(19) DANMARK

(10) **DK/EP 3776524 T3**

Patent- og
Varemærkestyrelsen

(12) Oversættelse af
europæisk patentskrift

(51) Int.Cl.: ***G 10 D 1/10 (2006.01)*** ***G 10 D 1/02 (2006.01)*** ***G 10 D 3/08 (2020.01)*** ***G 10 D 3/10 (2006.01)*** ***G 10 D 3/22 (2020.01)***

(45) Oversættelsen bekendtgjort den: **2024-08-26**

(80) Dato for Den Europæiske Patentmyndigheds
bekendtgørelse om meddelelse af patentet: **2024-07-03**

(86) Europæisk ansøgning nr.: **18721688.2**

(86) Europæisk indleveringsdag: **2018-02-09**

(87) Den europæiske ansøgnings publiceringsdag: **2021-02-17**

(86) International ansøgning nr.: **EP2018053249**

(87) Internationalt publikationsnr.: **WO2019154505**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **LARSEN STRINGS A/S, Ingolf Nielsens Vej 14A, 6400 Sønderborg, Danmark**

(72) Opfinder: **BACH SIGVARDT, Kristian, Alsgade 11a, 1., 6400 Sønderborg, Danmark**
LARSEN, Laurits Thorvald, Kongevey 82, 6400 Sønderborg, Danmark

(74) Fuldmægtig i Danmark: **Plougmann Vingtoft A/S, Strandvejen 70, 2900 Hellerup, Danmark**

(54) Benævnelse: **FREMGANGSMÅDE TIL FREMSTILLING AF EN STRENG, ISÆR EN STRENG TIL ET BUEMUSIKINSTRUMENT OG ET APPARAT TIL UDFØRELSE DERAF**

(56) Fremdragne publikationer:
GB-A- 143 677
GB-A- 2 073 469
US-A- 3 717 987
US-A1- 2011 005 365

DESCRIPTION

Description

[0001] The present invention relates to a method for fabricating a string, in particular a string for a bowed musical instrument, having a core with at least one winding strand helically wound thereon, and a string fabricating apparatus for fabricating a string, in particular a string for a bowed musical instrument, having a core with at least one winding strand helically wound thereon. The string can be a musical instrument string, in particular a string for a bowed instrument, or a musical string for other types of musical instruments, including plucked instruments or it can be a string for non-musical applications, such as sporting equipment or medical applications.

[0002] A bowed musical instrument string according to the state of the art consists, most commonly, of a core material, with an option of one or several layers of winding materials. The core can, for example, be made of either natural fibers, synthetic fibers, solid steel, or rope wire. Natural and synthetic fibers can either be a single fiber, e.g. a monofilament, or a fiber bundle, e.g. a multifilament. Examples of suitable fibers include animal gut, polyamide 66, and polyetheretherketone. The winding materials can be synthetic fiber, e.g. Perlon, or metal, e.g. aluminum, copper, or iron-chrome-aluminum stainless steel, or types of wire or ribbons, for example either round or flattened.

[0003] A winding layer consists of a strand of winding material, which has been wound onto the string, thereby covering the majority of the surface area of the string. The string is defined as the core plus any, if any, previously wound layers of winding. The strand of winding material can consist of one or several parallel strands of winding material, being wound onto the string simultaneously. The benefit of parallel winding is to speed up the winding process, as parallel strands will increase the total width of the winding strand, thereby reducing the number of string rotations required to cover the string with the new layer.

[0004] The cross-section of the winding materials can, for example, be circular, elliptical, oval, square, rectangular, rectangular with two or more rounded edges, or it can be a fiber bundle. Bowed musical instrument strings are produced by winding strands of winding materials around the core in layers, in order to add mass and thickness to the string. The reader should note that the future use of winding material or winding strand in this document, is taken to mean also any number of parallel strands of any given material.

[0005] Manufacturing musical strings requires specialized winding machinery. One example of a machine for producing wound musical strings is described in DE2736467 C3, where the core material is fastened between two hooks, which are aligned along the same axis, pointing towards each other. The hooks rotate simultaneously in the same direction and with the same speed. As the core is rotated, the winding strand is wound helically on to the core, such that the outer surface of the core is covered by the winding material, making the winding layer the new outer surface of the string. This is referred to as spinning the string. This process can be repeated a number of times, having from one to six winding layers making up the string, along with the central core. The winding strands can be wound onto the string by hand without any type of support, or it can be done using a supporting carriage. An example of a supporting carriage is seen in DE2736467 C3.

[0006] One important property of a wound musical string is the compactness of the core and winding layers. The compactness can be controlled by several parameters in the spinning process, including tension on the core during spinning and tension on the winding materials during spinning. However, these parameters have certain limitations. For example, the tension on the core is limited by the tension required of the string on the instrument to obtain the desired pitch, e.g. 440 hertz for a violin "A" string. Obviously, the core tension under string production cannot be much higher than the tension of the string on the instrument at the required pitch, as this would put the string in a relaxed state, relative to the manufacturing state, when on the instrument. The tension on the winding strands during spinning is limited by the physical strength parameters for the end user. This means the tensile strength of the winding strand is finite, which limits the tension that can be put on the winding strand during spinning.

[0007] If a musical string lacks compactness, the core and one or more winding layers are not sufficiently interlocked with one another. If the layers are not interlocked when the string is under tension, as it is on an instrument, the individual layers may shift relative to one another. This layer shifting causes increased friction between the core and the layers and/or between the different layers, which leads to a less efficient energy transfer between the bow and the string, when the string is being played by a musician, meaning that some energy from the bow will be used to overcome the increased core/layer and/or layer/layer friction. A less efficient energy transfer between bow and string makes for a poorer string response, as well as increased acoustical damping, which ultimately reduces string projection and harmonic output. Reduced string response is especially undesirable when playing passages with quick transitions of the bow between the strings. String projection is very important when playing in large halls, and reduced harmonic output has a direct influence on the sound perceived by the listeners.

[0008] In GB 2 073 469 A an apparatus is described for modifying musical instrument strings, i.e. strings that are already playable, by flattening the crowns of the winding strands, which have substantially round cross-sections, wound around solid steel cores of guitar strings. The known apparatus comprises two rollers, which are able to press on the finished string, flattening the crowns of the winding wire as the string moves along through the rollers. The flattening process involves slowly rotating the musical string and moving it slowly in an axial direction through the rollers. Thus, said apparatus requires the roller to be translationally stationary relative to the room, with the string moving.

[0009] GB 143 677 A discloses a method for fabricating a musical instrument string, said string having a core with at least one winding strand helically wound thereon, thereby forming a string with at least one core and at least one winding layer. The method comprises placing a core axially along a path and spinning the core about its central axis and helically winding at least one winding strand around the string. For increasing compactness of the string a friction force is applied to the at least one winding strand by a presser module, which is placed aside a traveller module being placed at the spinning point.

[0010] Accordingly, it is the aim of the present invention to provide a method and an apparatus for fabricating a string, in particular a string for a bowed musical instrument, said string having a core with at least one winding strand helically wound thereon, having at least one winding layer with increased compactness.

[0011] Each of GB 2 073 469 A and US 3 717 987 A discloses a method according to the preamble of claim 1.

[0012] This aim is achieved by a method for fabricating a string according to claim 1.

[0013] Furthermore, this aim is achieved by a string fabricating apparatus for fabricating a musical instrument string, according to claim 12.

[0014] Preferably the compression force and/or the friction force is/are controlled.

[0015] According to a further special embodiment, at least one winding strand is wound around the string during the spinning step.

[0016] According to a further special embodiment, the compactness increasing module comprises two contact plates and the applied friction force is the result of bringing at least one of the two contact plates in contact with the at least one winding strand therebetween and the compression force applied by exerting force on the at least one winding strand and the string by at least one of the two contact plates.

[0017] According to a further special embodiment, the compactness increasing module comprises between one and six contact plates, said contact plates being arranged in pairs in series along the length of the core/string, each pair consisting of one top contact plate and one bottom contact plate and if the number of contact plates is odd, one or more of the pairs will lack either a top plate or a bottom plate, and the row of bottom contact plates will be shifted slightly along the length of the string, relative to the top row of contact plates.

[0018] According to a further special embodiment of a method, the or at last one pair of contact plates is arranged such that it spans an angle α#=0° in a plane that is perpendicular to the length direction of the core, preferably with α being less than 30°, preferably less than 15° and most preferably less than 8°.

[0019] Alternatively, or additionally the at or least one pair of contact plates is be arranged such that it spans an angle β≠0° in a plane including the length direction of the core, preferably with β being less than 30°, more preferably less than 15° and most preferably less than 8°.

[0020] It is also possible that a compactness increasing module comprises only one contact plate, said contact plate being shaped as an open ring, and the ring is arranged such that the core with or without one or more winding strands wound thereon passes through the ring.

[0021] According to a special embodiment of the string fabricating apparatus, the compactness increasing module is mounted on a carriage that is movable parallel to the length of the fixed core.

[0022] Preferably the carriage is configured to also support the at least one winding strand.

[0023] Conveniently, the compactness increasing module comprises a compression force controlling means for adjusting the amount of compression force applied.

[0024] Preferably, the compactness increasing module also comprises a friction force controlling means for adjusting the friction force applied. Said friction force controlling means could be integral with the compression force controlling means for adjusting the amount of compression force introduced.

[0025] According to a special embodiment, the compactness increasing module comprises two contact plates, one thereof being a lower contact plate and the other thereof being an upper contact plate, the lower of the two contact plates being mounted on the carriage, such that it is below the fixed core, preferably with no downward force exerted on the lower contact plate by the core/string before the upper contact presses down on the core/ string, with the winding strand being wound thereon in direct contact with the lower contact plate, less than one full winding turn after winding onto the string and the upper contact plate being attached to the carriage such that it is above the fixed core and the upperside of the core with the at least one winding strand being wound thereon being in direct contact with the upper contact plate.

[0026] According to a further special embodiment, the compactness increasing module comprises between one and six contact plates, said contact plates being arranged in pairs in series along the length of the core, each pair consisting of one top contact plate and one bottom contact plate and if the number of contact plates is odd, one or more of the pairs will lack either a top plate or a bottom plate, and the row of bottom contact plates will be shifted slightly along the length of the string, relative to the top row of contact plates. Each pair can be either placed directly adjacent to its neighboring pair, or there may be a gap between the pairs. The compression force and the friction force of each pair of contact plates can be adjusted, independently of the neighboring pair(s) of contact plates. This allows for more diverse combinations of compression forces and friction forces, which may be beneficial in certain string configurations, e.g. strings where different winding materials are used for the same winding layer. Each bottom plate being fixed below the string and each top plate exerting individually adjustable downward forces on the string.

[0027] Preferably, the one or at least one pair of contact plates is angled with respect to one another.

[0028] In particular, the at least one pair of contact plates spans an angle $\alpha \neq 0°$ in a plane that is perpendicular to the length direction of the core.

[0029] Alternatively, or additionally, the at least one pair of contact plates spans an angle $\beta \neq 0°$ in a plane including the length direction of the core.

[0030] Conveniently, the contact surface of the contact plate or of at least one contact plate is coated with a surface coating.

[0031] According to a further special embodiment, the compactness increasing module comprises only one contact element, said contact element being shaped as an open ring arranged such that a core passes through it.

[0032] The compactness increasing module may be configured such that a radius of the ring can be increased or decreased.

[0033] The present invention is based on the surprising knowledge that an increased compactness of a wound string/winding layer can be achieved by introducing a compactness increasing module to the spinning process. The compactness increasing module can be in contact with the winding strand at the spinning point as the strand is wound onto the string, as well as the winding strand less than one full rotation around the string after the spinning point. The compactness increasing module can be designed in such a way that a winding strand is in contact with the upper and lower bounds of the compactness increasing module as the string rotates, thereby introducing a new source of friction at the spinning point, the increased friction being between the compactness increasing module and the winding strand, as well as introducing a compression of the current winding layer and the underlying string. Both the added friction and the compression add to an increased compactness of the winding layer and the underlying layers and/or core.

[0034] The compactness increasing module may be mounted on a carriage which also supports the winding strands. During spinning, the carriage follows the spinning point, meaning the carriage moves parallel to the string.

[0035] Due to the design of the compactness increasing module, one advantage is that the compactness increasing module allows for a much more controlled winding of several parallel strands of winding materials at once. When producing a musical string by hand, one challenge is the winding of two or more strands of winding materials at once, without introducing overlapping and/or large gaps between the strands. By using the compactness increasing module, upwards of five parallel strands can be wound onto the string at once, without introducing strand overlapping or undesired gaps.

[0036] Having overlapping of strands on the string creates an uneven surface with the winding strands due to a roof-tiling effect, where the first edge of the winding strand/winding turn overlaps (i.e. lies on top of) with the last edge of the previous strand/winding turn. This effect is uncomfortable for the musician as it makes the string rough under the fingers. This is undesirable, as some musicians play in excess of eight hours a day. Furthermore, there is also an increased risk of the bow getting stuck in the uneven windings of the string, leaving the string unplayable.

[0037] On the other hand, having gaps between the windings is also undesirable, as gaps present voids, in which dirt and dust can collect. Dirt and dust will increase the linear density of the string, but not in a continuous manner, as the added mass is only in the gaps, and not along the entire length of the string. As a result hereof, the string may exhibit impurity of the perfect fifth, causing the string to sound false and/or faulty.

[0038] Further features and advantages of the present invention will be clear from the accompanying claims and the following description of special embodiments in combination with the schematic drawings, wherein

Figures 1A to 1E
: show steps of a method of fabricating a string, in particular a string for a bowed musical instrument, said string having a core with at least one winding strand helically wound thereon according to a first special embodiment of the invention;

Figures 2A to 2E
: show steps of a method of fabricating a string, in particular a string for a bowed musical instrument, string having a core with at least one winding strand helically wound thereon according to a second special embodiment of the invention;

Figure 3
: a modification of the step shown in Figure 1D according to a special embodiment of the present invention;

Figure 4
: a modification of the step shown in Figure 1D according to a special embodiment of the present invention;

Figure 5
: a modification of the step shown in Figure 1D according to a special embodiment of the present invention;

Figure 6
: a modification of the step shown in Figure 1D according to a special embodiment of the present invention; and

Figure 7
: a modification of the step shown in Figure 1D according to a special embodiment of the present invention.

[0039] Figure 1 (figures 1A to 1E) shows a string fabricating apparatus 100 (figure 1A: upper left: front view; upper middle: side view; lower middle: top view) for fabricating a string, in particular a string for a bowed musical instrument, said string 110 having a core 3 with one winding strand 4 helically wound thereon according to a special embodiment of the present invention. Said apparatus 100 comprises means (not shown) for rotating the core 3, which is fixed, i.e. not moving, and for helically winding the winding strand 4 on said core 3 as the core rotates and a compactness increasing module 120 is configured to be in contact with the winding strand 4 at a spinning point 7 when the winding strand 4 is wound onto the core 3. The spinning point being defined as the point where the winding strand 4 is being wound on to the core 3, such that a friction force is introduced at the spinning point 7, the friction force being applied to increase the friction between the compactness increasing module 120 and the winding strand 4, and a compression force being applied to compress the winding strand 4 and the core 3.

[0040] The compression increasing module 120 is mounted on a carriage (not shown) that is movable parallel to the length of the fixed core 3 and comprises two contact plates 1 and 2. The lower of the two contact plates 2 is mounted on the carriage such that it is below the fixed core 3 and the underside of the core, with the winding strand 4 being wound thereon being in direct contact with the lower contact plate 2, preferably with no downward force exerted on the contact plate 2 by the core 3 with the winding strand 4 being wound thereon. The one upper contact plate 1 is mounted on the carriage such that it is above the fixed core 3 and the upperside of the core 3 with the winding strand 4 being wound thereon is in direct contact with the upper contact plate 1 during winding. The carriage is configured to also support the winding strand 4.

[0041] Furthermore, the compactness increasing module 120 comprises a force controlling means for adjusting the amount of compression force applied. Said force controlling means is also configured to adjust the friction force applied.

[0042] An arm (not shown) is carrying the upper contact plate 1 of the compactness increasing module 120.

[0043] The compactness increasing module 120 increases the compactness of the string 110, as the string is being spun, by increasing the compression force and friction. The friction is introduced at the contact point between the contact plates 1 and 2 and the winding strand 4, and the compression force comes from the arm carrying the upper plate 1 of the compactness increasing module 120, pressing down on the string 110, compressing the core 3 and winding strand 4 between the upper contact plate 1 and the lower contact plate 2.

[0044] The compression force being exerted by the compactness increasing module 120 onto the winding strand 4 and string 110 can be adjusted by the force controlling means. In the simplest case, the force controlling means may be a mechanism, consisting of a system of adding or removing mass from the movable arm of the compactness increasing module 120.

Increasing the mass of the arm will increase the downward force exerted by the arm on the string 110. However, it may also be a force controlling means based on, for example, force from a variable spring constant, pneumatics, hydraulics, magnetism, or an application of the reverse piezoelectric effect. It is important to be able to adjust the force exerted on the string 110 from the compactness increasing module 120, because several different layers with several different materials may be wound onto the same string 110. The materials are carefully selected based on density and dimensions, in order for the final music string to have a desired thickness and tension on the instrument. Different materials and material dimensions require different compressions forces, thus making the adjustability of the force critical to obtain the optimal effect of the compactness increasing module 120. A force in the range for example between 0 newton and 25 newtons is sufficient for most applications of the compactness increasing module 120.

[0045] The frictional force being exerted by the compactness increasing module 120 onto the winding strand can be adjusted by the compression force as well. However, the friction has another controlling component, namely the choice of material for the contact plates. Different materials have different coefficients of friction, which introduces another parameter for adjusting the frictional force exerted by the compactness increasing module. It should be noted that the choice of material is limited by the hardness of the winding strand material. If the contact plate material is softer than the winding strand material, the contact plates will be easily scratched and damaged by the winding strand, which will reduce the effect of the compactness increasing module. A suitable material for the contact plates is for example ceramic or steel, particularly hardened or tool steel, either blank or with a suitable coating. Examples of coatings 6 (see for example figures 2A to 2E) for the contact plates include carbon-based coatings, titanium nitride and chromium nitride. Most suitable coatings will be applied using physical or chemical vapor deposition (PVD or CVD). Also, the upper and lower contact plates may be coated with different coatings, or coatings consisting of more than one coating layer. Basically, any material with a suitable frictional coefficient, in particular a material with a low coefficient of friction, and with a hardness above that of the winding strand material will be sufficient. At all times the hardness of the contact plates will exceed that of the winding strand material being wound onto the string. By the correct choice of materials and coating, the frictional coefficient can be tuned to the desired value.

[0046] The figures 1A to 1E show steps of a method for fabricating a string, in particular a string for a bowed musical instrument, said string having a core with a winding strand helically wound thereon. In step 1 (figure 1A), a few windings of the winding strand 4 have been wound onto the core 3/ string 110. This is to fasten the winding strand to the core 3/string 110. The contact plates 1 and 2 are not in contact with the core 3/string 110. In step 2 (figure 1B), the compactness increasing module 120 has been moved into place, and it is ready to apply increased frictional force and compression force to the winding strand 4 (the upper 1 and lower plates 2 of the compactness increasing module 120 are not yet in contact with the core 3/winding strand 4). In the step 3 (figure 1C), the compactness increasing module 120 has moved into contact with the core 3/string 110, but is still at the beginning (left side in figure 1C) of the core 3/string 110. Step 4 (figure 1D) illustrates the string 110 in the process of being wound, with the string 110 rotating, where the compactness increasing module 120 moves parallel to the string, following the spinning point 7 of the string 110 and winding strand 4. In step 5 (figure 1E), the compactness increasing module 120 has been released from the string 110, and the core 3/winding strand 4/string 110 has reached the desired level of compactness.

[0047] The apparatus 100 shown in figures 2A to 2E is different from the apparatus 100 shown in figures 1A to 1E in that the contact plates 1 and 2 each comprise a coating 5 and 6 respectively, facing towards the core 3/ string 110. By way of said apparatus a method for fabricating a string, in particular a string for a bowed musical instrument, said string having a core with at least one winding strand helically wound thereon as described before can be carried out.

[0048] Figure 3 shows a further strand fabricating apparatus 100 for fabricating a string, in particular a string for a bowed musical instrument, said string 110 having a core 3 with (at least) one winding strand for helically wound thereon. Said apparatus differs from the apparatus 100 shown in figures 1A to 1E in that the contact plates 1 and 2 are not parallel to each other but span an angle α in a plane that is perpendicular to the length direction of the core 3.

[0049] In particular, figure 3 shows step 4 of above mentioned method.

[0050] The string fabricating apparatus 100 shown in figure 4 is different from the apparatus shown in figures 1A to 1E in that the contact plates 1 and 2 are not parallel to each other but span an angle β in a plane including the length direction of the core 3. It also shows step 4 of above mentioned method.

[0051] Figure 5 shows a string fabricating apparatus 100 that differs from the apparatus shown in figures 1A to 1E in that it comprises two pairs of contact plates 1 and 2 arranged side-by-side in the length direction of the core 3. It also shows step 4 of above mentioned method.

[0052] Figure 6 shows step 4 of the method described in connection with figures 1A to 1E. However, instead of one winding strand 4, three parallel winding strands 4 are simultaneously wound around the core 3.

[0053] In general, the compactness increasing module can be designed in a variety of ways, which all achieve the desired effect. The design described earlier, with the string wedged between one upper contact plate and one lower contact plate is simply one configuration. The same configuration can also be imagined with both contact plates being on movable arms, or the lower contact plate being on a movable arm with the upper contact plate being stationary. Also, the contact plate pair can be rotated between 0 and 90 degrees, such that the winding strand is at a non-right angle to the plates. It is also not required for the two contact plates to be parallel to one another. The contact plates can be at an angle between 0 and 90 degrees to one another, where an angle of 0 degrees means the contact plates are parallel to one another, and 90 degrees means the contact plates are perpendicular to one another. An angle less than 30° should be especially suitable, preferentially an angle less than 15°, most preferably less than 8°.

[0054] Another configuration of the invention is the compactness increasing module with between one and six contact plates, being arranged in pairs in series along the axis of the string, each pair consisting of one upper plate and one lower plate. If the number of contact plates is odd, one or more of the pairs will lack either an upper contact plate or a lower contact plate, or the upper and lower contact plates will be shifted, relative to each other, such that there is not a lower contact plate aligned directly below each top plate. Each pair can be either placed directly adjacent to its neighboring pair, or there may be a gap between the pairs. Also, each pair may be rotated to a desired configuration, as described above.

[0055] Yet another configuration according to an embodiment of the invention is a circular one. The compactness increasing module 120 (see figure 7) may be designed such that it has a ring-shaped contact element. The ring 13 has an opening 14, which allows for the winding strand 4 to reach the core 3/string 110. The opening 14 may be for example between % and 1/8th of the circumference of the circle. The core 3 passes through the ring 13. The compactness increasing module 120 has a contact region with the string 110, defined by the outer circumference of the string 110, the inner circumference of the ring 13, and the size of the opening 14 of the ring 13. The radius of the ring 13 can be increased or decreased by the use of, for example, piezoelectric actuators 12, placed on the outer circumference and/or the inner circumference of the ring 13. Because of a larger contact region between the compactness increasing module 120 and the winding strand 4, this configuration allows for a much larger frictional force being exerted on the winding strand 4 and string 110, but allows for only a smaller compression force, as there is no opposite part of the module to apply an equal but opposite force to the string. The compactness increasing module is mounted on a movable arm (not shown), which moves perpendicular to the string, with the string entering the center of the ring 13 via the ring opening 14. Alternatively, the compactness increasing module 120 may be mounted on a carriage (not shown), and the core 3 is passed through the ring 13, when it is being attached to hooks.

[0056] The compactness increasing module may be able to act on each winding layer as it is being wound onto the string, meaning that, in a finished string, which comprises a core and upwards of six different winding layers, the compactness increasing module can have acted on each individual layer, meaning that all layers may have been wound onto the string under increased compression force and increased frictional force. This differentiates the compactness increasing module at least according to a special embodiment of the present invention from the apparatus in GB2073469, which is described as a string modification apparatus, meaning it is able to modify an already playable string, as opposed to the compactness increasing module, which is an integrated part of the string production machinery and process.

[0057] Another distinction between at least a special embodiment of the present invention and the apparatus described in GB2073469 is that the apparatus is only able to modify the outermost layer of the string, and only if said outer layer has a substantially round cross-section. This introduces an additional manufacturing step to string production, or, at least limits the winding speed, as the apparatus is described as acting on the slowly moving string. This means that the compactness increasing module, which acts instantaneously on the string during spinning, causes little or no added production time or cost. Also, the compactness increasing module is able to apply compression and additional friction to any winding material, regardless of cross-sectional profile.

[0058] Furthermore, at least in a preferred embodiment, the contact surface between the winding material and the compression increasing module is completely different from the contact surface of the apparatus. In the apparatus, the contact point between the apparatus and the string is two rollers, which roll along the winding of the string, creating the desired effect. In the compactness increasing module, the contact surface between the module and the winding strand are, for example, rectangular plates, which are fixed in place and do not rotate. The fixed plates are a critical feature, as these can introduce a substantially larger frictional force than rollers can. Especially the difference in the contact surfaces is important for the distinction between the compactness increasing module and the invention of GB2073469, as the purpose of the compactness increasing module is not to flatten the outer layer, but to improve the compactness, and thus the response and acoustical output of the string, rather than noise reduction when rubbed axially by the fingers of the player, as is claimed for the apparatus in GB2073469. The, for example, rectangular plates should have an area between five and 200 square millimeters and minimum thickness of 0.1 millimeter. The two sides of the, for example, rectangular plates may be equal in length. The overall shape of the plates is not critical, as long as the shape allows for a sufficient contact point.

[0059] Depending on which end of the string 110 the winding is initiated and the direction of rotation of the string 110, either the upper contact plate or the lower contact plate of the compactness increasing module 120 is in contact with the spinning point. The contact plate of the compactness increasing module 120, which is not in contact with the spinning point 7, will be in contact with the winding strand 4, immediately after it has been wound onto the string, on the opposite side of the string 110. At least one of either the upper contact plate or the lower contact plate of the compactness increasing module 120 must be attached to the arm, which can move up and down perpendicular to the string, such that the compactness increasing module 120 can be attached and detached from the string 110.

[0060] It should be noted and understood that there can be improvements and modifications made of the present invention described in detail above without departing from the scope of the invention as set forth in the accompanying claims.

[0061] Figures 3 to 7 are marked here as relating to a modification of only step 4 shown in figure 1D. However, of course there may be further modifications to the entire process shown in figures 1A to 1E. In addition, the step shown in figures 3 to 7 could be steps of a method different from the method shown in figures 1A to 1E. The modifications made to the compactness increasing module shown in figures 3 to 7 may be applied to all steps shown in figure 1A to 1E and 2A to 2E.

[0062] The features in the foregoing description, in the claims and/or in the accompanying drawings may, both and in any combination thereof, be material for realizing the invention in diverse forms thereof.

Reference sign list

[0063]

1, 2
: contact plates

3
: core

4
: winding strand

5
: coating

6
: coating

7
: spinning point

12
: bending actuator

100
: apparatus

110
: string

120
: compactness increasing module

13
: ring

14
: opening

α
: angle

β
: angle

REFERENCES CITED IN THE DESCRIPTION

Cited references

Patent documents cited in the description

- DE2736467C3 [0005] [0005]
- GB2073469A [0008] [0011] [0056] [0057] [0058] [0058]
- GB143677A [0009]
- US3717987A [0011]

Patentkrav

1. Fremgangsmåde til fremstilling af en musikinstrumentstreng, hvilken streng (no) har en kerne (3) med mindst en viklingsstreng (4) spiralviklet derpå, hvorved der dannes en streng med mindst en kerne og mindst et viklingslag, hvilken fremgangsmåde omfatter:
- at anbringe en kerne (3) aksialt langs en bane,
- at spinde kernen (3) om dens centrale akse og spiralvikle mindst en viklingsstreng (4) omkring strengen;
hvor der for at øge strengens kompakthed påføres en friktionskraft på den mindst ene viklingsstreng med et kompakthedsforøgende modul (120) ved et spindepunkt (7), hvilket spindepunkt er defineret som det punkt, hvor den mindst ene viklingsstreng vikles på strengen, der består af mindst én kerne, og der påføres en kompressionskraft på den mindst ene viklingsstreng og strengen med det kompakthedsforøgende modul, når den mindst ene viklingsstreng spiralvikles omkring strengen **kendetegnet ved, at** under spinding bevæges det kompakthedsforøgende modul (120), således at det følger spindepunktet (7).

2. Fremgangsmåden ifølge krav 1, hvor spiralviklingen omfatter spiralvikling af mindst én viklingsstreng (4) omkring strengen uden overlapninger og/eller store mellemrum på mere end ca. 12% af bredden af den individuelle viklingsstreng mellem tilstødende viklinger.

3. Fremgangsmåden ifølge et hvilket som helst af de foregående krav, hvor kompressionskraften og/eller friktionskraften styres.

4. Fremgangsmåden ifølge et hvilket som helst af de foregående krav, hvor mindst én viklingsstreng (4) vikles omkring strengen under spindetrinnet.

5. Fremgangsmåden ifølge et hvilket som helst af de foregående krav, hvor det kompakthedsforøgende modul (120) omfatter to kontaktplader (1, 2), og den påførte friktionskraft er resultatet af at bringe mindst en af de to kontaktplader i kontakt med den mindst ene viklingsstreng (4) derimellem under spinding, og kompressionskraften påføres ved at udøve en kraft på den mindst ene viklingsstreng (4) og strengen med mindst en af de to kontaktplader (1, 2).

6. Fremgangsmåden ifølge et hvilket som helst af kravene 1 til 4, hvor det kompakthedsforøgende modul (120) omfatter to, fire eller seks kontaktplader (1, 2), hvilke kontaktplader er anbragt i et par eller par i rækkefølge langs længden af kernen eller strengen, hvor hvert par består af to kontaktplader, der vender mod hinanden.

7. Fremgangsmåden ifølge krav 5 eller 6, hvor det ene eller mindst ene par af kontaktplader er arrangeret således, at det spænder over en vinkel $\alpha \neq 0°$ i et plan, der er vinkelret på kernens længderetning.

8. Fremgangsmåden ifølge krav 7, hvor vinklen α er mindre end 30°.

9. Fremgangsmåden ifølge et hvilket som helst af kravene 5 til 8, hvor kontaktpladerne eller i det mindste et par af kontaktplader er arrangeret således, at det spænder over en vinkel $\beta \neq 0°$ i et plan, der inkluderer længderetningen af kernen.

10. Fremgangsmåden ifølge krav 9, hvor vinklen β er mindre end 30°.

11. Fremgangsmåden ifølge et hvilket som helst af kravene 1 til 4, hvor det kompakthedsforøgende modul (120) kun omfatter én kontaktplade, hvilken kontaktplade er formet som en åben ring, og ringen er arrangeret således, at kernen med eller uden en eller flere viklingsstrenge, der er viklet derpå, passerer gennem ringen.

12. Strengefremstillingsapparat (100) til fremstilling af en musikinstrument-streng, hvor strengen (110) har en kerne (3) med mindst en viklingsstreng (4) spiralviklet derpå, hvorved der dannes mindst et viklingslag, hvilket apparat omfatter:
- organ til at spinde en fast kerne (3) af en streng, især en streng til et buemusikinstrument, og til spiralvikling af mindst en viklingsstreng (4) på kernen (3), mens kernen spinder, hvorved der dannes en streng med mindst en kerne og mindst et viklingslag, og

- et kompakthedsforøgende modul (120) konfigureret til at være i kontakt med viklingsstrengen (4) eller en aktuel øverste viklingsstreng ved et spindepunkt (7), når viklingsstrengen (4) eller den aktuelle øverste viklingsstreng vikles på strengen, bestående af mindst en kerne, hvor spindepunktet (7) er defineret som det punkt, hvor den mindst ene viklingsstreng vikles på strengen, således at der indføres en friktionskraft ved spindepunktet mellem det kompakthedsforøgende modul og den mindst ene viklingsstreng under spinding, og en kompressionskraft, der fører til øget kompression af den mindst ene viklingsstreng og strengen, **kendetegnet ved, at** det kompakthedsforøgende modul (120) er konfigureret til at bevæge sig under spinding, således at det følger spindepunktet (7).

13. Apparatet (100) ifølge krav 12, hvor det kompakthedsforøgende modul (120) er monteret på en vogn, der kan bevæges parallelt med længden af den faste kerne (3).

14. Apparatet (100) ifølge krav 13, hvor vognen er konfigureret til også at støtte den mindst ene viklingsstreng (4).

15. Apparatet (100) ifølge et hvilket som helst af kravene 12 til 14, hvor det kompakthedsforøgende modul omfatter et kompressionskraftstyrende organ til justering af mængden af indført kompressionskraft.

16. Apparatet (100) ifølge et hvilket som helst af kravene 12 til 14, hvor det kompakthedsforøgende modul også omfatter et friktionskraftstyrende organ til justering af mængden af friktionskraft, der indføres.

17. Apparatet (100) ifølge et hvilket som helst af kravene 12 til 16, hvor det kompakthedsforøgende modul omfatter to kontaktplader (1 og 2), hvoraf den ene er en nedre kontaktplade og den anden er en øvre kontaktplade, hvor den nedre af de to kontaktplader (2) er monteret på vognen, således at den er under den faste kerne (3), hvor viklingsstrengen (4) vikles derpå i direkte kontakt med den nedre kontaktplade (2), mindre end en hel viklingsdrejning efter vikling på strengen, og den øvre kontaktplade (1) er fastgjort til vognen, således at den er over den faste kerne (3), og oversiden af kernen (3) med den mindst ene viklingsstreng (4) viklet derpå er i direkte kontakt med den øvre kontaktplade (1) under spinding.

18. Apparatet (100) ifølge krav 17, hvor der ikke udøves nogen nedadgående kraft på den nedre kontaktplade af kernen (3)/strengen, før den øvre kontaktplade (1) presser ned på kernen (3)/strengen.

19. Apparatet (100) ifølge et hvilket som helst af kravene 12 til 16, hvor det kompakthedsforøgende modul (120) omfatter mellem en og seks kontaktplader (1, 2), hvilke kontaktplader er anbragt i par i rækkefølge langs længden af kernen (3), hvert par består af en topkontaktplade og en bundkontaktplade, og hvis antallet af kontaktplader er ulige, vil et eller flere af parrene mangle enten en topplade eller en bundplade, og rækken af bundkontaktplader vil blive forskudt lidt i længden af strengen i forhold til den øverste række af kontaktplader.

20. Apparatet (100) ifølge krav 17 eller 18, hvor kontaktpladerne eller i det mindste et par af kontaktplader er vinklet i forhold til hinanden.

21. Apparatet (100) ifølge krav 20, hvor det mindst ene par af kontaktplader (1 og 2) spænder over en vinkel $\alpha \neq 0°$ i et plan, der er vinkelret på længderetningen af kernen (3).

22. Apparatet (100) ifølge krav 20, hvor det mindst ene par af kontaktplader (1 og 2) spænder over en vinkel $\beta \neq 0°$ i et plan, der inkluderer længderetningen af kernen (3).

23. Apparatet (100) ifølge et hvilket som helst af kravene 17 til 22, hvor kontaktfladen af kontaktpladen eller af mindst en kontaktplade er coatet med en overfladecoating.

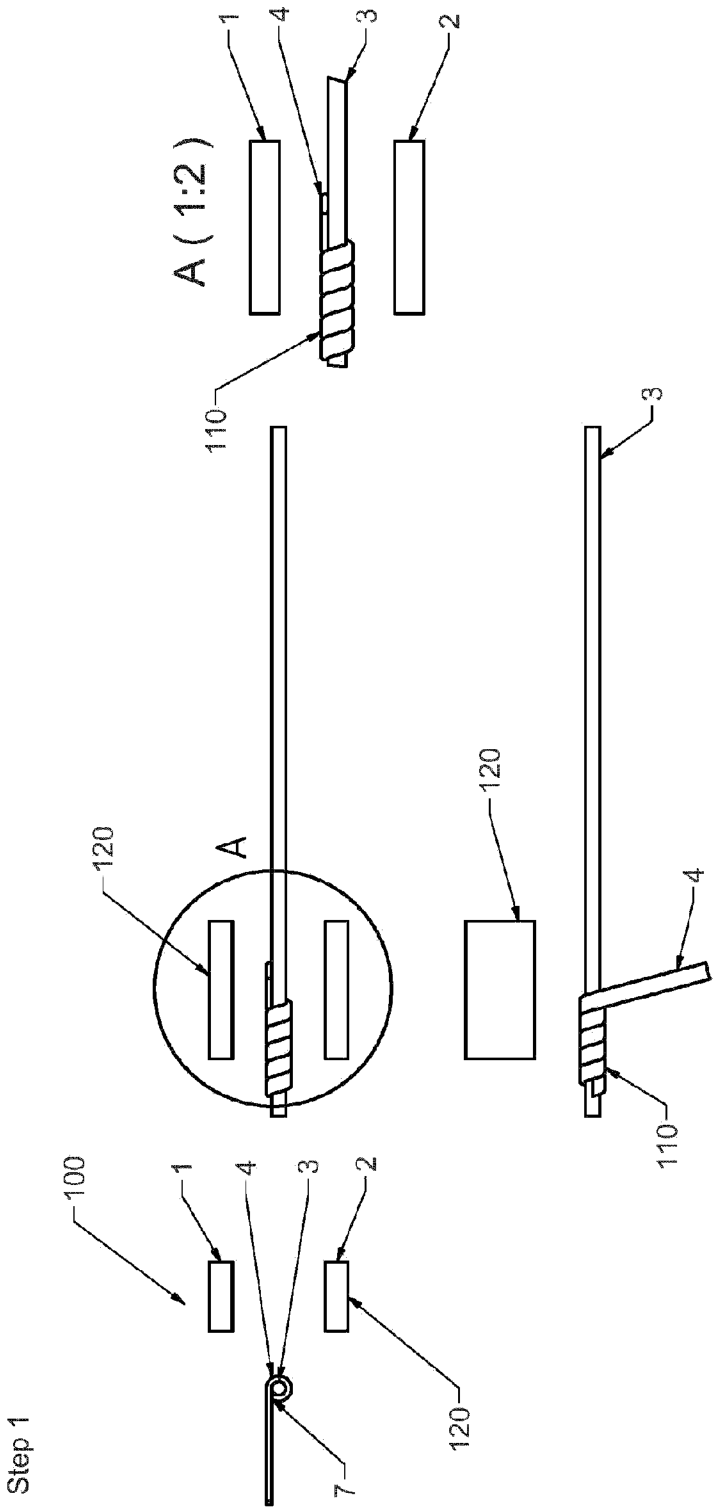
24. Apparatet (100) ifølge et hvilket som helst af kravene 12 til 16, hvor det kompakthedsforøgende modul (120) kun omfatter ét kontaktelement, hvor kontaktelementet er formet som en åben ring arrangeret således, at en kerne (3) passerer gennem det.

25. Apparatet (100) ifølge krav 24, hvor kontaktelementet er coatet på en kontaktflade.

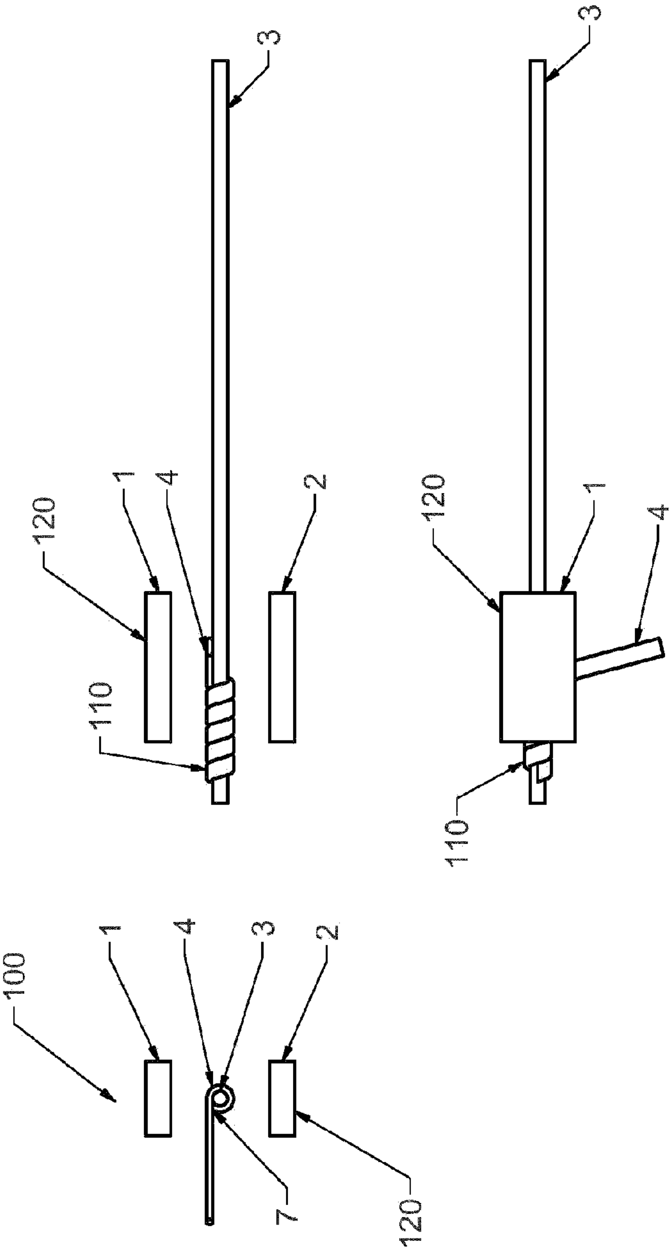
26. Apparatet (100) ifølge krav 24, hvor det kompakthedsforøgende modul (120) er konfigureret således, at ringens (13) radius kan øges eller formindskes.

DRAWINGS

Drawing

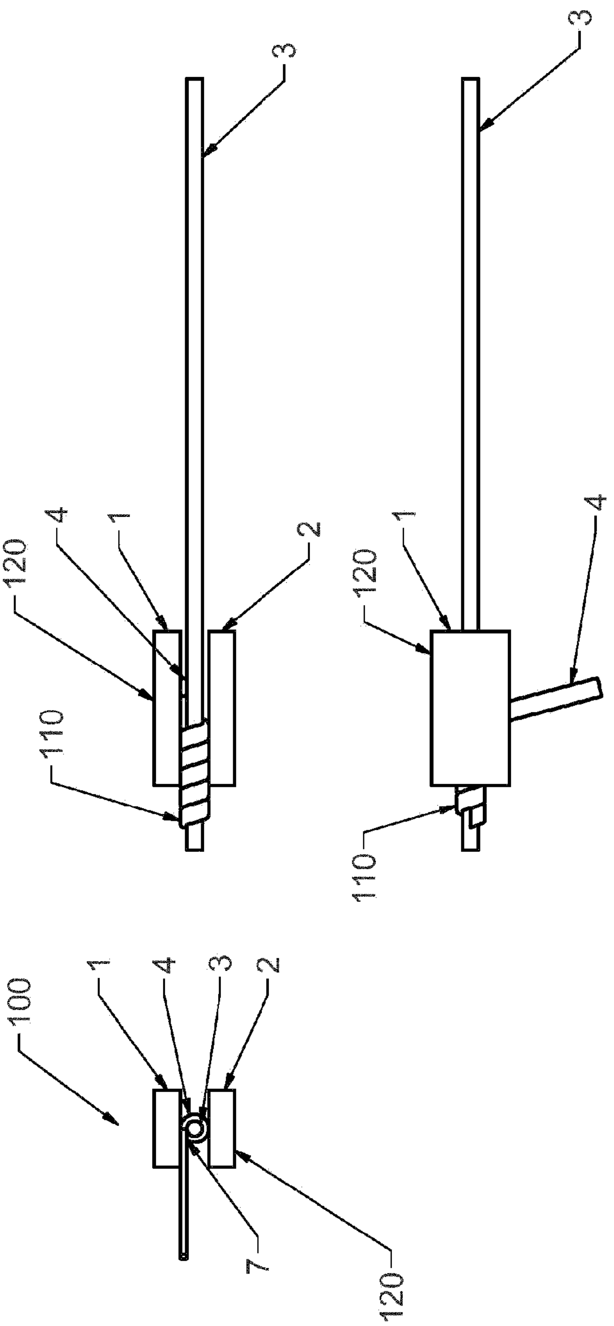


Figur 1A



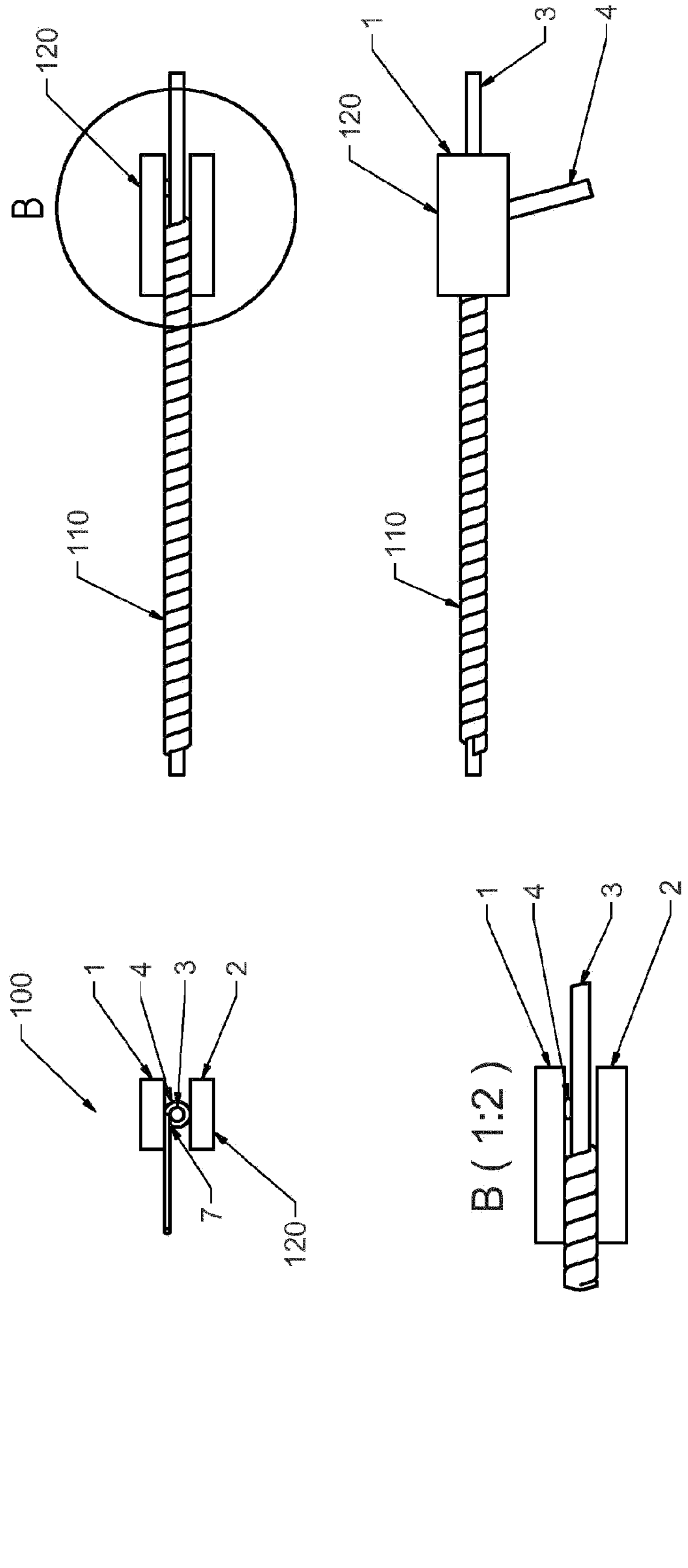
Figur 1B

Step 2



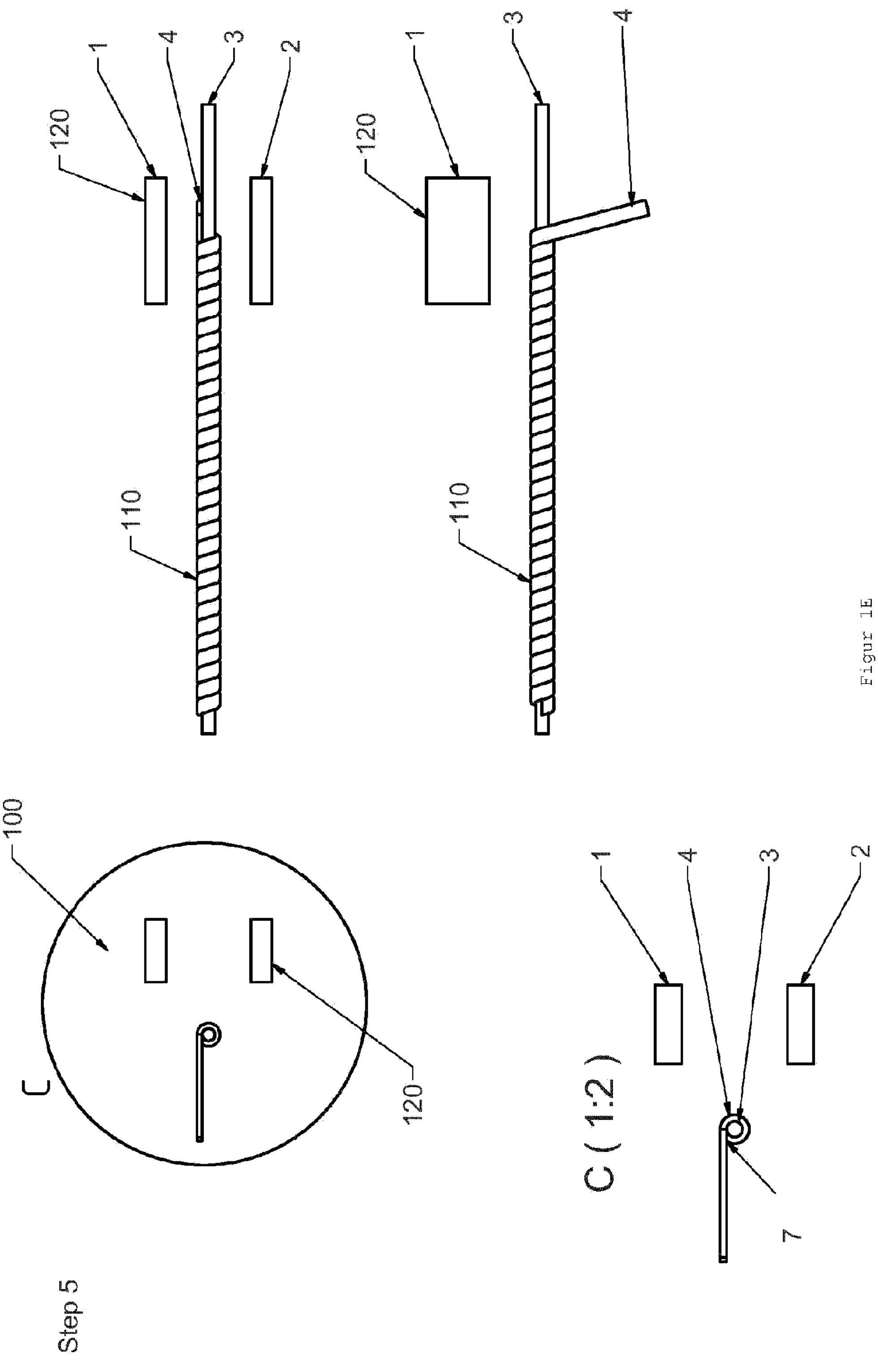
Figur 1C

Step 3

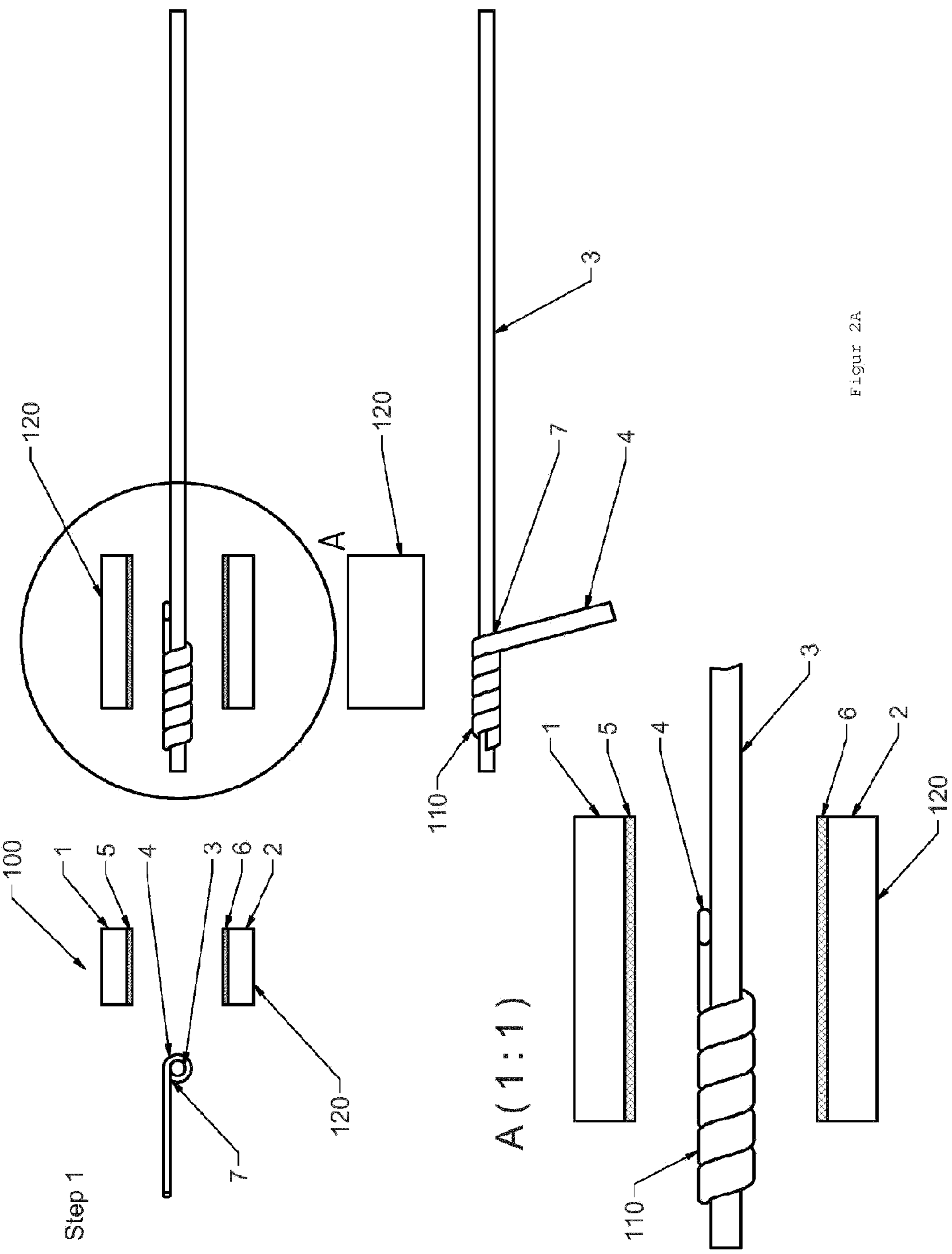


Figur 1D

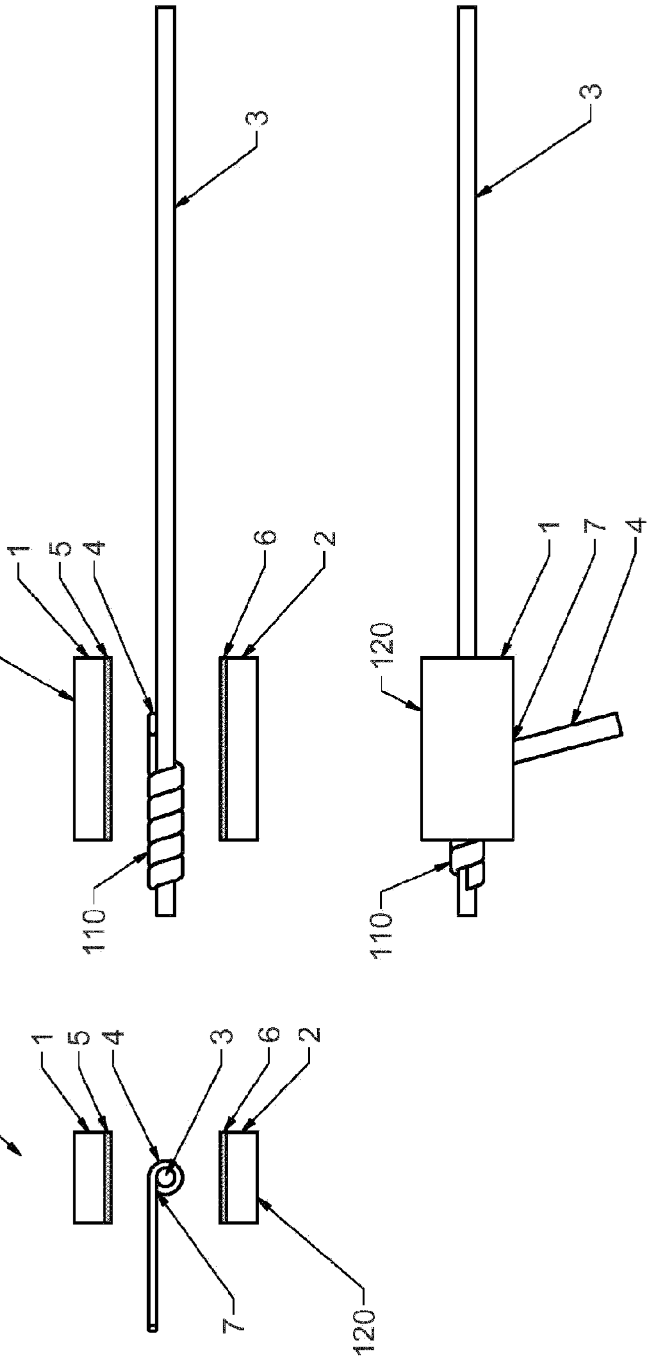
Step 4



Figur 1E

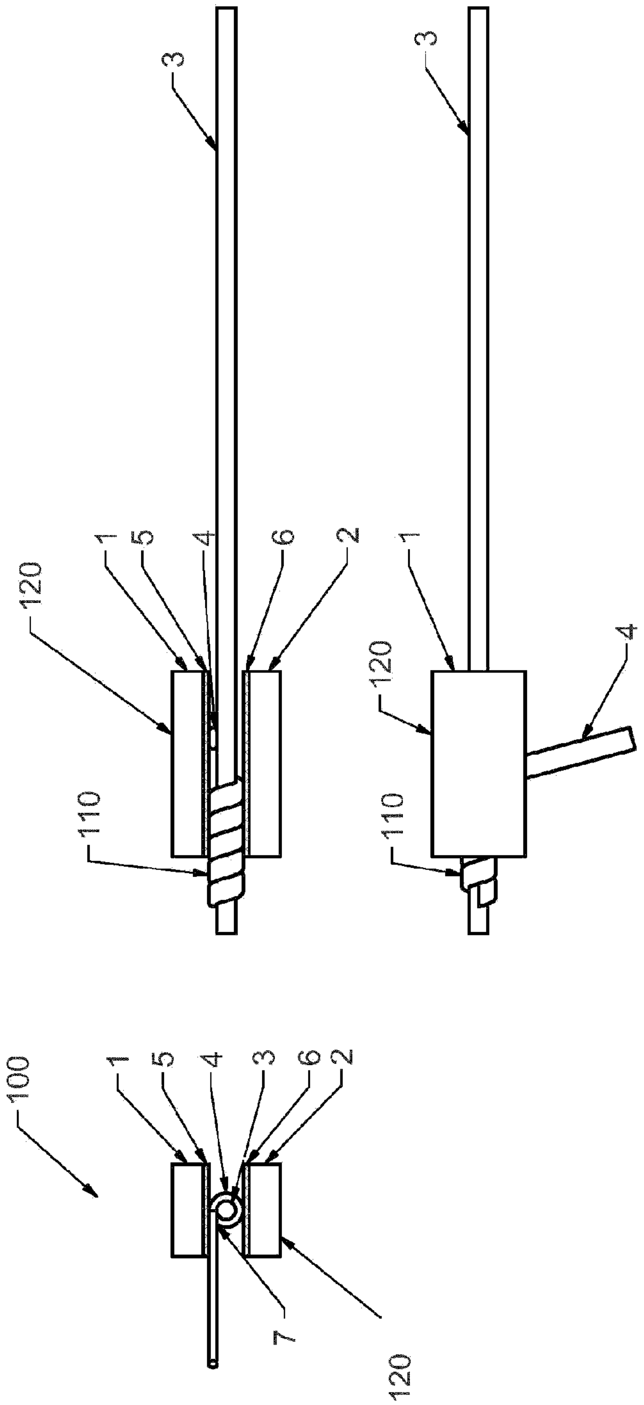


Figur 2A



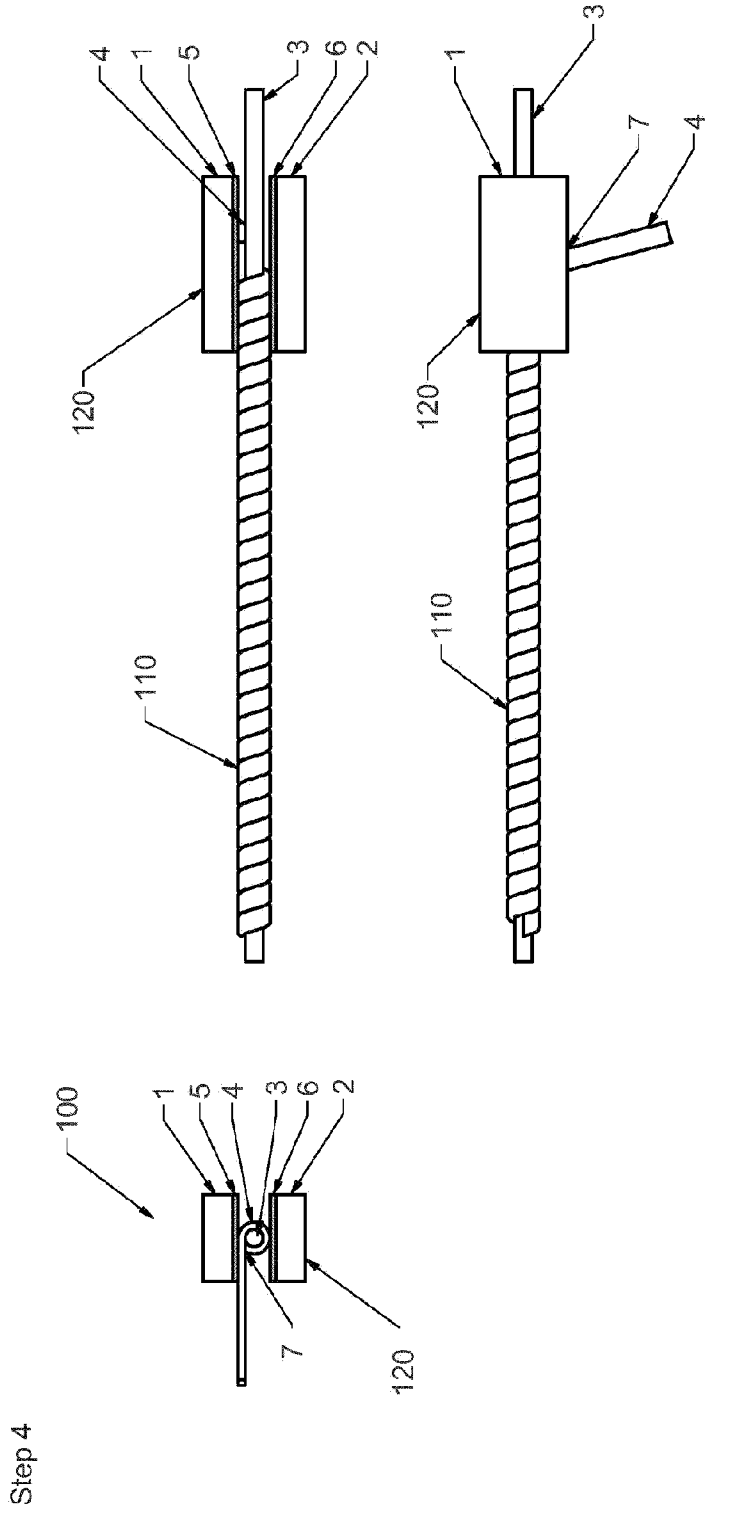
Step 2

Figur 2B

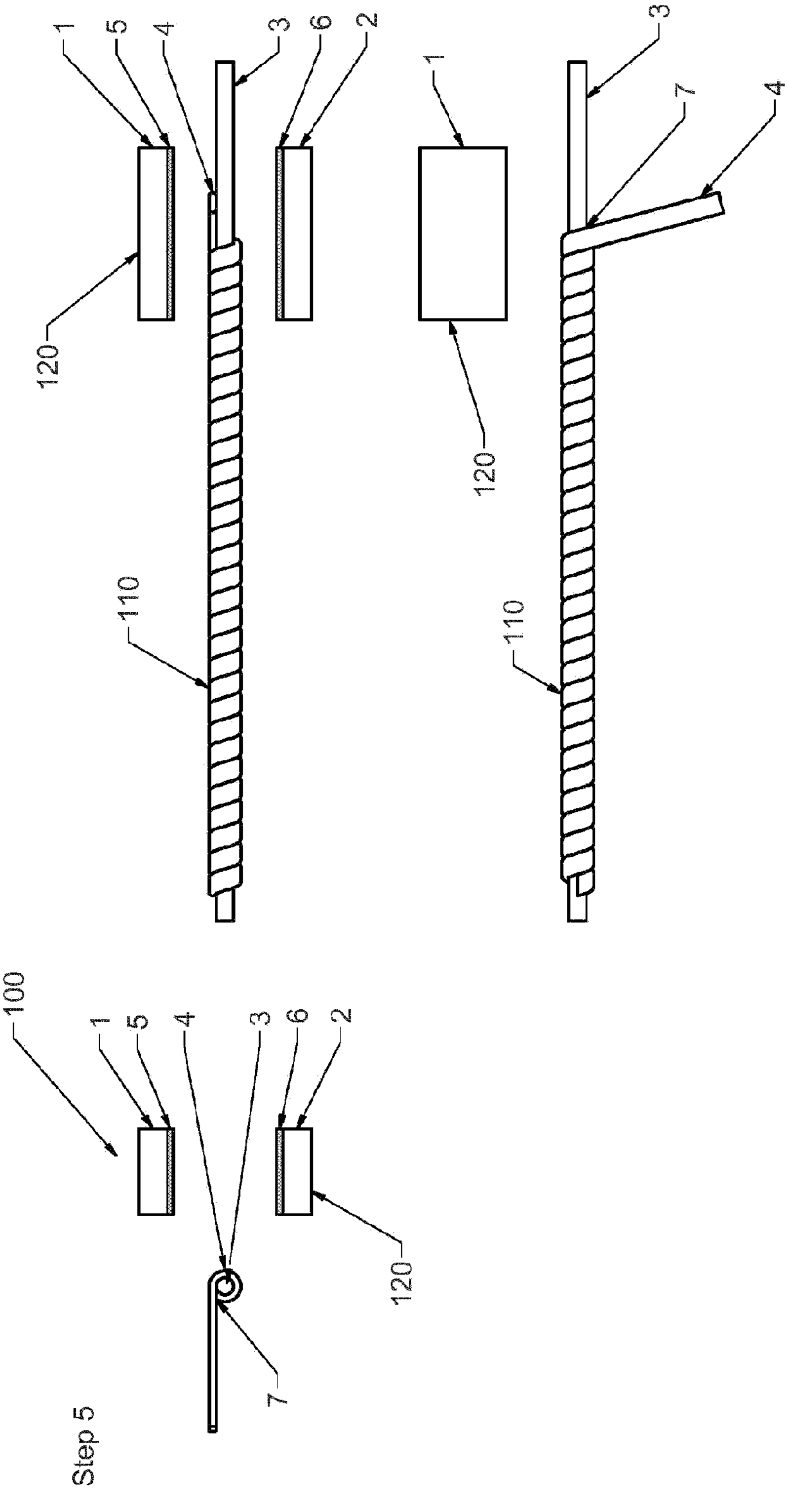


Step 3

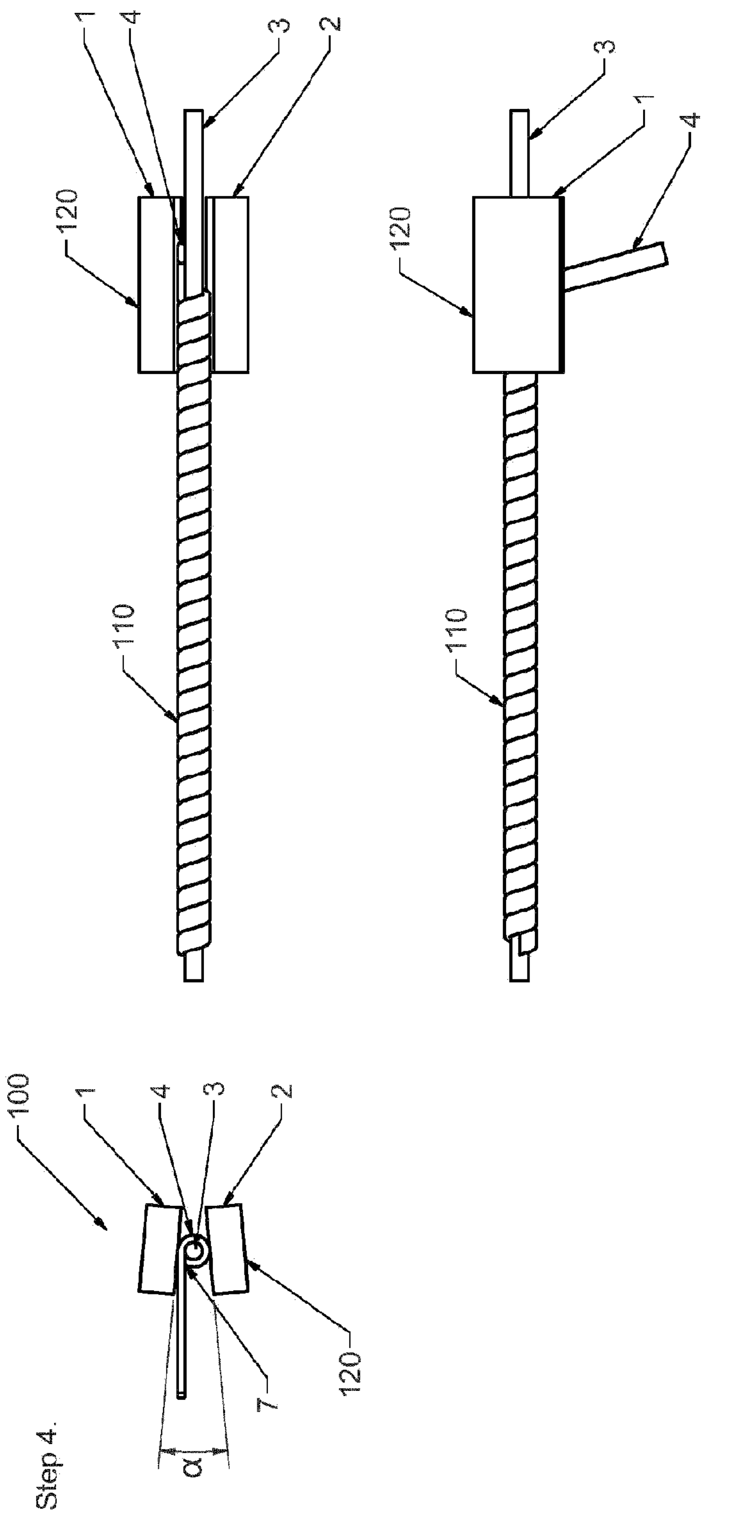
Figur 2C



Figur 2D

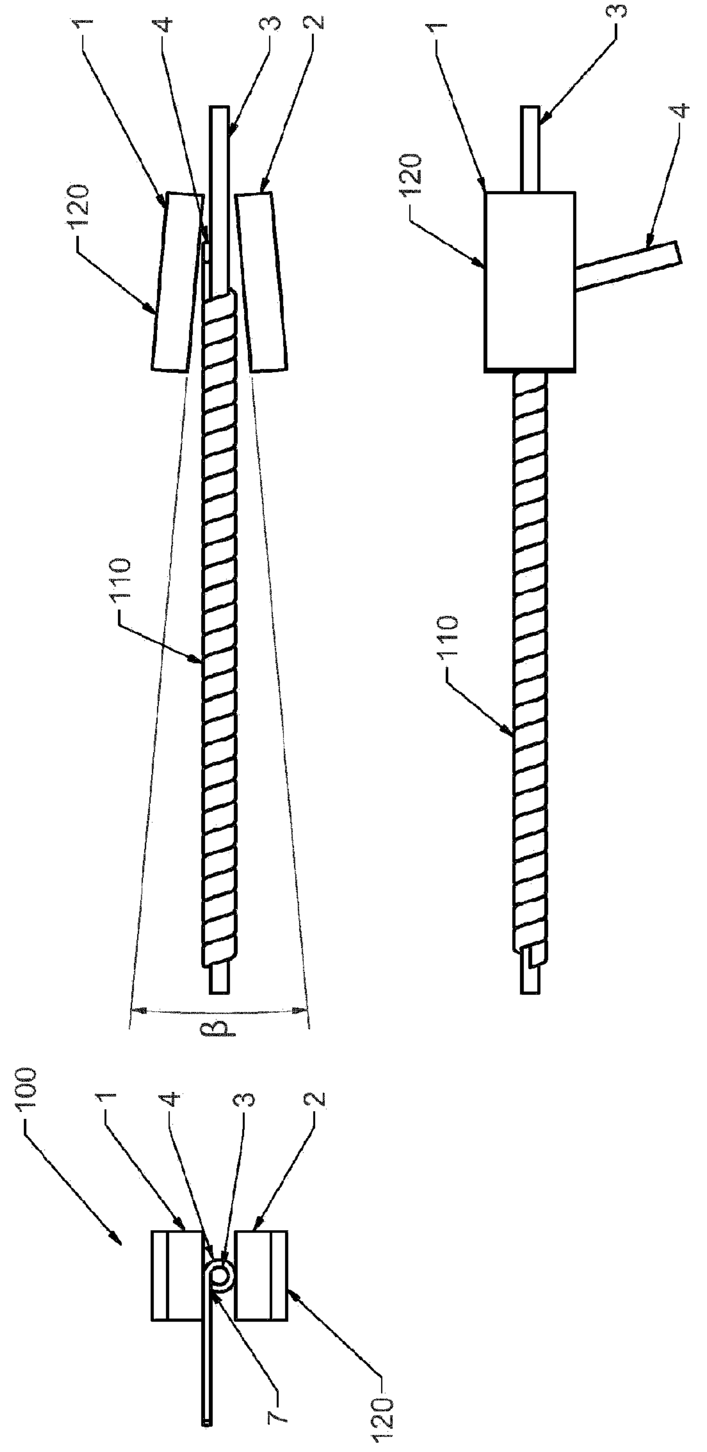


Figur 2E



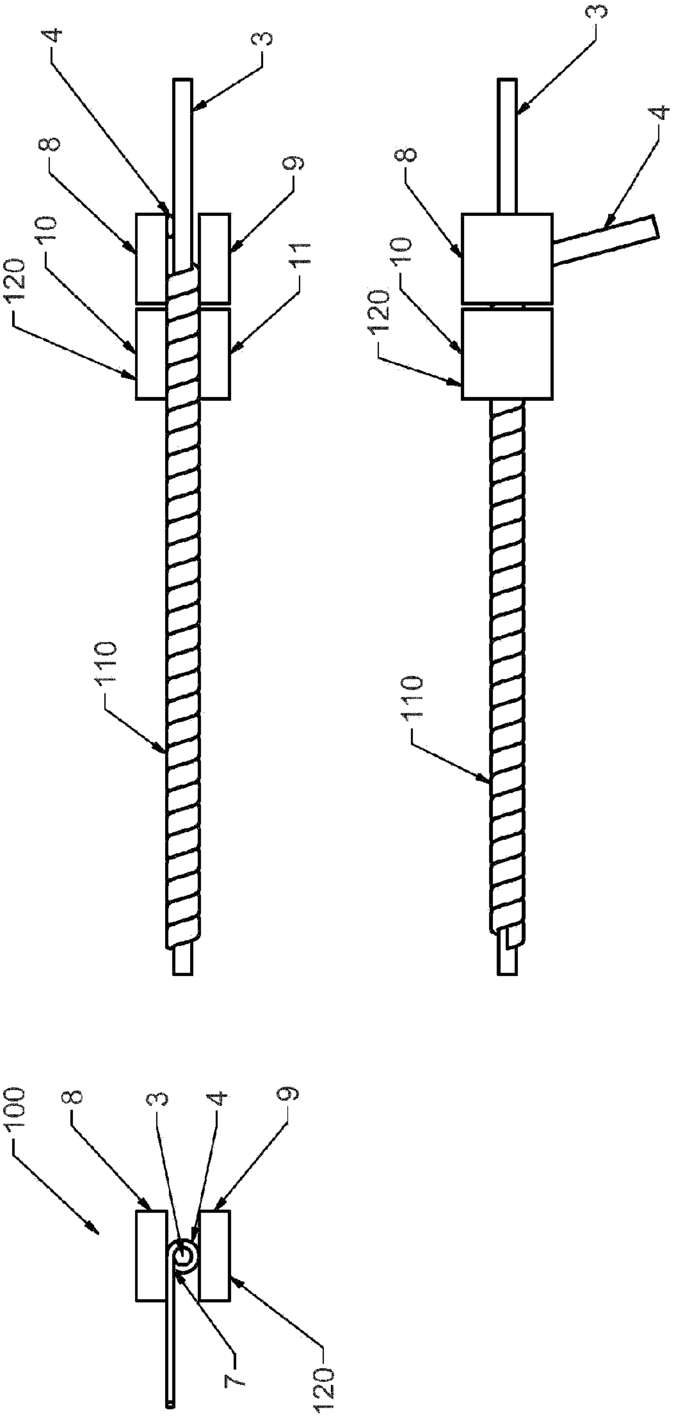
Figur 3

Step 4.

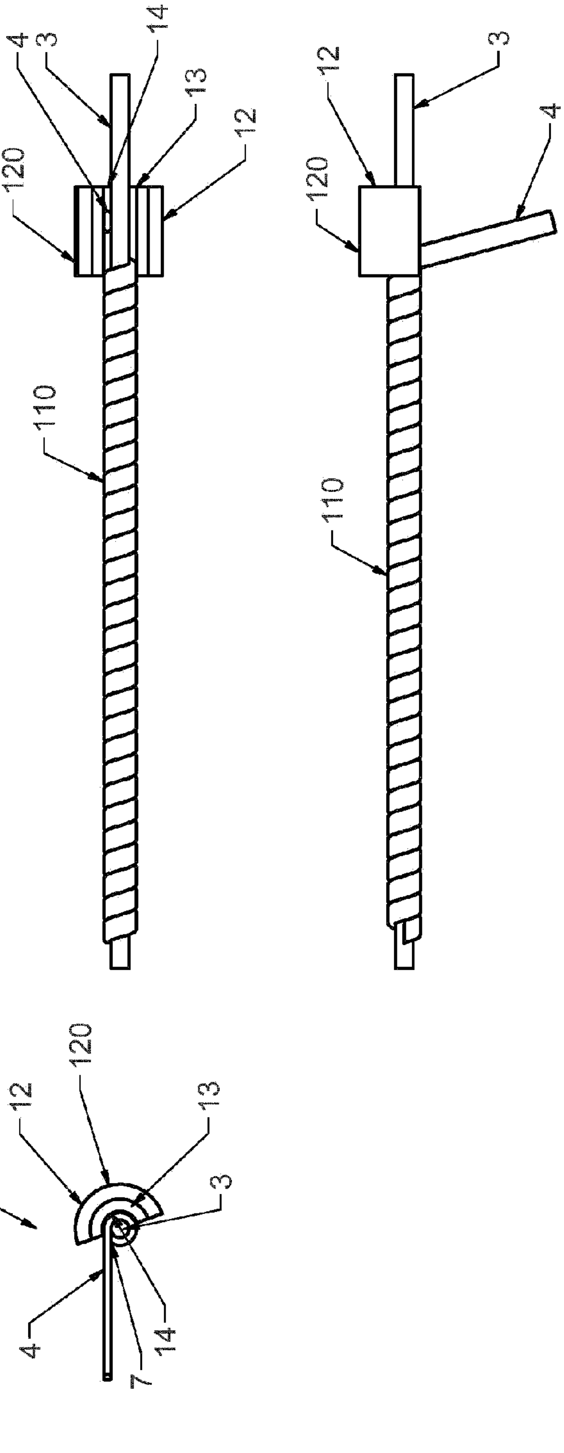


Figur 4

Step 4.

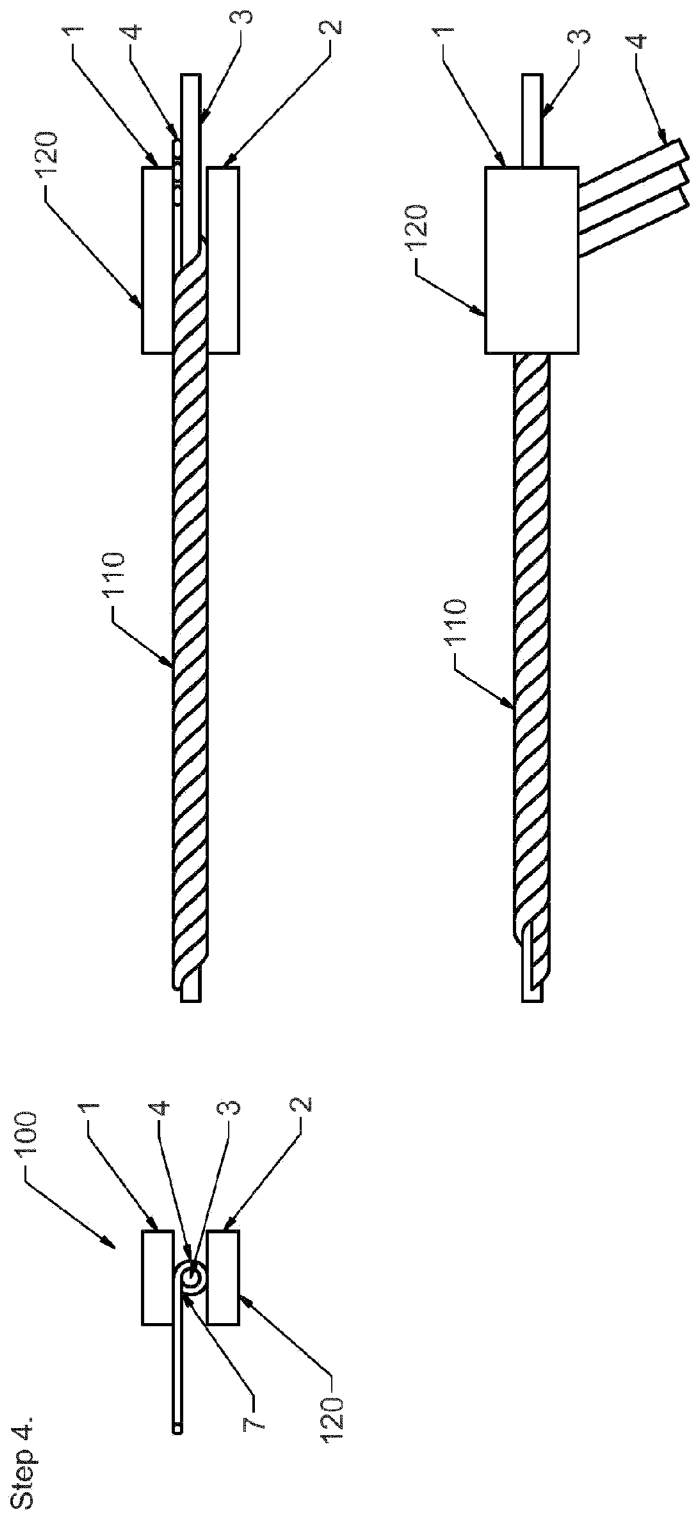


Figur 5



Step 4.

Figur 6



Figur 7