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(54) MACHINE FOR WINDING FABRICS MADE OF COMPOSITE MATERIALS ON A MANDREL

MASCHINE ZUM WICKELN VON COMPOSITMATERIAL AUF EINEN KERN

MACHINE POUR ENROULER DU MATERIAU COMPOSITE SUR UN NOYAU

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EP 3 770 091 B1

Description

Technical field

[0001] The invention relates to the sector of machinery for producing cylindrical, or conical, products, with fabrics made of composite material.

[0002] More in detail, the invention concerns a machine for winding preimpregnated fabrics made of composite material on a mandrel, in particular carbon fiber fabrics preimpregnated with synthetic resin. Such machines are disclosed in e.g. EP 0 860 392 A2 or WO2012112999 A1.

[0003] Fabrics made of preimpregnated composite material, known in the art as prepreg, consists of fibers of carbon, Kevlar, glass, zylon, etc., impregnated in a matrix of epoxy or phenol thermosetting synthetic resin, or of vinyl ester or cyanate ester type, etc.

[0004] These preimpregnated fabrics are wound around cylindrical, tapered or conical mandrels, preferably but not exclusively made of metal, and allow the construction of products such as poles, tubes, rollers, rods or cylinders of various lengths, diameters and thicknesses.

[0005] The fibers provide these fabrics with mechanical properties such as modulus of elasticity, stiffness, strength, etc. The synthetic resin matrix (after curing by means of which it polymerizes with a catalytic or vitrification process) gives stability to products made with these fabrics, influences their modulus of elasticity and is selected to enhance or attenuate these and/or other properties thereof.

[0006] For example, a composite material with fibers with a high modulus of elasticity will be designed with the lowest possible percentage of resin (35% - 40%), so as not to attenuate the mechanical properties of this fiber. The resin has a modulus of elasticity close to zero and in combination with a fiber with a modulus of elasticity of 100 GPa, if the product has 40% by volume of resin, the modulus of elasticity of the finished product will be reduced to 60 GPa.

[0007] Composite prepreg materials are physically created as a fabric.

[0008] In fact, their fibers are woven on special looms to form cloths with infinite weave options (50% warp and 50% weft, unidirectional, +/-45°, twill, plain, etc.), designed to provide both different optical effects and different mechanical properties.

[0009] The cloths obtained are stored wound on reels, are the same width as the respective looms (usually from 1000 mm to 1300 mm) and the same length as the respective reels (from 25 m to 50 m), and are impregnated in a synthetic resin matrix to obtain a preimpregnated (or prepreg) composite fabric formed of fibers and resin.

[0010] The chemical-physical properties of the resin mean that the prepreg fabric obtained must be stored at a temperature below zero (-20/-30 °C for long term storage, -8/-20 °C for short term storage), as the catalysis process starts autonomously at room temperature making subsequent use of the material ineffective.

[0011] Substantially two techniques are used to form a cylindrical product having a prepreg fabric made of composite material as raw material: molding technology and sheet winding technology (John T. Kanne and Jerome S. Berg, "HANDBOOK OF COMPOSITES" - Ed. S.T. Peters 1998).

[0012] Molding technology is used to create products with complex or linear geometrical shapes, also non-cylindrical. In this case, the operator cuts pieces of prepreg composite fabric to size, positions them on a mold that defines their shape and cures them in an autoclave or oven.

[0013] Sheet winding technology is instead used to create products with a cylindrical, tapered or conical shape. In this case, the operator cuts the prepreg composite fabric to size, based on variables such as mandrel length, mandrel diameter and number of turns on the mandrel that determine the thickness, thereby obtaining a sheet, and then proceeds to wind it around this mandrel.

[0014] Besides the technique of winding a prepreg composite fabric on a mandrel, there is also the technique of winding unimpregnated carbon (or other) fibers, in reel form, on a mandrel with impregnation through immersion in a resin bath positioned immediately upstream of the mechanical head that winds the filaments around a mandrel (Filament Winding).

Background art

[0015] The state of the art of machinery for winding preimpregnated fabrics made of composite material on a mandrel is represented by the winding machine known in the art with the name Rolling Table (John T. Kanne and Jerome S. Berg, "HANDBOOK OF COMPOSITES" - Ed. S.T. Peters 1998, pp. 425-432).

[0016] This winding machine is substantially composed of two parallel horizontal tables, one lower and one upper, with which the following operations are carried out in sequence:

- a piece of prepreg composite fabric, previously cut to size, is positioned on the lower table;
- the mandrel, usually made of metal, is positioned on the lower table, in the correct position with respect to the piece of prepreg fabric;
- the upper table is brought into contact with the mandrel, so that the mandrel is in contact with both the lower table and the upper table;
- the machine movement is started, consisting in horizontal stroke of the upper table with respect to the lower table, so that this movement imparts a rolling motion to the mandrel closed between the two tables and that the forced rolling of the mandrel causes the prepreg fabric to wind around the mandrel, copying its shape.

[0017] Subsequently:

- the prepreg composite fabric rolled on the mandrel is cured, determining polymerization of the synthetic resin;
- the mandrel is extracted from the semi-finished product;
- finishing operations (mechanical and other) are carried out on the semi-finished product to obtain the finished product therefrom.

[0018] The rolling table winding machine has some important negative aspects and operating problems.

[0019] To wind the prepreg fabric on the mandrel, the rolling table winding machine exploits the rolling motion of the mandrel, which is transmitted by the translation movement of the upper table with respect to the lower table. Each winding step corresponds to a forward and return stroke of the upper table, with consequent variable dimensions. In the case of large machines, the aforesaid operating steps involve large moving masses, with high energy costs and high risk of danger to operators.

[0020] The rolling table winding machine operates with the mandrel always idle and this aspect causes a rolling friction on the prepreg fabric only in two contact areas, due to rolling of the mandrel. In the case of a large machine, for each winding stroke the mandrel starts to roll after overcoming its inertia. This aspect translates into an initial rubbing of the mandrel on the prepreg fabric, which can become wrinkled, nullifying the correct compaction thereof. The industrial use of the rolling table winding machine is therefore optimized for mandrels of limited sizes and weights, while instead its performance is less than optimal with mandrels having diameters exceeding 250-300 mm, lengths exceeding 6000-6500 mm and weights exceeding 400-500 kg.

[0021] To compact the fabric on the mandrel, the rolling table winding machine exploits the concept of pressure applied by the downward thrust of the upper table, where the contact areas between mandrel, prepreg fabric and parallel tables are two, aligned on the vertical plane with respect to the working plane. The pressure applied by the upper table on the mandrel and the weight of the mandrel in fact cause two forces aligned on the vertical plane. In the case of large machines (diameter 250-800 mm, mass 500-1500 kg), the resulting pressure can be damaging to the point that it nullifies the precision of the operations. Moreover, in the case in which the mandrel is replaced with a semi-finished cylindrical product made of composite material, without a mandrel as it has already been subjected to one or more winding and curing steps, the pressure applied can be damaging to the point that the semi-finished product is broken. Industrial use of the rolling table winding machine is therefore only optimal with mandrels having small sizes and weights.

[0022] The state of the art of machinery for winding carbon fibers or other fibers in the form of filaments rather than fabric on a mandrel is represented by the winding machine known in the art with the name Filament Winding.

[0023] The filament winding technique requires a high percentage by volume of resin (from 45% - 55%), which causes resin excesses the end of the production processes of the products. Resin has a modulus of elasticity close to zero, and therefore the excess resin with which the filament winding technique operates is a limitation both for reaching the desired weights of the products and for their mechanical performance, represented more specifically by Young's modulus. Although it is possible to remove part of the excess resin from the products with subsequent processes, it is highly probable that the space left free will be filled with air bubbles that compromise the final compaction of the fibers of the products. Moreover, in filament winding operations fibers with a very high modulus of elasticity are subject to deteriorations, as they are very sensitive to mechanical stresses and frictions.

OBJECT OF THE INVENTION

[0024] The object of the invention is to overcome the negative aspects and operating problems of current machinery for winding preimpregnated fabrics made of composite material on a mandrel, in particular rolling table machinery.

[0025] The object of the invention is achieved with a machine for winding preimpregnated fabrics made of composite material on a mandrel, according to the main independent claim 1. Further features of the invention are contained in the dependent claims.

Brief description of the invention

[0026] The machine for winding preimpregnated fabrics made of composite material, pre-cut in sheets, on a mandrel according to the invention acts with a mandrel and rollers peripheral to the mandrel, arranged to be rotated or braked synchronously or asynchronously to one another. The user can therefore personalize the synchronization of rotation or braking of the mandrel and of the peripheral rollers that constrain it, thereby completely controlling the various types of friction involved. Customized management of sliding or rolling frictions between the rotating rollers allows composite prepreg fabrics to be maintained under suitable mechanical tension in order to reach optimal compaction, preventing the formation of creases during winding. The machine for winding prepreg fabrics made of composite material on a mandrel according to the invention is not only flexible for winding on mandrels with a very wide range of lengths, diameters and thicknesses, but also allows winding of semi-finished cylindrical products without mandrels, as they have already been subjected to least one step before winding and curing, which themselves represent the mandrel.

[0027] Therefore, hereinafter the term mandrel shall mean both a form about which the semi-finished product

is produced, removable therefrom, and a semi-finished product to which a further coating of fabric made of composite material must be applied.

[0028] This versatility of use is achieved through a distributed management of the thrust forces with respect to the circumference of the mandrel and to the possibility of customizing this distribution, optimizing it.

Advantages of the invention

[0029] The machine for winding preimpregnated fabrics made of composite material according to the invention achieves numerous and important advantages.

[0030] To wind the prepreg fabric on the mandrel, the machine of the invention exploits the rotation motion of a mandrel constrained by peripheral rollers. Therefore, each winding step takes place with subsequent rotations of the mandrel, no translation bodies are present and the size of the machine is fixed.

[0031] Through the possibility of customizing synchronization of rotation or braking of the mandrel and of the peripheral rollers that constrain it, the machine of the invention generates both rolling and sliding friction in at least three contact areas with the prepreg fabric. The sliding friction is greater than the rolling friction and the possibility of controlling it offers a control of the mechanical tension to which the prepreg fabric is subjected. Greater control of frictions translates into greater versatility in usage of the machine.

[0032] To compact the prepreg fabric on the mandrel, the machine of the invention exploits the concept of mechanical tension of the fabric, by means of sliding frictions in at least three contact areas, radially distributed on the surface of the mandrel. Moreover, only the weight of the mandrel and of the peripheral roller above contribute to the pressure on the prepreg fabric. Therefore, the performance of the machine of the invention is optimal even when the mandrel is represented by a semi-finished product, which has already been subjected to at least one winding and curing step. In this scenario, the pressure of the peripheral roller above the mandrel and the weight of the semi-finished product are distributed on three contact areas not aligned on the vertical plane, with a lower force with respect to the same operation carried out with the rolling table machine.

[0033] With the machine of the invention it is possible to control the percentage by weight of resin selecting specific prepreg fabrics and to prevent the formation of air bubbles through compaction controlled by means of adequate frictions between prepreg fabric, mandrel and peripheral rollers that constrain it. The machine of the invention is suitable for producing products with a high compaction level, minimum resin percentage, and hence with high mechanical performance and low weight. More specifically, the products obtained with the machine of the invention can have diameters up to 450 mm, lengths greater than 10000 mm, thicknesses from 1 mm to over 30 mm. Moreover, prepreg fabrics containing fibers with a very high modulus of elasticity can be used without compromising, through winding stress, the mechanical performance of the fibers of which they are composed.

Brief description of the drawings

[0034] Further features and advantages of the invention will be more apparent from the more detailed description set forth below, with the aid of the drawings that show a preferred embodiment, by way of nonlimiting example, wherein:

- Fig. 1 shows, in a side view, a machine for winding preimpregnated fabrics made of composite material on a mandrel according to the invention, highlighting the mandrel and the peripheral rollers above and below it, the corresponding rotation axes and the friction areas between the rollers, the mandrel and the composite fabric;
- Fig. 2 shows said machine in a perspective front view, highlighting the table on which the preimpregnated fabric made of composite material pre-cut in a sheet runs and overall dimensions;
- Figs. 3-4 show said machine in a rear perspective view and in a front plan view, highlighting the sensors and the position actuators of the peripheral rollers above the mandrel and the overall dimensions;
- Fig. 5 shows said machine in a partial perspective front view, highlighting the handling components.

Detailed description of the invention

[0035] With reference to the details of the figures, there is illustrated a machine for winding preimpregnated fabrics of the type made of composite material comprising fibers and a thermosetting synthetic resin on a mandrel according to the invention.

[0036] Said machine comprises:

- a table 1 on which a fabric 6 of prepreg type, pre-cut in a sheet, runs;
- a forming mandrel 5, preferably cylindrical, tapered or conical in shape, with rotation axis A5, for winding said prepreg fabric 6;
- a pair of peripheral rollers 2 and 3, with respective rotation axes A2, A3, under the rotation axis A5 of the mandrel 5;
- at least one peripheral roller 4, with rotation axis A4 above the rotation axis A5 of the mandrel 5;
- a pair of arms 8, preferably foldable, for supporting and moving the peripheral roller 4, comprising constraint means for said peripheral roller 4 adapted to allow a free or braked movement thereof;
- a structural frame 7, for supporting the mandrel 5, the peripheral rollers 2 and 3 and the arms 8 for supporting and moving the peripheral roller 4;
- first electric motor means 15 and second motor means 16, for the independent and selective com-

mand of the rotation respectively of the mandrel 5 and of the peripheral rollers 2 and 3;

- actuator means 9, for adjustment and correction of the horizontal distance between the rotation axes A2, A3 of the peripheral rollers 2 and 3;
- a control board 10 of the first and second electric motor means 15 and 16;
- a mechanism 11, applicable reversibly to the mandrel 5, for transmitting the rotation command from said motor means 15 to said rotation axis A5;
- a mechanism 12 applied to the peripheral rollers 2 and 3 for transmitting the rotation command from said motor means 16 to said rotation axes A2 and A3;
- sensor means 13, for vertical detection of the position of the peripheral rollers 2 and 3;
- actuator means 14, for vertical correction of the alignment and of the bending of the rotation axes A2, A3 of the peripheral rollers 2 and 3.

[0037] The mandrel 5 is made, preferably but not exclusively, of metal materials, is replaceable, and has diameters and lengths customizable from small to large dimensions. The free, motor-driven or braked rotation of the mandrel 5, implemented by means of the first electric motor means 15, can be synchronous or asynchronous with respect to the peripheral rollers 2, 3 and 4 that constrain it by means of three contact points, respectively F2, F3, F4. The mandrel 5 can therefore rotate in idle, motor-driven or braked mode.

[0038] The mandrel 5 ensures an adequate rolling friction, if motor-driven or idle, or an adequate sliding friction, if braked, so as to obtain a correct mechanical tension on the prepreg fabric 6 during winding, in order to achieve optimal compaction thereof. The mandrel 5, as stated, can consist of a semi-finished cylindrical product, previously subjected to at least one winding and curing step on a mandrel, if the production process requires this.

[0039] The peripheral rollers 2 and 3 are made, preferably but not exclusively, of steel and have diameters ranging indicatively from 150 mm to 400 mm and lengths ranging indicatively from 4000 mm to 10000 mm.

[0040] The free, motor-driven or braked rotation motion of the peripheral rollers 2 and 3, implemented by means of the second electric motor means 16, takes place in tandem and can be synchronous or asynchronous with respect to the mandrel 5. The peripheral rollers 2 and 3 can therefore be motor-driven, idle or braked. The peripheral rollers 2 and 3 ensure an adequate rolling friction, if motor-driven or idle, or an adequate sliding friction, if braked, so as to obtain a correct mechanical tension on the prepreg fabric 6 during winding on the mandrel 5, for the purposes of achieving optimal compaction thereof.

[0041] The peripheral rollers 2, 3 can be associated with a heating system, so as to promote the adhesion of the prepreg fabric 6 on the mandrel 5 during the first winding step. In this way, the probability of the prepreg fabric 6 detaching from the mandrel 5 in the segments F2-F3, F3-F4 and F4-F2 is reduced.

[0042] The peripheral roller 4 is made, preferably but not exclusively, of metal materials and is removable from the operating position.

[0043] Unlike the mandrel 5 and the peripheral rollers 2 and 3, the peripheral roller 4 is not motor-driven, but only rotatingly supported or braked by means of specific constraint means (not illustrated), as it only performs the additional task of controlling the friction and the tension on the prepreg fabric 6. The rotation motion of the peripheral roller 4 can therefore be idle or braked, and can be synchronous or asynchronous with respect to the mandrel 5 and to the peripheral rollers 2 and 3. The peripheral roller 4 ensures an adequate rolling friction, if idle, or an adequate sliding friction, if braked, so as to obtain a correct mechanical tension on the prepreg fabric 6 during winding on the mandrel 5, for the purposes of achieving the optimal compaction thereof.

[0044] In particular, the task of the peripheral roller 4 is that of contributing to the correct mechanical tension of the prepreg fabric 6 in the friction area F4 during winding, so as to promote the compaction of the prepreg fabric 6 in the arcs of circle F3-F4 and F4-F2.

[0045] In equivalent variants of the invention, the peripheral roller 4 can be associated with other peripheral rollers having the same function.

[0046] The folding arms 8 allow the peripheral roller 4 to be maintained above the mandrel 5 or to move it from the operating position, to allow simpler handling of the mandrel 5 for example with the use of a bridge crane.

[0047] The actuators 9 allow the peripheral rollers 2 and 3 to be geometrically adapted for the use of mandrels 5 both of small and of large dimensions, with tolerances below a few tenths of millimeter (a mandrel 5 with a larger diameter corresponds to a greater distance between the respective rotation axes A2, A3).

[0048] The control board 10 allows the selective and reversible passage from command of the mandrel 5 to command of the peripheral rollers 2 and 3 during winding, based on the machining process implemented.

[0049] The transmission mechanism 11 is removable and allows operations to change the mandrel 5 to be implemented.

[0050] The sensors 13 allow measurement of the vertical movements of the peripheral rollers 2 and 3 with respect to predetermined values, with tolerances lower than a tenth of millimeter.

[0051] The actuators 14 allow correction of the alignment and vertical bending of the rotation axes A2, A3 of the peripheral rollers 2 and 3 which, potentially alterable by a very heavy mandrel 5, can compromise compaction of the prepreg fabric 6 on the mandrel 5. The actuators 14 thus ensure that the contact lines between the peripheral rollers 2 and 3 and the mandrel 5 are continuous for the entire length of the mandrel, during winding of the prepreg fabric 6.

[0052] The table 1 can have a rubber-coated surface so as to create a sliding friction F1 on the prepreg fabric

6 during winding and consequently increase the mechanical tension of the fabric in the friction area F2 to improve its compaction on the mandrel 5.

[0053] The table 1 allows the prepreg fabric 6, previously cut to size, to be positioned correctly before starting to wind it on the mandrel 5. In this way positioning errors, which must be linear and accurate in the friction area F2 for the entire length of the mandrel 5, are prevented, consequently preventing propagations of position defects during the various winding steps of the prepreg fabric 6 on the mandrel 5 (for example, if the prepreg fabric 6 is positioned misaligned with respect to the mandrel 5, a spiral of prepreg fabric 6 will be formed thereon instead of a cylinder or of a cone that accurately reproduces the shape thereof).

Detailed operation of the invention

[0054] The operating principle of a machine for winding composite preimpregnated fabrics made of composite material on a mandrel according to the invention can be summed up as described below.

[0055] By means of said machine, the operator carries out the following operations in sequence:

- positioning the prepreg fabric 6 previously cut to size in a sheet on the table 1;
- moving the prepreg fabric 6 toward the friction area F2 between the mandrel 5 and the first of the peripheral rollers 2 and 3, so that at the start of the rotation movement of the mandrel 5 the fabric 6 is pulled and wound around it uniformly;
- starting the rotation movement of the mandrel 5 with specific commands 11, so that the prepreg fabric 6 carries out the first winding turn around the mandrel 5;
- choosing from the control board 10 whether to command the first electric motor means 15, and the transmission mechanism of the rotation command 11 to be applied to the mandrel 5, or whether to command the second electric motor means 16, and the transmission mechanism of the rotation command 12 to be applied to the peripheral rollers 2 and 3, based on the production process, the size and the weight of the mandrel 5 and of the type of fabric 6 used;
- if necessary, customizing the transmission mechanisms of the rotation commands 11 and 12 during winding, leaving idle or braking the rollers 2 and 3, based on the frictions required in the areas F2 and F3 to ensure the correct mechanical tension of the prepreg fabric 6 and its compaction;
- lowering the supporting arms 8 of the peripheral roller 4 until it is brought into contact with the mandrel 5, producing the friction area F4, so as to exert a pressure imparted, or through gravity, to the prepreg fabric increasing the compaction thereof;
- if necessary, braking the peripheral roller 4 to establish a sliding friction in the area F4, which ensures a greater mechanical tension on the prepreg fabric 6 and promotes its compaction;
- at the end of winding the prepreg fabric 6 on the mandrel 5, carrying out a few idle rotations of the mandrel 5 about its axis A5, with the peripheral rollers 2 and 3 motor-driven and the peripheral roller 4 idle, so as to exert a continuous radial pressure on the mandrel 5 and finalize compaction of the prepreg fabric 6 in a uniform manner;
- finally, lifting the peripheral roller 4 from the position in contact with the mandrel 5 and removing the transmission mechanism of the rotation command 11 from the mandrel 5.

[0056] The mandrel 5 with the prepreg fabric 6 wounds thereon is lifted with a bridge crane, or other device suitable for this purpose, and carried to the subsequent workstation to be prepared for the curing step.

Claims

1. Machine for winding preimpregnated fabrics, made of composite materials comprising fibers and thermosetting synthetic resin, on a mandrel, **characterized in that** it comprises:

   - a flat supporting surface for a preimpregnated fabric (6) pre-cut in a sheet;
   - a forming mandrel (5), with a rotation axis (A5), for winding said preimpregnated fabric (6);
   - a pair of peripheral rollers (2, 3), with respective rotation axes (A2, A3), under the rotation axis (A5) of the mandrel (5);
   - at least one peripheral roller (4), with a rotation axis (A4), above the rotation axis (A5) of the mandrel (5);
   - a pair of arms (8), for supporting and moving the peripheral roller (4), comprising constraint means for said peripheral roller (4) adapted to allow a free or braked movement thereof;
   - a structural frame (7), for supporting the mandrel (5), the peripheral rollers (2, 3) and the arms (8) of the peripheral roller (4);
   - first electric motor means (15) and second motor means (16), for the independent and selective command of the rotation respectively of the mandrel (5) and of the peripheral rollers (2, 3);

   where said first and second electric motor means (15, 16) cause the free, motor-driven or braked rotation respectively of the mandrel (5) and the peripheral rollers (2, 3), and where the arms (8) place the peripheral roller (4) in contact with the mandrel (5), so as to create between the peripheral rollers (2, 3, 4) and the mandrel (5) corresponding areas of rolling or sliding friction (F2, F3, F4) adapted to determine on the preimpregnated fabric (6) a mechanical ten-

sion capable of promoting its winding and compaction on the mandrel (5).

2. Machine according to claim 1, **characterized in that** it comprises a mechanism (11) for transmitting the rotation command from said motor means (15) to said rotation axis (A5), where said mechanism (11) is applicable reversibly to the mandrel (5), so that said mandrel (5) can be removable.

3. Machine according to claim 1, **characterized in that** it comprises a mechanism (12) applied to the peripheral rollers (2, 3) for transmitting the rotation command from said motor means (16) to said rotation axes (A2, A3).

4. Machine according to claim 1, **characterized in that** the peripheral rollers (2, 3) comprise heating means, adapted to promote adhesion of the preimpregnated fabric (6) on the mandrel (5) during the first winding step.

5. Machine according to claim 1, **characterized in that** it comprises a control board (10) of the first and second electric motor means (15, 16) for rotating the mandrel (5) and the peripheral rollers (2, 3).

6. Machine according to claim 1, **characterized in that** it comprises a structural frame (7), for supporting the mandrel (5), the peripheral rollers (2, 3) and the arms (8) for supporting and moving the peripheral roller (4).

7. Machine according to claim 1, **characterized in that** it comprises actuators (9) for adjusting and correcting the horizontal distance between the rotation axes (A2, A3) of the peripheral rollers (2, 3).

8. Machine according to claim 1, **characterized in that** it comprises sensor means (13), for vertical detection of the position of the peripheral rollers (2, 3).

9. Machine according to claim 1, **characterized in that** it comprises actuator means (14), for vertical correction of the alignment and of the bending of the rotation axes (A2, A3) of the peripheral rollers (2, 3).

10. Machine according to claim 1, **characterized in that** said flat surface comprises a table (1) on which the preimpregnated fabric (6) pre-cut in a sheet runs, where said table (1) comprises a rubber-coated surface, adapted to determine a friction (F4) on the preimpregnated fabric (6) to increase the mechanical tension thereof in the friction area (F1) and consequently improve the compaction thereof on the mandrel (5).

Patentansprüche

1. Maschine zum Wickeln von vorimprägnierten Geweben aus Compositmaterial, umfassend Fasern und wärmehärtendes Kunstharz, auf einen Kern, **dadurch gekennzeichnet, dass** sie Folgendes umfasst:

   - eine flache Stützfläche für ein vorimprägniertes Gewebe (6), das in einem Bogen vorgeschnitten ist;
   - einen Formungskern (5) mit einer Drehachse (A5) zum Wickeln des besagten vorimprägnierten Gewebes (6);
   - - ein Paar Umfangsrollen (2, 3) mit entsprechenden Drehachsen (A2, A3) unter der Drehachse (A5) des Kerns (5);
   - mindestens eine Umfangsrolle (4) mit einer Drehachse (A4) oberhalb der Drehachse (A5) des Kerns (5);
   - ein Paar Arme (8) zum Stützen und Bewegen der Umfangsrolle (4), umfassend Beschränkungsmittel für die besagte Umfangsrolle (4), die geeignet sind, eine freie oder gebremste Bewegung derselben zu ermöglichen;
   - einen strukturellen Rahmen (7) zum Stützen des Kerns (5), der Umfangsrollen (2, 3) und der Arme (8) der Umfangsrolle (4);
   - ein erstes Elektromotormittel(15) und ein zweites Motormittel (16) für die unabhängige und selektive Steuerung der Drehung des Kerns (5) und der Umfangsrollen (2, 3);

   wobei das besagte erste und zweite Elektromotormittel (15, 16) jeweils die freie, motorisierte oder gebremste Drehung des Kerns (5) und der Umfangsrollen (2, 3) verursachen, und wobei die Arme (8) die Umfangsrolle (4) in Kontakt mit dem Kern (5) bringen, um zwischen den Umfangsrollen (2, 3, 4) und dem Kern (5) entsprechende Roll- oder Gleitreibungsbereiche (F2, F3, F4) zu schaffen, die geeignet sind, auf dem vorimprägnierten Gewebe (6) eine mechanische Spannung zu bestimmen, die fähig ist, dessen Wickeln und Verdichten auf dem Kern (5) zu fördern.

2. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie einen Mechanismus (11) zur Übertragung des Drehbefehls von den besagten Motormitteln (15) auf die besagte Drehachse (A5) umfasst, wobei der besagte Mechanismus (11) reversibel auf den Kern (5) anwendbar ist, so dass der besagte Kern (5) entfernbar sein kann.

3. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie einen Mechanismus (12) umfasst, der an den Umfangsrollen (2, 3) angebracht ist, um den Drehbefehl von den besagten Motormit-

teln (16) auf die besagten Drehachsen (A2, A3) zu übertragen.

4. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die Umfangsrollen (2, 3) Heizmittel umfassen, die geeignet sind, die Haftung des vorimprägnierten Gewebes (6) auf dem Kern (5) während des ersten Wickelschrittes zu fördern.

5. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie eine Steuertafel(10) des ersten und zweiten Elektromotormittels (15, 16) zum Drehen des Kerns (5) und der Umfangsrollen (2, 3) umfasst.

6. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie einen strukturellen Rahmen (7) zum Stützen des Kerns (5), der Umfangsrollen (2, 3) und der Arme (8) zum Stützen und Bewegen der Umfangsrolle (4) umfasst.

7. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie Aktuatoren (9) zum Einstellen und Korrigieren des horizontalen Abstands zwischen den Drehachsen (A2, A3) der Umfangsrollen (2, 3) umfasst.

8. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie Sensormittel (13) zur vertikalen Erfassung der Position der Umfangsrollen (2, 3) umfasst.

9. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** sie Aktuatormittel (14) für die vertikale Korrektur der Ausrichtung und der Biegung der Drehachsen (A2, A3) der Umfangsrollen (2, 3) umfasst.

10. Maschine gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die besagte flache Fläche einen Tisch (1) umfasst, auf dem das vorimprägnierte Gewebe (6), das in einem Bogen vorgeschnitten ist, läuft, wobei der besagte Tisch (1) eine gummibeschichtete Oberfläche umfasst, die geeignet ist, eine Reibung (F4) auf dem vorimprägnierten Gewebe (6) zu bestimmen, um dessen mechanische Spannung im Reibungsbereich (F1) zu erhöhen und folglich dessen Verdichtung auf dem Kern (5) zu verbessern.

Revendications

1. Machine pour enrouler des tissus pré-imprégnés, faits de matériaux composites comprenant des fibres et une résine synthétique thermodurcissable, sur un noyau, **caractérisée par le fait qu'**elle comprend :

- une surface de support plate pour un tissu pré-imprégné (6) prédécoupé en feuille ;
- un noyau de formation (5), avec un axe de rotation (A5), pour enrouler ledit tissu pré-imprégné (6) ;
- une paire de rouleaux périphériques (2, 3), avec des axes de rotation respectifs (A2, A3), sous l'axe de rotation (A5) du noyau (5) ;
- au moins un rouleau périphérique (4), avec un axe de rotation (A4), au-dessus de l'axe de rotation (A5) du noyau (5) ;
- une paire de bras (8), pour supporter et déplacer le rouleau périphérique (4), comprenant des moyens de contrainte pour ledit rouleau périphérique (4) adaptés pour permettre un mouvement libre ou freiné de celui-ci ;
- un cadre structurel (7), pour supporter le noyau (5), les rouleaux périphériques (2, 3) et les bras (8) du rouleau périphérique (4) ;
- des premiers moyens moteurs électriques (15) et des seconds moyens moteurs électriques (16), pour la commande indépendante et sélective de la rotation respectivement du noyau (5) et des rouleaux périphériques (2, 3) ;

où lesdits premier et second moyens moteurs électriques (15, 16) provoquent la rotation libre, motorisée ou freinée respectivement du noyau (5) et des rouleaux périphériques (2, 3), et où les bras (8) placent le rouleau périphérique (4) en contact avec le noyau (5), de manière à créer entre les rouleaux périphériques (2, 3, 4) et le noyau (5) des zones correspondantes de friction de roulement ou de glissement (F2, F3, F4) adaptées pour déterminer sur le tissu pré-imprégné (6) une tension mécanique capable de favoriser son enroulement et son compactage sur le noyau (5).

2. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend un mécanisme (11) pour transmettre la commande de rotation dudit moyen moteur (15) audit axe de rotation (A5), où ledit mécanisme (11) est applicable de manière réversible au noyau (5), de sorte que ledit noyau (5) peut être retiré.

3. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend un mécanisme (12) appliqué aux rouleaux périphériques (2, 3) pour transmettre la commande de rotation desdits moyens moteurs (16) auxdits axes de rotation (A2, A3).

4. Machine selon la revendication 1, **caractérisée par le fait que** les rouleaux périphériques (2, 3) comprennent des moyens de chauffage, adaptés pour favoriser l'adhésion du tissu pré-imprégné (6) sur le noyau (5) pendant la première étape d'enroulement.

5. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend une carte de commande (10) des premier et second moyens moteurs électriques (15, 16) pour faire tourner le noyau (5) et les rouleaux périphériques (2, 3).

6. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend un cadre structurel (7), pour supporter le noyau (5), les rouleaux périphériques (2, 3) et les bras (8) pour supporter et déplacer le rouleau périphérique (4).

7. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend des actionneurs (9) pour régler et corriger la distance horizontale entre les axes de rotation (A2, A3) des rouleaux périphériques (2, 3).

8. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend des moyens capteurs (13), pour la détection verticale de la position des rouleaux périphériques (2, 3).

9. Machine selon la revendication 1, **caractérisée par le fait qu'**elle comprend des moyens d'actionnement (14), pour la correction verticale de l'alignement et de la flexion des axes de rotation (A2, A3) des rouleaux périphériques (2, 3).

10. Machine selon la revendication 1, **caractérisée par** le fait ladite surface plate comprend une table (1) sur laquelle le tissu pré-imprégné (6) prédécoupé en une feuille se déplace, où ladite table (1) comprend une surface revêtue de caoutchouc, adaptée pour déterminer une friction (F4) sur le tissu pré-imprégné (6) pour augmenter la tension mécanique de celui-ci dans la zone de friction (F1) et par conséquent améliorer le compactage de celui-ci sur le noyau (5).

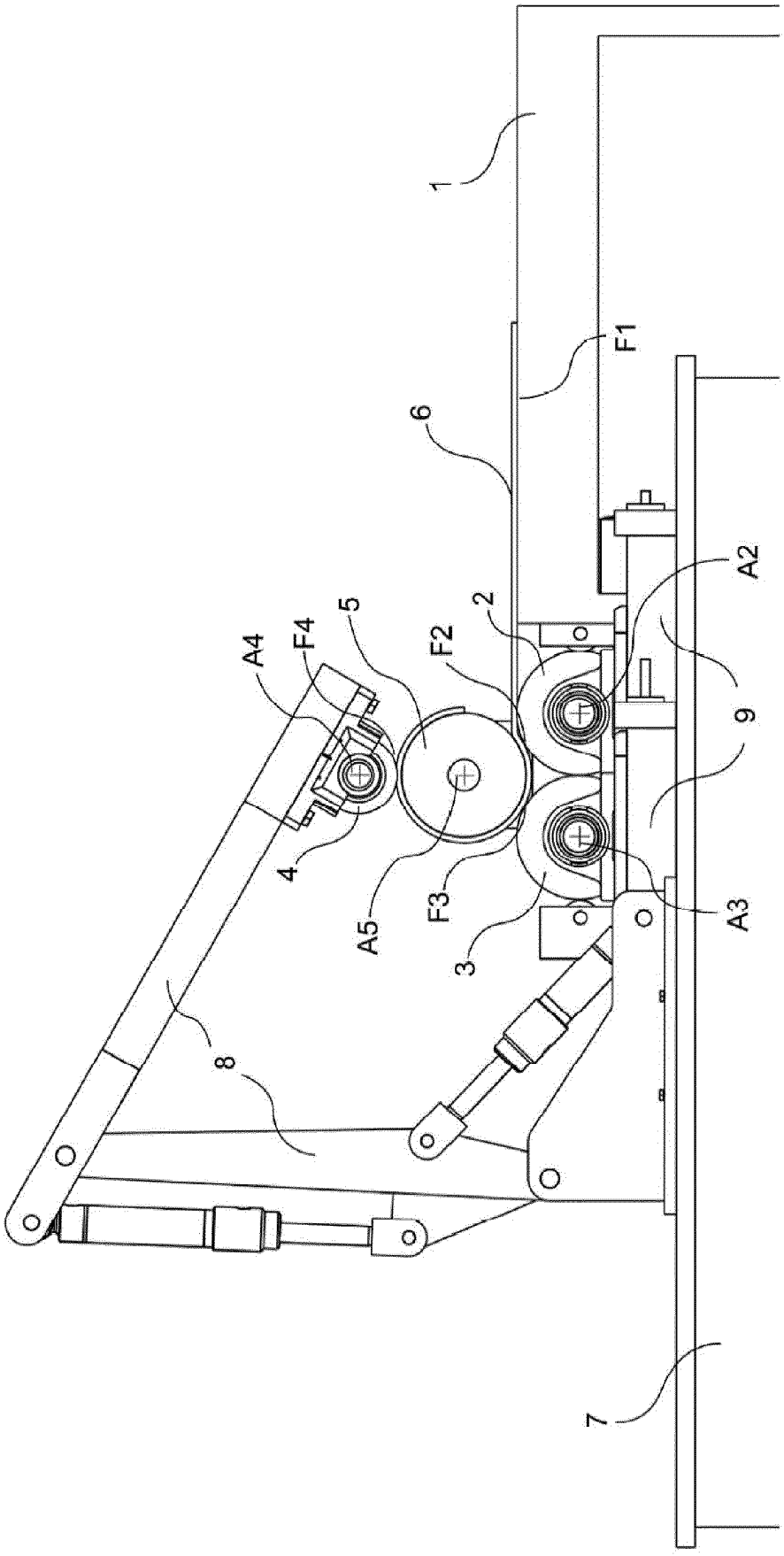


FIG. 1

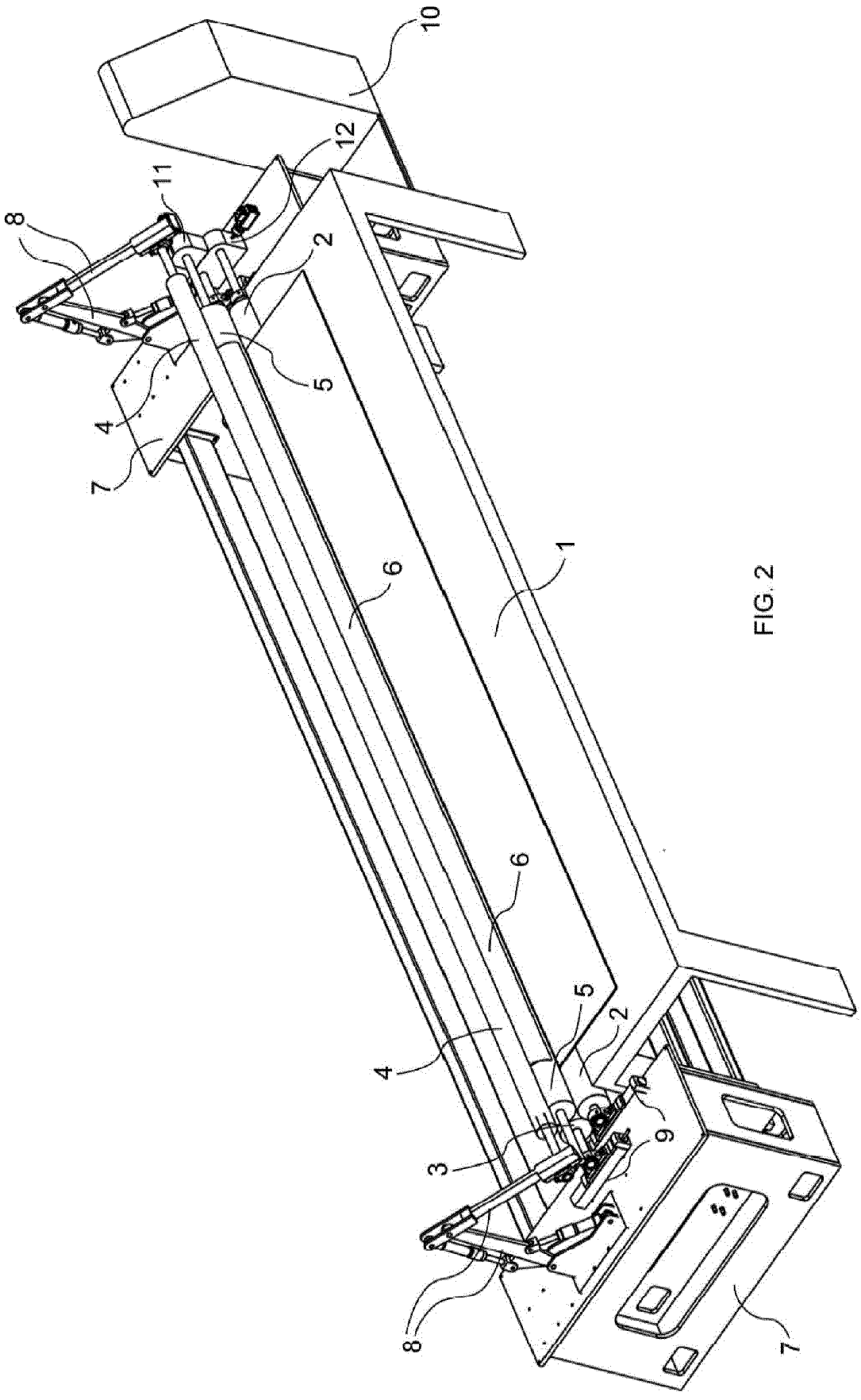


FIG. 2

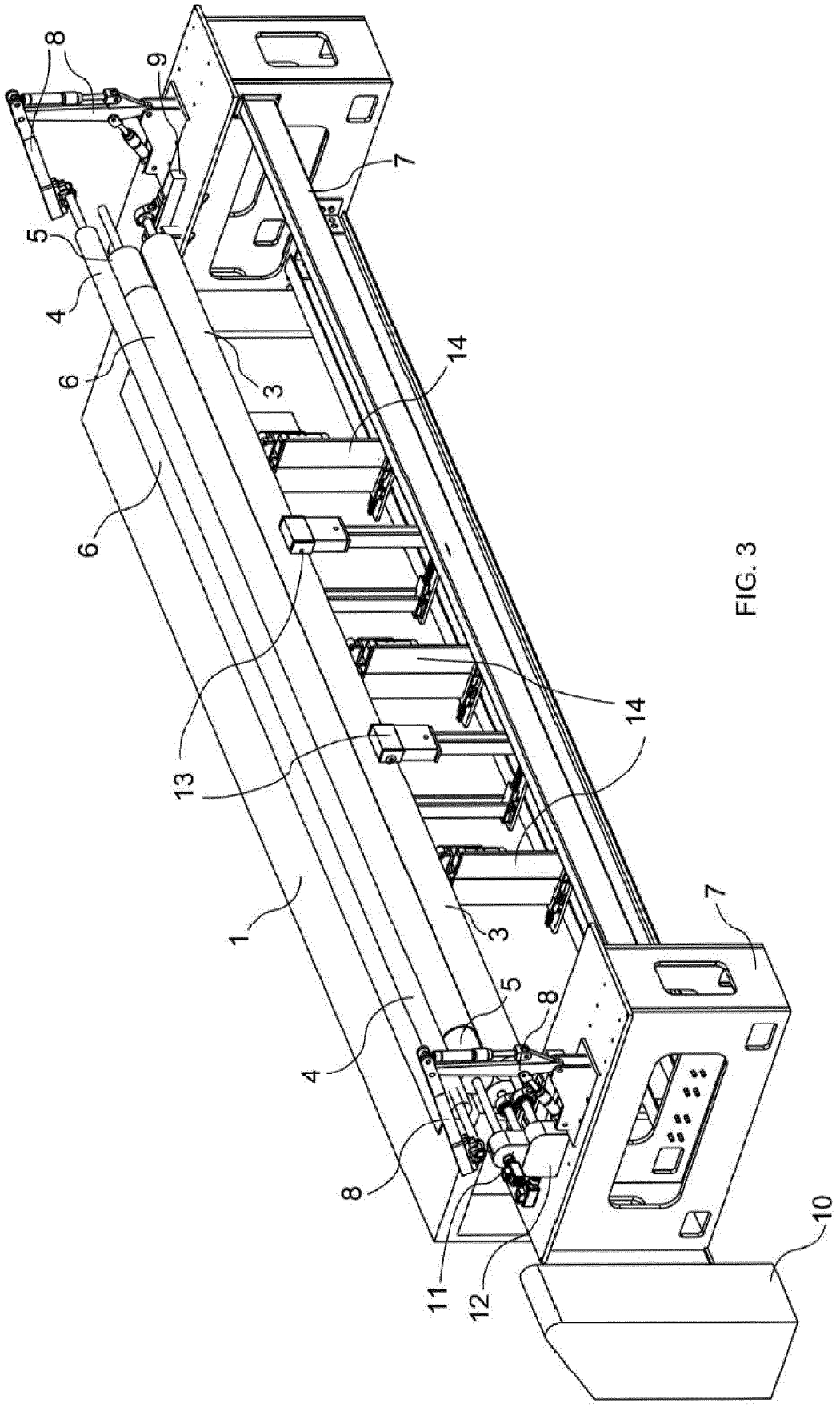


FIG. 3

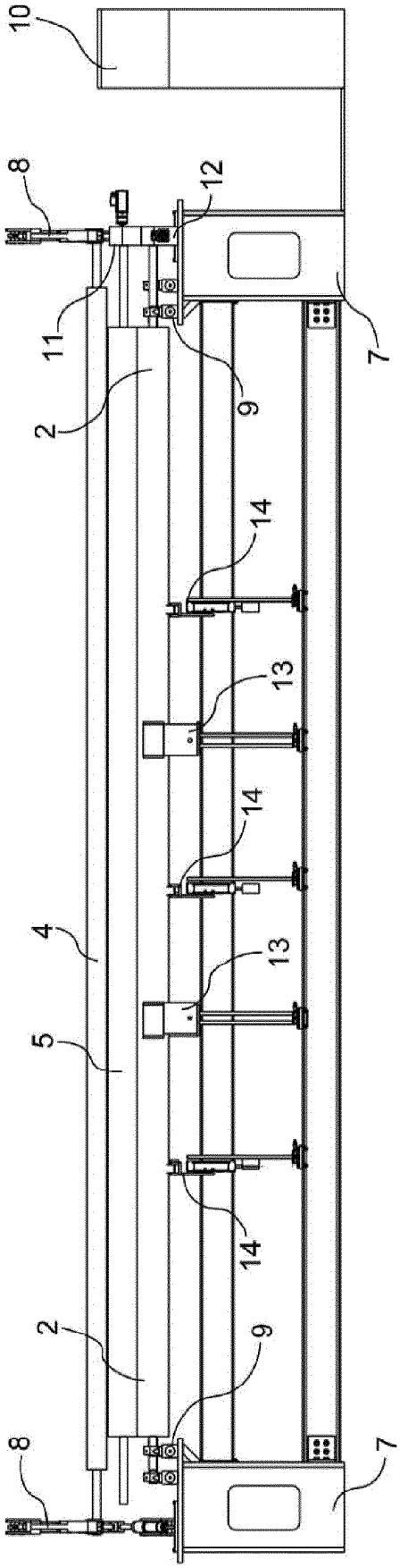


FIG. 4

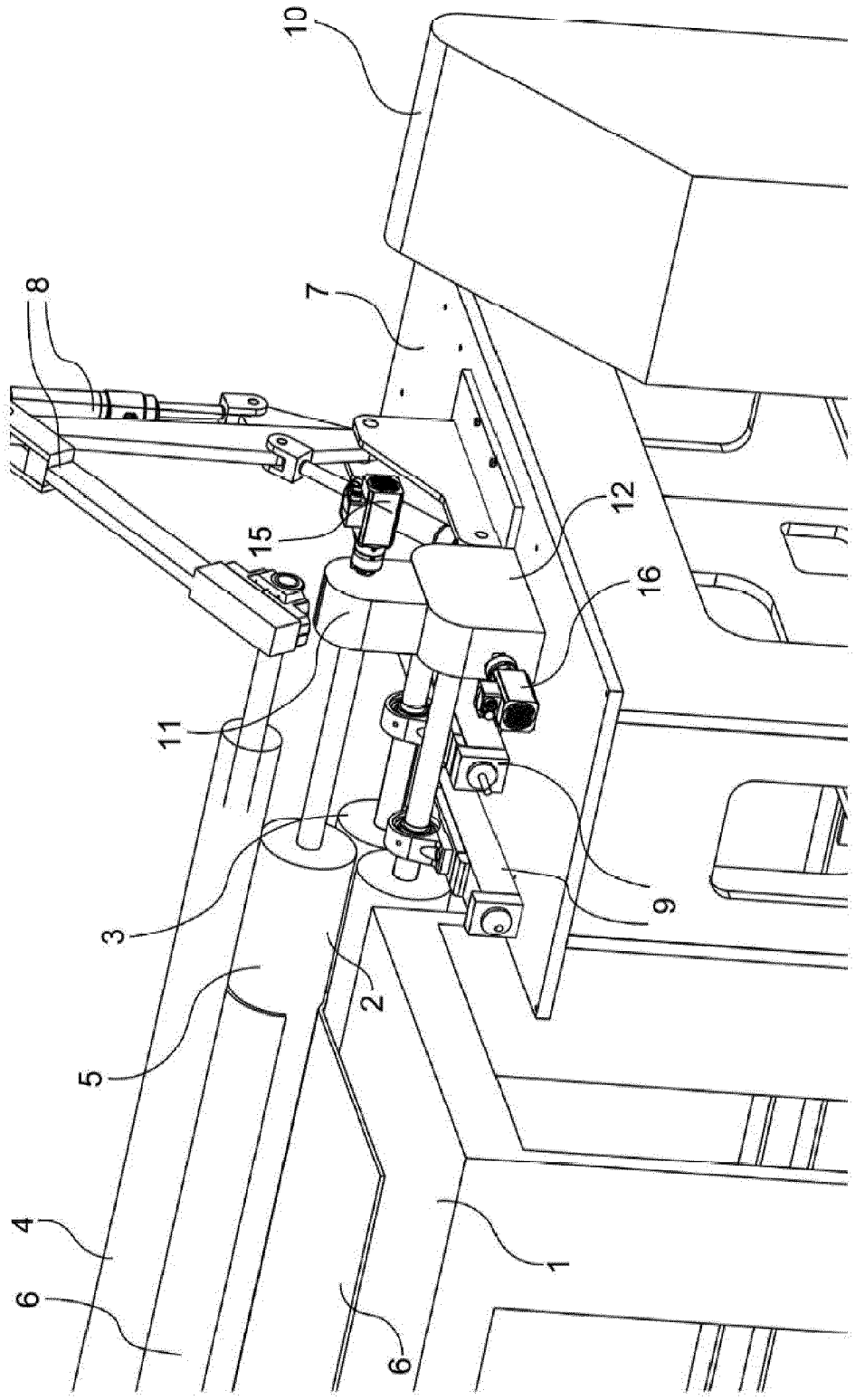


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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