise generation, there are therefore known synchronous generators with a rotor and a stator, wherein the stator has a special construction

in order to counteract the noise generation. For example, there is a known practice of positioning the slots and teeth by means of which a winding of the stator, namely the stator winding, is located nonuniformly, rather than uniformly, in the circumferential direction of the stator.

5 This ensures that rotor or runner poles distributed uniformly in the circumferential direction do not reach the corresponding teeth and slots, which are offset or staggered relative to one another, at exactly the same time during the rotary motion of the rotor. This reduces vibration, thereby also reducing noise generation by such generators and hence also by the overall wind turbine itself.

10 US 2012/0175994 A1 discloses a generator for a wind turbine in which the grooves for the stator windings have an irregular distribution.

The winding of the stator of a generator of this kind is generally produced using an insulated endless round wire, which is manufactured from copper, for example. For this purpose, the wire of a phase is wound into a multiplicity of slots,
15 each containing several windings, a phase thus being produced from a continuous piece of the wire. This winding of the stator is very laborious and must sensibly be carried out by hand in order to monitor the integrity of the wires and also of the insulation of the wire even during winding, especially at the bends.

20 It is thus the underlying object of the invention to address at least one of the abovementioned problems. In particular, the aim is to propose a solution which is less laborious than the method of winding the stator with continuous phases by hand. At the very least, the aim is to propose an alternative method to previously known solutions.

25 The German Patent and Trademark Office has searched the following prior art in the priority application for the present application: WO 2012/097107 A1 and EP 2 454 802 B1.

According to the invention according to the independent claim 1, a synchronous generator of a gearless wind turbine is proposed. The synchronous generator is, in particular, a multipole synchronous ring generator of a gearless wind turbine. Such a multipole synchronous ring generator of a gearless wind turbine has a multiplicity of stator poles, in particular at least 48 stator teeth, and often even significantly more stator teeth, in particular 96 stator teeth, for example. The magnetically active region of the generator, namely both of the rotor, which can also be referred to as a runner, and of the stator, is arranged in an annular region around the axis of rotation of the synchronous generator.

Thus, in particular, a region of 0 to at least 50% of the radius of the air gap is free from materials which conduct electric current or an electric field of the synchronous generator. In particular, this internal space is completely free and, in principle, also accessible. Often, this region also accounts for more than 0 to 50% of the air gap radius, in particular up to 0 to 70% or even 0 to 80% of the air gap radius. Depending on construction, there may be a supporting structure in this interior region, but this can be of axially offset design in some embodiments.

Accordingly, the synchronous generator comprises a rotor and a stator, wherein the stator has a stator ring having teeth and slots arranged therebetween for receiving a stator winding. According to the invention, the stator ring is divided into stator segments in the circumferential direction. Each stator segment has the same number of slots, and, within a segment, the slots have a substantially equal spacing with respect to one another in the circumferential direction.

In a connecting region of two segments, which, in particular, corresponds to the region in which two segments are arranged adjacent to one another, are situated adjacent to one another or touch one another in the circumferential direction, the spacing of two adjacent slots, which are each assigned to one of two different segments, namely the segments which are situated adjacent to one another in this connecting region, is different from the spacing of the slots

within a segment. The two slots of two different segments which are situated adjacent to one another thus have a spacing which is greater or smaller than the spacing of the slots within a segment. Moreover, the stator winding is formed with form coils. In this context, form coils comprise, in particular, an
5 electric conductor which has been given a predetermined shape in a plurality of windings and has two terminals, by means of which the form coil can be connected to further form coils in order to form a phase by means of a plurality of series-connected coils of the generator.

Hitherto, it has been the case that form coils were not economical for a stator
10 of this kind owing to the different spacings of the slots, since form coils are only economical if they all have the same shape within one stator. However, in the case of synchronous generators with different slot spacings, this advantage is at first sight not available since form coils of different sizes have to be selected to enable them to be arranged in the slots spaced apart at different distances,
15 and, at the same time, power losses must be expected.

However, it has been recognized that, in the case where the stator is divided into a plurality of segments, each having the same number of slots, it is always possible to provide a particular number of form coils, in particular single-layer form coils, within one segment, and it is thus possible to use form coils of the
20 same shape despite different slot spacings. In this case, therefore, the form coils of the segments are connected to one another instead of providing form coils which are also inserted in slots across segments.

Thus, a relatively advantageous synchronous generator with asymmetrically distributed slots can be obtained without using expensive manual winding in-
25 volving endless wires.

According to one embodiment, the form coils each have two legs, wherein the legs are connected to one another by two winding overhangs, which are also referred to as end windings, and the terminals are preferably arranged in the region of one of the winding overhangs. Apart from the region of the terminals,

the legs and winding overhangs of all the form coils of the stator winding have the same shape. This ensures that, in production, the form coils can all be pre-shaped on a substantially identical fixture and hence a large number of form coils can be produced, thereby further reducing production costs.

5 According to another embodiment, the legs of each form coil are arranged in the stator in an identical radial region of the stator. Here, a radial region corresponds to a region between two circles of different radii extending around the stator axis. Accordingly, therefore, all the legs of all the form coils in the stator advantageously have the same spacing with respect to a central point of the
10 stator. This arrangement of the form coils corresponds to a single-layer arrangement, wherein just a single leg of a form coil is arranged in each slot. This single-layer arrangement of the form coils in the slots furthermore ensures that legs of the same form coil do not have to be placed in slots of adjacent segments in the connecting regions of two segments - as is the case with oth-
15 erwise frequently used two-layer windings. In the case of a two-layer arrangement of the form coils, for example, it would namely also be necessary to arrange form coils across segments. This would in turn necessitate form coils of different shapes, namely those which are within a segment and those which have a shape that enables cross-segment slots to be connected to one an-
20 other.

According to another embodiment, each segment has six, or a multiple of six, form coils. According to this embodiment, six of the terminals of the form coils of a segment are furthermore connected to six terminals of the form coils of a segment arranged ahead of it in the circumferential direction and to six termi-
25 nals of the form coils of a segment situated after it in the circumferential direction. This results in six phases of the stator, thus allowing the generator to be operated as a six-phase generator. Vibration is thereby furthermore reduced since the torque fluctuation is reduced by virtue of six phases in place of the otherwise customary three phases.

According to another embodiment, the connection of two of the terminals in each case is established with a connecting element which has a U shape. In this arrangement, the ends of the U shape are each connected to one terminal of different form coils. U-shaped connecting elements are particularly advantageous since they can be arranged in series in the circumferential direction in an arrangement rotated through 180 degrees relative to one another and thus one or more ends of the U shape can extend into the central space between two ends of the U shape of a different connecting element, thus making possible a space-saving construction.

10 According to the invention, form coils of different materials are used for the stator. In this case, form coils with a first resistivity are inserted at least into the slots, the spacing of which is less than the spacing of the slots within a segment. In the majority of the remaining slots, however, a form coil with a higher resistivity than the first resistivity is used.

15 During operation, the heat generation in the legs of the form coils is directly correlated with the resistivity of the material from which the form coils are produced. This means that, as the resistivity increases, heat generation during the flow of a current through the form coil also increases.

Precisely in the region of the slots in which two legs of form coils are very close together, it is therefore necessary to maintain lower heat generation than in the other slots in order to keep the overall heat generation in the stator below certain limits. It therefore has a particularly advantageous effect to use form coils with a lower resistivity at least in the slots which have a small spacing with respect to one another than in slots which have a larger spacing.

25 According to another advantageous embodiment, legs of a form coil produced with or from copper are inserted into the slots, the spacing of which is less than the spacing of the slots within a segment, and a leg of a form coil produced with or from aluminum is inserted into each of the majority of the remaining slots. Aluminum can be procured at low cost in very large quantities and is, at

the same time, easy to process. It is therefore particularly advantageous to insert form coils made of aluminum into the majority of the slots. Copper can also be procured in sufficient quantities. Although copper is more expensive to procure than aluminum, copper has a lower resistivity, and therefore the use
5 of copper is advantageous, at least in slots situated very close together, since the temperature behavior and the associated advantage with the heat generation of a stator compensates for the higher procurement price.

According to another embodiment, at least one terminal of a form coil containing or composed of aluminum is connected to at least one terminal of a form
10 coil containing or composed of copper. The connection is established by means of a connecting element which is produced from a copper-aluminum alloy in accordance with the first alternative above. An alloy of this kind composed of copper and aluminum is used to establish a secure connection between the terminals of the form coils made of different materials.

15 According to another alternative, the connecting element is a connecting element composed of both conductor materials. Thus, the connecting element is composed of copper on one side and of aluminum on the other side, for example, wherein the two materials are joined together, e.g. by cold pressure welding, friction stir welding or pressure brazing or pressure welding.

20 According to the further procedure, the copper and aluminum coils, i.e. two different form coils, are connected to one another by a connecting element which is composed of aluminum and, during the manufacture of the copper coil, has already been connected to the copper coil by cold pressure welding, friction stir welding, pressure brazing or pressure welding before the equipping
25 of the stator.

According to another embodiment, the stator ring of the stator is joined together from a plurality of stator ring parts at at least two locations, in each case

particularly in the connecting region of two segments, in particular of two adjacent slots, which are each assigned to one of two different segments and the spacing of which is greater than the spacing of the slots within a segment.

Accordingly, therefore, the stator ring is produced from a plurality of stator ring parts. These are pre-manufactured, for example, wherein the form coils can be inserted into the slots of the stator ring parts during the process of pre-manufacture itself. It is only at the location of use that the individual stator ring parts are then connected to one another. It is advantageous if the stator ring is divided precisely where two segments, the outer slots of which have a greater spacing in the assembled state than the remaining slots of a segment, abut. These locations for the division of the stator ring are particularly advantageous since the large slot spacing means that no particularly narrow teeth of the stator are formed, which could be damaged during transportation, for example. A robust construction of the stator is thus ensured. The divisibility simultaneously allows the transportation of particularly large stators.

According to another embodiment, the form coils comprise one of the following shapes, in each case in the region of the end winding thereof. According to a first form of the form coils of this embodiment, outside the stator ring, the legs are offset in opposite directions and extend in parallel as far as a 180 degree bend which connects the legs. As an alternative, outside the stator ring, the legs are bent in the same direction with different spacings and then extend in parallel as far as a 180 degree bend which connects the legs. Here, the bend of the two legs is in the same direction and has an angle in a range of from 0 to 90 degrees. According to another alternative embodiment, the bend is provided in the same direction with an angle of 90 degrees. Coils shaped in this way advantageously lead to single-layer form coils, which can therefore be arranged in the same radial region of the stator.

Moreover, the invention relates to a method for producing a synchronous generator as described in independent claim 11. According to the method, six, or a multiple of six, form coils, are inserted into each segment. Furthermore, six

of the terminals of the form coils of a segment are connected to six terminals of the form coils of a segment arranged ahead of it in the circumferential direction and to six terminals of the form coils of a segment situated after it in the circumferential direction. This advantageously gives rise to six phases of in
5 each case continuous electric leads or strands through the stator of a synchronous generator. For this purpose, it is possible to use form coils which allow relatively advantageous production of a synchronous generator in comparison with a hand-wound synchronous generator while, at the same time, different slot spacings are possible in order to reduce noise generation by the generator
10 during operation.

According to one embodiment of the method, the form coils are wound before being inserted into the slots by winding one or more wires, in particular flat wires, arranged in parallel around a winding core, which is preferably formed from two mandrels. The resulting coil is spread apart until the desired spacing
15 of the two legs corresponding to the spacing of the slots within a segment is obtained. The end windings are then bent by fixing sections of the coil in fixtures and then moving these fixtures relative to one another until the desired shape of the form coil is obtained by plastic deformation. Simple pre-manufacture of high numbers of form coils of the same shape is thus possible.

20 According to another embodiment of the method, in the case of offset form coils, the coil in the region of the winding overhang is offset first in the opposite direction before the legs are spread apart. This ensures that the spacing of the legs of the coil is not accidentally changed during the offsetting process.

According to another embodiment of the method, different form coils are connected by means of U-shaped connecting parts by cold welding, pressure
25 brazing or friction stir welding. It is thereby possible to dispense with contact rings, by means of which form coils are usually connected. Space-saving construction, especially in respect of the depth of the stator, is thus possible.

Further embodiments will become apparent from the illustrative embodiments described in greater detail in the figures.

Figure 1 shows a wind turbine,

Figure 2 shows a schematic side view of a synchronous generator designed
5 as a ring generator,

Figure 3 shows a form coil of one illustrative embodiment of the synchronous generator according to the invention,

Figure 4 shows an enlargement of the end winding of the coil from figure 3,

Figure 5 shows an end winding wound in a different way from the illustrative
10 embodiment in figures 3 and 4,

Figure 6 shows another embodiment of the shape of a form coil,

Figure 7 shows three segments of a stator ring shown by way of example in side view, and

Figure 8 shows an illustrative view of three segments of a stator in a view of
15 the stator from the outside.

Figure 1 shows a schematic illustration of a wind turbine according to the invention. The wind turbine 100 has a tower 102 and a nacelle 104 on the tower 102. An aerodynamic rotor 106 with three rotor blades 108 and a spinner 110 is provided on the nacelle 104. During the operation of the wind turbine, the
20 aerodynamic rotor 106 is set in rotation by the wind and thus also rotates a rotor or runner of a generator, which is coupled directly or indirectly to the aerodynamic rotor 106. The electric generator is arranged in the nacelle 104 and generates electric energy. The pitch angles of the rotor blades 108 can be

changed by means of pitch motors at the rotor blade roots 108b of the respective rotor blades 108.

Figure 2 shows a generator 130 schematically in a side view. It has a stator 132 and an electrodynamic rotor 134 mounted rotatably relative to the latter and is attached to a machine support 138 by means of its stator 132 via an
5 axle journal 136. The stator 132 has a stator support 140 and laminated stator cores 142, which form stator poles of the generator 130 and are attached to the stator support 140 via a stator ring 30.

The electrodynamic rotor 134 has rotor pole shoes 146, which form the rotor
10 poles and are mounted so as to be rotatable on the axle journal 136 about the axis of rotation 152 by means of a rotor support 148 and bearings 150. The laminated stator cores 142 and the rotor pole shoes 146 are separated only by a narrow air gap 154, which is a few millimeters thick, in particular less than 6 mm, but has a diameter of several meters, in particular more than 4 m.

15 The laminated stator cores 142 and the rotor pole shoes 146 each form a ring and, together, are also annular, with the result that the generator 130 is a ring generator. In line with its intended purpose, the electrodynamic rotor 134 of the generator 130 rotates together with the rotor hub 156 of the aerodynamic rotor, of which initial portions of rotor blades 158 are indicated.

20 Figure 3 shows a first illustrative embodiment of a form coil 10 for the synchronous generator 130 according to the invention. The form coil 10 has two legs 12. Moreover, the coil 10 has two end windings 14. Two terminals 16 are illustrated in the region 18 of the end winding 14 illustrated on the left-hand side. The region 18 of the form coil 10, namely the two legs 12 in this region 18, are
25 subsequently inserted into the slots 32 of one and the same segment of a stator 132 of a synchronous generator 130. The segments just mentioned are described below in connection with the description of figures 7 and 8. The end windings 14 correspond to bends in the legs 12 in order to connect the two legs 12 to one another.

Figure 4 shows an enlarged illustration of one of the end windings 14 of the form coil 10 from figure 3. This end winding 14 corresponds to the end winding illustrated on the right-hand side in figure 3, wherein the rear view is illustrated here as compared with figure 3. The end winding 14 comprises the legs 12 being bent in the same direction with different spacings, namely according to spacing 20, on the one hand, and spacing 22, on the other hand. In a region 24, the two bent legs 12 once again run parallel and are connected to one another by a 180 degree bend 26. Here, the bend in the legs 12 in the same direction is about 40 degrees.

10 An alternative embodiment of the form coil 10 is illustrated in figure 5, in which the end winding 14 is bent through 90 degrees according to spacings 20, 22. By means of these illustrated form coils 10, it is possible to insert any desired number of these coils 10 formed in this way into the slots 32 of a stator 132 without the individual windings touching and nevertheless to arrange the legs
15 12 at the same radial distance from or in the same radial region with respect to the center of a stator 132.

Figure 6 shows yet another illustrative embodiment of an end winding 14 of a form coil 10, in which the legs 12 are offset in opposite directions with the same spacing, i.e. initially being bent through 90 degrees in opposite directions and
20 then being bent again through 90 degrees in the same direction. A region 24 is thereby likewise produced, in which the two offset regions of the legs 12 run substantially parallel. Once again, a 180 degree bend 26 is provided, which connects the two legs 12.

Figure 7 shows, by way of example, a detail of a stator ring 30, which is shown without curvature for greater clarity. The stator ring 30 has slots 32 and teeth
25 34. Here, three segments 36 are illustrated. Form coils 10 are inserted into the slots 32 of the segments 36. Each of the segments 36 has six form coils 10. The legs 12 of the form coils 10 and the slots 32 within a segment 36 each have the same spacing 33 with respect to one another. In connecting region
30 38 and in connecting region 40, however, the slots 32 have a spacing 42 which

is different from the spacing 33 of the slots 32 within a segment 36. In connecting region 38, for example, the spacing of the two slots 32 is equal to zero and is thus smaller than the spacing 33 of the slots 32 within a segment 36. In connecting region 40, on the other hand, the spacing 42 of the slots 32 is approximately twice as wide as the spacing 33 of the slots 32 within a segment. In the illustration, the upper side 45 of the stator ring 30 corresponds to the radially inner side of the stator 132.

Figure 8 shows a view of the stator 132 radially from the outside. Here too, by way of example, only the region with three segments 36 is illustrated. According to the illustrative embodiment shown in figure 8, the two form coils 44 are produced from copper. The remaining form coils 10 are produced from aluminum. By virtue of the copper form coils 44, the legs 12 of which are very close together in the connecting region 38, 40 of the two segments 36, there is less heat generation during operation than if these two coils were manufactured from aluminum, since copper has a lower resistivity than aluminum. Thanks to the use of aluminum form coils and copper form coils, a relatively advantageous stator 132 or synchronous generator 130 can be produced, which has advantageous properties in respect of heat distribution.

P a t e n t k r a v

5 **1.** Synkrongenerator i et gearløst vindenergianlæg (100), omfattende en rotor (106) og en stator (132), hvor statoren (132) har en statorring (30) med tænder (34) og derimellem anbragte noter (32) til optagelse af en statorvikling, og statorringen (30) i omkredsretning er opdelt i statorsegmenter (36) med respektivt et samme antal af noter (32), og inde i et segment (36) har noterne (32) en i det væsentlige samme afstand (33) til hinanden i omkredsretning, hvor i mindst et forbindelsesområde (38, 40) af to segmenter (36) afstanden (42) af mindst to naboliggende noter (32), som er respektivt tilordnet et af to forskellige segmenter (36), adskiller sig fra noternes (32) afstand (33) inde i et segment (36),

kendetegnet ved, at

15 statorviklingen er dannet med formspoler (10), hvor formspolerne (10) er fremstillet af forskellige materialer, hvor der i naboliggende noter (32), hvis afstand (42) er mindre end noternes (32) afstand (33) inde i et segment (36) i forhold til hinanden, er indsat et ben (12) af en formspole (10) med en første specifik modstand, og der i flerheden af de øvrige noter (32) er indsat respektivt et ben (12) af en formspole (10) med en sammenligningsvist højere specifik modstand.

25 **2.** Synkrongenerator ifølge krav 1, hvor formspolerne (10) har respektivt to ben (12), benene (12) via to viklingshoveder (14) er forbundet med hinanden, og formspolerne (10) har respektivt to tilslutninger (16) i området (18) af et af viklingshovederne (14), hvor bortset fra tilslutningerne (16) benene (12) og viklingshovederne (14) af alle formspoler (10) af statorviklingen har i det væsentlige den samme form.

30 **3.** Synkrongenerator ifølge krav 1 eller 2, hvor benene (12) af hver formspole (10) i statoren (132) er anbragt i et samme radialområde (24) af statoren (132).

4. Synkrongenerator ifølge et af de foregående krav, hvor hvert segment (36) har respektivt seks eller et multiplum af seks formspoler (10) med respektivt en første tilslutning (16) og en anden tilslutning (16), hvor seks af tilslutnin-

gerne (16) af formspolerne (10) af et segment (36) er forbundet med seks tilslutninger (16) af formspolerne (10) af et segment (36), som ligger foran i omkredsretningen, og seks tilslutninger (16) af formspolerne (10) af et segment (36), der ligger bagved i omkredsretning.

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5. Synkrongenerator ifølge et af de foregående krav, hvor forbindelsen af to af tilslutningerne (16) af forskellige formspoler (10) er etableret med U-formede forbindelseselementer, hvor enderne af U-formen er respektivt forbundet med en tilslutning (16).

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6. Synkrongenerator ifølge et af de foregående krav, hvor der i de naboliggende noter (32), hvis afstand (42) er mindre end noternes (32) afstand (33) inde i et segment (36) i forhold til hinanden, er indsat et ben (12) af en med eller af kobber fremstillet formspole (44), og der i flerheden af de øvrige noter (32) er indsat respektivt et ben (12) af en med eller af aluminium fremstillet formspole (10).

15

7. Synkrongenerator ifølge et af de foregående krav, hvor forbindelsen af mindst to af tilslutningerne (16) af forskellige formspoler (10) er respektivt etableret ved hjælp af et forbindelseselement, som består af aluminium og ved fremstillingen af kobberspolen før bestykning af statoren ved koldtryksvejsning, svejsning ved hjælp af omrøringsfriktion, tryklodning eller tryksvejsning blev forbundet med kobberformspolens tilslutning, som efter bestykningen af statoren er forbundet med en tilslutning af en aluminiumsformspole.

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8. Synkrongenerator ifølge et af de foregående krav, hvor mindst en tilslutning (16) af en formspole (10) med eller af aluminium er forbundet med mindst en tilslutning (16) af en formspole (44) med eller af kobber, og forbindelsen er etableret fortrinsvis med et forbindelseselement, som er fremstillet af en kobber-aluminium-legering, eller som består af to ledematerialer, som forbindes med hinanden til en del før forbindelsen af tilslutningerne.

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9. Synkrongenerator ifølge et af de foregående krav, hvor statorens (132) statorring (30) er sammenføjet af flere statorringdele i det mindste på to steder respektivt især i forbindelsesområdet (40) af to segmenter (36), især mellem

35

to naboliggende noter (32), som er respektivt tilordnet et af to forskellige segmenter (36), og hvis afstand (42) er større end noternes (32) afstand (33) inde i et segment (36).

- 5 **10.** Synkrongenerator ifølge et af de foregående krav, hvor formspolerne (10) respektivt i området af viklingshovedet (14) har en af de følgende former:
- uden for statorringen (30) er benene (12) forkrøppet i modsat retning og forløber parallelt indtil en 180-graders-bøjning (26), som forbinder benene (12), eller
 - 10 - uden for statorringen (30) er benene (12) i forskellige afstande (20, 22) bøjet i den samme retning og forløber så parallelt indtil en 180-graders-bøjning (26), som forbinder benene (12), hvor bøjningen (26) i den samme retning har en vinkel i området fra 0 til 90 grader, eller
 - 15 - uden for statorringen (30) er benene (12) i forskellige afstande (20, 22) bøjet i den samme retning og forløber så parallelt indtil en 180-graders-bøjning (26), som forbinder benene (12), hvor bøjningen (26) i den samme retning har en vinkel på 90 grader.
- 20 **11.** Fremgangsmåde til fremstilling af en synkrongenerator (130) ifølge et af de foregående krav, hvor synkrongeneratoren (130) har en statorring (30), som er opdelt i flere segmenter (36), hvor der i hvert segment (36) indsættes respektivt seks eller et multiplum på seks formspoler (10), hvor hver formspole (10) har to tilslutninger (16), og seks af tilslutningerne (16) af formspolerne (10)
- 25 af et segment (36) forbindes med seks tilslutninger (16) af formspolerne (10) af et segment (36), som ligger foran i omkredsretningen, og seks tilslutninger (16) af formspolerne (10) af et segment (36), som ligger bagved i omkredsretningen.
- 30 **12.** Fremgangsmåde ifølge krav 11, hvor formspolerne (10) respektivt vikles før indsætningen i noterne (32), ved at en eller flere parallelt anbragte tråde, især fladtråde, vikles om en viklingskerne, som fortrinsvis er dannet af to dorne, og den derved opnåede spole spredes på en sådan måde, at den ønskede afstand (20, 22) for de to ben (12) svarende til noternes (32) afstand
- 35 (33) inde i et segment (36) opnås, og viklingshovederne (14) bøjes, ved at

spolens (10) afsnit fikseres i indretninger, og disse indretninger så bevæges mod hinanden på en sådan måde, at den ønskede form af formspolen (10) opnås ved plastisk deformation.

5 **13.** Fremgangsmåde ifølge krav 12, hvor i tilfælde af forkrøppede formspoler (10) spolen i området af viklingshovedet (14) først forkrøppes i modsat retning, før benene (12) spredes.

10 **14.** Fremgangsmåde ifølge et af kravene 11 til 13, hvor tilslutningerne (16) af forskellige formspoler (10) forbindes med U-formede forbindelsesdele ved koldsvejsning, tryklodning eller svejsning ved hjælp af omrøringsfriktion.

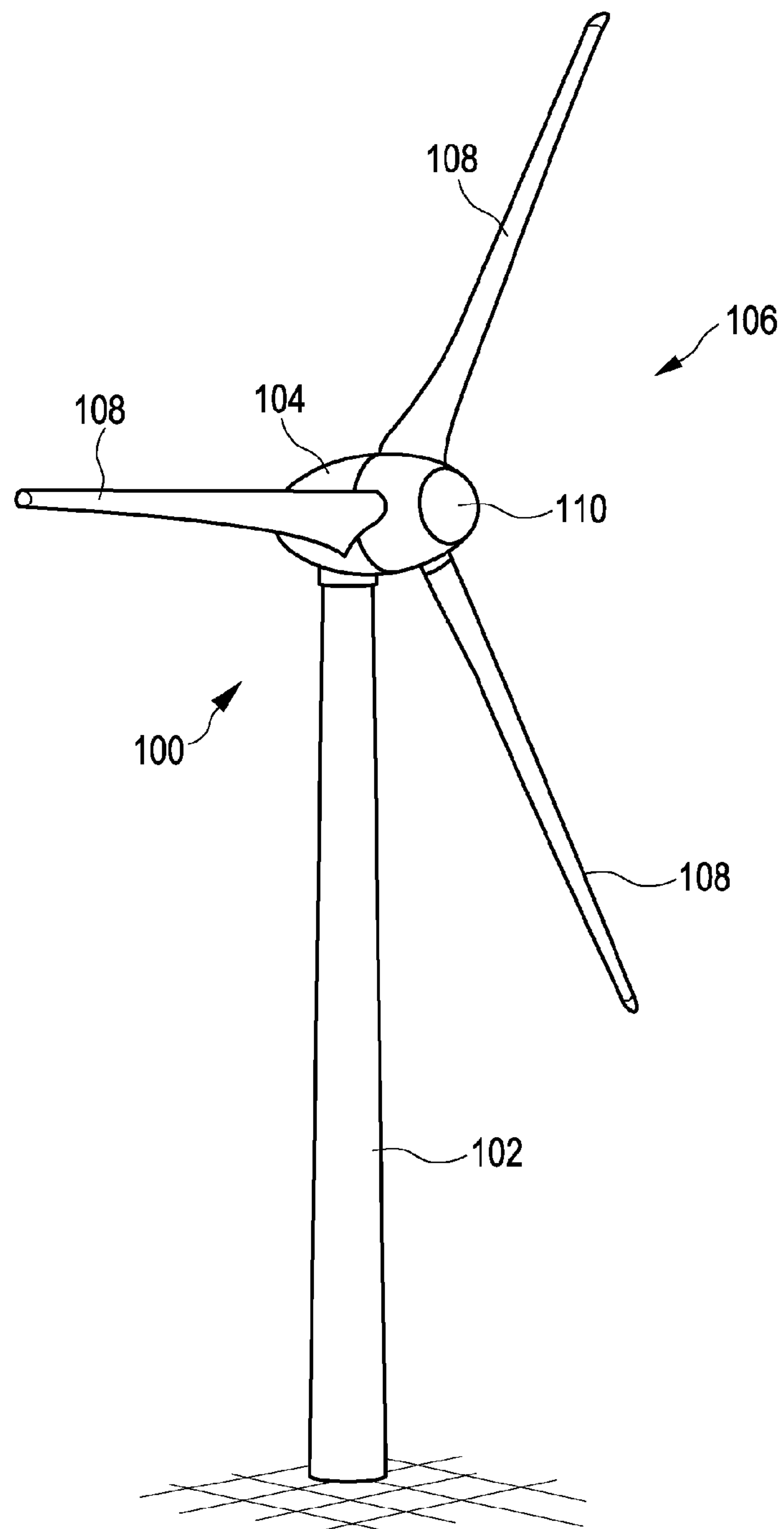


Fig. 1

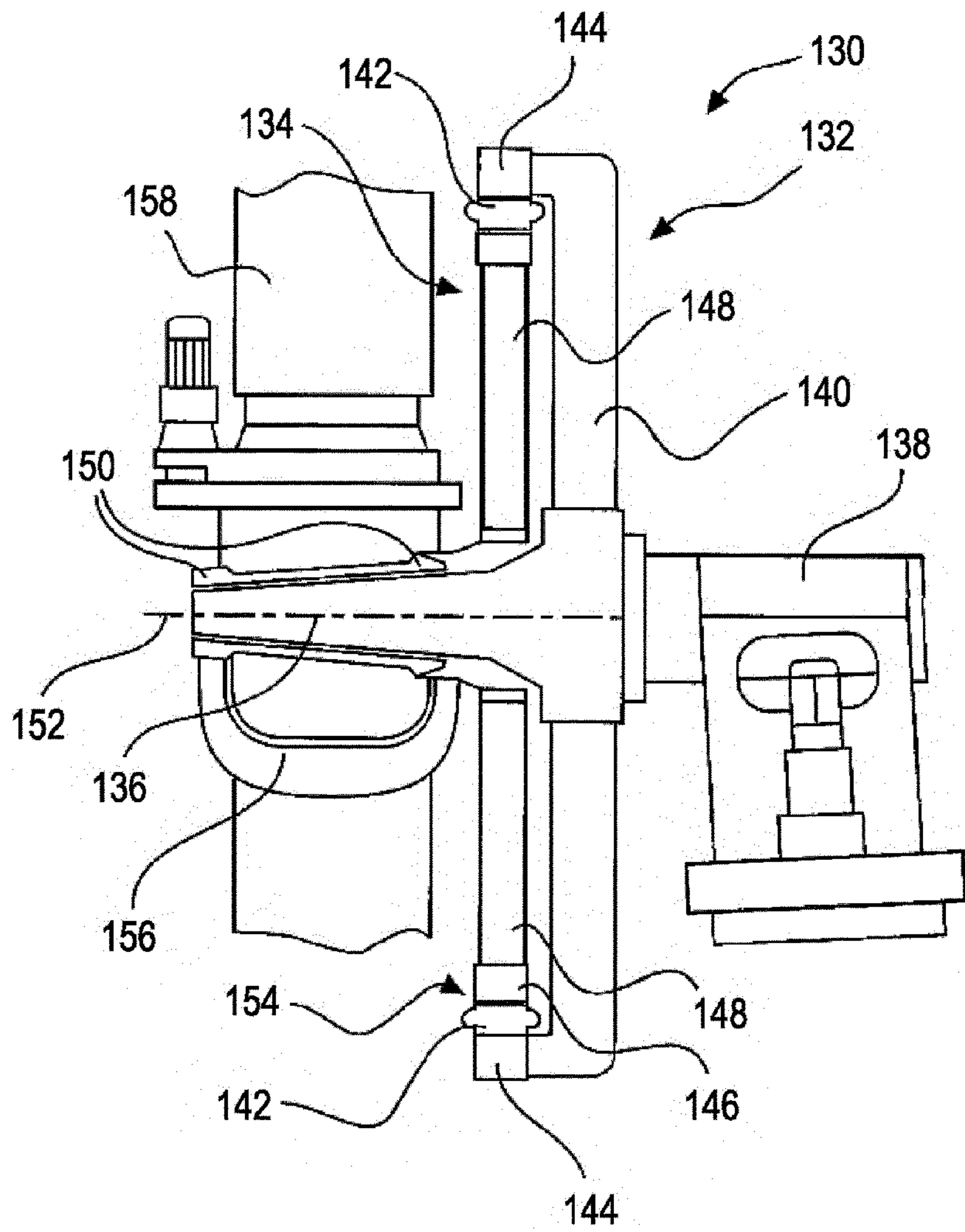


Fig. 2

Fig. 3

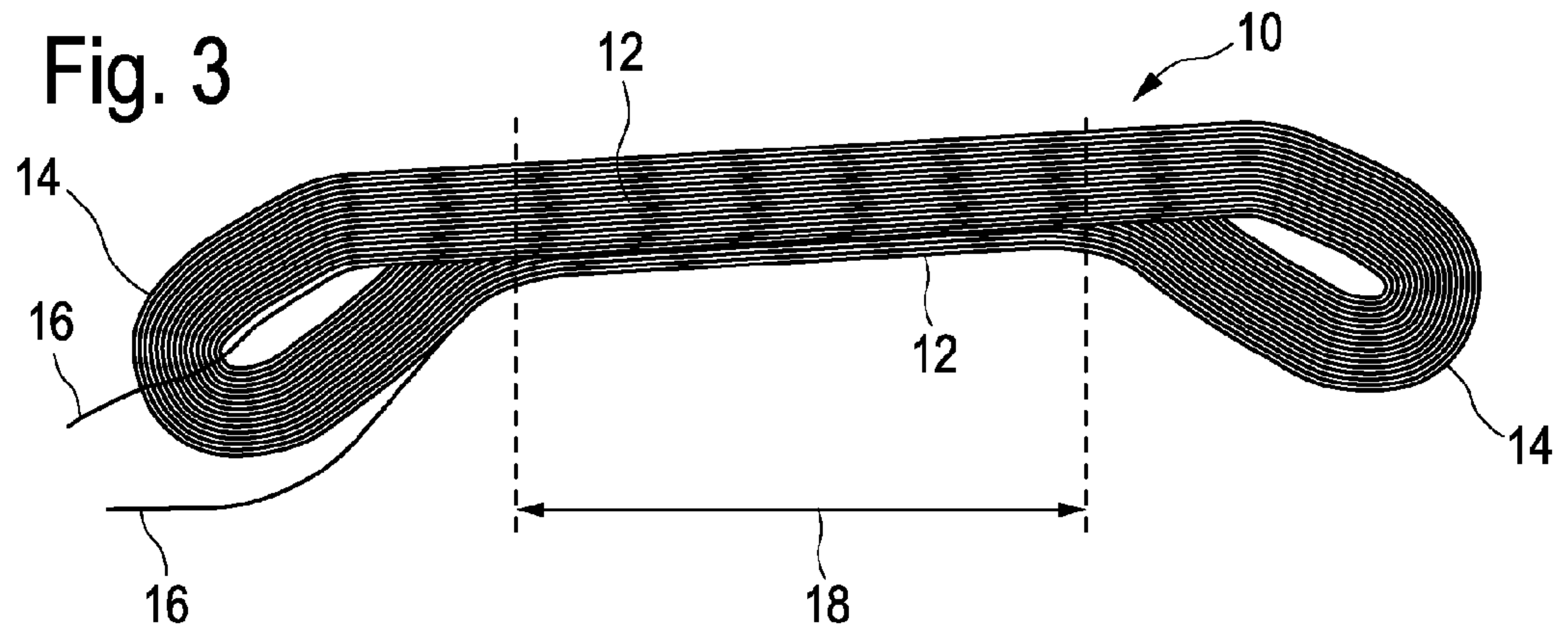


Fig. 4

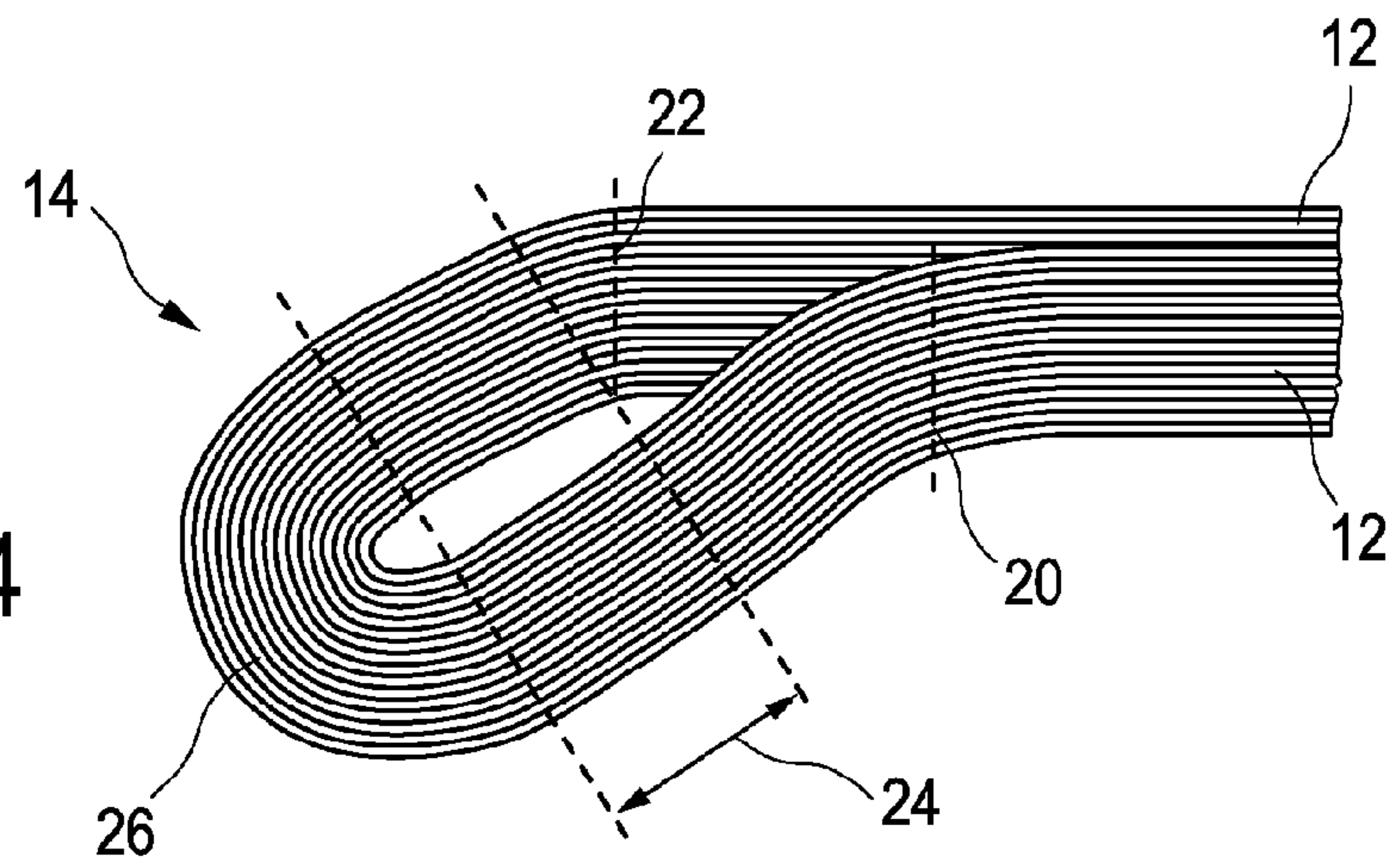


Fig. 5

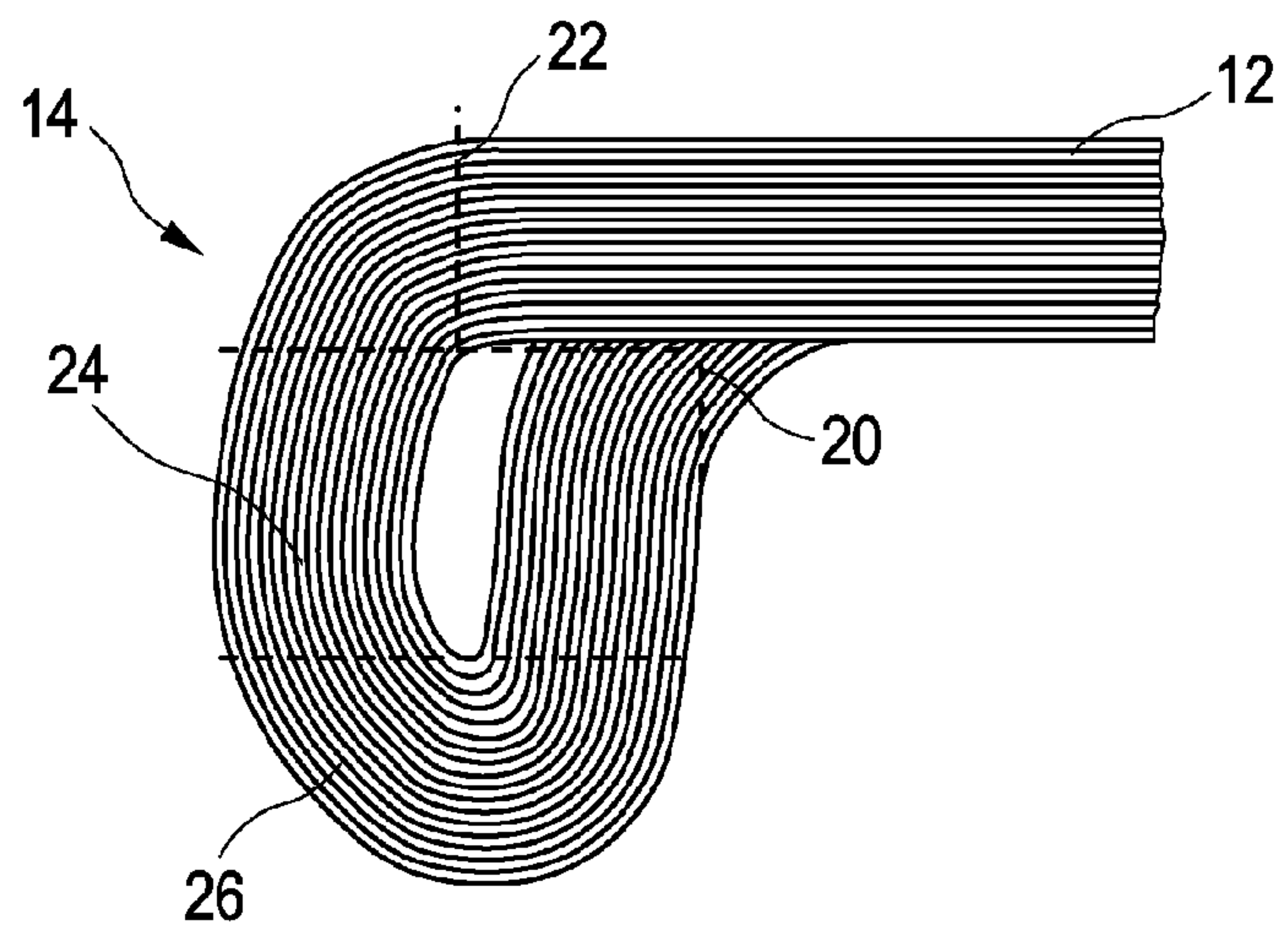


Fig. 6

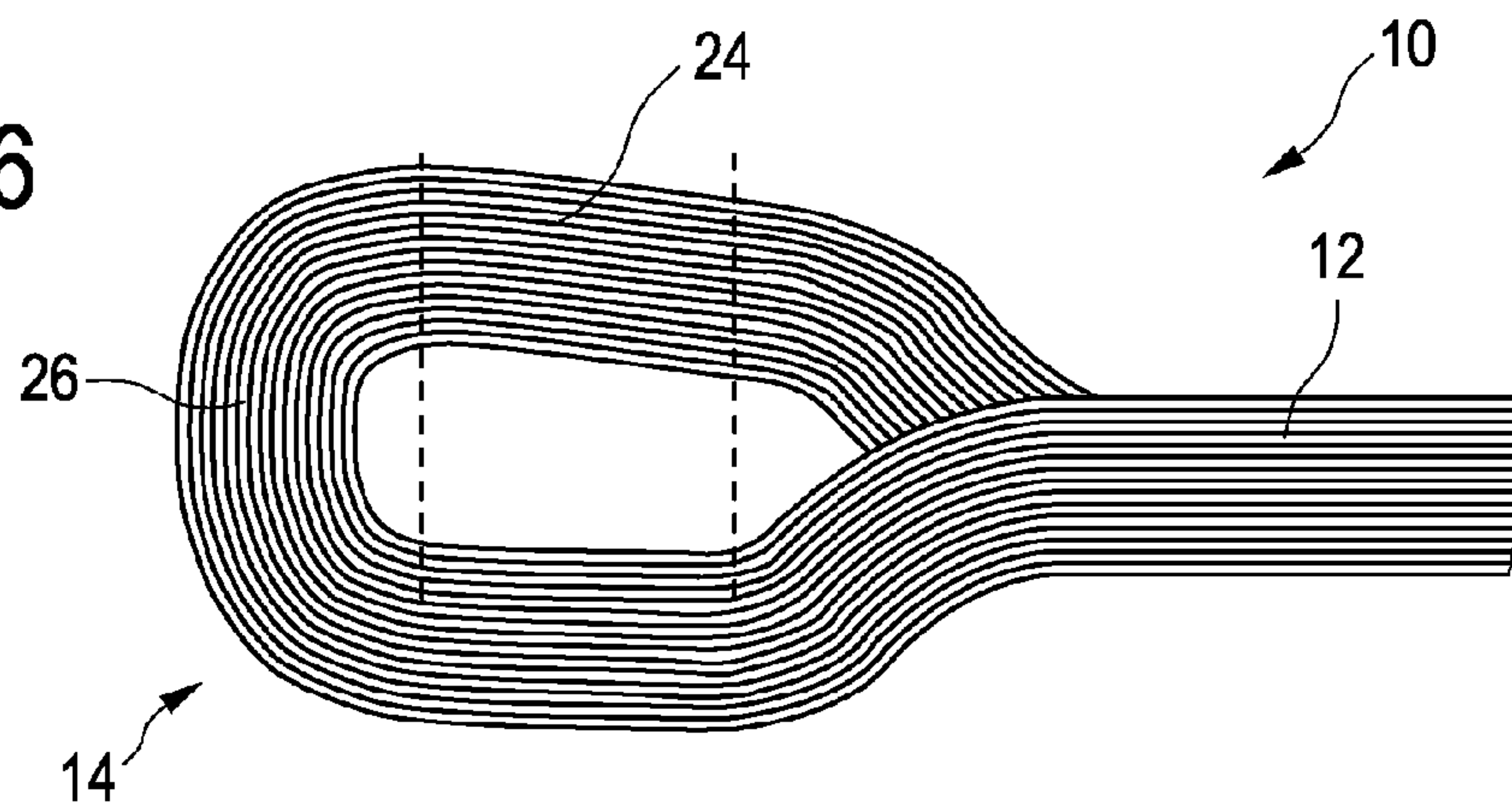


Fig. 7

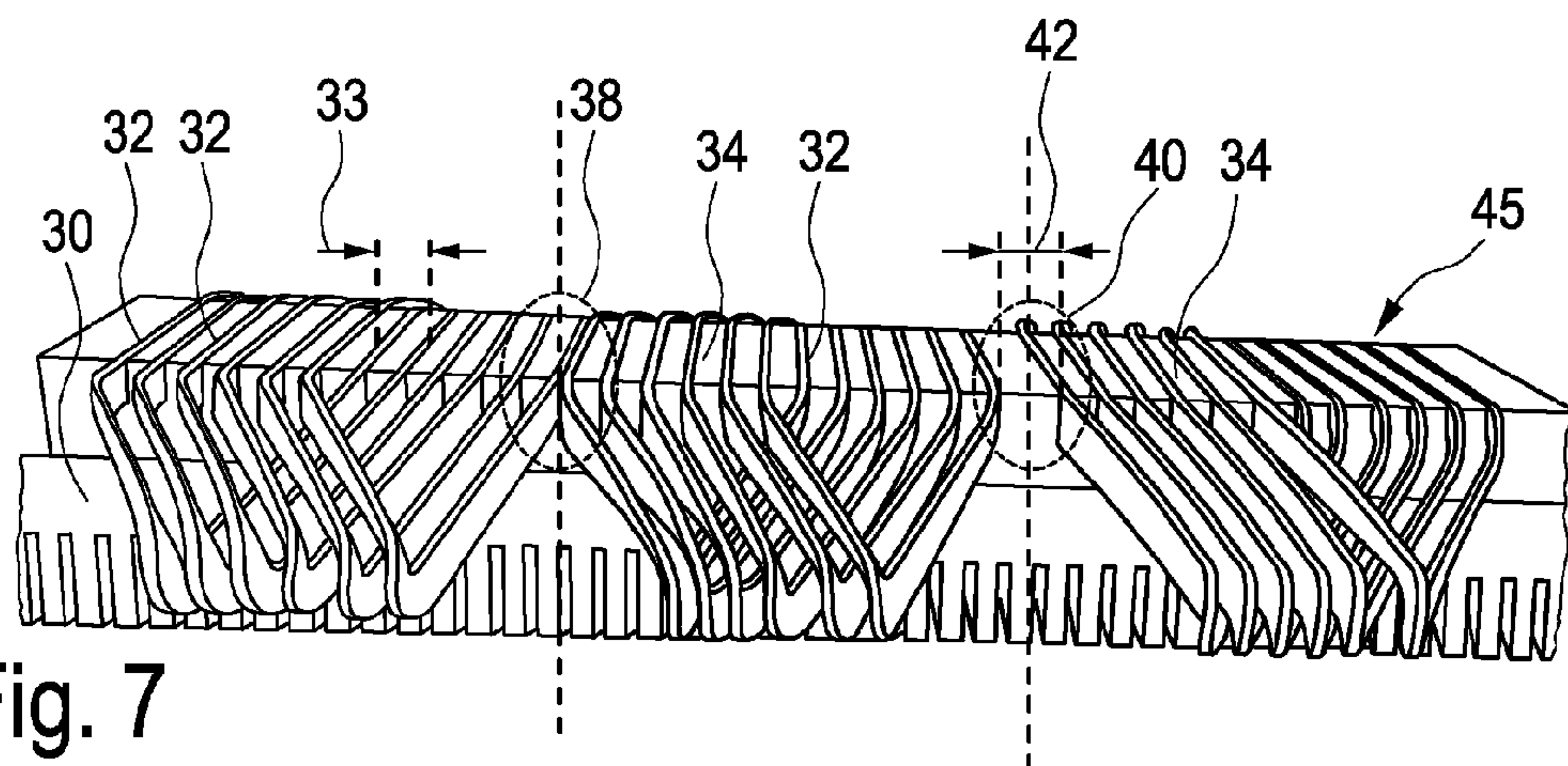


Fig. 8

