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(54) **TRIAXIAL MULTILAYER ARMATURE AND ITS MANUFACTURING PROCESS**

(57) These armatures used for making composite material parts have three yarn orientations, one main axial and the two other bias, by example at +60° and -60°. They are made by alternatively layers of axial straight yarns (1) and layers of bias yarns (2) and (3). All the layers of those armatures are linked together by little axial yarns (4) that link together two bias yarns layers tying between them each layer of straight axial yarn. They are made at high speed on specific machine named 3D Rotary Weaving Machines composed by discontinuous circumferential tracks on which shuttles moves at a con-

stant speed but in alternate opposite sense to deliver the bias yarns. Fixed tubes (16) deliver the straight axial yarns (1) between those tracks, while other tubes (17) move quickly by crossing the shuttle tracks to deliver the linking yarns (4).. All the yarns go around a central mandrel on which the armature is created.

These armatures have a majority of yarns in their length sense, very few internal voids and give parts with high mechanical values. They are made at a weaving speed not achievable by none other existing process.

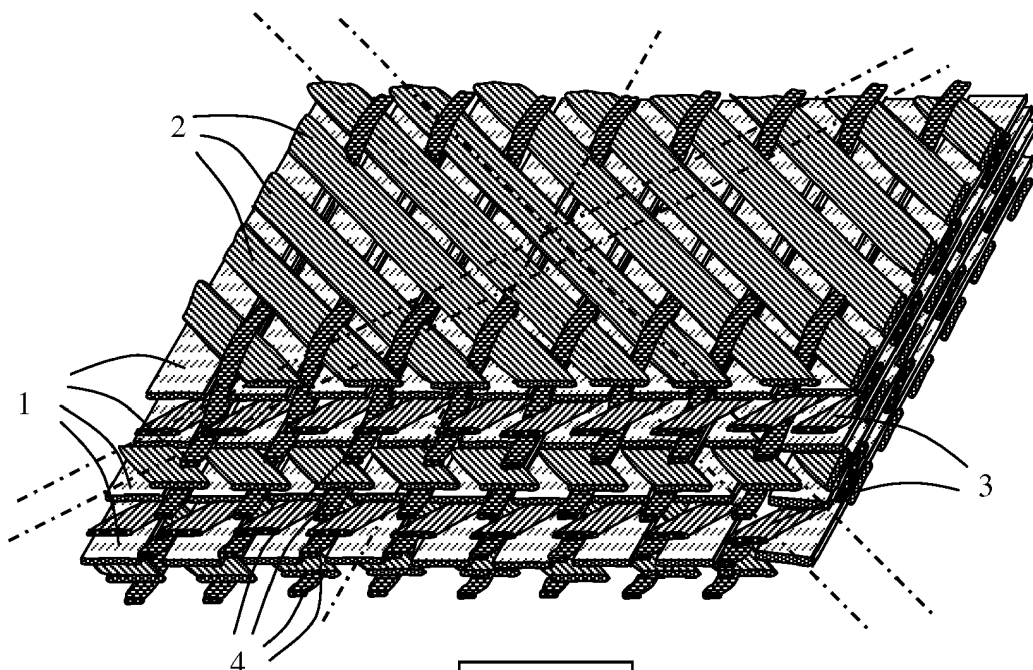


FIG.1

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Description

[0001] The present invention relates to the domain of composite materials that are constituted by a textile armature, or long fibre reinforcement, impregnated with a resin named matrix.

[0002] That invention is a new type of textile armature and its manufacturing process that allows obtaining low cost parts with complex shapes, open or closed, with high mechanical performances. Those armatures are obtained by using a completely new type of textile machinery named 3D Rotary Weaving Machine. That invention is more precisely an armature with a new type of textile architecture, a triaxial multilayer woven textile reinforcement with a majority of the yarns in the longitudinal direction and a constant thickness. It's well known that for obtaining high performance composite materials, it's necessary that the yarns in those armatures have to have none or very few fibre crimps and don't create any internal void due to their crossing or linking. That is the goal and the result brightly achieved by this invention.

[0003] Our invention creates at high speed in-shape parts, by introducing in the center of the circular weaving machine a mandrel that is recovered by the yarns. It's an efficient and cheap way to obtain high performance composite parts.

[0004] A previous try to resolve that problem can be found in the French patent Nb. 2 753 993 of Georges CAHUZAC that creates a high quality triaxial fibre architecture. That textile armature holds layers of axial yarns disposed in quincunxes and linked two by two by the bias yarns. The first axial layer is linked with the second layer by the bias yarns with one orientation while the second layer is linked with the third one by the bias yarns with the other orientation. That textile armature is well done but is not symmetrical into its thickness and that can create some deformation during the polymerization with shrinkage of the resin matrix. Its manufacturing process consists in using a braiding machine that has notched wheels disposed in quincunxes inside a cylinder. The path of the moving bobbins holding the bias yarns is obtained by the combination of the rotation of those notched wheels with the changing of angle of guiding needles. That mechanism is complex and could block the functioning if not correctly tuned. The gears that are disposed in quincunxes under a cylinder are difficult to machine correctly. This braiding machine is expensive to build and uneasy to tune. Another example of prior art is given in the French patent Nb. FR2884836 invented by Georges CAHUZAC. The described multilayer textile armature allows the realization of good quality parts. Its manufacturing process consists in using a very special type of braiding machine in which the bobbins carriers move sequentially in zigzag, which is a limitation in the braiding speed. The simultaneously deposition of all the yarn layers of a part compensates for that slow speed, but it's a less flexible process than a speedy deposition of some independent layers with optimized braiding for each one.

[0005] A third example of previous art is given in the European patent Nb EP 2 740 824 of Georges CAHUZAC. That invention consists in a high quality triaxial textile armature, that has three fibre orientations, the first one axial and the two others making an angle, by example $+60^\circ$ et -60° , with the axial direction, in which those bias yarns don't cross each other during getting through the layer of axial yarns, but get it through in their said odd and even intervals. The $+60^\circ$ yarns get through the axial yarn layer in each odd interval while the -60° yarn get through it in each even interval. The quality of those armatures is improved by adding little axial yarns on the upper and lower side of those intervals to obtain armatures with three layers of axial yarns, in which the central layer yarns are bigger than the side layer ones. Those armatures have a remarkably constant thickness and all their yarns have very smooth paths. A braiding machine for making an armature in accordance is built with two circumferential rows of adjacent wheels and three rows of tubes for introducing the axial yarns. The tubes of the external and internal rows are situated at the center of the notched wheels, while the tubes of the central row are situated at or near the crossing of the diagonals linking the axes of fourth adjacent wheels. That process makes armatures with only one layer of each bias yarns and three layers of axial yarns.

[0006] By opposite, 3D Rotary Weaving Machines can create armatures with a lot of layers linked together. This new invention has none limitation in the number of layers.

[0007] The functioning principle of this 3D rotary weaving machine is very simple and permits to reach very high weaving speed even when using heavy bobbins while obtaining in-shape tri-axial multilayer woven reinforcements very useful for making cheaply composite material parts for any kind of applications.

[0008] The way for weaving those multilayer tri-axial armatures is by using specific circular weaving machines, built for that purpose as they are described in the following pages. Those high quality armatures will allow a cheap way of making long and in-shape composite parts. That invention fulfils a hole in the range of existing processes to make cheaply composite parts in huge numbers as needed for many applications as cars, plane stiffeners, bridges, etc....

[0009] An **armature** in accordance with the invention has three yarn orientations, the main axial and the two others bias, making any angle, by example $+60^\circ$ et -60° , with that main axial direction. The bias (or oblique) yarn, never cross each one but are separated by a layer of axial yarns. Each layer of axial yarns has two kinds of yarns: straight yarns and linking yarns. Each layer of axial yarns is between two layers of bias yarns. Into each layer of axial yarns, the straight axial yarns are separated by the linking yarns. Into that armature, the layers of axial yarns are separated by layers of bias yarns. In each layer of axial yarns, there is the alternate presence of straight axial yarns and of linking yarns. These linking yarns link the bias yarns of the layer under any axial layer with the

bias yarns of the layer above this axial yarn layer, tying those straight axial yarns in-between these two layers of bias yarns and therefore making all the yarn layers of that armature linked together.

[0010] We can describe **the process** for weaving armatures in accordance with this invention as moving shuttles, each one carrying its own bobbin, along circular tracks by the means of gearwheels regularly disposed in such a way that always a gearwheel is in contact with the gear rack fixed on each shuttle. Those tracks are not continuous but are made of separate portions. The voids between two portions are necessary to allow the high speed moving of tubes through which are delivered the linking yarns while the shuttles are moving. The straight yarns are delivered between the tracks, by passing through tubes fixed between two tracks, in their filled portions. The shuttles on a track are moving continuously in the same direction, and they are moving in opposite direction on their adjacent tracks. Therefore these shuttles are moving along circular tracks in alternate opposite direction from one track to the following one, each shuttle carrying one bobbin of bias yarn, a free moving space existing between these shuttles on their tracks to allow their quick crossing by tubes that deliver the linking yarns while the straight yarns are delivered by tubes situated between the circular tracks.

[0011] A 3D Rotary Weaving Machine in accordance with the invention has many circumferential tracks. This number depends of the thickness of the armature to weave. It's possible to dispose these tracks concentrically on a disk and each track has its own diameter, or on a cylinder and therefore all the tracks have the same diameter. In the both cases, all the yarns are moving to a central mandrel to recover it with the created armature, as in a braiding process. The annexed figures will help to better understand how this invention can be made.

[0012] The **figure 1** is a view of an example of a multilayer tri-axial armature in accordance with the invention. We see on that figure 4 layers of axial straight yarns (1), separated alternatively by 5 layers of bias yarns (2), (3), (2),(3) and (2). The linking yarns (4) situated in the first layer of axial yarns (1) link the first layer of bias yarns (2) to the second layer of bias yarns (3). The linking yarns (4) situated in the second layer of axial yarns (1) link the second layer of bias yarns (3) to the third layer of bias yarns (2). The linking yarns (4) situated in the third layer of axial yarns (1) link the third layer of bias yarns (2) to the fourth layer of bias yarns (3). The linking yarns (4) situated in the fourth layer of axial yarns (1) link the fourth layer of bias yarns (3) to the fifth layer of bias yarns (2). The linking yarns (4) separate the straight axial (1) inside each layer of axial yarns.

[0013] This armature is woven as a closed shape, usually a cylinder, but can be axially cut to obtain a flat armature, easily shapeable into any shape, due to the weak linking between the layers, allowing some sliding that increases the conformability of that armature into a mold.

[0014] The **figures 2A,2B,2C** are longitudinal sections

perpendicular at the armature surface showing the parallelism into the thickness of the trajectories of the linking yarn (4), which avoids any creation of internal voids. We can see that only the linking yarns have some crimps or waves. Each linking yarns don't link directly a bias yarns (2) with a bias yarn (3), or the opposite, but keep parallel with the straight yarns (1) on a distance corresponding at a bias yarns. Any internal bias yarn (2) or (3) is linked with bias yarns of the upper and lower layer of bias yarns. The trajectory of the linking yarns (4) have two axial portions in each elementary motive of their trajectory, side by side with the axial yarns (1), before going on top of a bias yarn (2) or (3) and before going below a bias yarn (3) or (2) and therefore the length of a trajectory elementary motive is the length in the axial direction of 4 bias yarns (2) or (3).

[0015] The **figure 2A** shows an armature with only one linking yarn (4) between the straight yarns (1).

[0016] The **figure 2B** shows an armature with two linking yarns (4) between the straight yarns (1).

[0017] The **figure 2C** shows an armature with four linking yarns (4) between the straight yarns (1).

[0018] The **figures 3** show the top view, or the surface, of this armature. We can see that the unit cell of this armature has a dimension of 4*4. A bias yarn (2) is recovered each 4 straight yarns (1). Each linking yarns (4) become visible on the surface each 4 bias yarns (2). The trajectory of the linking yarns (4) have two axial portions in each elementary motive of their trajectory, side by side with the axial yarns (1), before going on top of a bias yarn (2) or (3) and before going below a bias yarn (3) or (2) and therefore the length of a trajectory elementary motive is the length in the axial direction of 4 bias yarns (2) or (3).

[0019] The **figure 3A** shows an armature with only one linking yarn (4) between the straight yarns (1).

[0020] The **figure 3B** shows an armature with two linking yarns (4) between the straight yarns (1).

[0021] The **figure 3C** shows an armature with four linking yarns (4) between the straight yarns (1).

[0022] The **figure 3D** shows an armature with only one linking yarns (4) between the straight yarns (1), but their linking is axially shifted to have an armature with a smoother surface.

[0023] The **figure 4** shows an axial section, a very schematic view of an average size **3D Rotary Weaving Machine** in accordance with the invention. The shuttles (9) move in opposite sense depending of the rank of their circumferential tracks

[0024] The top part of this figure shows the tubes (17), holding the linking yarns (4), while they are crossing through the shuttle (9) tracks. These tubes (17) are linked together into the shape of a comb (18). All the combs (18) are linked together by a ring (19). The tube (17) crossing of the shuttle tracks happens while the shuttles (9) are moving at a constant speed, allowed by circumferential voids situated between the shuttles (9). The linking yarns (4) come from the bobbins (8) that don't move when the tubes (17) move.

[0025] The bottom part of that figure 4 shows the shuttles (9) moving through the tubes (16) that hold the straight axial yarns (1). Those tubes (16) don't move. The space between two shuttle tracks is in the range of 10mm. These straight yarns (1) come from the bobbins (5). We see on that figure 4 that all the yarns go to a central mandrel (30) on which they are tied, creating the armature (29).

[0026] The figure 5 shows a section view perpendicular to its axe of a little 3D Rotary Weaving Machine. This figure 5 shows the configuration of such a machine which is mainly made by axial tiles (10) which held the mechanisms to guide and move the shuttles (9). An axial space between each two tiles allows the track crossing by the tubes (17) delivering the linking yarns (4). The bobbins (5) of the straight yarns (1) and the bobbins (8) of the linking yarns (4) are placed near their delivering tubes (16) and (17). We see also on that figure 5 that all the yarns go to a central mandrel (30) on which they are tied, creating the armature (29).

[0027] The figure 6 shows a tile (10) under which are fixed 3 drive shafts, the central drive shaft (11) turning in one sense and the lateral drive shafts (12) in the opposite sense.

[0028] A gear rack (15) is fixed on top of each shuttle (9) and gears (13) are fixed at the right position on each drive shaft to drive the shuttles on each track in the right sense. Therefore their positions on each drive shaft are alternated between the central drive shaft (11) and the lateral drive shafts (12), to be in accordance with the sense of displacement of the shuttles on their tracks. Only the gears (13) fixed on the lateral drive shafts are in the same plane. The gear fixed on the central drive shaft is at a position corresponding at the next shuttle track.

[0029] Under each tile are fixed the little wheels (14) that are guiding the shuttles (14) along their circumferential tracks.

[0030] On this figure 6, we see a shuttle (9) with its gear rack (15) fixed on its top face and also one of the two guiding trails with a bow shape. The cross section of that trail is complementary with the one of the guiding wheels. The parts that would be necessary to hold the bobbin carried under this shuttle are not showed, as they are not specific to this invention.

[0031] The figure 7 shows an axial section view of a tile (10). We can see a gearwheel (13) fixed to a driving shaft (11) moving a shuttle (9) guided by wheels (14) linked to that tile (10). We have to note that a void exists between the two shuttles. That void is necessary for putting in it the tubes (16) that are fixed on the tile while going through it. Only one gearwheel is shown because the other one isn't in the same plane.

[0032] The figure 8A shows the shuttles (9) moving along the tubes (17) while they are stopped between two tracks.

[0033] The figure 8B shows the tubes (17) quickly crossing the shuttles tracks while the shuttles (9) are moving.

[0034] The figure 9 shows how the central driving shaft (11) of a tile (10) drives the two lateral drive shafts (12) by the means of 3 gearwheels (20) situated at the tile end. That mechanism is at the rear end of the tiles in order of allowing the free displacement of the combs (18).

[0035] The figure 10 shows how all the drive shafts (11) are linked together by the mean of a chain (32) driving the pinions (21) fixed at their ends. That chain (32) goes on the pinions (22) that drive the Genova mechanisms and also on a pinion fixed on the electric motor, not shown, that makes that machine moving.

[0036] The figures 11 show how the four quick displacements of the ring (19) that hold the combs (18) on which the tubes (17) are fixed are created to deliver the linking yarns (4) between the shuttle tracks in accordance with their trajectories shown on figure 2. Those displacements are created by a Genova mechanism. The figures 11A to 11D show how while the command wheel (23) makes a complete turn, the Genova wheel (24) turns quickly only a quarter of turn and don't move during $\frac{3}{4}$ of the command wheel turn (23).

[0037] The figures 11E at 11H show the different positions of the groove (26) linked with the ring (19) in which the roll of the manifold (25) fixed on the Genova wheel (24). We can see that 4 turns of the wheel (23) make the 4 positions of the tubes (17) that create the linking yarn trajectory shown on figures 2 of the linking yarns (4).

[0038] A machine in accordance with this invention will have at least 3 Genova mechanisms at 120° per number of linking yarns (4). Each wheel (23) is fixed on a 90° angular gearbox. On its entrance shaft, a gear is moved by the chain (32), or by a different chain also linked with the motor of that machine.

[0039] We will describe two examples of rotary weaving machine able of weaving the multilayer triaxial armature in accordance with this invention, and also an example of armature doable on such a machine.

[0040] The first rotary weaving machine is schematically shown on figure 4. It has 6 circular tracks for guiding the shuttles (9), the shuttles on the tracks 1, 3 and 5 going in a sense and the shuttles on the tracks 2, 4 and 6 going at the same speed but in the opposite sense. The tile (10) number is 36 and hence the shuttle (9) number is 36 on each track giving a total number of 216 shuttles. The pitch between two tracks is 80 mm, with a shuttle wideness of 70 mm to keep a 10 mm free space for the tubes (16) that distribute the straight yarns (1). A comb (18) is placed between each two tiles, therefore this machine has 36 combs with 5 tubes (17) on each one, with a total of 180 tubes for delivering 180 linking yarns (4). There are also on each tile 5 tubes (16) fixed between the circular tracks for delivering the straight yarns (1) making a total number of 180 tubes for 180 straight yarns. It's easy to put more than one tube (16) on a tile between two tracks to deliver a greater number of straight yarns. Each shuttle (9) carry a 64 mm diameter bobbin (6) or (7), with a mechanism to deliver its yarn with a constant tensile and at the required wideness. These bobbins (6)

or (7) are radially oriented, perpendicular with their shuttles (9).

[0041] The nominal diameter of such a rotary weaving machine is 1620 mm, situated at the contact diameter between the gear racks (15) with the pinions (13). Each pinion nominal diameter is 45 mm, with 30 teeth modulus 1.5. When the pinions make a turn, the shuttles move of 141.37 mm on the circumference corresponding at the machine nominal diameter. The maximum length of each shuttle is $\frac{3}{4}$ of this value hence 106 mm.

[0042] The free space between two tiles (10) is 15 mm. The tile sides hold the guiding wheels, not shown, for guiding the combs (18).

[0043] As they are 3 shafts (11) and (12) on each tile, and 3 pinions (13) per shaft, they are on this machine 108 shafts with 324 pinions (13). They are also 108 pinions (20) to make the shafts rotating together on each tile and 36 pinions (21) to link together by a chain (32) all the central shafts of the tiles.

[0044] The shuttle guiding wheel (14) number is 6 per shuttle per tracks per tile, hence 1296 with the disposition shown on figures 6 and 7. It's also possible to decrease that number to 756 if each wheel guides the shuttles on two join tracks. But it's not possible in that case to tune the distance between two guiding wheels and all the parts have to be precisely machined.

[0045] The combs (18) are guided by wheels fixed on the tiles (10) and are linked together at a ring (19) moved axially by 3 Genova mechanisms creating 4 axial 80mm displacements each 4 circumferential shuttle displacements. This displacement between the moving shuttles of the tubes delivering the linking yarns is made while the shuttles are moving at a constant speed. That is the reason why the working speed of such a rotary weaving machine is greater than any other existing machine making armatures for composite material parts. None comparable process exists today. The nominal speed of this machine is 6 displacements of the ring (19) per second, and hence a complete turn takes only 6 seconds.

[0046] This rotary weaving machine makes armatures with 5 layers of 36 straight yarns, 3 layers of 36 bias yarns at 45° and 3 layers of 36 bias yarns at -45° . All those layers are linked by 5 layers of 36 linking yarns. Each yarn in that armature could have its own nature and size.

[0047] We take as an example a weaving with the bias yarns at 45° , with none void between bias yarns with a 3 mm wideness. The weaving speed is 1.5 m/mn or 90 m/h, on a 50mm diameter mandrel. If the bias yarns have a 6mm wideness and by weaving on a 100 mm diameter mandrel, the weaving speed is 3 m/mn or 180 m/h.

[0048] That armature could have a shape different of a straight cylinder, as the shape of the armature depends of the shape of the mandrel on which this armature is woven.

[0049] The mechanisms for pulling the mandrel or for pulling the armature that is sliding on its mandrel are not shown here as they are well known mechanisms, the same than those used on braiding machines.

[0050] We will describe a **second example of rotary weaving machine** in accordance with this invention. That machine is schematically shown figure 5.

[0051] That machine has 12 tiles and 6 circular shuttle tracks. Hence it has 36 shafts and 108 pinions to move 72 shuttles guided by 432 wheels. Its nominal diameter is 1080 mm. The pinions have 30 teeth modulus 1.5 and make two turns to move a shuttle from one tile to the following one creating a displacement of 282.7mm. The shuttle length is $282.7 \times \frac{3}{4} = 212\text{mm}$. The bobbins are fixed parallel with the shuttles. The Genova drive mechanism is turning at half the speed of the shaft speed to synchronize the comb displacements with the shuttle displacements.

[0052] This little rotary weaving machine is made to demonstrate this process for making armatures for composite material parts. Its size was chosen to allow its easy moving for exhibitions. By using 6 mm wide yarns, the realization of tubes making bike frames is possible, and also any kind of little profiles.

[0053] The **industrial machine size** will be designed in accordance with the size of the parts to make. This size will be usually many meters in diameter, up to 10 or 12 meters for some applications.

[0054] We will take as an example a rotary weaving machine of a 5 meter size. This machine will have 108 tiles and 12 circular tracks.

[0055] By weaving on a 750 mm diameter mandrel with SGL 50K carbon yarn for the bias and straight yarns, the created cylindrical armature will be open to give a 2.3 m wide triaxial fabric made with 23 layers. The bias yarns will have a 55° angle with the axial straight yarns. The thickness will be 5.4 mm with a fibre volume fraction of 55%, and its area weight 5.3 Kg/m² dry and 8 Kg/m² after resin impregnation. The weaving speed will be around 250 m/h or 3 Tons/h.

[0056] A 10 m rotary weaving machine will be very useful to quickly make wind mill blades with this new high speed process.

[0057] By comparison with the actual processes for making composite parts, this new process is cheaper, as all the layers can be put in one path, with all the needed yarn orientations included in this armature. The quality of the created fiber architecture is better than the one created by the Non Crimp Fabric because the number of axial yarn layers is greater and are situated between the bias yarn layers. This armature has interlock architecture and it's well known that that is very good to resist shocks, by limiting delamination area. The most important thing: those machines allow to makes parts with a yarn deposit rate impossible to reach by any other existing process.

[0058] Those rotary weaving machines are well adapted to make in the aeronautical field blades for fan jet motors, for helicopters, or for making any kind of stiffeners and fuselage frames.

[0059] These new textile armatures will make in-shape, bended or not, tubes for making frames of bikes, of motorbike, of cars. They will be used also as transmis-

sion shafts due to the high quality of the created fibre architecture that gives high mechanical performance parts.

[0060] These armatures are woven with a closed shape. They can be axially cut to give flat multilayer tri-axial fabrics for a lot of applications. They can be bent to obtain profiles with different shapes.

[0061] All of the yarns inside such an armature come from its own bobbin and hence can differ in nature and size.

[0062] This invention is full of promise to become an important way for making composite parts with a huge range of possible applications, going from the aeronautical field, the cars lightening field and also the sport equipment field.

Claims

1. A **multilayer triaxial armature** for making composite material having three yarn orientations, one main axial and two others bias, making any angle, by example $+60^\circ$ et -60° , with that main axial direction **characterized by** the separation of the layers of axial yarns by layers of bias yarns and by the alternate presence in each layer of axial yarns of straight axial yarns (1) and of linking yarns (4) that link the bias yarns (2) or (3) of the layer under any axial layer with the bias yarns (3) or (2) of the layer above this axial yarn layer, tying those straight axial yarns (1) in-between these two layers of bias yarns and therefore making all the yarn layers of that armature linked together. 20
2. Multilayer triaxial armature in accordance with claim 1 **characterized by** the parallelism of the linking yarns (4) into the thickness of this armature. 35
3. Multilayer triaxial armature in accordance with claims 1 and 2 **characterized by** the trajectory of the linking yarns (4) that have two axial portions in each elementary motive of their trajectory, side by side with the axial yarns (1), before going on top of a bias yarn (2) or (3) and before going below a bias yarn (3) or (2) and therefore the length of a trajectory elementary motive is the length in the axial direction of 4 bias yarns (2) or (3). 40 45
4. **Process** for making multilayer armature in accordance with the claims 1 to 3 **characterized by** using rotary weaving machine in which shuttles (9) are moving along circular tracks in alternate opposite direction from one track to the following one, each shuttle carrying one bobbin (6) or (7) of yarn (2) or (3), a free moving space existing between these shuttles on their tracks to allow their crossing by tubes (17) that deliver the linking yarns (4), while the straight yarns (1) are delivered by tubes (16) situated 50 55

between the circular tracks.

5. Process in accordance with the claim 4 **characterized by** the command of the displacement of the tubes (17) by a mechanism enough rapid to make these displacements while the shuttles (9) are moving at a constant speed. 5
6. **Machine** in accordance with the claims 4 and 5 **characterized by** having a cylindrical configuration made by curved parts (10) fixed on their both ends on circular frames (31), keeping a free space between them, holding the circular shuttles guides (14) and the shafts (11) and (12) with their pinions (13) that drive the shuttles (9) on which a gear rack (15) is fixed. 10 15
7. Machine in accordance with the claim 6 **characterized by** using a Genova drive mechanism (24) synchronized with the shaft (11) and (12) rotations to make the quick displacements of the tubes (17) delivering the linking yarns in the moving intervals between the shuttles (9) while they are moving at a constant speed. 20
8. Material **composite part characterized by** having in its structure at least one armature object of this invention. 25 30

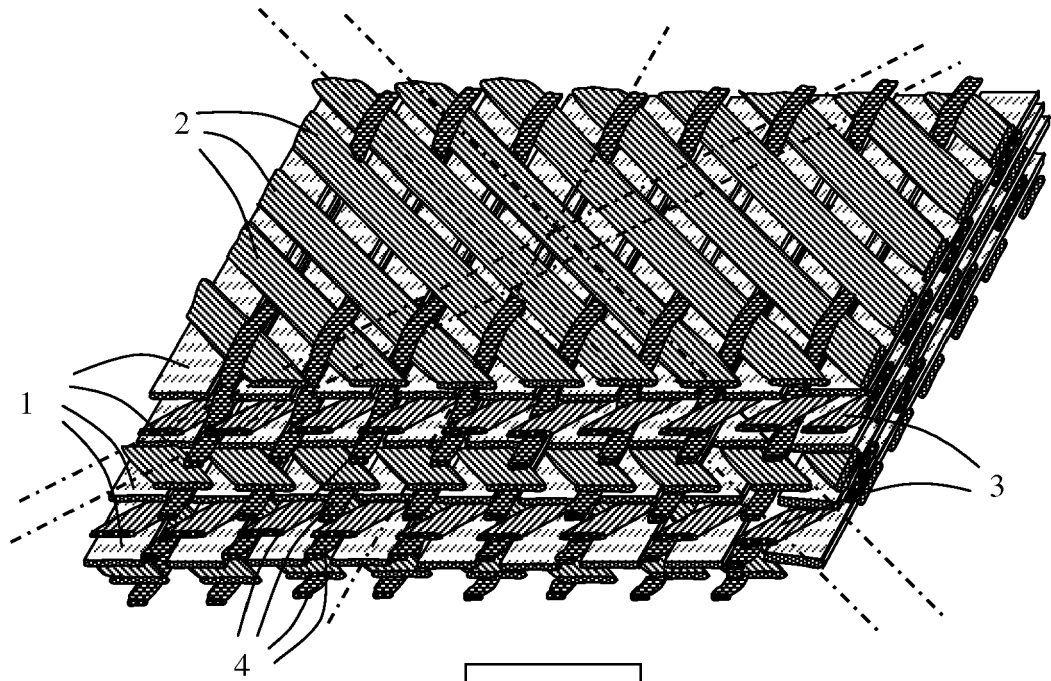


FIG.1

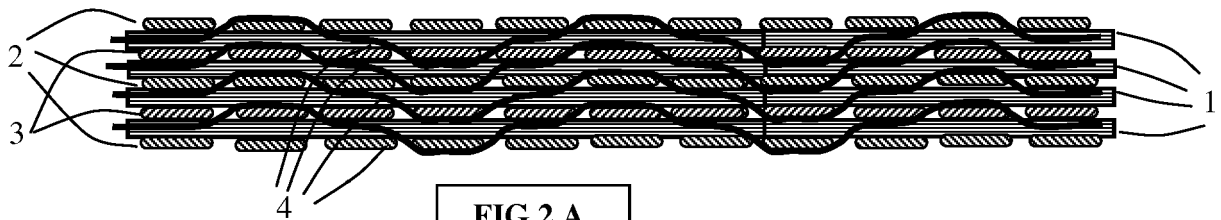


FIG.2 A

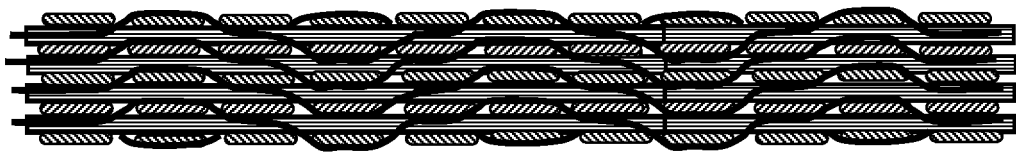


FIG.2 B

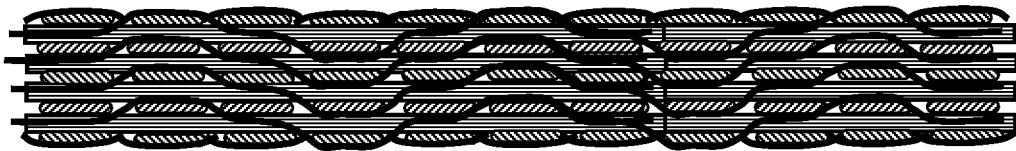


FIG.2 C

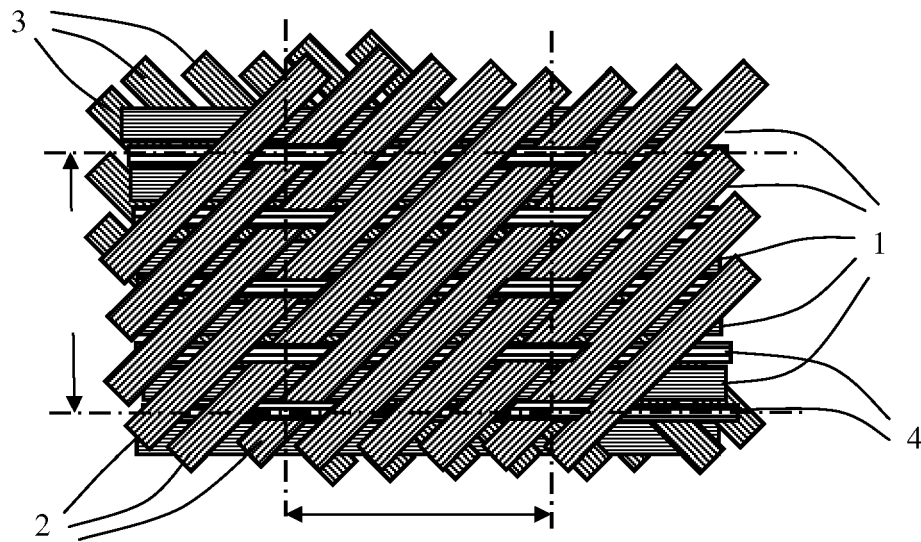


FIG. 3A

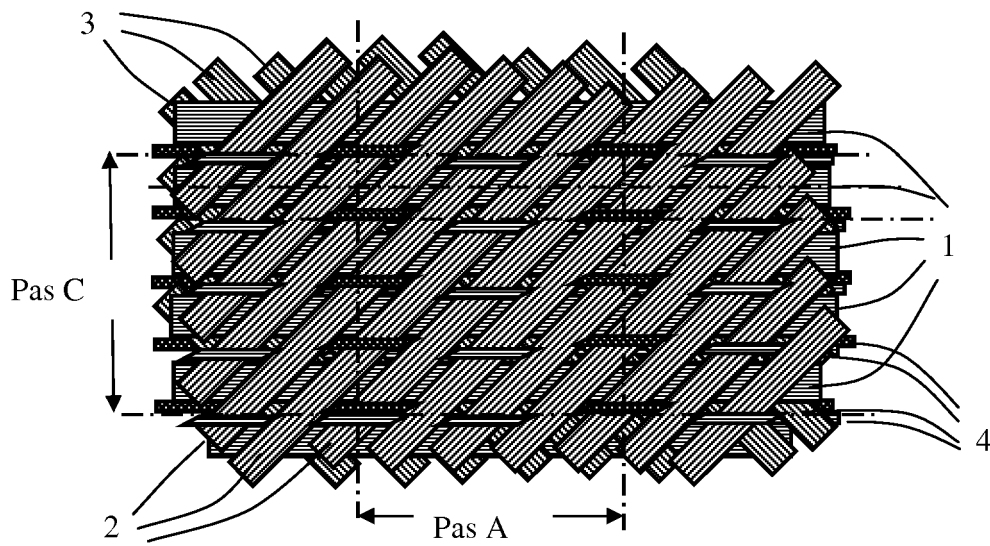


FIG. 3-B

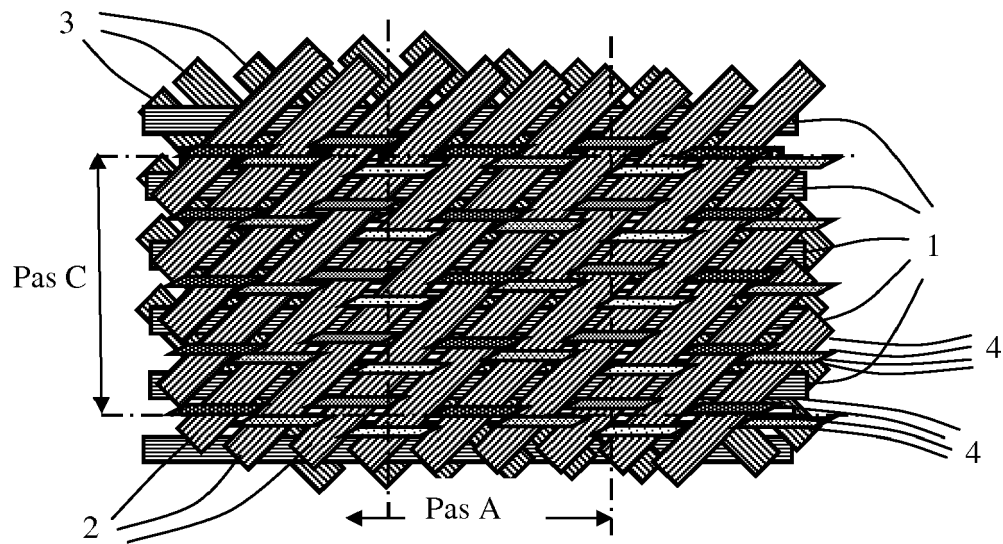


FIG. 3-C

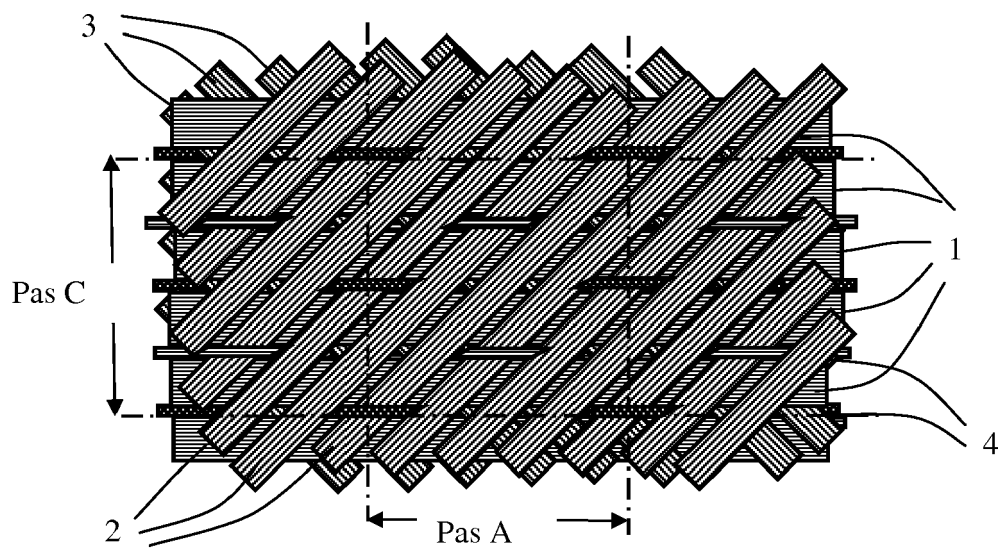
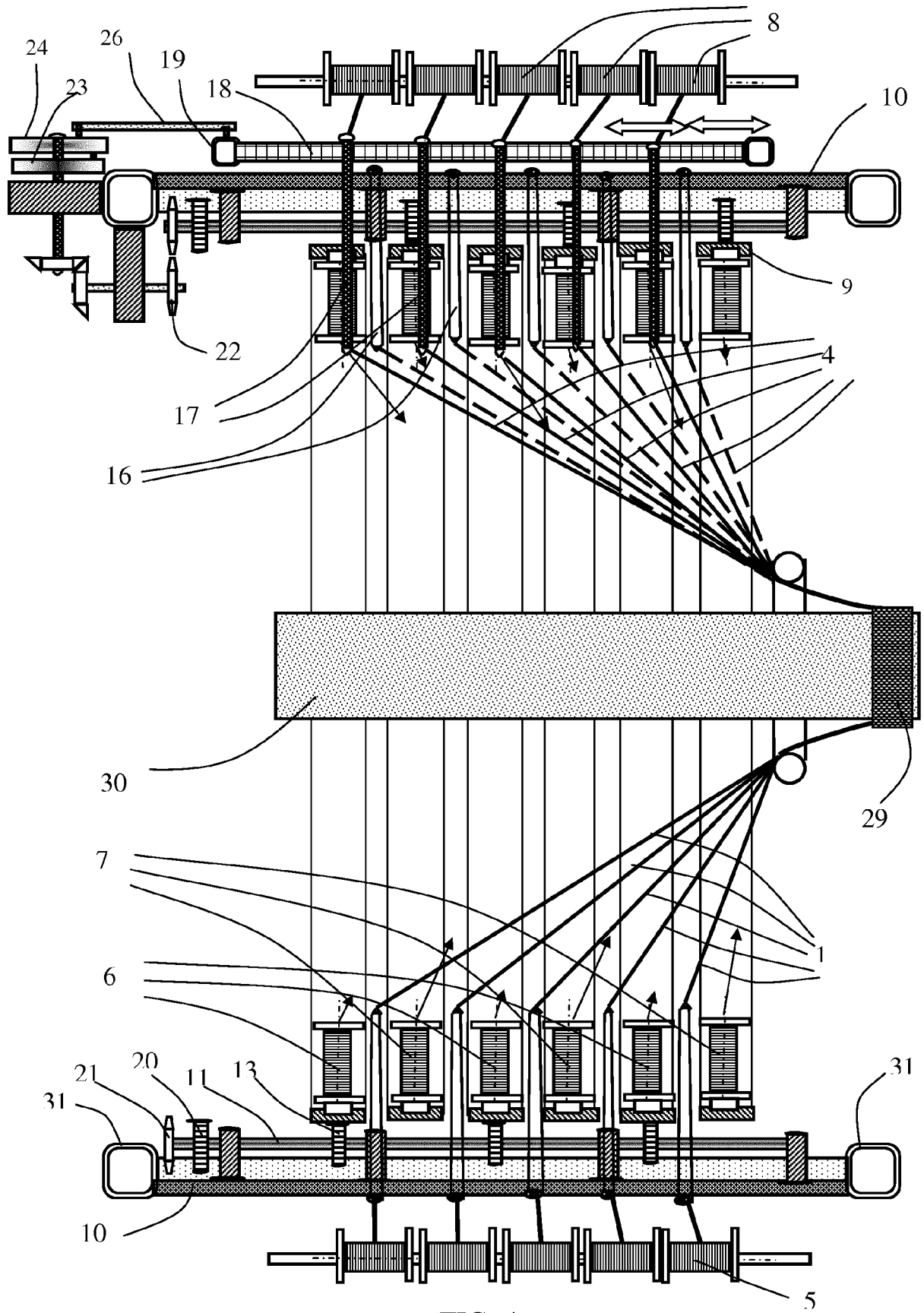


FIG. 3-D



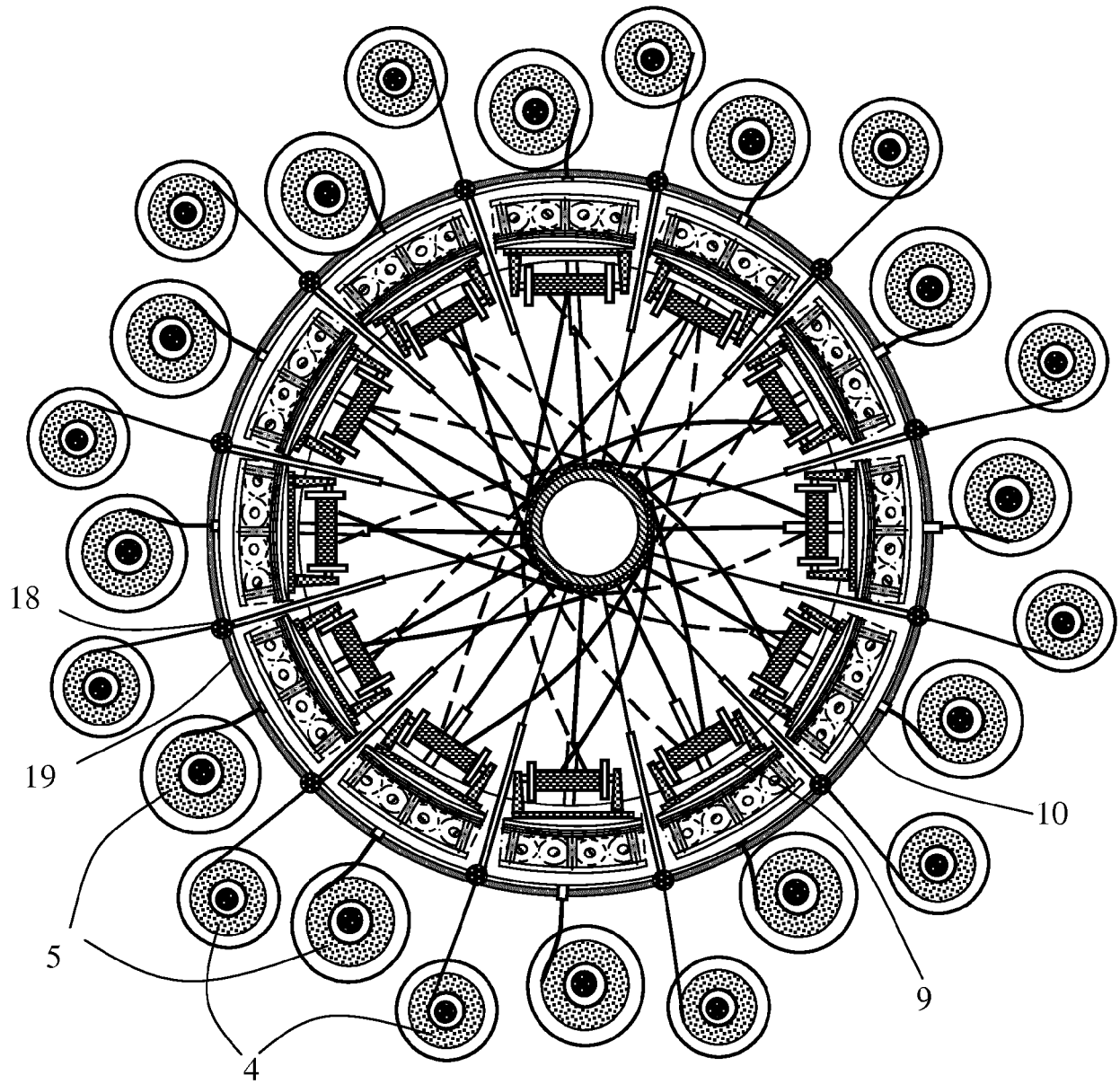


FIG. 5

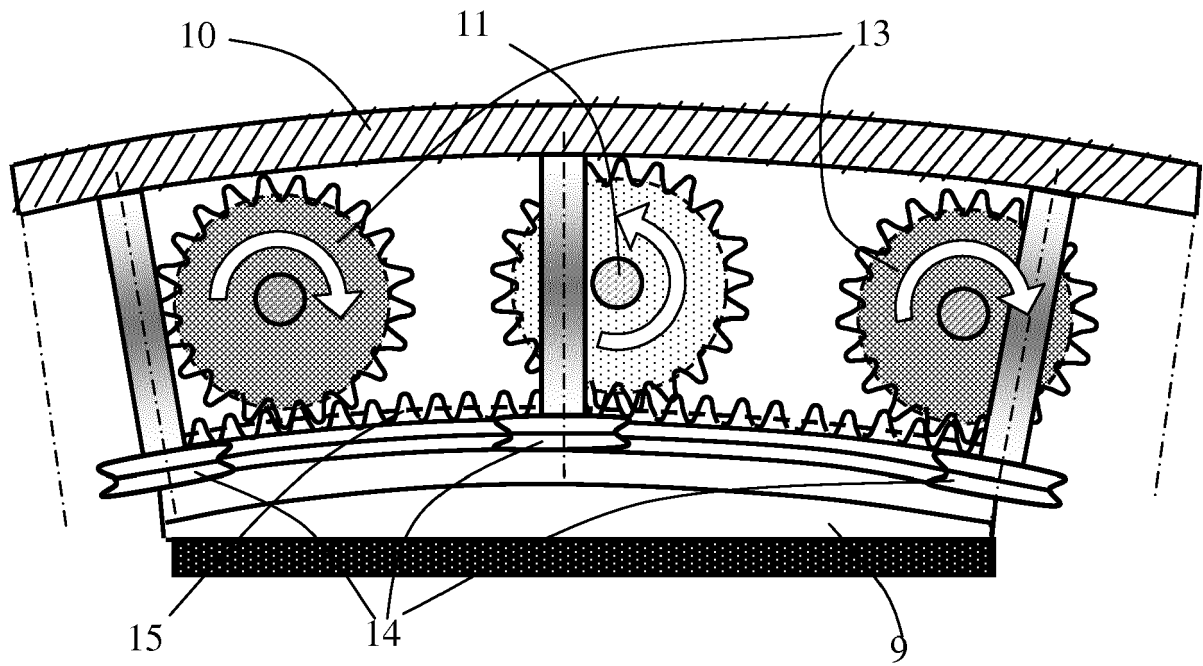


FIG. 6

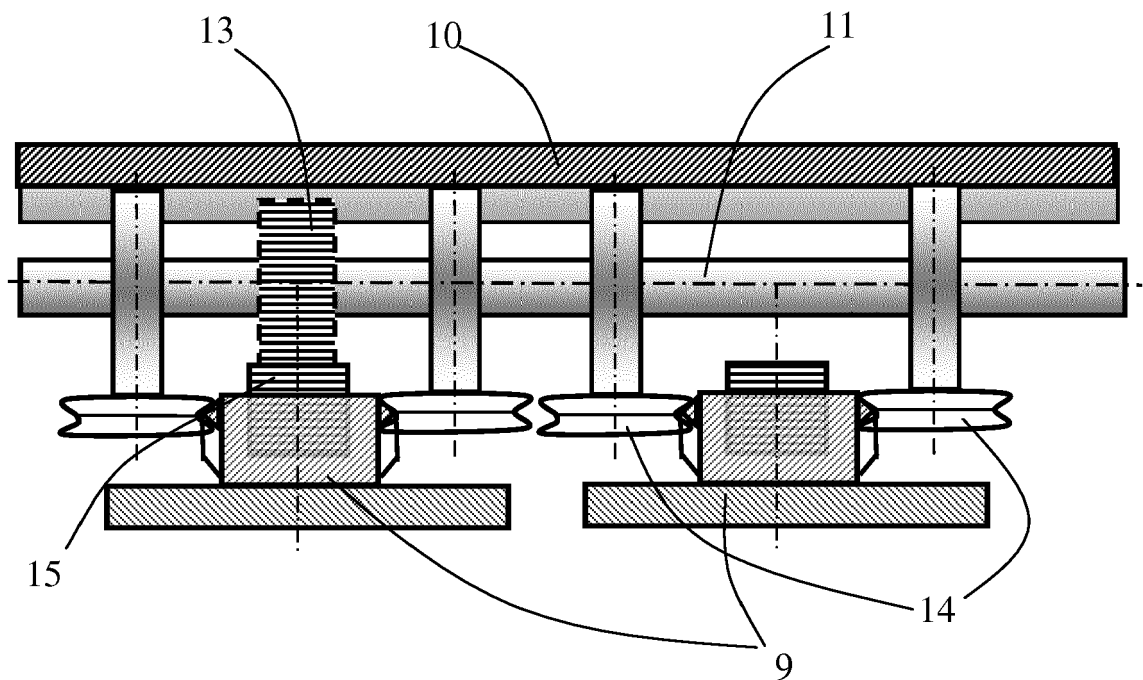


FIG. 7

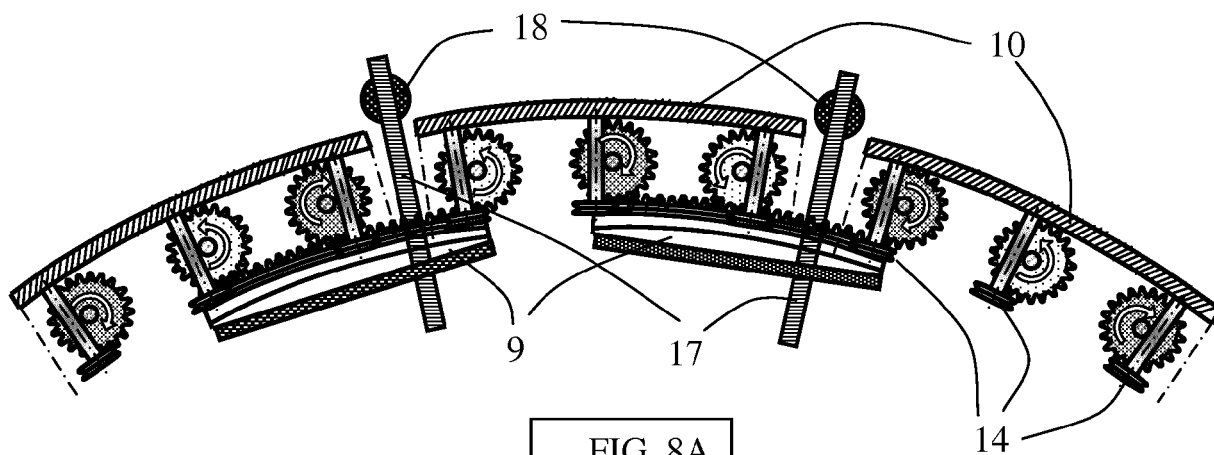


FIG. 8A

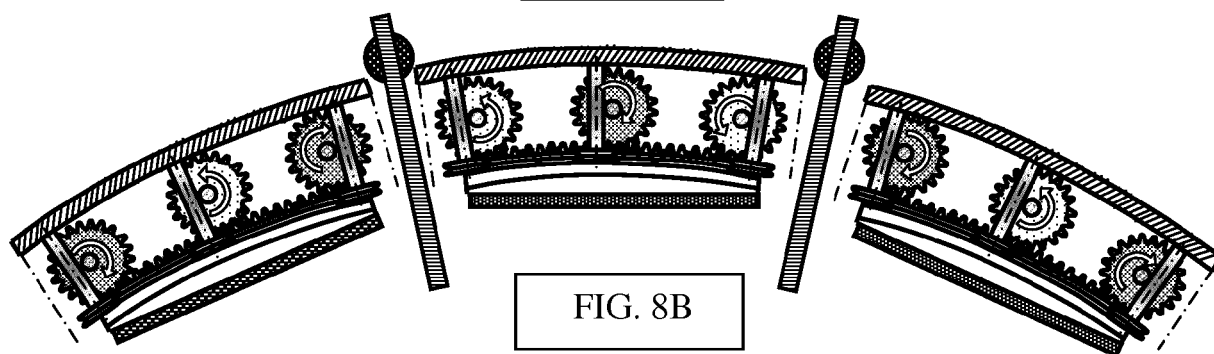


FIG. 8B

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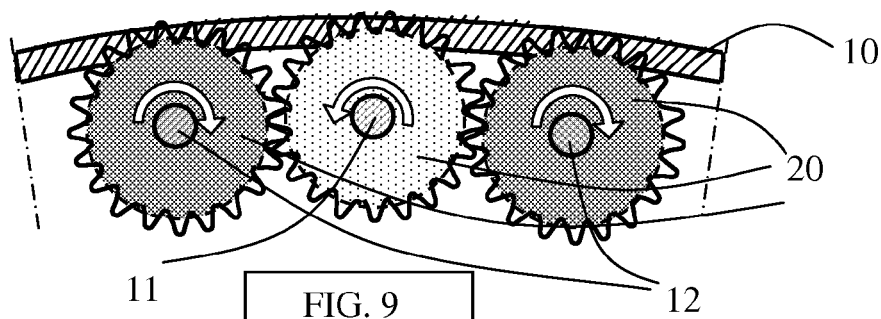


FIG. 9

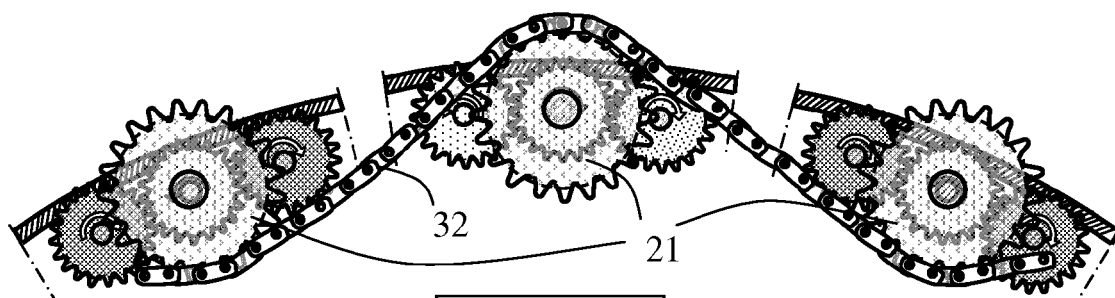


FIG. 10

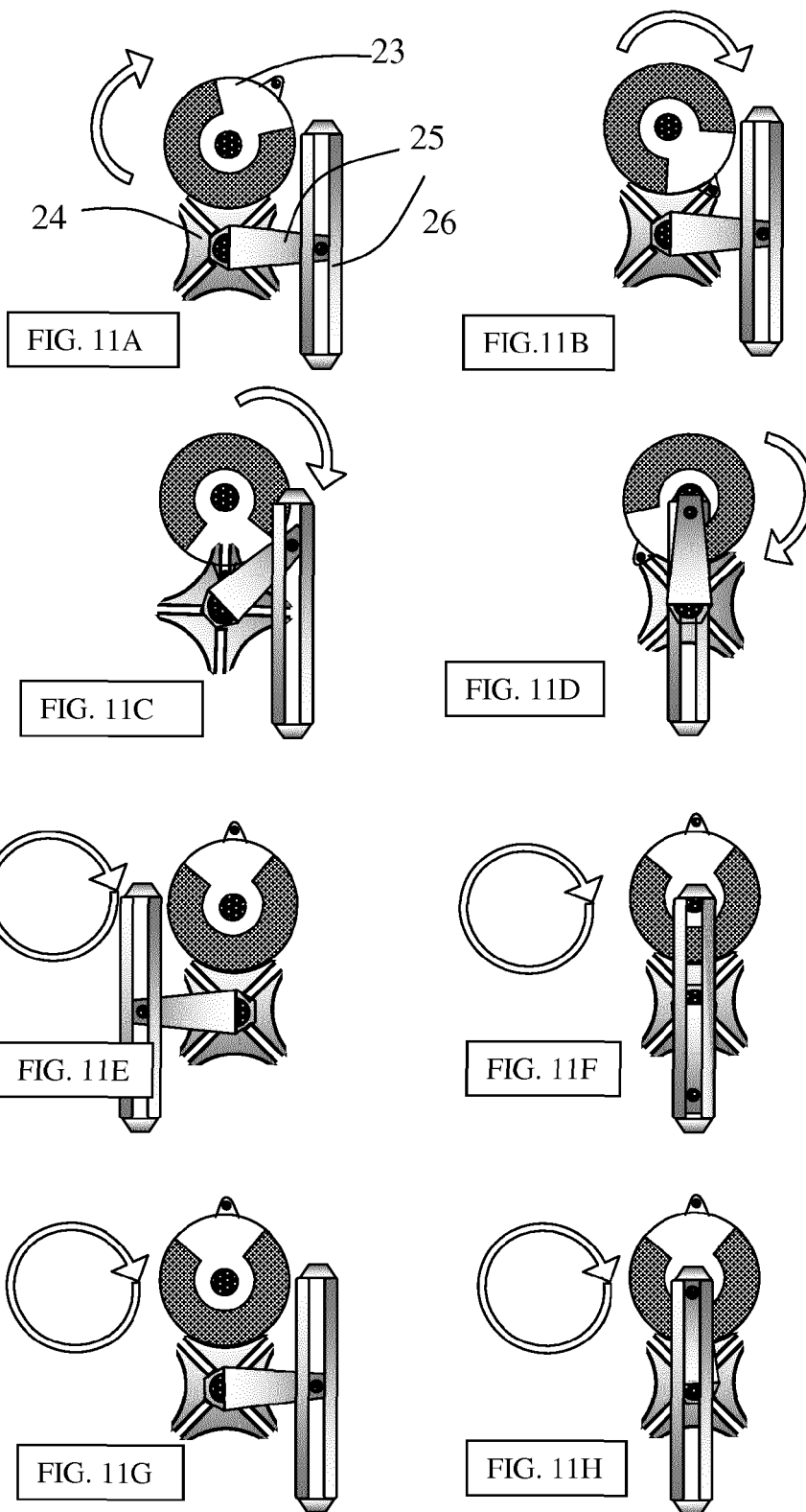


FIG. 11



EUROPEAN SEARCH REPORT

Application Number
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			D03D D03C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 February 2020	Examiner Louter, Petrus
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