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(71) Applicant: **Silmek S.R.L.**
36040 Brendola (VI) (IT)

(72) Inventor: **GONELLA, Gianfranco**
36100 VICENZA (IT)

(74) Representative: **Marchioro, Paolo**
Studio Bonini S.r.l.
Corso Fogazzaro, 8
36100 Vicenza (IT)

(54) **AN AUTOMATIC MACHINE FOR TRANSFORMER DISC WINDINGS**

(57) A winding machine (1) with radial and longitudinal stratification of an electrical conductor (C) for the realisation of windings for electrical transformers, comprising: a winding cylinder (2) whereon the electrical conductor (C) is adapted to be wound; a calendering set (5) for forming each of the discs (D) on the winding cylinder (2); a resting plane (7) of the discs (D) arranged externally to the winding cylinder (2) and configured to be moved along the direction defined by the vertical axis of rotation (Y); an electronic control set (9) configured to control the movement of the winding cylinder (2), of the calendering set (5) and of the resting plane (7) for realising the windings.

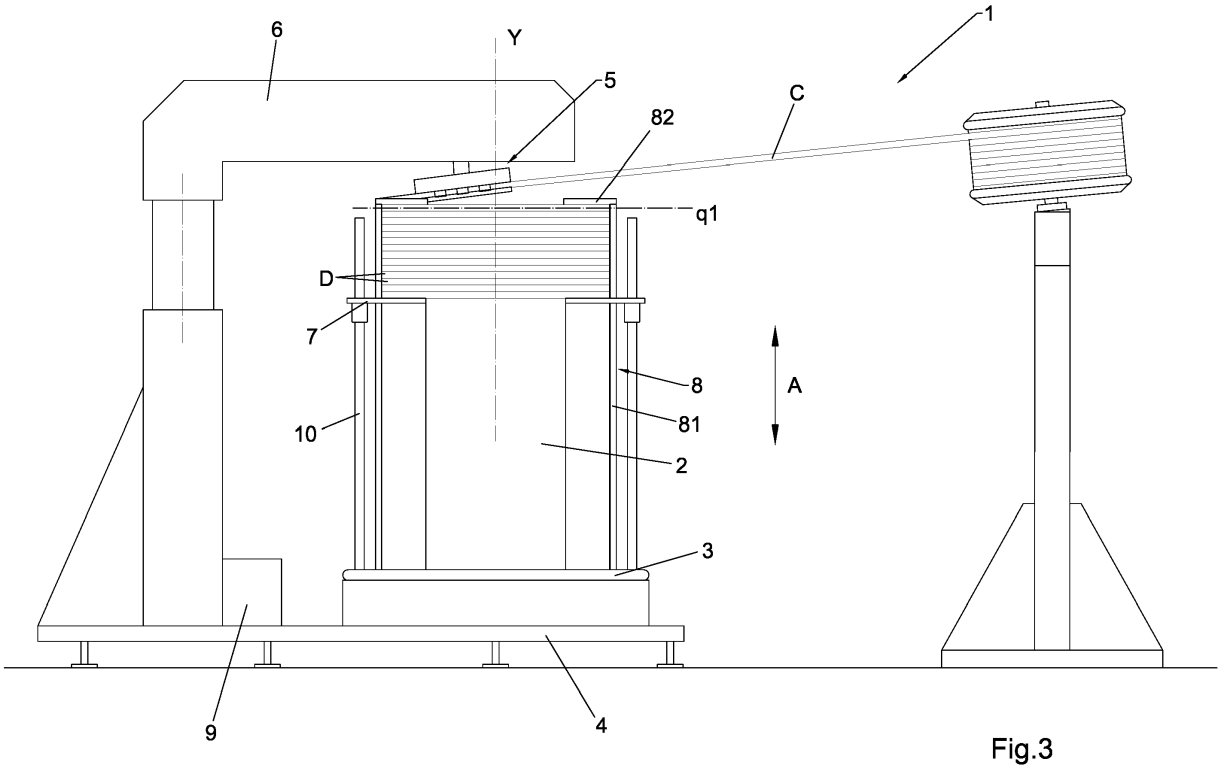

Fig.3

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Description

[0001] The invention relates to an improved winding machine with radial and longitudinal stratification of a conductor with rectangular or circular section for making windings for electrical transformers.

[0002] It is known that the disc winding technique of coils of an electrical conductor is mainly used for making windings for electrical transformers of medium or high power, with oil cooling or cast in resin, the latter also known as "CAST RESIN TRANSFORMERS".

[0003] In the specific technical sector of windings for electrical transformers, as represented schematically in fig. 1 of the prior art, the expression "disc winding" or more simply "disc" means the radial stratification of the electrical conductor for a predefined number of times, based on the electrical features to be provided to the winding to be obtained.

[0004] These "disc" windings, as can be observed in fig. 2 of the prior art, provide a plurality of said disks **D** stratified in the longitudinal direction.

[0005] Essentially, two main techniques are known, and the related winding machines, for the definition of these disc windings.

[0006] According to a first technique, the electrical conductor is wound on a winding cylinder that rotates according to an essentially horizontal axis of rotation. Before being wound on the winding cylinder, said electrical conductor is arranged on a spool able to rotate and translate along an axis that is parallel to the horizontal axis of rotation of the same cylinder.

[0007] The winding technique, of the manual type, entails fixing the free end of the electrical conductor on the winding cylinder and, setting in rotation the same winding cylinder, starting to stratify the coils thereon beginning from the innermost coil to reach the outermost coil so as to form the first disc. Following the completion of the first disc, the operator proceeds to make a so-called accumulation winding at a certain distance from the disc that has just been completed, proceeding, in this case as well, to the stratification of the coils starting from the innermost coil to reach the outermost coil. In this case, however, this stratification takes place with a certain slack between coil and coil because the operator must manually make, side by side with the first disc, the actual second disc starting from the aforesaid accumulation disk by reversing the order of the coils with respect thereto. More specifically, the operator will extract the innermost coil of the accumulation disc and will make it assume a diameter equal to the outer diameter of the first disc and so on until reaching the outermost coil of the accumulation disc which will be dimensioned to become the innermost coil of the actual second disc.

[0008] To make the subsequent discs, the operator proceeds by alternatively repeating the operations for making the first disc and the second disc as has just been described.

[0009] These operations are necessary because in this way the segment of the electrical conductor between adjacent discs undergoes bending only in the direction defined by the aforesaid axis of rotation and not also in the radial direction, as would instead occur if one were to proceed, for each disc, with the accumulation of the coils from the innermost to the outermost.

[0010] This technique is clearly complex and its execution requires a considerable quantity of time because it is carried out purely manually, as there are no machines able to carry out the aforesaid operating steps.

[0011] Moreover, an additional disadvantage of this technique is that the operator's ability to wind the coils is decisive to obtain a result that is in line with design specifications.

[0012] According to a second main technique for making said disc windings, the winding cylinder is arranged in a vertical, rather than horizontal position, and the coils are radially stratified so as to define each disc, by using a capstan with variable geometry arranged above the winding cylinder. The capstan then lets the coils fall by gravity that are deposited on the bottom or on the last disc made. Every disc is obtained with a progressive variation of the diameter of the capstan between the minimum diameter and the maximum diameter, and vice versa, of the winding to be obtained.

[0013] However, even this second technique and the related machines for its execution have some technical drawbacks.

[0014] In fact, it is known, disadvantageously, that the aforesaid vertical winding technique can be used merely with electrical conductors with cylindrical cross section and with diameter no greater than a certain dimension. This limitation is due to the fact that as the dimensions of the conductor increase, the difficulty in executing the operation of radially stratifying the coils for the definition of each disc also increases.

[0015] In any case, this technique does not allow to assure precise packing of the various coils, but such packing occurs with a certain randomness which determines the inability to obtain a winding with the desired design electrical specifications.

[0016] The present invention intends to overcome all the aforementioned drawbacks. In particular, a purpose of the invention is to provide a winding machine with radial and longitudinal stratification able to realise a winding for electrical transformers in shorter times than the times required with the execution and utilisation of known winding techniques and winding machines.

[0017] An additional purpose of the invention is to provide an automatic winding machine that is able to define windings with a high coefficient of packing of the coils both radially and longitudinally with respect to windings obtained with the techniques and machines of the prior art.

[0018] Therefore, a purpose of the invention is to provide a winding machine that is able to make a winding for electrical transformers that more closely meets the desired design electrical specifications.

[0019] Said purposes are achieved with the construction of a winding machine in accordance with the main claim.

[0020] Further features of the winding machine of the invention are described in the dependent claims.

[0021] The aforesaid purposes, together with the advantages that will be mentioned farther on, will be readily apparent during the description of a preferred embodiment of the invention, which is given by way of non-limiting indication with reference to the accompanying drawings, where:

- fig. 1 of the prior art is a top view of a disc of a winding for electrical transformers;
- fig. 2 of the prior art is a lateral view of a plurality of discs that define a winding for electrical transformers;
- fig. 3 is a lateral view of the winding machine of the invention;
- fig. 4 is the top view of the winding machine of the invention;
- figs. 5 and 6 schematically show two operating positions of the calendering set with respect to the winding cylinder in the work configuration;
- fig. 7 schematically shows a lateral view of the position of the calendering set with respect to the position of the winding cylinder;
- fig. 8 is the top view of the winding machine of the invention in the resting configuration;
- fig. 9 schematically shows the action carried out by the bending set belonging to the winding machine of the invention.

[0022] The winding machine of the invention is represented in figs. 3 and 4, where it is indicated in its entirety by the numeral **1.**

[0023] The aforesaid winding machine **1** of the invention is configured to carry out a radial and longitudinal stratification of an electrical conductor with rectangular or circular section **C** for making windings for electrical transformers.

[0024] As shown in fig. 3, the winding machine **1** of the invention comprises a winding cylinder **2** configured to rotate according to a vertical axis of rotation **Y.** In particular, preferably, said winding cylinder **2** is fixedly associated to a base plane **3.** These last two elements are configured to rotate according to the aforesaid axis of rotation **Y** relative to a support frame **4** belonging to the same winding machine **1.** The winding cylinder **2**/base plane **3** assembly, able to rotate relative to the aforesaid support frame **4,** is called, in technical term, "carrousel".

[0025] Clearly, the aforesaid winding cylinder **2** serves as a support for the radial stratification of the electrical conductor **C** for the definition of individual discs **D** at a predefined forming height **q1,** as will be described in detail below. Moreover, on said winding cylinder **2** the plurality of the discs **D** is able to be stratified longitudinally along the direction defined by said vertical axis of rotation **Y.**

[0026] Preferably, the winding cylinder **2** consists of a single body, as shown in fig. 3.

[0027] Alternatively, said winding cylinder **2** may be defined by a plurality of elements with substantially longitudinal development arranged vertically along a circumference **c1** whose centre corresponds to said vertical axis of rotation **Y.** In any case, the circumference **c1** defined by the winding cylinder **2** or, alternatively, the circumference along which said plurality of elements are arranged has a radius equal to the smaller (or inner) radius of the winding to be obtained.

[0028] The winding machine of the invention further comprises a calendering set **5** for forming each of the discs **D** on the aforesaid winding cylinder **2,** at the aforesaid predetermined forming height **q1.** As shown schematically in fig. 7, the calendering set **5** is arranged on the aforesaid winding machine **1,** for a predefined working configuration, at a greater working height **q2** than the aforesaid forming height **q1.** In particular, the distance between the working height **q2** of the calendering set **5** and the forming height **q1** defined on the winding cylinder **2** must be at least equal to the height of the electrical conductor **C** with which the winding is to be formed.

[0029] In particular, preferably, as shown schematically in fig. 7 and for the reasons indicated below, the calendering set **5** is arranged in an inclined position relative to the plane of rotation of the winding cylinder **2** so as to direct the electrical conductor **C** towards the same cylinder at the aforesaid forming height **q1.**

[0030] In addition, as will be described in detail during the description of the step of obtaining a winding by means of the winding machine **1** of the invention, the calendering set **5** is configured to be moved in a radial direction relative to the vertical axis of rotation **Y,** indicated in figs. 5 and 6 with **r,** so as to progressively change the radius of curvature of the coils during the formation of each of the discs **D.**

[0031] As shown in figs. 3 and 4, the calendering set **5** is operatively connected to a support column **6** integral with the support frame **4.** This means that the calendering set **5** is not configured to rotate together with the winding cylinder **2** around the vertical axis of rotation **Y,** but it is configured only to be moved along the aforesaid radial direction **r,** as shown schematically in figs. 5 and 6.

[0032] The support column **6** is also configured to move the calendering set **5** from its working configuration, described hitherto, to a resting configuration, and vice versa. The aforesaid resting configuration, as shown in fig. 8, entails the arrangement of the same calendering set **5** laterally relative to the area of definition of the winding so as to allow the winding to be extracted from the upper part of the winding cylinder **2.**

[0033] According to the preferred embodiment of invention, the calendering set **5** comprises a support plate **51** whereon are rotatably coupled, according to axes of rotation **Y1, Y2, Y3** and **Y4** substantially parallel to the vertical axis of rotation **Y,** a pair of lateral rollers **52** be-

tween which is interposed a pair of central rollers **53.**

[0034] As shown in figs. 5 and 6, the central rollers **531** and **532** belonging to the aforesaid pair **53** are mutually aligned, in the working configuration of the calendering set **5,** in radial direction relative to the vertical axis of rotation **Y.** Between the aforesaid two central rollers **531** and **532** must be defined a space that is at least sufficient to allow the passage of the electrical conductor **C** in the middle.

[0035] Preferably, said central rollers **531** and **532** are driving wheels, therefore configured to make the electrical conductor **C** advance from a spool towards the winding cylinder **2,** at the aforesaid forming height **q1.**

[0036] Moreover, preferably, in the winding machine **1** of the invention the pair of lateral rollers **52** and the pair of central rollers **53** are configured to change their mutual position according to the radial direction **r** relative to the vertical axis of rotation **Y.**

[0037] In yet more detail, in the preferred embodiment of the invention the pair of central rollers **53** is slidably coupled to the support plate **51** so as to be able to be moved in a radial direction with respect thereto and with respect to the pair of lateral rollers **52,** which instead have their own axes of rotation **Y1** and **Y2** defined in fixed position with respect to the same support plate **51.**

[0038] The winding machine **1** of the invention is also provided with a resting plane **7** for the discs **D** arranged externally to the winding cylinder **2.** Said resting plane **7,** as indicated by the arrow **A** of fig. 3, is configured to be moved along the direction defined by the vertical axis of rotation **Y** so as to lower the accumulation of the discs **D** at the end of the operation for forming each of these, as will be described in detail farther on.

[0039] According to the preferred embodiment of the invention, as shown in fig. 3, the resting plane **7** is slidably associated to a plurality of sliding elements **10** protruding in the vertical direction from the base plane **3.**

[0040] This means that the base plane **3,** the winding cylinder **2** and the resting plane **7** are configured to rotate together around the aforesaid vertical axis of rotation **Y** and with respect to the aforesaid support frame **4.**

[0041] Preferably but not necessarily, the winding machine **1** of the invention also comprises a containment cage **8** provided with a plurality of vertical containment elements **81** with substantially longitudinal development and arranged parallel to said vertical axis of rotation **Y.** As shown in particular in fig. 4, said plurality of vertical containment elements **81** is arranged along a circumference **c2** that is coaxial to the winding cylinder **2** and with its radius substantially corresponding to the greater (or outer) radius of the winding for electrical transformers to be obtained.

[0042] The function of the aforesaid containment cage **8** is to delimit the greatest external perimeter which the winding to be obtained will have to assume.

[0043] Furthermore, in embodiment variants of the invention said vertical containment elements **81** may be absent.

[0044] Returning to the preferred embodiment of the winding machine **1** of the invention, as shown in figs. 3 and 4, the containment cage **8** also comprises horizontal containment elements **82** arranged radially between the winding cylinder **2** and the vertical containment elements **81** at a height that is immediately above the aforesaid forming height **q1** defined on the same winding cylinder **2.**

[0045] These containment elements **82** are preferably realised with pressing elements acting on the vertical, parallel to the axis of the winding cylinder **2,** so as to be able to produce a slight pressure on the disc **D** that is being formed on the forming height **q1.**

[0046] The function performed by said horizontal containment elements **82** consists of avoiding the accidental, undesired movement upwards, beyond the forming height **q1,** of the electrical conductor **C** during the winding of the same electrical conductor **C** for forming the aforesaid discs **D** and in improving the packing of the electrical conductor **C.**

[0047] The winding machine **1,** preferably but not necessarily, comprises a bending set **11** for bending the conductor **C,** positioned at the input and integrally with the calendering set **5.** Said bending set **11** is configured to be able to create, when actuated, at the working height **q2** a bend in the conductor **C** in parallel direction to the axis of the winding cylinder **2,** thus orthogonal to the curvature generated by the calendering set **5.** Said bend is adapted to assure a good packing in the passage between one disc **D** and the next, in particular if conductors with large cross section are used. More specifically, the aforesaid bend creates a difference in level in the conductor **C** equal to the height of the conductor **C** itself, but leaving the preceding segment of conductor **C** and the segment successive to the bend substantially parallel to each other. It is specified that if not in function, the bending set **11** allows the normal sliding of the conductor **C** towards the calendering set **5** without interfering with the normal winding work.

[0048] Lastly, the winding machine **1** of the invention comprises an electronic control set **9** configured to control mainly the movement of the winding cylinder **2,** of the calendering set **5** and of the resting plane **7** in order to execute the method for making a winding for electrical transformers by means of the winding machine **1** of the invention, as will be described in detail shortly.

[0049] In particular, the aforesaid electronic control set **9** is configured to control the movement of the aforesaid elements belonging to the winding machine 1 of the invention for the realisation of a winding performing the sequence of operations described hereafter.

[0050] In yet more detail, operatively the electronic control set **9** is configured to arrange, at the start of the procedure for making a winding for electrical transformers, the resting plane **7** inferiorly to the forming height **q1** so that the electrical conductor **C** to be wound on the winding cylinder **2** is adapted to rest on the same resting plane **7.**

[0051] Subsequently, the calendering set **5** is arranged

at a radial distance with respect to the vertical axis of rotation **Y** substantially equal to the radius of the winding cylinder **2,** as shown in fig. 6, so as to execute the forming of the first disc **D** from the innermost coil to the outermost coil. Simultaneously, the electronic control set **9** is configured to mutually position the pair of central rollers **53** and the pair of lateral rollers **52** so as to determine a radius of curvature for the electrical conductor **C** to be wound that is substantially equal to the radius of the aforesaid winding cylinder **2.**

[0052] At this point, the winding machine **1** of the invention is configured to proceed to the actual step of making the winding, and in particular of the first disc **D.**

[0053] In fact, once the setting operations described above are completed, the electronic control set **9** is configured to set the winding cylinder **2** in rotation synchronously with the actuation of the calendering set **5** to proceed to wind the first coil of the electrical conductor **C** directly on the winding cylinder **2.** This winding takes place at the forming height **q1** and resting on the resting plane **7.** In detail, the electrical conductor **C,** according to the preferred embodiment of the invention, is driven by the calendering set **5,** arranged at the working height **q2,** towards the forming height **q1,** identified on the winding cylinder **2,** since the same calendering set **5** is arranged inclined towards said forming height **q1,** as described previously. Moreover, the electrical conductor **C** is maintained at said forming height **q1** on the winding cylinder **2** during the winding operation by means of the aforesaid horizontal containment elements **82** belonging to the aforesaid containment cage **8.**

[0054] Before concluding the disc **D,** the electronic control set **9** actuates the bending set **11** which, as shown in fig. 9, goes to create a bend in the vertical direction in the conductor **C** of a height at least equal to the height of the conductor **C** itself. This operation takes place in such a way that said bend goes to position itself exactly at the end of the last coil of the disc **D** in formation. The bending set **11** is then deactivated by the electronic control set **9.**

[0055] Once the winding of a coil is carried out, the electronic control set **9** displaces the calendering set **5** radially outwards by a quantity equal to the thickness of the electrical conductor **C** and simultaneously displaces the pair of central rollers **53** radially outwards with respect to the pair of lateral rollers **52** so as to define a radius of curvature for the same electrical conductor **C** that is substantially equal to the outer radius of the coil realised previously.

[0056] These displacements are carried out maintaining the winding cylinder **2** in rotation and maintaining the calendering set **5** to wind a coil of the electrical conductor **C** externally to the coil realised previously. The operations of displacing the calendering set **5** and the pair of central roller **53** relative to the pair of lateral rollers **52** and the operation of winding a coil on the coil realised previously are repeated by the electronic control set **9** until a disc **D** with a predefined number of coils is realised.

[0057] Once the realisation of the aforesaid disc **D** is completed, the electronic control set **9** proceeds to stop the rotation of the winding cylinder **2** and to deactivate the calendering set **5.** Subsequently, the electronic control set **9** commands the lowering of the resting plane **7** by a quantity at least equal to the height of said electrical conductor **C.** The latter operation thus makes it possible to wind, at the aforesaid forming height **q1** on the winding cylinder **2,** a second disc **D** longitudinally superposed to the previously obtained disc **D.**

[0058] Thanks to the bending set **11,** the conductor **C** has already previously gained the suitable difference in height to proceed with the winding of the disc **D** to the new forming height **q1.**

[0059] To proceed with the winding, the electronic control set **9** commands the rotation of the winding cylinder **2** synchronously with the actuation of said calendering set **5.** In this case, since the calendering set **5** is placed, with respect to the winding cylinder **2** at a radial distance equal to the outer radius of the winding to be realised, as shown in fig. 5, the first coil that will be wound will rest on the inner part of the vertical containment elements **81.**

[0060] Subsequently, proceeding with the inwards radial displacement of the calendering set **5** by a quantity equal to the thickness of the electrical conductor **C** and simultaneously to the inwards radial displacement of the pair of central rollers **53** with respect to the pair of lateral rollers **52,** so as to define a radius of curvature substantially equal to the inner radius of the coil realised previously, the progressive definition of a disc **D,** realised from the exterior towards the interior, is carried out. This thus comprises setting in rotation the winding cylinder **2** synchronously to the actuation of the calendering set **5** so as to wind each coil internally to the coil realised previously and to repeat the aforesaid displacing and winding operations until realising a disc with a predefined number of coils.

[0061] At the conclusion of the realisation also of the aforesaid second disc **D,** after activating the bending set **11,** the electronic control set **9** is configured to stop the rotation of the winding cylinder **2** and the activity of the calendering set **5** and to lower the resting plane **7** by a quantity substantially equal to the height of the electrical conductor **C.**

[0062] The aforesaid operations necessary for the realisation of the disc **D** from the interior towards the exterior and the next disc **D** from the exterior towards the interior are repeated by the electronic control set **9** until realising a winding for electrical transformers provided with a predefined number of mutually superposed disks **D.**

[0063] Following the conclusion of the aforesaid sequence of operations, the electronic control set **9** moves the support column **6** to which the calendering set **5** is associated from the aforesaid working configuration to the resting configuration, as shown in fig. 8, so as to allow the extraction of the realised winding from above.

[0064] Based on the above, it is deemed that the wind-

ing machine **1** of the invention has achieved the indicated purposes.

[0065] In particular, it achieves the purpose of providing a winding machine with radial and longitudinal stratification able to realise a winding for electrical transformers in shorter times than the times required with the execution and utilisation of known winding techniques and winding machines.

[0066] Also achieved is the purpose of providing an automatic winding machine that is able to define windings with a high coefficient of packing of the coils, both radially and longitudinally, with respect to windings obtained with the techniques and machines of the prior art.

[0067] Therefore, also achieved is the purpose of providing a winding machine that is able to make a winding for electrical transformers that more closely meets the desired design electrical specifications.

Claims

1. A winding machine (1) with radial and longitudinal stratification of an electrical conductor (C) for the realisation of windings for electrical transformers, **characterised in that** it comprises:

- a winding cylinder (2) configured to rotate according to a vertical axis of rotation (Y), said electrical conductor (C) being able to be wound with radial stratification for defining individual disks (D) at a predefined forming height (q1) on said winding cylinder (2), the plurality of said discs (D) being adapted to be stratified longitudinally on said winding cylinder (2) along the direction defined by said vertical axis of rotation (Y);
- a calendering set (5) for forming each of said discs (D) on said winding cylinder (2), said calendering set (5) being positioned at a greater working height (q2) than said forming height (q1) by a quantity equal at least to the height of said electrical conductor (C), said calendering set (5) being further configured to be moved in radial direction with respect to said vertical axis of rotation (Y) so as to progressively vary the radius of curvature of said coils during the formation of each of said discs (D);
- a resting plane (7) of said discs (D) arranged externally to said winding cylinder (2) and configured to be moved along the direction defined by said vertical axis of rotation (Y) so as to lower the accumulation of said discs (D) at the end of the operation of forming each of said discs (D);
- an electronic control set (9) configured to control the movement of said winding cylinder (2), of said calendering set (5) and of said resting plane (7) for the realisation of said windings.

2. Winding machine (1) according to claim 1, **characterised in that** said calendering set (5) comprises a support plate (51) on which are rotatably coupled according to axes of rotation (Y1, Y2, Y3, Y4) that are substantially parallel to said vertical axis of rotation (Y) a pair of lateral rollers (52) between which is interposed a pair of central rollers (53), said central rollers (531, 532) being mutually aligned in radial direction with respect to said vertical axis of rotation (Y) and being distanced from each other in such a way as to allow the passage of said electrical conductor (C), said pair of lateral rollers (52) and said pair of central rollers (53) being configured to vary their mutual position according to a radial direction with respect to said vertical axis of rotation (Y).

3. Winding machine (1) according to claim 2, **characterised in that**:

- said pair of central rollers (53) is slidably coupled to said support plate (51) so as to be moved in radial direction with respect to said support plate (51) and said pair of lateral rollers (52);
- said pair of lateral rollers (52) has its axes of rotation (Y1, Y2) defined in fixed position with respect to said support plate (51).

4. Winding machine (1) according to any one of the preceding claims, **characterised in that** each of said central rollers (531, 532) is a driving wheel able to make said electrical conductor (C) advance along said calendering set (5) towards said winding cylinder (2).

5. Winding machine (1) according to claim 4, **characterised in that** it comprises a containment cage (8) provided with a plurality of vertical containment elements (81) with substantially longitudinal development arranged parallel to said vertical axis of rotation (Y) and distributed along a circumference (c2) that is coaxial to said winding cylinder (2) and with its radius substantially corresponding to the outer radius of the winding for electrical transformers to be realised.

6. Winding machine (1) according to claim 5, **characterised in that** said containment cage (8) comprises horizontal containment elements (82) arranged radially between said winding cylinder (2) and said vertical containment elements (81) at a height that is immediately above said forming height (q1) so that said electrical conductor (C) wound on said winding cylinder (2) by said calendering set (5) is contained superiorly by said horizontal containment elements (82), said horizontal containment elements (82) being preferably configured to exercise a pressure in the vertical direction.

7. Winding machine (1) according to any one of the

preceding claims, **characterised in that** said resting plane (7) is slidably associated to a plurality of sliding elements (10) protruding in vertical direction from a base plane (3) to which said winding cylinder (2) is associated.

8. Winding machine (1) according to claim 6, **characterised in that** said winding cylinder (2) is fixedly associated to said base plane (3), said base plane (3) being configured to rotate together with said winding cylinder (2).

9. Winding machine (1) according to any one of the preceding claims, **characterised in that** said calendering set (5) is operatively connected to a support bracket (6) configured to move said calendering set (5) from a working configuration to a resting configuration and vice versa, said resting configuration comprising the positioning of said calendering set (5) laterally to the area of definition of a winding for electrical transformers in order to extract said winding superiorly to said winding cylinder (2).

10. Winding machine (1) according to any one of the preceding claims, **characterised in that** said electronic control set (9) in the step of realising a winding for electrical transformers is configured to carry out in sequence the operations of:

a) arranging said resting plane (7) inferiorly to said forming height (q1) so that said electrical conductor (C) to be wound of said winding cylinder (C) is adapted to be placed to rest on said resting plane (7);
b) arranging said calendering set (5) at a radial distance with respect to said vertical axis of rotation (Y) that is substantially equal to the radius of said winding cylinder (2);
c) mutually positioning said pair of central rollers (53) and said pair of lateral rollers (52) along said radial direction so as to determine a radius of curvature of said electrical conductor (C) that is substantially equal to the radius of said winding cylinder (2);
d) setting in rotation said winding cylinder (2) synchronously to the actuation of said calendering set (5) so as to wind a first coil of said electrical conductor (C) directly on said winding cylinder (2) at said forming height (q1) and resting on said resting plane (7);
e) radially displacing said calendering set (5) outwardly by a quantity equal to the thickness of said electrical conductor (C) and simultaneously radially displacing said pair of central rollers (53) outwardly with respect to said pair of lateral rollers (52) so as to define a radius of curvature of said electrical conductor (C) that is substantially equal to the outer radius of the coil realised previously;
f) maintaining in rotation said winding cylinder (2) and maintaining active said calendering set (5) so as to wind a coil of said electrical conductor (C) externally to the previously realised coil;
g) repeating the steps e) and f) until realising a disc (D) with a predefined number of coils;
h) stopping the rotation of said winding cylinder (2) and the activity of said calendering set (5) and lowering said resting plane (7) by a quantity at least equal to the height of said electrical conductor (C);
i) setting said winding cylinder (2) in rotation synchronously to the actuation of said calendering set (5) so as to wind a first coil of said electrical conductor (C) resting on the inner part of said vertical containment elements (81);
l) radially displacing said calendering set (5) inwardly by a quantity equal to the thickness of said electrical conductor (C) and simultaneously radially displacing said pair of central rollers (53) inwardly with respect to said pair of lateral rollers (52) so as to define a radius of curvature of said electrical conductor (C) that is substantially equal to the inner radius of the coil realised previously;
m) maintaining in rotation said winding cylinder (2) and maintaining active said calendering set (5) so as to wind a coil internally to the previously realised coil;
n) repeating the steps l) and m) until realising a disc (D) with a predefined number of coils;
o) stopping the rotation of said winding cylinder (2) and the activity of said calendering set (2) and lowering said resting plane (7) by a quantity substantially equal to the height of said electrical conductor (C);
p) repeating the steps from d) to o) until realising said winding for electrical transformers provided with a predefined number of mutually superposed discs (D).

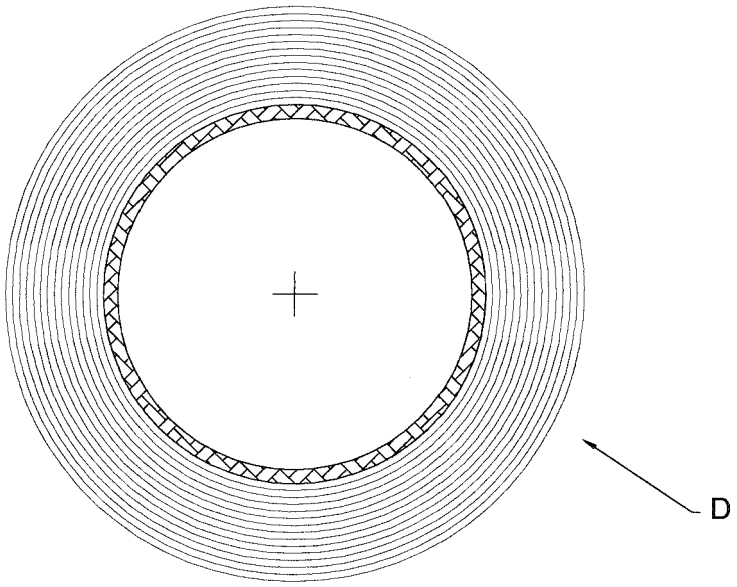

Fig.1 - PRIO ART

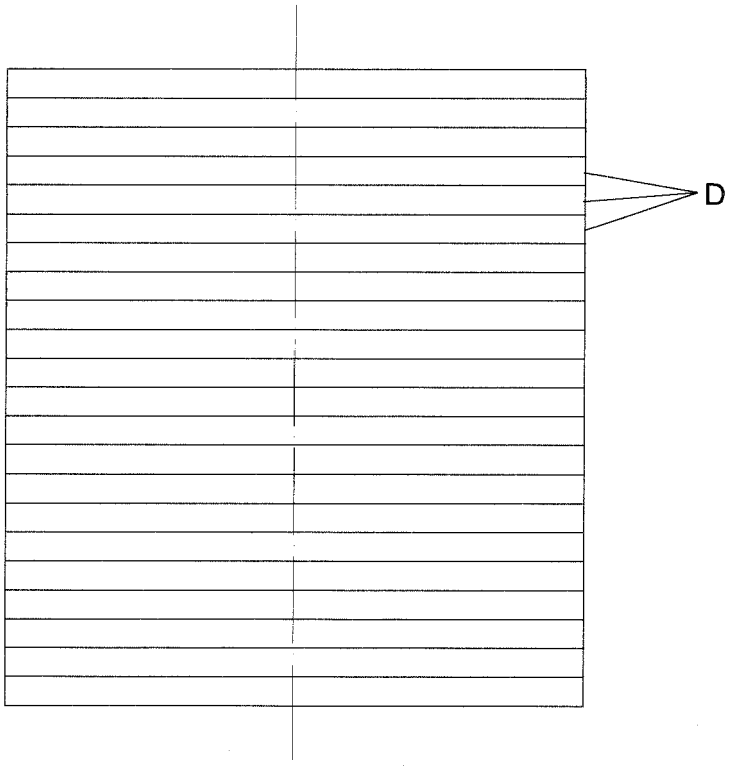

Fig.2 - PRIO ART

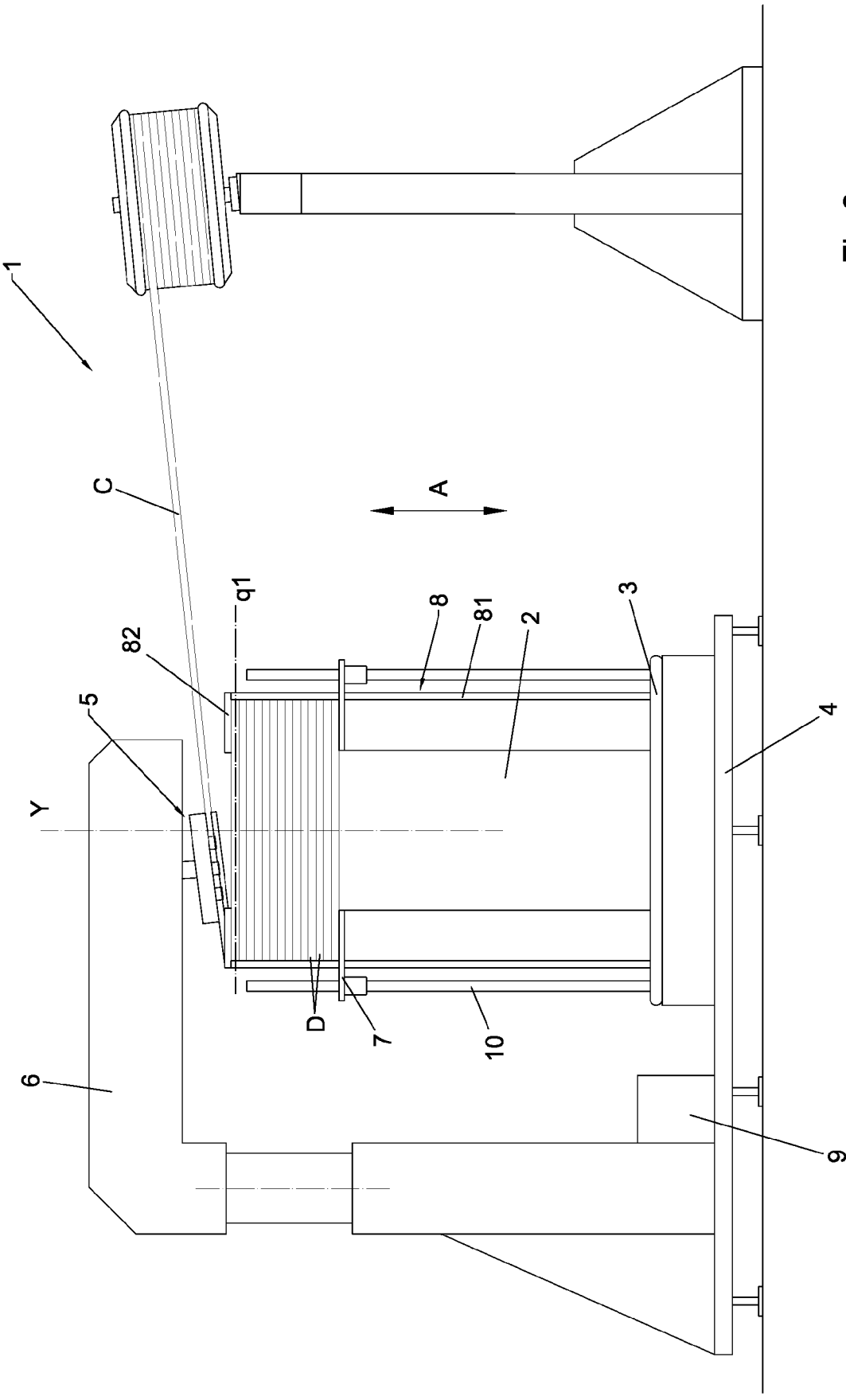

Fig.3

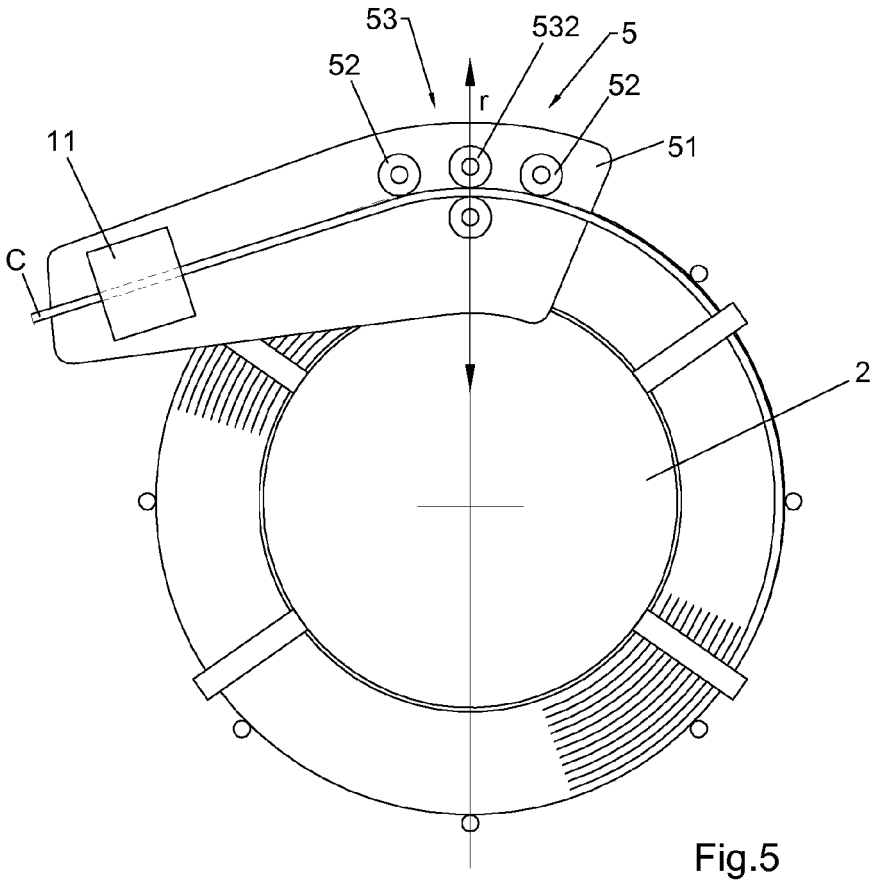

Fig.5

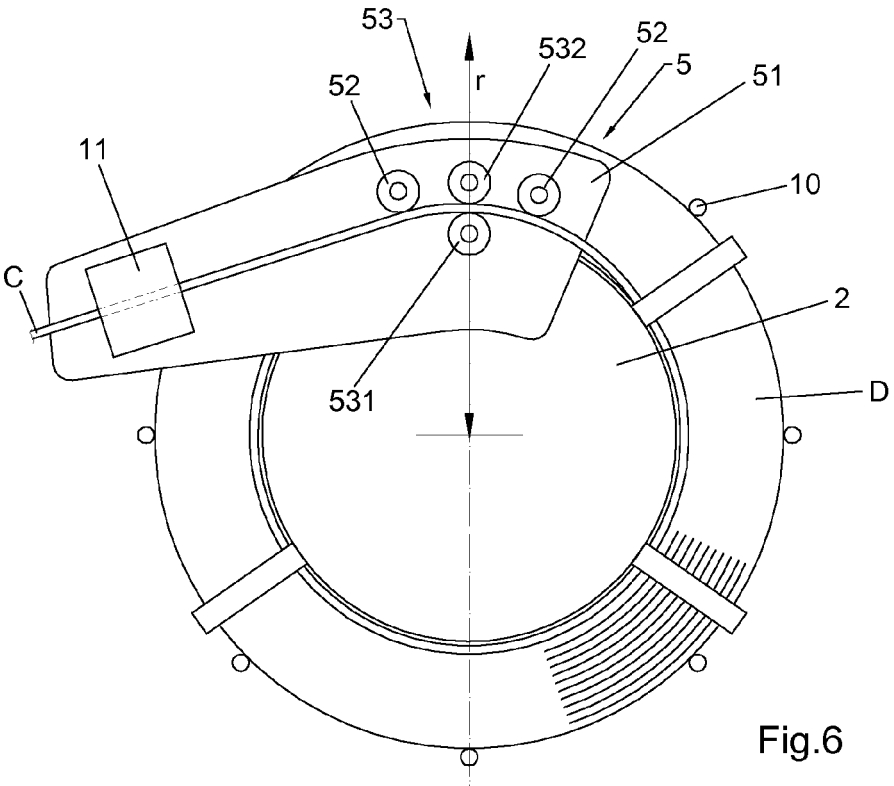

Fig.6

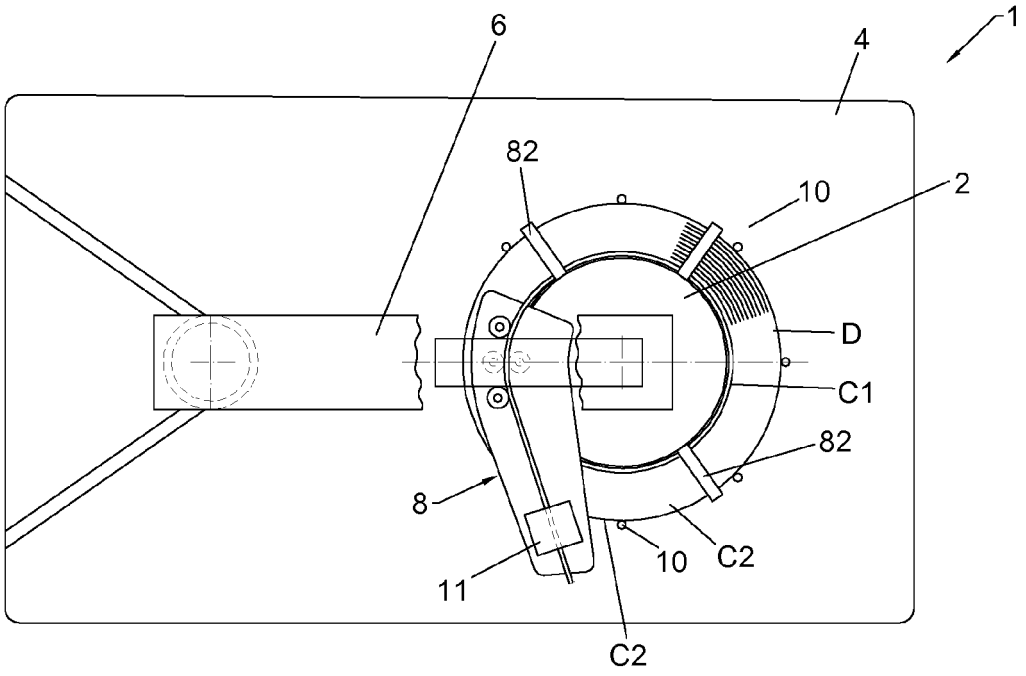

Fig.4

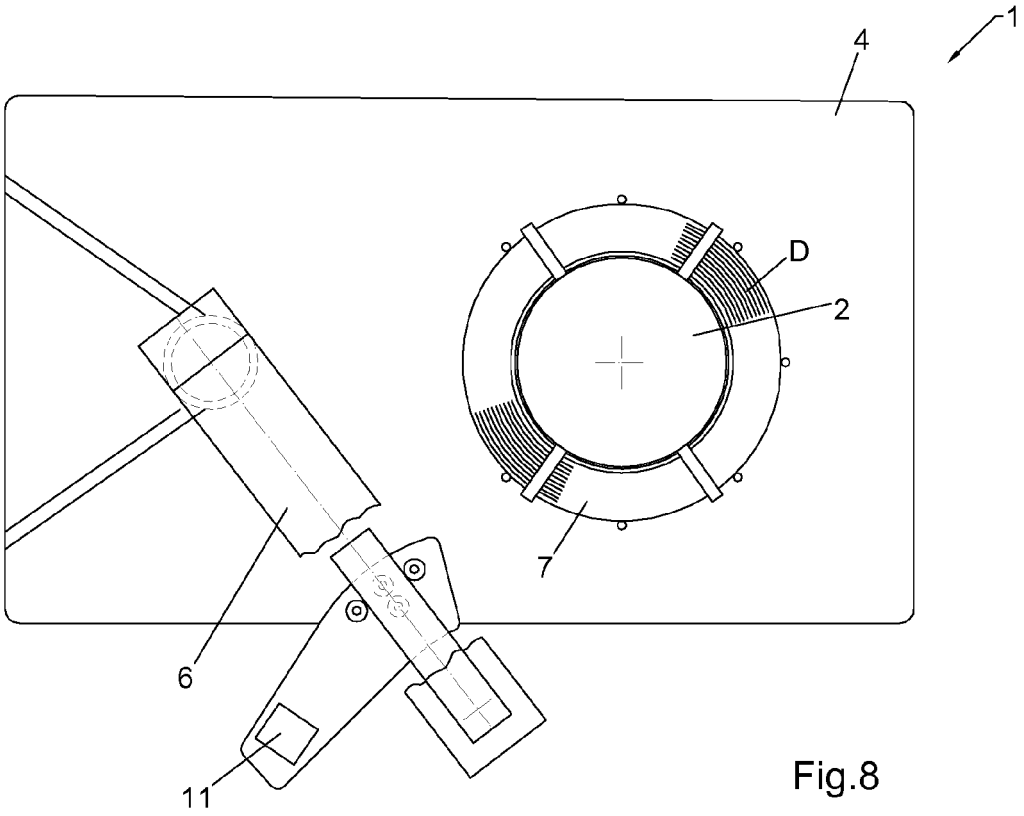

Fig.8

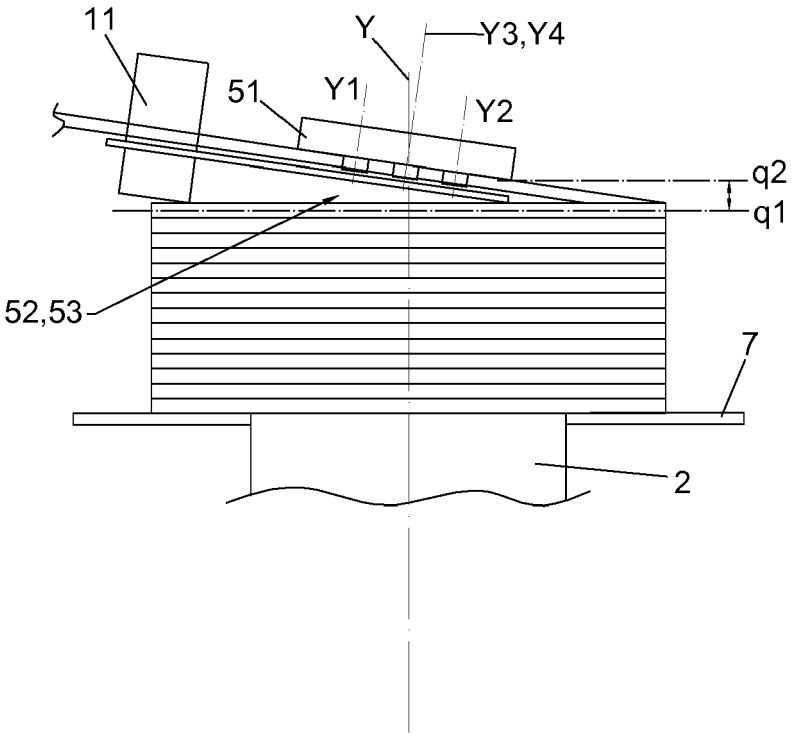

Fig.7

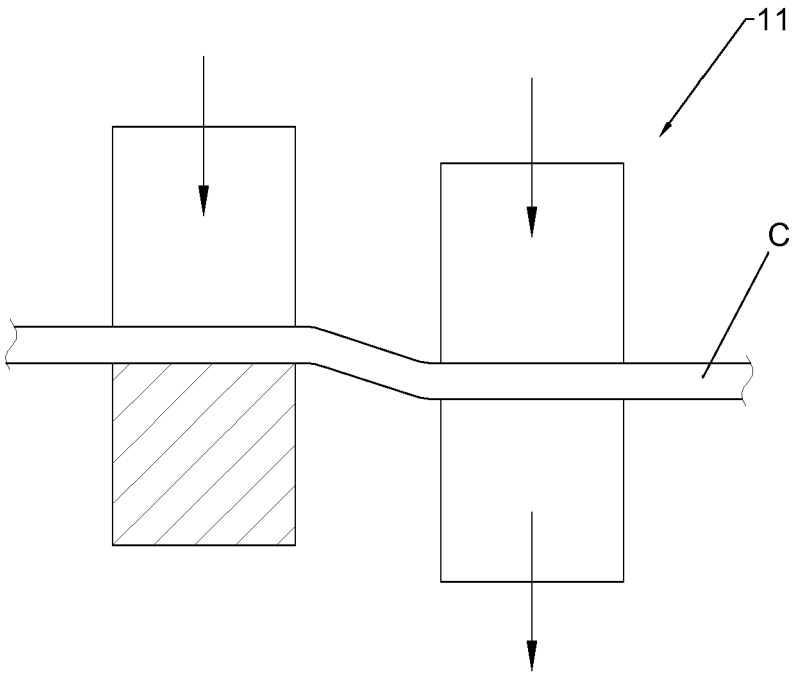

Fig.9