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(74) Fuldmægtig i Danmark: **COPA COPENHAGEN PATENTS K/S, Rosenørns Allé 1, 2. sal, 1970 Frederiksberg C, Danmark**

(54) Benævnelse: **SYSTEM OG FREMGANGSMÅDE TIL FREMSTILLING AF EN FIBERKOMPOSITARTIKEL**

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FR-A1- 2 950 285

DESCRIPTION

Field of the Invention

[0001] The present invention relates to a system and method for the manufacture of an article, in particular a fibre-composite article in a mould, preferably at least a portion of a blade for a wind turbine.

Background of the Invention

[0002] The manufacture of fibre-composite articles generally involves the layup of fibre-composite material in a shaped mould, the fibre-composite material normally applied as strips of a continuous layer. A resin can then be applied to the fibre-composite material in the mould which is subsequently cured to solidify the fibre-composite material into the moulded article. The moulded article can be then removed from the mould for additional processing or machining, with the mould prepared for the layup and curing of the next article in the mould.

[0003] Traditionally, the layup material is manually applied to the surface of the mould. However, as some fibre-composite articles are of considerable length, for example modern wind turbine blades can be in excess of 40 metres in length, such manual layup results in a considerable cycle time for the manufacture of a single article.

[0004] In an effort to reduce the manufacturing time for such articles, fibre-composite material can be dispensed from an automated layup head, which is arranged to apply such material from a roll provided at or on the layup head, the material applied along a linear application plane. The layup head can be moved relative to the mould, to dispense the material along any desired mould portion.

[0005] However, while the use of such a layup head can result in faster layup times, the automation of the layup sometimes results in misalignments of fibre-composite material in the mould, in particular when the mould comprises an inclined or sloped mould surface. In such a case, the dispensing of the material from a linear application plane to a curved surface can result in slippage of the fibre-composite material due to the effects of gravity on the material, causing the material to lie off the desired layup path in the mould. The correction of this misalignment can require manual inspection and rectification of the layup material position, thereby introducing additional time and effort to the manufacturing process. In addition, the application of material in a near-vertical alignment can result in a layup head being near a kinematic singularity, meaning that the flexibility or adaptability of the layup head is restricted.

[0006] In some systems, tackifier can be applied to the fibre-composite material and/or clamps can be applied to the edges of the material after layup to prevent movement or slippage after layup. However, such systems do not completely eliminate the slippage problem, and/or introduce additional steps to the manufacturing process.

[0007] WO 2010129492 describes automated application of glass fibre to a mould using gantry means.

[0008] FR 2950285 describes an apparatus for automatically placing fibre material in a mould.

[0009] It is an object of the invention to provide an improved system and method for the manufacture of a fibre-composite article which seeks to reduce these problems.

Summary of the Invention

[0010] Accordingly, there is provided a method of manufacturing a fibre-composite article in a mould, preferably a portion of a blade for a wind turbine, the fibre-composite article having an inclined or curved surface, the method comprising the steps of:

providing a mould having an inclined or curved surface;

defining a layup plane in said mould, said layup plane arranged to intersect at two points with at least a portion of the inclined or curved surface of said mould to which it is desired to apply a fibre material layer;

providing a layup head for the dispensing of a fibre material layer, wherein said layup head has a defined application plane where said fibre material layer is dispensed from said layup head along said application plane;

positioning said layup head wherein said application plane is rotated relative to said layup plane, such that the slope of said layup plane, relative to the horizontal plane, is greater than the slope of said application plane;

applying at least one fibre material layer from said rotated application plane of said layup head to said layup plane of said mould, such that the applied fibre material falls under the effect of gravity to said inclined or curved surface of said mould;

applying a resin to said at least one fibre material layer in said mould; and

curing said resin to form a fibre-composite article having an inclined surface.

[0011] By arranging the application plane of the layup head to have a smaller angle of incline than the layup plane of the mould, accordingly the risk of misalignment of the fibre layer due to gravity will be reduced. Furthermore, the layup head will be removed from a possible kinematic singularity at relatively high levels of incline. Preferably, the application plane is rotated about the longitudinal or horizontal axis between 5-30 degrees relative to said layup plane, to a more horizontal alignment compared to said layup plane.

[0012] It will be understood that the slope of a plane is a measure of the inclination of the plane, and is measured with respect to the horizontal axis. It will further be understood that the slope of said application plane and the slope of said layup plane are measured in the same direction.

[0013] Preferably, the method comprises the steps of:

providing a notional reference layup frame for said layup head for application of fibre material along a surface of said mould, an application plane of said reference layup frame initially provided coincident with said layup plane;

rotating said notional reference layup frame about the longitudinal or horizontal axis such that said application plane has a more horizontal orientation relative to said layup plane; and

moving said layup head to be coincident with said rotated layup frame for the application of fibre material from said layup head.

[0014] Preferably, the fibre material layer is applied to a layup path defined along a portion of the surface of said mould, the layup path extending along a longitudinal extent of said mould, the layup path having a first longitudinal path edge and a second longitudinal path edge, wherein said first and second path edges are located on said layup plane, and wherein the method comprises the step of:
aligning a first edge of the fibre material layer dispensed from said layup head with said first path edge of said layup path, such that as said at least one fibre material layer is applied from said layup head to said mould, a second edge of said fibre material layer drops to said second path edge of said layup path.

[0015] It will be understood that said longitudinal layup path defined on the surface of the mould may comprise a substantially concave surface between said first and second path edges. Preferably, the method comprises the step of moving said layup head along a portion of the longitudinal extent of said mould parallel to said layup path, to apply said layer of fibre material to said layup path. It will be understood that the width of the fibre material layer and/or the width of the layup path may vary along the length of the mould.

[0016] Preferably, said step of positioning said layup head comprises:

providing a notional reference layup frame for said layup head for application of fibre material along said layup path, an application plane of said reference layup frame initially provided coincident with said layup plane;

rotating said notional reference layup frame about the longitudinal direction of said layup path such that said application plane has a more horizontal orientation relative to said layup plane;

offsetting said rotated frame to locate said first edge of the fibre material layer dispensed from said layup head at said first edge of said layup path to provide a notional translated layup frame;

moving said glass layup head to be coincident with said notional translated layup frame; and

subsequently applying fibre material layer along mould based on said notional translated layup frame.

[0017] Preferably, said step of rotating comprises rotating said application plane between 5-30 degrees relative to said layup plane.

[0018] Additionally or alternatively, said step of rotating said application plane is performed when said layup plane is oriented within 30 degrees of the vertical plane, preferably within 20 degrees of the vertical plane.

[0019] By only performing the rotation of the application plane when the layup plane, and the associated layup path, are substantially vertical, the relatively complicated operation of translating the layup head is only performed for those areas of the mould where the effects of gravity and kinematic singularities are greatest.

[0020] Preferably, said step of offsetting comprises adjusting the layup head position to account for clearance above the mould.

[0021] Preferably, the slope of said layup plane varies along the length of the layup path, and wherein the method comprises the step of adjusting the position of the layup head to vary the slope of said application plane in response to said variation of the slope of the layup plane, as the layup head moves along the length of the layup path.

[0022] As the shape of the mould may vary along the mould length, accordingly the layup path and the associated layup plane may vary in inclination. In such a case, it is preferable that the layup head is operable to adjust for such variation, to ensure that the layer of fibre material is accurately applied to the surface of the mould.

[0023] Preferably, said step of adjusting the position of the layup head to vary the slope of said application plane comprises the step of when the slope of said layup plane is below a threshold value, said layup head is adjusted such that said application plane is coincident with said layup plane.

[0024] If the slope of the layup path and the associated layup plane is decreased to such an extent that the negative effects of gravity on the layer application process is reduced, and/or the angle of the layup path is sufficiently away from a kinematic singularity of the layup head, the layup head may be arranged to follow the layup path without correction or offsetting.

[0025] Preferably, the fibre material layer is a glass fibre layer, a carbon fibre layer, or a hybrid glass-carbon fibre layer.

[0026] Preferably, the fibre material layer is dispensed from a roll of said fibre material provided on said layup head.

[0027] Preferably, the method comprises the step of applying a hot melt adhesive or tackifier in said mould before said step of applying at least one fibre material layer.

[0028] Through the use of a suitable hot melt adhesive or tackifier in the mould, the fibre material layer is prevented from slippage inside the mould after application from the layup head. It will be understood that the hot melt or tackifier may be applied directly to the mould surface, and/or may be applied on top of a preceding layer of fibre material applied in the mould. Additionally or alternatively, clamps may be provided to secure the layer of fibre material in position on the mould, as the layer is applied along the length of the layup path.

[0029] Preferably, the method comprises the step of applying at least one roller and/or brush to the at least one fibre material layer in the mould after application from the layup head.

[0030] By using a roller or brush on top of the fibre material layer after application, the layer can be smoothed to ensure compliance with the mould surface, and/or to bond with hot melt or tackifier provided in the mould. The use of a roller and/or brush on the fibre material layer ensures that a gentle downward pressure is applied to the material layer in the mould, without distortion of the layup path.

[0031] Preferably, the method comprises the step of providing said at least one roller and/or brush on said layup head, wherein said at least one roller or brush are downstream from the point of dispensing of said at least one fibre material layer from said layup head.

[0032] Providing the at least one roller and/or brush on the layup head downstream from the application point of the fibre material layer ensures that the at least one roller and/or brush are maintained in close alignment with the fibre material layer after dispensing from the layup head.

[0033] Preferably, the method comprises the step of providing a fibre material layer or a layup material having a width that varies along the length of the layup path.

[0034] Preferably, the method comprises the step of varying the fibre material layer along the length of the layup path, preferably cutting the fibre material layer along the length of the layup path.

[0035] There is also provided a method of manufacturing a wind turbine blade comprising:

manufacturing at least one fibre-composite part of a wind turbine blade according to any of the method steps as described above; and

assembling said at least one fibre-composite part to form a wind turbine blade.

[0036] There is further provided a computer program product adapted to perform the steps of the above method. There is further provided a computer-readable storage medium/data carrier comprising a computer program adapted to perform the method.

[0037] Additionally, there is provided a manufacturing system for manufacturing a fibre-composite article in a mould, preferably a portion of a blade for a wind turbine, the system comprising:

a mould to receive a fibre-composite material to form a fibre-composite article, the mould having at least one inclined surface;

an adjustable layup head operable to dispense a fibre material layer in said mould; and

a controller operable to control the operation of said layup head, wherein said controller is operable to implement the steps of the above-described method.

[0038] There is further provided a fibre-composite article, preferably a portion of a blade for a wind turbine, manufactured according to the above-described method.

Description of the Invention

[0039] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, which will be understood to be illustrative only, and are not provided to scale.

Fig. 1 is a cross-sectional view of a step for a manufacturing method for an article in a mould, for an initial layup of material in the mould along a layup path from a layup head;

Fig. 2 is a cross-sectional view of the method of Fig. 1, after a rotation of the layup head relative to the layup path;

Fig. 3 is a cross-sectional view of the method of Fig. 2, after an alignment of the layup head with an edge of the layup path;

Fig. 4 is a cross-sectional view of the method of Fig. 3, after an offsetting of the layup head to compensate for mould clearance; and

Fig. 5 is a cross-sectional view of the method of the invention, in the application of layup material having reduced width.

[0040] Fig. 1 shows a cross-sectional illustrative view of a portion of a system for the manufacturing of an article in a mould 10. The mould 10 comprises a shaped cross-sectional profile having a curved or inclined surface, the mould surface corresponding to the desired profile of the finished article. A layer material, preferably a fibre-composite material, is to be applied to the surface of the mould 10 which can be subsequently cured to form the desired article. The fibre-composite material is applied along layup paths arranged along the longitudinal length of the mould 10.

[0041] A layup path 12 is indicated by the dashed line in Fig. 1, the layup path 12 provided along a portion of the curved surface of the mould 10 and extending along the longitudinal direction of the mould 10. The layup path 12 comprises an upper edge 12a and a lower edge 12b, the upper and lower edges 12a,12b provided on an inclined layup plane 14.

[0042] The manufacturing system comprises an articulated layup head 16, which is operable to dispense layers of layup material along an application plane, preferably fibre-composite material. The application plane is indicated at 18, provided along the surface of the layup head 16 from which the material is dispensed. The material is dispensed between a first edge 18a and a second edge 18b of the layup head 16 surface.

[0043] It will be understood that the material to be dispensed from the layup head 16 may be provided in roll form, the roll (not shown) mounted on or coupled with said layup head 16. The material may comprise any suitable fibre-composite material, e.g. glass fibres, carbon fibres, etc., in any suitable composition, arrangement and/or dimensions. In one embodiment, the material is Combi 1250 GPV glass fibre, having a thickness of 0.88mm, and a width of either 400mm, 600mm, 800mm, or 1200mm.

[0044] The layup head 16 is coupled or provided with a controller (not shown) which is operable to control the orientation and translation of the layup head 16 relative to the mould 10. It will be understood that the controller is provided with an indication of the profile of the mould 10. This indication may be pre-defined based on a priori knowledge of the mould profile, e.g. through an initial mapping of the mould profile and/or from a design template setting out the particular dimensions of the mould 10. Additionally or alternatively, the indication may be based on the output of sensors coupled to the controller and arranged to dynamically scan and detect the shape of the mould surface, e.g. vision systems, ultrasonic distance sensors, etc.

[0045] In general, the layup head 16 is preferably aligned such that the layup head 16 is arranged adjacent to the layup path 12 in the mould 10, wherein the application plane 18 of the layup head 16 is coincident with the layup plane 14 of the layup path 12.

[0046] However, when it is determined that the current or future layup path 12 in the mould 10 is along a curved section of the mould 10, such that an application of a material layer to the layup path 12 from the application plane 18 of the layup head 16 will result in a misalignment of the material layer in the mould 10, the controller is operable to perform a number of corrective steps to the orientation of the layup head 16, to reduce the risk of misalignment of the material layer in the mould 10.

[0047] It will be understood that the controller is operable to define a notional reference frame corresponding to the position of the layup head 16, and to apply translation operations to said notional reference frame to provide a resultant reference frame, the ultimate reference frame providing the adjusted orientation for the layup head 16.

[0048] With reference to Fig. 2, the notional reference frame (indicated by the dashed outline 20) is rotated about the longitudinal direction of the mould 10, about a point corresponding to the midpoint of the layup path 12 between the upper and lower edges 12a,12b. As a result of the rotation, the application plane 18 defined on the reference frame 20 is orientated in a more horizontal alignment compared to the layup plane 14 of the layup path 12.

[0049] The angle of rotation of the reference frame 20 is chosen to provide for an application of material from the application plane 18 of the layup head 16 to the inclined layup path 12 which will not result in a misalignment of the material along the layup path 12. Preferably, the reference frame 20 is rotated between approximately 5-30 degrees relative to said layup plane 14.

[0050] With reference to Fig. 3, the reference frame 20 is then offset, such that the first edge 18a of the application plane 18 defined on the translated reference frame 20 is located in register with the upper edge 12a of the layup path 12. This arrangement should ensure that layup material dispensed from a layup head 16 arranged at said translated reference frame 20 will accurately fall onto the layup path 12 under the effect of gravity. In particular, a first edge of the layup material dispensed from the layup head 16 will be located at the said upper edge 12a of the layup path 12, and an opposed second edge of the layup material will fall from the layup head 16 to land at the said lower edge 12b of the layup path 12, as indicated by arrow A in Fig. 3.

[0051] Depending on the interpretation of the boundaries of the translated reference frame 20 with regard to the structure of the mould 10, a further step of offsetting the reference frame 20 may be performed, to provide for adequate clearance of the mould structure by a layup head 16. In such a case, the position of the reference frame 20 is adjusted to ensure that the frame 20 does not overlap with any portion of the mould surface, such that the layup head 16 will by unimpeded by the mould 10 when positioned in the reference frame 20. It will be understood that this step does not need to be carried out if there is no overlap between the mould 10 and the translated reference frame 20.

[0052] With reference to Fig. 4, the layup head 16 is then positioned to align with the reference frame 20, where the application plane 18 of the layup head 16 is orientated in a more horizontal alignment than the layup plane 14. Layup material can now be dispensed from the layup head 16 to the layup path 12 as the layup head 16 is moved along the length of the mould 10. It will be understood that the orientation of the layup head 16 may be dynamically adjusted by the controller as the layup head 16 travels along the length of the mould 10, based on the variation of the slope of the layup plane 14 along the length of the mould 10. This adjustment may be based on the a priori knowledge of the shape of the mould 10, and/or based on the output of various sensor systems coupled to the controller.

[0053] The procedure can be repeated for different layers of layup material, and/or for different layup paths provided in the mould 10, having differently-inclined layup planes. Once the layup material has been applied in the mould 10, a resin can be applied to the material, which is subsequently cured to form the desired article, the curved surfaces of the mould 10 imparting the desired profile onto the article.

[0054] In a particularly preferred aspect, the system is used to manufacture at least a portion of a blade for a wind turbine, for example a blade shell substantially forming an upwind or a downwind portion of a wind turbine blade. In such an embodiment, it will be understood that the layup procedure may be performed in a plurality of moulds for providing separate portions of the blade, wherein the portions are assembled to form a wind turbine blade after the curing of the individual portions.

[0055] In a further aspect of the invention, it will be understood that the width of the layup material may vary along the length of the layup path 12. This may be due to variations of the width of the layup path 12 along the length of the mould 10, for example due to the particular longitudinal profile of the article to be formed by the mould 10. Accordingly, the layup material may be provided in a pre-cut format, having predefined variations in width based on a priori knowledge of the mould 10 geometry. Additionally or alternatively, the layup material may be cut during the application process, based on a priori and/or dynamically monitored knowledge of the mould profile and/or the layup path 12. In these cases, it will be understood that the adjustment of the layup head 16 will be performed to ensure that a first edge of the layup material will be aligned with the upper edge 12a of the layup path 12, following any variation in the width of the layup material.

[0056] With reference to Fig. 5, a layup path 12 of reduced width is defined along an edge of the mould 10. In this case, the layup material to be applied to the layup path 12 does not extend across the entire face of the layup head 16 between the first and second edges 18a,18b of the application plane 18. Rather, the layup material has a width corresponding to the distance between an edge point 18c and the second edge 18b, defined on the application plane 18. Accordingly, the layup head 16 is arranged as described above, wherein the edge point 18c is aligned with the upper edge 12a of the layup path 12. The layup material is then applied along the layup path 12, wherein the layup material applied from the second edge 18b will fall to the lower edge 12b of the layup path 12, as indicated by arrow A. It will be understood that the location of the edge point 18c between the first and second edges 18a,18b may vary along the length of the layup path 12. For example, the edge point 18c may start at or towards the first edge 18a, and move towards the second edge 18b as the length along the layup path varies, and vice versa.

[0057] It will be understood that the system may comprise the use of tackifiers or hot-melt adhesives in the mould 10, which act to partly hold the layup material in place in the mould and to arrest any slippage of the layup material in the mold 10. Additionally or alternatively, clamps or any other suitable securing mechanisms may be used to further prevent material slippage.

[0058] It will be understood that suitable rollers or brushes may be provided at said layup head 16, at a location downstream of the dispensing point of the layup head 16, to ensure that the layup material is applied with some pressure to the surface of the mould 10.

[0059] In a preferred aspect, the system is focused such that the layup head 16 may be initially provided wherein the application plane 18 is coincident with the layup plane 14 of the layup path 12, and wherein the above steps of rotation and subsequent offsetting of the layup head 16 are performed only for those sections of the mould 10 wherein the desired layup path 12 is in a substantially vertical alignment, preferably wherein the layup pane 14 of the desired layup path 12 is within 20-30 degrees of the vertical axis. Outside of this range, the gravity and/or singularity effects may be minimised.

[0060] It will be understood that the provision of a layup head 16 in a relatively more horizontal alignment compared to the layup plane 14 of the desired layup path 12 both provides for a reduction of the negative effects of gravity on the alignment of the layup material, and distances the layup head 16 from a kinematic singularity.

[0061] The invention is not limited to the embodiment described herein, and may be modified or adapted without departing from the scope of the present invention.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO2010129492A [0007]

- FR2950285 [0008]

KRAV

1. Fremgangsmåde til fremstilling af en fiberkompositartikel, hvor fiberkompositartiklen omfatter en skrå eller buet overflade, hvor fremgangsmåden omfatter trinnene:

tilvejebringelse af en form (10) med en skrå eller buet overflade;
definering af et oplægningsplan (14) i nævnte form, hvor nævnte oplægningsplan er arrangeret så det skærer, med mindst en del af den skrå eller buede overflade af nævnte form hvortil det ønskes at påføre et fibermaterialelag, i to punkter;
tilvejebringelse af et oplægningshoved (16) til dispensering af et fibermaterialelag, hvor nævnte oplægningshoved har et defineret påføringsplan (18), hvor nævnte fibermaterialelag leveres fra nævnte oplægningshoved (16) langs nævnte påføringsplan (18);
positionering af nævnte oplægningshoved (16), hvor nævnte påføringsplan drejes i forhold til nævnte oplægningsplan, således at hældningen af nævnte oplægningsplan er større end hældningen af nævnte påføringsplan, i forhold til det vandrette plan;
påføring af mindst et fibermaterialelag fra nævnte drejede påføringsplan af nævnte oplægningshoved til nævnte oplægningsplan af nævnte form, således at det påførte fibermateriale, ved hjælp af tyngdekraften, falder ned på nævnte skrå eller buede overflade af nævnte form;
påføring af en resin til nævnte mindst ene fibermaterialelag i nævnte form; og
hærdning af resinen for at danne en fiberkompositartikel med en skrå overflade.

2. Fremgangsmåde ifølge krav 1, hvor nævnte trin med positionering omfatter at dreje nævnte påføringsplan (18) omkring den langsgående eller vandrette akse mellem 5-30 grader i forhold til nævnte oplægningsplan.

3. Fremgangsmåde ifølge krav 1 eller krav 2, hvor fremgangsmåden omfatter trinnene:

tilvejebringelse af en tænkt referenceoplægningsramme (20) til nævnte oplægningshoved (16) til påføring af fibermateriale langs en overflade af nævnte form, hvor et påføringsplan (18) af nævnte referenceoplægningsramme oprindeligt tilvejebragt er sammenfaldende med nævnte oplægningsplan (14);
drejning af den tænkte referenceoplægningsramme (20) omkring den langsgående eller vandrette akse, således at nævnte påføringsplan har en mere vandret orientering i forhold til nævnte oplægningsplan (14); og

bevægelse af nævnte oplægningshoved så det falder sammen med nævnte drejede oplægningsramme til påføring af fibermateriale fra nævnte oplægningshoved.

4. Fremgangsmåde ifølge et hvilket som helst af kravene 1-3, hvor fibermaterialelaget påføres en oplægningsbane defineret langs en del af overfladen af nævnte form, hvor oplægningsbanen strækker sig langs en langsgående udstrækning af nævnte form, hvor oplægningsbanen har en første langsgående banekant og en anden langsgående banekant, hvor nævnte første og anden banekant er placeret på nævnte oplægningsplan, og hvor fremgangsmåden omfatter trinnet:
tilpasning af en første kant af fibermaterialelaget, leveret fra nævnte oplægningshoved, med nævnte første banekant af nævnte oplægningsbane, således at mens nævnte mindst ene fibermaterialelag påføres fra nævnte oplægningshoved til nævnte form, falder en anden kant af nævnte fibermaterialelag til nævnte anden banekant af nævnte oplægningsbane.

5. Fremgangsmåde ifølge krav 4, hvor nævnte trin med positionering af nævnte oplægningshoved omfatter:

tilvejebringelse af en tænkt referenceoplægningsramme til nævnte oplægningshoved til påføring af fibermateriale langs oplægningsbanen, hvor et påføringsplan af nævnte referenceoplægningsramme oprindeligt tilvejebragt er sammenfaldende med nævnte oplægningsplan;
drejning af den tænkte referenceoplægningsramme omkring den langsgående retning af nævnte oplægningsbane, således at nævnte påføringsplan har en mere vandret orientering i forhold til nævnte oplægningsplan;
forskydning af den drejede ramme for at positionere nævnte første kant af fibermaterialelaget leveret fra oplægningshovedet ved nævnte første kant af nævnte oplægningsbane for at tilvejebringe en overført oplægningsramme;
bevægelse af nævnte oplægningshoved så det falder sammen med den overførte oplægningsramme; og
efterfølgende påføring af fibermaterialelag langs form baseret på nævnte overførte oplægningsramme.

6. Fremgangsmåde ifølge krav 5, hvor trinnet med forskydning omfatter justering af oplægningshovedets position for at tage højde for frigang over nævnte form.

7. Fremgangsmåde ifølge et hvilket som helst af kravene 4-6, hvor hældningen af nævnte oplægningsplan varierer langs længden af oplægningsbanen, og hvor fremgangsmåden omfatter trinnet med at justere positionen af oplægningshovedet for at variere hældningen af nævnte påføringsplan som reaktion på nævnte variation af hældningen af oplægningsplanet, når oplægningshovedet bevæger sig langs længden af oplægningsbanen.

8. Fremgangsmåde ifølge krav 7, hvor nævnte trin med justering af positionen af oplægningshovedet for at variere hældningen af nævnte påføringsplan omfatter trinnet, når hældningen af nævnte oplægningsplan i forhold til det vandrette er under en tærskelværdi, justeres nævnte oplægningshoved således at nævnte påføringsplan falder sammen med nævnte oplægningsplan.

9. Fremgangsmåde ifølge et hvilket som helst af kravene 1-8, hvor nævnte trin med positionering af nævnte oplægningshoved, således at nævnte påføringsplan drejes i forhold til nævnte oplægningsplan, udføres, når hældningen af nævnte oplægningsplan i forhold til det vandrette plan er over en tærskelværdi.

10. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor fibermaterialelaget er et glasfiberlag, et carbonfiberlag eller et hybrid-glas-carbon-fiberlag.

11. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor fremgangsmåden omfatter et trin med påføring af et klæbemiddel der smelter ved høj varme (ENG: hot melt adhesive) eller klæbemiddel der forhøjer klæbning (ENG: tackifier) i nævnte form før nævnte trin med påføring af mindst et fibermaterialelag.

12. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor fremgangsmåden omfatter trinnet at gøre brug af mindst en rulle og/eller børste på det mindst ene fibermaterialelag i nævnte form efter påføring fra nævnte oplægningshoved.

13. Fremgangsmåde ifølge krav 12, hvor fremgangsmåden omfatter trinnet at tilvejebringe nævnte mindst ene rulle og/eller børste på nævnte oplægningshoved, hvor nævnte mindst ene rulle eller børste er nedstrøms fra dispenseringspunktet af nævnte mindst ene fibermaterialelag fra nævnte oplægningshoved.

14. Fremgangsmåde til fremstilling af en vindmøllevinge omfattende:

fremstilling af mindst en fiberkompositdel af en vindmøllevinge ifølge fremgangsmåden ifølge et hvilket som helst af kravene 1-13; og

samling af nævnte mindst ene fiberkompositdel for at danne en vindmøllevinge.

15. Et fremstillingssystem til fremstilling af en fiberkompositartikel i en form, fortrinsvis en del af en vinge til en vindmølle, hvor systemet omfatter:

en form til at modtage et fiberkompositmateriale for at danne en fiberkompositartikel, hvor formen har mindst en skrå overflade;

et justerbart oplægningshoved, der kan styres til at levere et fibermaterialelag i nævnte form; og

en styreenhed, der kan styre oplægningshovedet, hvor nævnte styreenhed kan styres til at implementere trinnene ifølge et hvilket som helst af kravene 1-14.

DRAWINGS

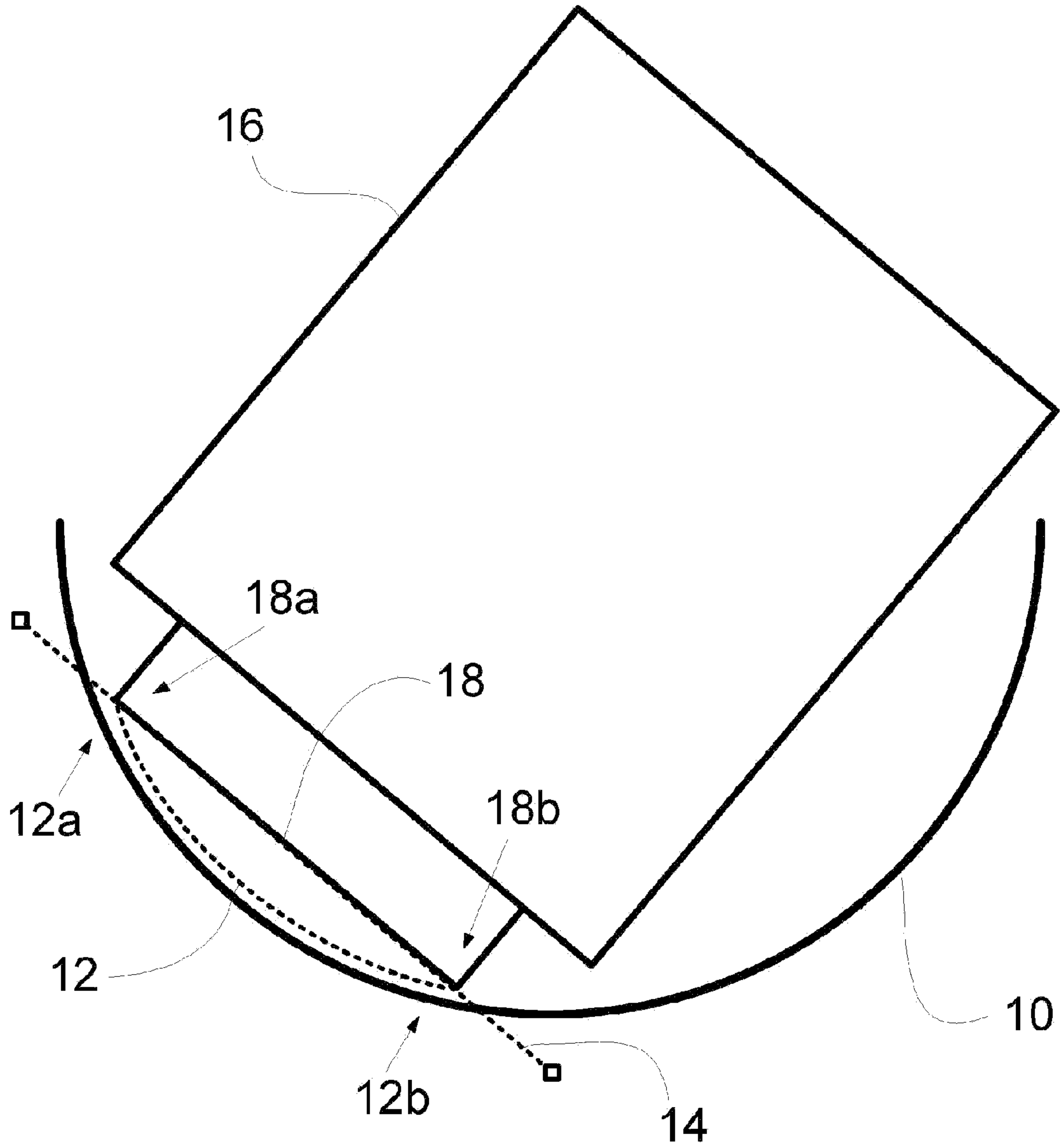

Fig. 1

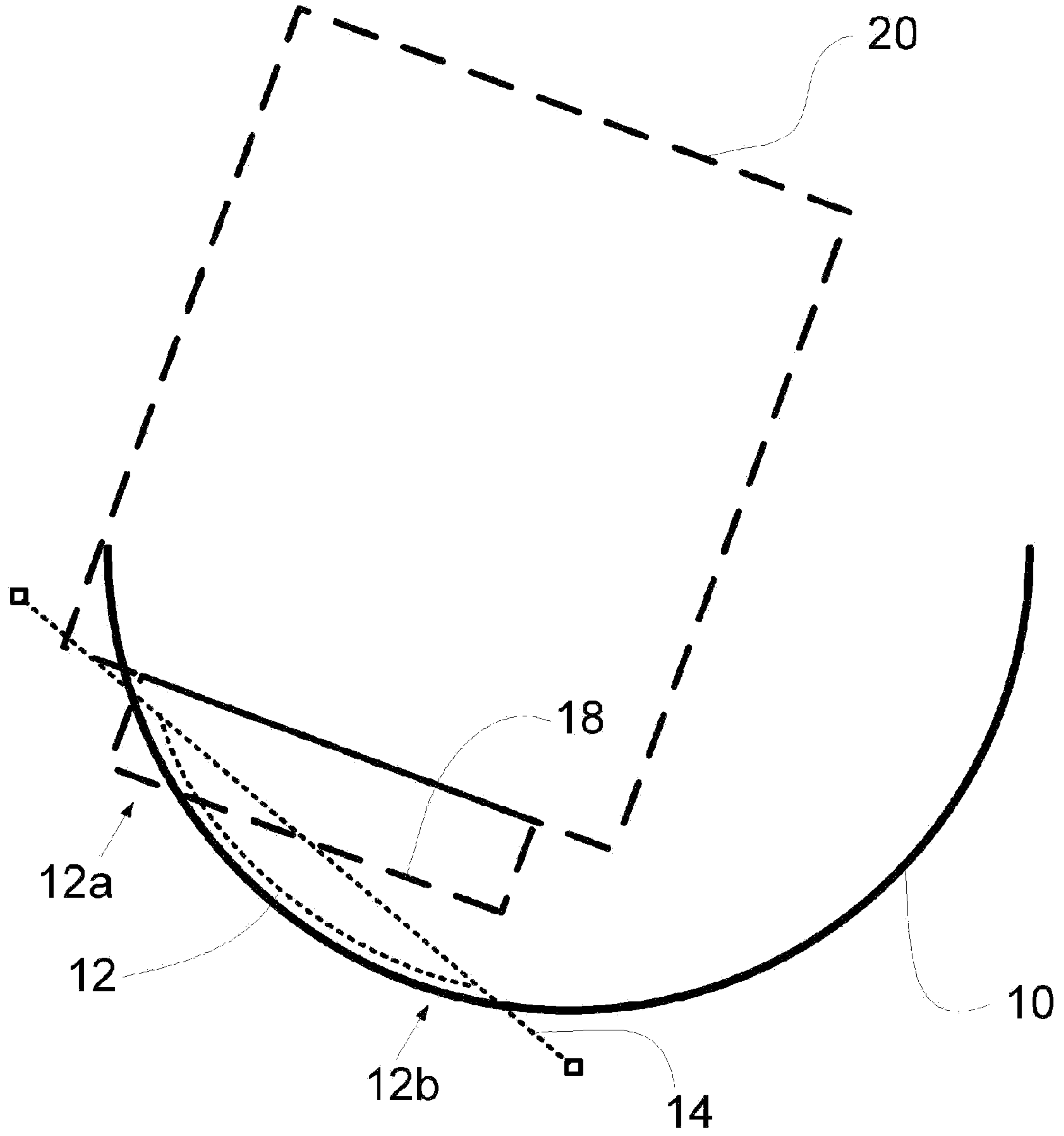

Fig. 2

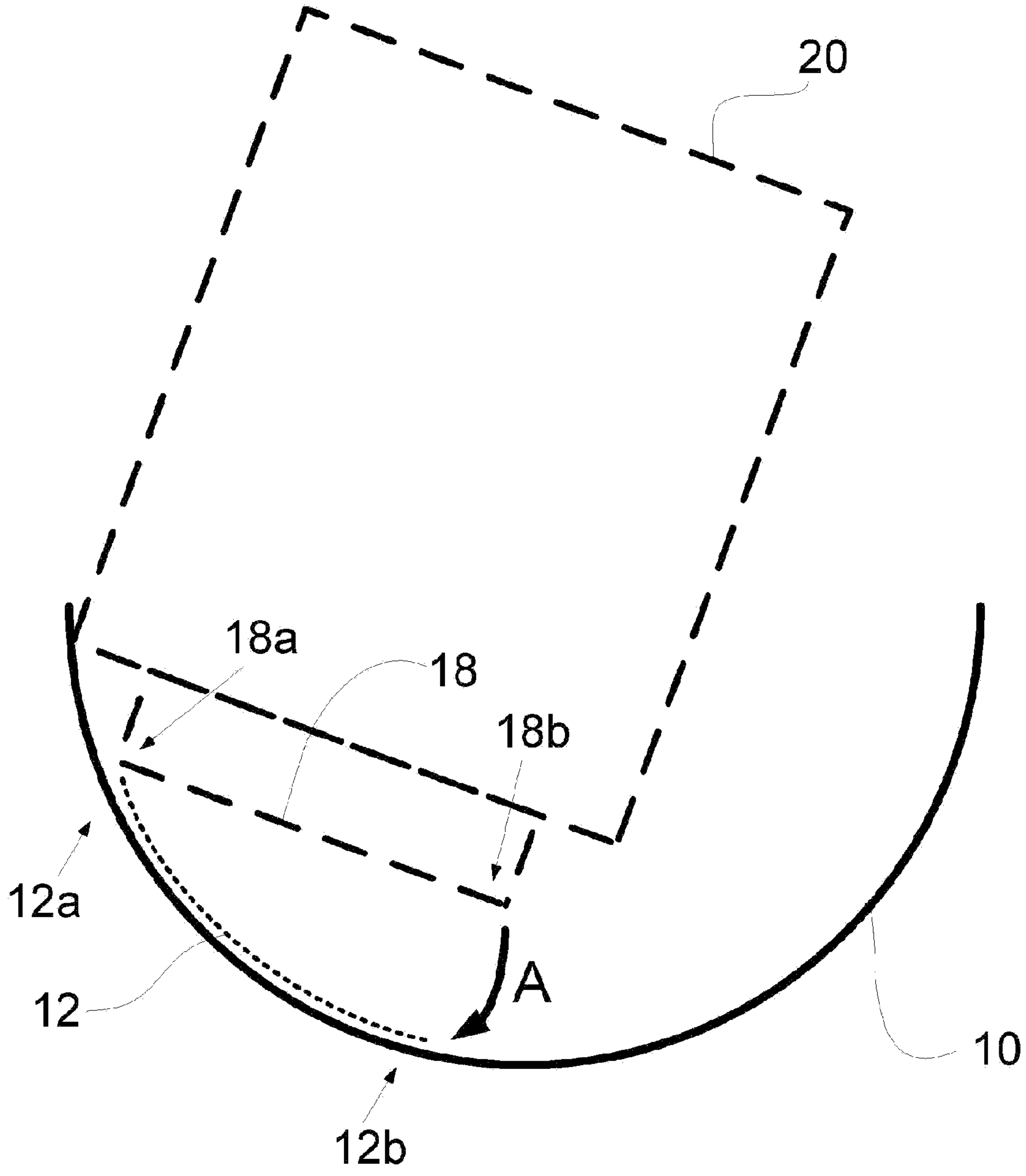

Fig. 3

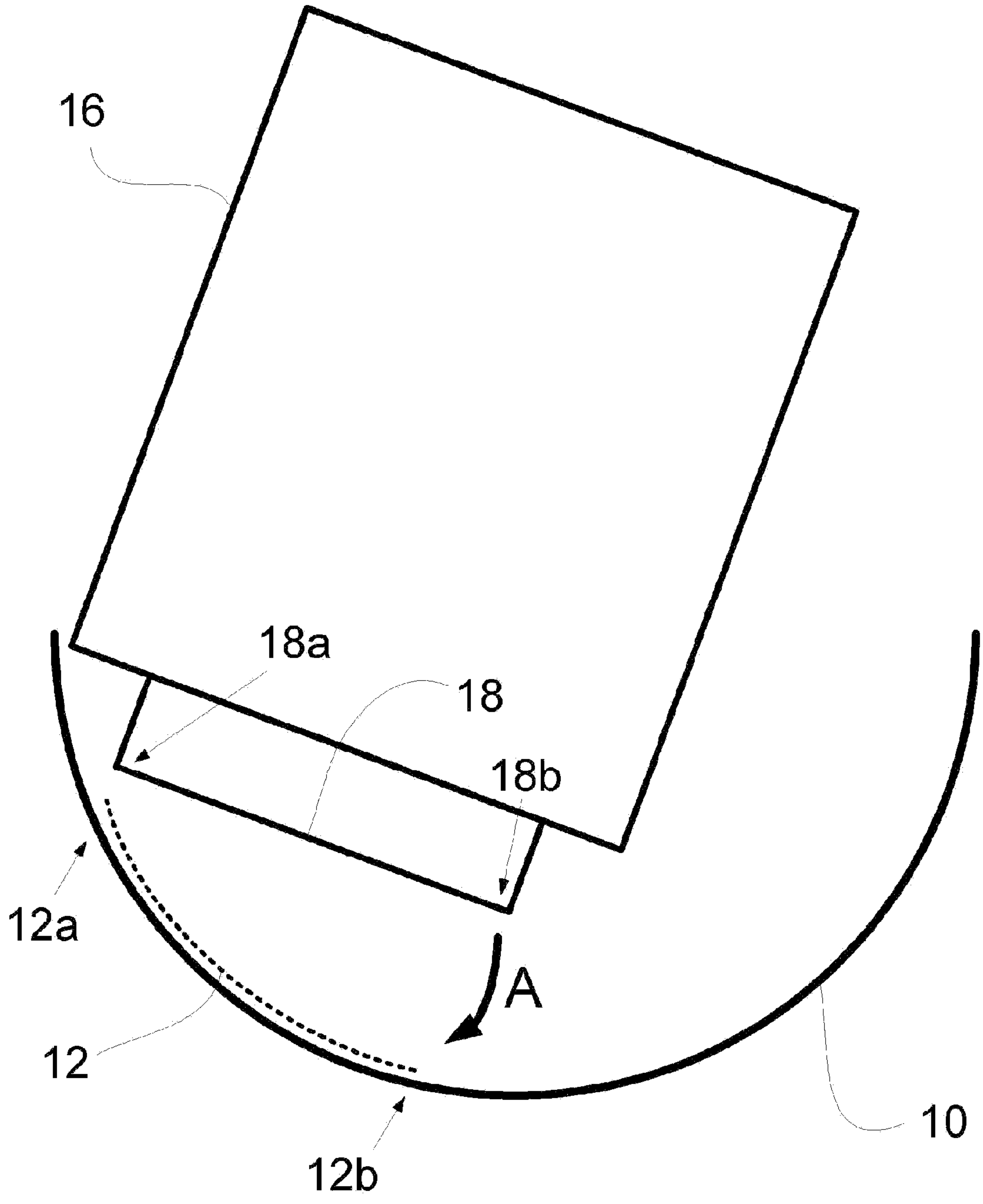

Fig. 4

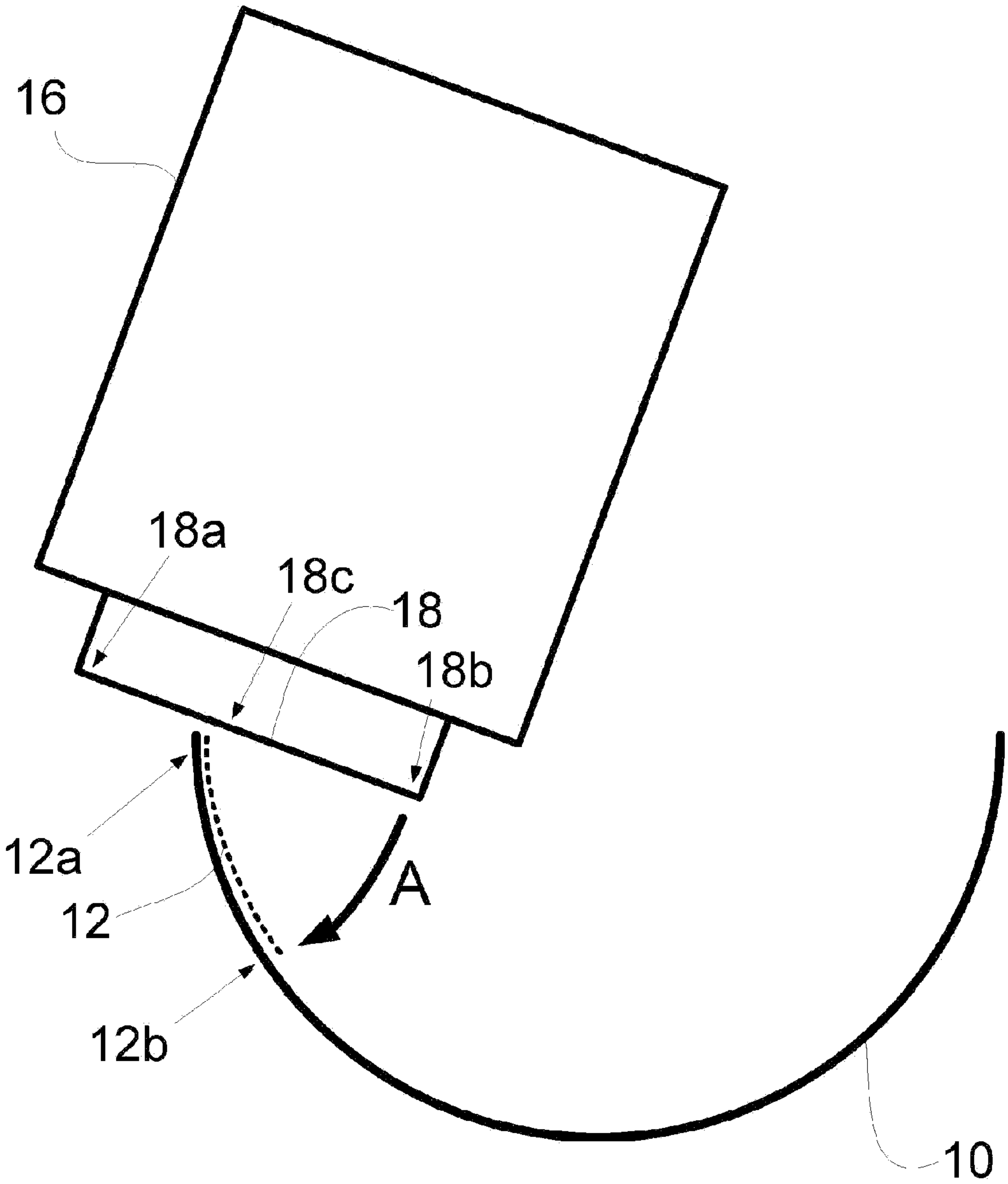

Fig. 5