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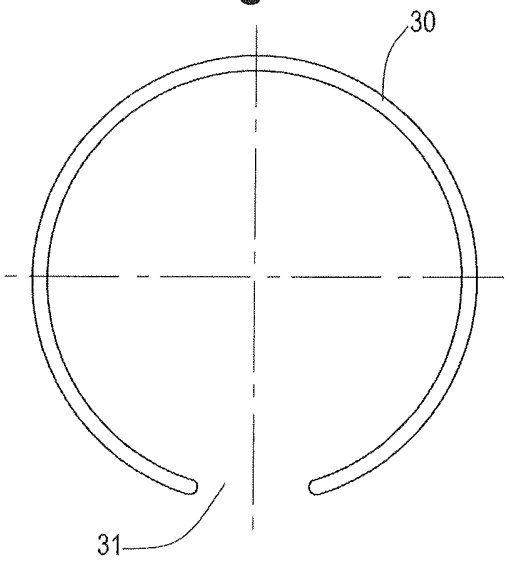
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(54) FLEXIBLE WINDING MANDREL WITH CORE SEGMENTS FOR PRODUCING ROLLS OF WOUND PAPER

(57) A flexible mandrel (30) is provided for holding cores or core segments (16') so that a roll of sheet material can be wound on the core segments in a winding machine. The mandrel and core segments are coupled through elastic interference between the mandrel and the core segments so that the core segments are arranged either adjacent to each other or spaced apart. A method for producing rolls of sheet material on the novel combination of mandrel and core segments feeds cores (16) in an apparatus, transversely cuts the cores to form portions of core or core segments (16'), feeds a flexible mandrel (30) into the core segments for supporting and maintaining the axial position of the core segments. Coupling is by elastic interference between the flexible mandrel and the core segments to form an assembly in which the core segments are arranged on the mandrel spaced apart or adjacent one to the other.

Fig. 8



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Description

Technical Field

[0001] The present invention relates to a flexible mandrel with core segments for producing convolutely wound rolls of web material, such as bathroom tissue and kitchen towel.

[0002] The present invention also relates to a method and apparatus for producing such rolls using a flexible mandrel to hold the core segments. It is especially suited for use in surface (or peripheral) type rewinders. However, specific embodiments of the invention are suited for use also in turret (or central) type rewinders.

Background

[0003] Many webs are convolutely wound onto cores, or core pieces, herein referred to as core segments or split cores when mounted on a common mandrel. Typically, the web is slit into ribbons and the edges of the web ribbons approximately align with the ends of the core segments. Patents US 2,553,052 and US 2,769,600 describe turret rewinders that can operate with core segments. Patents US 1,076,189 and US 1,437,398 describe a surface rewinder that can operate with core segments.

[0004] There are some applications where the web is not slit into ribbons, but rather is wound into a full width log about core segments. Subsequently these logs are cut in a saw, with the saw cuts not in alignment with the ends of the core segments, so that each finished roll has two pieces of core in it. Patents US 7,107,888, US 7,127,974, US 7,389,716, and US 7,789,001 describe a means to accomplish this on a turret rewinder.

[0005] The cores are held in place by rigid mandrels with actuating elements. The actuating elements are retracted during loading and unloading of the cores. They are engaged during conveyance and winding to hold the core segments securely in place. Various types of mandrels used to hold cores or core segments during winding of web material are taught in

[0006] Patents US 2,901,192, US 2,537,492, US 2,711,863, US 5,372,331, and EP 2 462 045 B1.

[0007] It is desirable to make finished rolls that utilize core segments as part of their manufacturing process on high speed, high exchange rate, continuous operating, automatic transfer, surface rewinders. By way of example, but not exclusively, several types used in production of bathroom tissue and kitchen towel include US 6,056,229, US 7,175,126, US 5,979,818, and US 7,942,363.

[0008] The goal of producing these products on a modern surface rewinder stems from the possibility of higher maximum cycle rate, greater machine width, winding of firmer products, faster winding speed, or merely operating preference. In one specific case it is especially desirable to achieve this so that a rewinder can be construed to switch quickly and easily between normal production with standard cores, production with core segments, as described herein, and production without cores, as described in U.S. Patent Publication No. 2014/0084102 A1.

[0009] Drawbacks of state of the art mandrels for this application include the following. These drawbacks stem from the mandrels having at least one relatively rigid portion, typically made of metallic alloy or fiber-reinforced polymer composite.

1. These mandrels are assemblies comprised of many intricate parts. Thus they are relatively complex, expensive to manufacture, and expensive for maintenance.
2. They are very heavy, with high mass and high polar inertia. This makes them difficult to immediately accelerate at the moment of insertion and difficult to control at high speeds. It causes them to resist the very sudden changes to their translational and rotational velocities required when they enter the nip between the upper and lower rolls. It also restricts the variety of products a surface winder can produce. It is not practical to wind low density and low firmness rolls with a very heavy mandrel inside.
3. The high mass and stiffness of these mandrels combine to give them the capacity to damage other parts of the machine during a web blowout or high speed crash.
4. Carbon fiber composite mandrels can break into many pieces during a crash. The debris is akin to splinters and can be dangerous to operators cleaning them up and to end users if bits get into the finished product.
5. If the actuators impart the radial stiffness of the mandrel to the core, then the surface winder must accommodate this. This may be accomplished with an oscillating cradle, as taught in US 5,769,352 (col. 2, lines 2-12), a deformable cradle as taught in same (col. 5, lines 42-48), or compliant surfaces, as taught in US 6,056,229 (col. 5, lines 50-52 and col. 6, lines 1-5). However, oscillating, deformable, and compliant accommodations are not predisposed to operation at high speed without premature wear and failure.

Summary of the Invention

[0010] An object of the present invention is obviating the disadvantages stated above.

[0011] More particularly, an object of the present invention is a winding mandrel capable of holding a core or core segments securely in place that does not suffer from the drawbacks of the current art. Instead it has the following attributes.

- Low mass and inertia (for rapid accelerations at high web speed).
- Low polar inertia (for rapid accelerations at high web

speed).

- Low cost.
- Adequate flexural stiffness (to be conveyed).
- Adequate tensile strength (for extraction).
- Abrasion and wear resistance (to be durable).
- Adequate fatigue life (for longevity).
- Available in custom sizes (to match various core diameter requirements).
- Natural corrosion resistance (to resist transfer glue, water, and washing).
- Non-toxic (preferably food contact compliant).
- Some ductility (to maintain integrity during a crash).
- Recyclability (for disposal after it has worn out or broken).

[0012] A further object of the present invention is a flexible mandrel that behaves much like the circular, tubular cardboard cores or core segments set upon it, including their radial stiffness, so it flexes with the cores, and therefore can be used in essentially the same rewinders as use cores.

[0013] A further object of the present invention is to provide a method for the production of rolls with core segments on a flexible mandrel in a surface winder suitable for allowing the production of a roll or unit which, when subjected to the cutting step in a shearing or sawing station, allows rolls of paper to be obtained, provided with an inner precut core to be used in dedicated container/dispenser elements.

[0014] A further object of the present invention is that specific embodiments of the invention are suited for use also in turret or central type rewinders.

[0015] A further object of the present invention is to provide a method for the production of rolls with split cores suitable for allowing an optimization and reduction of cycle times with a consequent reduction in the associated costs.

[0016] A further object of the invention is to make available to users a method for the production of rolls with cut cores on a flexible mandrel in a surface winder suitable for ensuring a high value of reliability in time and such that, moreover, it can be easily and economically implemented in the production plant.

[0017] These and other objects are achieved by the device of the invention that has the features of claim 1.

[0018] According to the invention a method is provided for the production of rolls of sheet material with split cores on a flexible mandrel, comprising the steps of feeding of cores in an apparatus for the production of split cores, transverse cutting of the cores to form portions of core, feeding of a flexible mandrel in said apparatus for a support and maintaining in axial position of the portions of core, coupling through elastic interference between said flexible mandrel and said core portions of the core in said apparatus to form an assembly wherein said core portions are arranged adjacent on said mandrel, or spaced apart one with respect to the other, moving and feeding of said assembly to a rewinder to produce a log of sheet material, extraction of the flexible mandrel from the log, and cutting of the log into rolls.

[0019] Advantageous embodiments of the invention are disclosed by the dependent claims.

Description of the Drawing

[0020] The constructive and functional features of the method for the production of rolls with split cores on a flexible mandrel of the present invention will be made clearer by the following detailed description in which reference is made to the accompanying drawings which show embodiments thereof solely by way of a non-limiting examples in which:

Figure 1 represents schematically an axonometric view of an apparatus for receiving unitary cores, cutting them into segments, receiving flexible mandrels, loading the core segments on to the flexible mandrels, and discharging the assembly for use in a rewinder to produce rolls of sheet material with core segments according to the present invention;

Figure 2 represents schematically a further axonometric view of the apparatus of Figure 1, according to an opposite point of view;

Figure 3 represents schematically a side elevational view of the apparatus of Figure 2;

Figure 4 represents at schematic level a plan view from above of the apparatus of Figure 3;

Figure 5 represents schematically an enlarged view of a section of the apparatus of Figure 3 taken along the cutting plane A-A of Figure 3;

Figure 6 represents schematically an enlarged view of a section of the apparatus of Figure 3 taken along the cutting plane B-B of Figure 3;

Figure 7 represents a side view of a preferred embodiment of flexible mandrel for the support of the cores for the rolls of paper used in the apparatus of the invention;

Figure 8 represents schematically an end view of the mandrel of Figure 7;

Figures 9 and 10 are views similar to Figures 7 and 8, respectively, showing spaced-apart core segments fitted on the flexible mandrel distanced one from the other;

Figure 10A is an enlarged axial sectional view of a roll in accordance with the invention obtained after cutting of the log with core segments which are spaced apart along the axis of the roll;

Figure 10B is a view similar to Figure 10A with core segments which are adjacent to each other;

Figure 11 represents a diagram illustrating an operational phase carried out on the apparatus of the invention;

Figures 11A to 11C represent at schematic level the sequence of steps relating to the operational phase of Figure 11 and relating to a coupling of the core for rolls with a flexible mandrel;

Figure 12 schematically represents a detail of a section made along a plane C-C of Figure 11 showing a phase of loading of a flexible mandrel;

Figure 13 represents a diagram illustrating the method and the apparatus of production of split cores on a flexible mandrel to be used in surface rewinders for producing rolls of sheet material according to the invention, specifically it schematically represents a side view of a converting line illustrating means to convey unitary cores to the apparatus depicted in Fig. 1, convey assemblies of flexible mandrels with core segments to a rewinder infeed, and convey flexible mandrels after extraction back to the apparatus depicted in Fig. 1;

Figures 14 - 20 are views of alternative embodiments of the flexible mandrel used in the method and in the apparatus according to the invention, in particular: Figure 14 is an end view of a C-shaped sectioned mandrel like that of Figure 8, but with non-uniform wall thickness; Figure 15 is an axonometric view of a C-shaped mandrel with material removed to obtain a mass balancing; Figure 16 is an end view of a tubular mandrel with overlapped parts; Figure 17 is an end view of a coiled tubular mandrel; Figure 18 is an end view of a mandrel with flutes forming generally the shape of a star; Figure 19 is an end view of a tubular mandrel with closed circular section; Figures 20a and 20b are end and perspective views of a circular tubular mandrel with projecting tabs.

Figure 21 is a perspective view of a flexible winding mandrel and spaced-apart core segments which are supported by a rigid mandrel of a center rewinder or turret rewinder;

Figure 22 is an elevational view of the structure of Figure 21; and

Figure 23 is a sectional view taken along the line A-A of Figure 22.

Description of Specific Embodiments of the Invention

[0021] With reference to the above figures, the apparatus is illustrated for the production of core segments or split cores on a flexible mandrel in a rewinder in order to obtain rolls of sheet material according to the present invention.

[0022] A subject of the invention is a flexible, lightweight, low inertia mandrel that holds cores or core segments securely in place with friction. The preferred embodiment is comprised of plastic material, generally tubular in shape, that is larger than the inside surface of the cores when at rest, and so is compressed radially when inside the cores, the reduction in size of the mandrel being the cause of the pressure that induces the holding friction.

[0023] Because the mandrel is flexible and compliant the assembly of mandrel and cores together retains significant radial compliance. This novelty allows the assembled unit-- core or cores with mandrel inside -- to be used in machines that require compression of the cores for operation, such as modern surface winders. Further, the low mass and low inertia of the novel mandrel allow the assembled unit to be utilized at high speeds without special modifications, premature wear of machine components, or sacrificing product variety or quality. And this all is accomplished with a low cost mandrel.

[0024] This mandrel can be used to hold cores or core segments in new and existing rewinders that currently wind rolls of paper with cores. Exemplary surface rewinders of this type are described in Patents US 6,056,229, US 6,422,501, US 6,497,383, and US 7,104,494, which issued to Paper Converting Machine Co. The mandrel can also be used in other models of surface rewinders from this supplier, both continuously operating and start-stop.

[0025] The mandrel can also be used in surface rewinders from other suppliers, both continuously operating and start-stop, for example, and not limited to, rewinders described in Patents US 5,150,848 (Consani), US 5,979,818 (Perini), US 6,945,491 (Gambini), US 7,175,126 (Futura), US 7,175,127 (Bretting), and others.

[0026] The mandrel can also be used in turret rewinders or center rewinders, both continuously operating and start-stop. It is possible then to cut and load core segments outside the rewinder. Exemplary center rewinders of this type are described in Patents US 2,769,600, US 2,995,314, US 5,725,176, and US RE 28,353. The mandrel can also be used in turret and center rewinders from other suppliers.

[0027] When this novel mandrel is used in turret or center rewinders of the type described in Patents US 2,553,052 and US 2,769,600 or Patents US 7,107,888, US 7,127,974, US 7,389,716, and US 7,789,001 the original, relatively rigid, winding mandrels can be retained and reside inside the novel flexible mandrels upon which the cores are set. An illustration of this is provided in Figures 21-23. The internal relatively rigid mandrel supports the long flexible mandrel with cores and the weight of the paper wound thereupon. In this case the actuating elements of the rigid mandrels engage the inside surface of the flexible mandrel rather than with the inside surface of the core or core segments. This engagement is necessary to support and rotationally drive the novel mandrel with cores and paper thereupon.

[0028] The mandrel can also be used in center-surface rewinders, both continuously operating and start-stop, for example, and not limited to, rewinders such as described in Patents US 7,942,363 and US 7,909,282.

[0029] When this novel mandrel is used in center-surface rewinders of the type described in Patent US 7,909,282 a winding mandrel having at least one relatively rigid portion may be present inside the novel mandrel to engage the inside surface of the novel mandrel, and support and rotationally drive the novel mandrel, with cores and paper thereupon.

[0030] Regarding mandrel shape, the simplest ap-

proach is a tubular mandrel made of flexible and elastic material of the type described in U.S. Patent Publication No. 2014/0084102 A1. This approach is feasible, but has the following challenge relative to practical operation: the tube dimensions and core size must be precise to realize consistent holding force mandrel to mandrel, core piece to core piece, day to day, in an industrial environment. This is because the change in diameter of this type mandrel under moderate loads is small relative to the magnitude of variations typical in the tubes and cores.

[0031] This may be addressed by making the tube undersized and axially restraining the cores just at the ends. But, it is preferable to have the mandrel seat snuggly against the inside surface of the core or cores and thereby operate as a unit.

[0032] This issue is preferably addressed by utilizing a shape disposed to provide large dimensional changes under moderate loads to accommodate the variations in tube and core geometry. Its greater tolerance of variation makes the process robust, allowing normal cores to be used, and low cost commercial extrusions to be used for the mandrel.

[0033] Figures 7 and 8 illustrate the most preferred embodiment of the novel mandrel. The mandrel 30 has a substantially tubular development and has an opening 31 longitudinally developed for the entire length of the mandrel and which confers on said mandrel a "C" shape cross-section. This profile tube can be withdrawn from the finished product using the same mandrel extractor as described in U.S. Patent Publication No. 2014/0084102 A1. Thus switching between production with cores, with core segments, and with no cores is very fast and simple. Also, because the mandrel has a void at its center, it can be used also in turret or central rewinders, seating on the original winding mandrels of the rewinder, as illustrated in Figures 21-23. Lastly, this embodiment is low cost because its shape can be extruded and does not require follow-up cutting, forming, nor joining operations.

[0034] Alternative embodiments of the mandrel 30 of the invention are illustrated in Figures 14 - 20. These figures are meant to be examples of the invention and not construed as limiting. Many other shapes and types may be used to accomplish this effect without deviating from the spirit and scope of the invention.

Fig. 14 is an end view of a generally C-shape mandrel with non-uniform wall thickness. The profile in Fig. 14 has greater wall thickness 32 near the opening 31 so the mandrel can be mass balanced when compressed inside the core or cores.

Fig. 15 illustrates a way of removing material by providing holes 33 in a generally C-shape mandrel with uniform wall thickness to achieve mass balance when compressed inside the core or cores.

Figs. 16, 17, and 18 are end views of a split tubular mandrel with overlap, of a coiled tubular mandrel, and of a generally star shape mandrel, respectively.

The star shaped mandrel of Fig. 18 includes a plurality of flexible flutes or points which curve or spiral outwardly from a central hub.

[0035] Features like the tabs 34 illustrated in Figs. 20a and 20b can be added to tubes through hot working, cold working, cutting, etc. Alternatively, they could be attached to the tube by crimping, welding, heat fusing, etc. Flexible projections, such as these, from the surface of a tubular mandrel can be used to develop the pressure between mandrel and cores that induces the holding friction.

[0036] The flexible mandrel 30 can also have a closed circular profile as shown in Figure 19. In the case of a mandrel with closed circular section, the axial locking of the core segments on the mandrel can be realized by means of additional lock bushings inserted before the first and after the last core segments.

[0037] There are diverse options for mandrel material and construction. The shapes in Figs. 16 and 17 could be achieved by coiling thin sheets of metal or plastic. The shapes in Figs. 8 and 14 could be achieved by curving thin sheets of metal or forming thin sheets of plastic. Most of the shapes could be achieved by extruding thermoplastic polymers. A mandrel with tabs as shown in Figs. 20a and 20b can be produced by cutting the tabs in the wall of a plastic tube and bending them out. Alternatively, similar tabs could be produced by mounting metal or plastic pieces to the surface of a tube.

[0038] Though options abound, the preferred mandrel material is plastic, more preferably a thermoplastic, which are characterized by relatively low elastic modulus and mass density. They also are relatively low cost and can be extruded into various shapes. Having the mandrel extruded to a shape that is similar to the shape it takes in operation, slightly larger than the inside dimension of the cores, is cost-effective and allows a simple device to be used to load cores onto the mandrel and convey extracted mandrels back to the loading station.

[0039] Many of the desired properties for this mandrel are in common with those for the mandrel described in U.S. Patent Publication No. 2014/0084102 A1, the content of which is incorporated herein by reference. Therefore, it may be supposed the same plastic is most preferred. But, it is beneficial that this mandrel have the ability to hold the core segments securely over time. Therefore, creep resistance and stress relaxation characteristics are more important in this application.

[0040] Viscoelastic materials creep under constant stress and relax under constant strain. This means a mandrel comprised of viscoelastic material subjected to a constant load will continue to deform. It means this same mandrel subjected to constant deformation will undergo a reduction in stress. It is as though the elastic modulus of the material decreases over time when loaded.

[0041] The mandrel inside the core or core segments is compressed a fixed amount. If the material undergoes

too much stress relaxation, it will lose its friction against the cores and not hold them adequately. If the material undergoes too much creep while inside the core or core segments, it may not return to its original shape, so cannot be returned to the loading apparatus and reused.

[0042] It has been found, largely for this reason of dimensional stability under load over time, that rigid PVC is a good choice of material for this application. The following excerpt is from http://www.pvc.org/en/p/pvcs-physical-properties:

> "PVC is a chemically stable material, which shows little change in molecular structure, and also exhibits little change in its mechanical strength. However, long chain polymers are viscoelastic materials and can be deformed by continuous application of exterior force, even if the applied force is well below their yield point. This is called creep deformation. Although PVC is a viscoelastic material, its creep deformation is very low compared with other plastics due to limited molecular motion at ordinary temperature, in contrast to PE and PP, which have greater molecular motion in their amorphous sections."

[0043] Though as a material rigid PVC is not as flexible and elastic as other thermoplastics, a mandrel comprised of it can be made adequately radially compliant by choice of its geometric shape, as described above. A secondary benefit of utilizing a shape disposed to provide large dimensional changes under moderate loads is that there are diverse options for material, because the geometry contributes to the flexibility.

[0044] Numerous other thermoplastics could be used, notably high density polyethylene (HDPE) or polypropylene (PP), known for their low density, flexibility, and extreme toughness. Though common grades are inferior to rigid PVC regarding creep resistance and stress relaxation, grades with better resistance to creep and stress relaxation may perhaps be found or compounded. Alternatively, or additionally, the time the mandrel resides in the cores before use can be minimized. Furthermore, a device can mechanically expand the mandrels back to their original size following extraction, before reuse.

Description of the method and apparatus for cutting unitary cores into segments and loading them onto flexible mandrels

[0045] Such an apparatus, denoted overall by 10 in Figures 1 to 6, comprises a first processing station 12 and a second processing station 14 placed in line and suitable for performing the loading and the moving of a central core of a certain length (for example 280 cm) to be cut into portions or segments of core of predetermined length, for example, to 100 mm, (the segments being of equal or variable length), a coupling of the core segments with a mandrel for support of said core segments and the movement of said assembly (core segments and mandrel) to the devices arranged downstream of the apparatus 10, in particular, a rewinder with surface winding for the production of logs, a saw machine for cutting the logs into rolls, etc.

[0046] More particularly, a core 16, typically defined by a tubular element with longitudinal development and made in cardboard or paperboard, is loaded in the first processing station 12 and moved by means of a conveyor belt 18 subtended between two opposite shoulders 19 of the support structure or frame of the first processing station 12 and driven by a conventional electric motor 17 (Fig. 6), in the direction of the second processing station 14.

[0047] The second processing station 14 defines a station for cutting and moving of the core 16 and is provided with a rotating turret 20 with three processing positions and developed longitudinally between two opposite ends or shoulders 21 of the frame or support structure of said second station 14 (the longitudinal development of said rotating turret is chosen as a function of the length of the cores 16).

[0048] The turret 20, schematized in detail in Figure 5, driven in rotation with respect to its longitudinal axis by means of a commonly known electric actuator or motor, comprises a first position 22 or loading position in which the core 16, coming from the first processing station 12 by means of the conveyor belt 18, is fitted on a support shaft 23 (shown in the diagram of Figure 11) suitable for supporting said core 16 during its movement in the second processing station 14 by means of the rotation of the turret 20 (in the direction indicated by the arrow X in Figure 5), a second position 24 or cutting position at which the core 16 is subjected to an action of transverse cutting (as detailed below) suitable for forming a plurality of segments or portions of core 16', and a third position 26 or position of unloading of the portions of core 16' in the direction of the first processing station 12.

[0049] The second position 24 or cutting position comprises a plurality of cutting heads 25 restrained with respect to a cross member 15 fixed between the opposite shoulders 21 of the frame of the second processing station 14 and arranged parallel to, and typically, though not necessarily, equidistant one from the other; the number and the distance between the single cutting heads are selected as a function of the number and of the longitudinal extension of the portions of core which are to be made.

[0050] Said cutting heads 25 comprise a blade or cutting disc 25' actuated to move towards/away with respect to the central core 16 to be subjected to cutting action by means of a pneumatic drive defined, typically, by a pneumatic actuator or cylinder 27 coupled to the single cutting head 25, the cutting heads 25 co-operate with counter-heads 25" fixed to the turret 20 at the cutting position and driven in rotation in order to impose the rotation of the core 16 with respect to its axis to create a circumferential cutting of the same.

[0051] At the third position 26 of the turret 20, the core

16 cut into the plurality of portions or segments of core 16' is moved in the direction of the first processing station 12 to be fitted on a mandrel 30, whose features were described previously in detail, by means of a device also detailed below with reference to its technical-functional features.

[0052] Said mandrel has the function of supporting and maintaining in position the core portions 16' of the core 16 during subsequent processing steps that provide, for example, for the winding of the reel of paper on said portions of cores.

[0053] The external diameter of said mandrel 30 is greater with respect to the internal diameter of the core 16, so that the coupling between said mandrel and the core 16 takes place through interference and, in particular, on the coupling between said mandrel 30 and said core 16 divided into the plurality of core portions 16', the radial force exerted by the elastic return of the mandrel determines an action of pressure on the internal side surface of each core portion 16' so as to prevent any possible axial displacement of the same portions of core.

[0054] Furthermore, the features of elastic return of the material constituting the mandrel and the resulting radial force exerted by the same on the core portions 16' are selected taking account of the coefficient of friction between the material of the mandrel and the core portions so as to allow, also, the extraction of said mandrel from said core portions at the end of the production cycle, for return and reuse of the mandrel.

[0055] The coupling between the core 16 divided into the plurality of portions of core 16' following the step of cutting carried out in the second position or cutting position 24 of the rotating turret 20 of the second processing station 14 and the elastic mandrel 30 takes place at the first processing station 12 as shown schematically in Figures 11 and 12 and detailed here below.

[0056] For this purpose, the first processing station 12 of the apparatus 10 for the production of split cores is provided with a section of coupling between the elastic mandrel 30 and the portions of core 16' of the central core 16 that comprises a conveyor 40, longitudinally placed between the opposite shoulders 19 of said first processing station 12 and parallel to the conveyor belt 18 which, as previously described, has the function of moving the still intact core 16 to the second processing station 14 for carrying out the cutting operation.

[0057] The conveyor 40 comprises two superimposed motorized conveyors, respectively, an upper motorized belt 40' and a lower motorized belt 40" each provided with elements or inserts in rubber 41 for the function hereinafter detailed.

[0058] The upper motorized belt 40' is fixed with respect to the frame of the first processing station 12, while the lower motorized belt 40" cyclically moves towards/away relative-to the upper motorized belt. It moves down and away to allow discharge of a completed mandrel and core segments assembly, and remains down to allow entry of a bare mandrel for the next loading cycle. It moves back up to cooperate with the upper motorized belt for the next loading sequence.

[0059] The moving of said lower conveyor belt 40" towards/away with respect to the upper conveyor belt 40' is realized by means of an articulated quadrilateral mechanism 42 (Fig. 3) actuated, for example, by means of pneumatic or hydraulic actuators 44 or in accordance with another known movement mode suitable for the purpose.

[0060] The first processing station 12, moreover, at the conveyor 40, comprises a linear actuator 46 fixed to the frame or support structure of said first processing station, suitable for axially aligning and imposing a translation in axial direction of the mandrel 30 with respect to the core 16 divided into portions of core 16' (as detailed below).

[0061] The second processing station 14, at the third position 26 and in the direction of the first processing station 12 (in the vicinity of the shoulder 21 turned in the direction of the adjacent shoulder 19 of the first processing station 12) is provided with a wheel or roller motor 50 having the function of sliding the split core 16 along the support shaft 23 and of moving it in the direction of the first processing station 12.

[0062] Furthermore, the same second processing station 14, again at the third processing position 26, comprises a pusher 49, defined by a linear actuator suitable for moving in a linear axial direction the core 16 divided into portions of core 16' as hereinafter described.

[0063] In an intermediate position between the conveyor 40 and the support shaft 23 on which the core portions 16' of the core 16 are fitted, are arranged two opposite wings 47, defining a funnel and having the function of defining the elements of deformation for the mandrel 30 and of access for the mounting of the core portions 16' on said same mandrel, as detailed below with reference to Figures 11A to 11C.

[0064] The elements or inserts in rubber 41 of the upper 40' and lower 40" conveyor belts co-operate with the motor roller 50 to embrace the core portions 16' of the core 16 and move them to fit them on the mandrel 30; in particular, the motor roller 50 moves said core portions 16' in the direction of the conveyor 40 and the rubber inserts 41 wind and embrace the portions of core 16', taking them from the shaft support 23 and fit them equidistant one from the other on the mandrel, or adjacent to each other on the mandrel, which, as previously detailed, is elastically deformed.

[0065] Moreover, taking into account the fact that the mandrel 30 has an external diameter greater than the internal diameter of the core portions 16', the upper 40' and lower 40" conveyors belts by means of the inserts in rubber 41 move said portions of core 16' taken from the support shaft 23, arranging them along the entire length of the same mandrel as shown schematically in Figure 9, in the case of this illustration with uniform gaps between the core segments.

[0066] More particularly, the linear actuator 46 imposes a linear translation of the mandrel 30 (as indicated by

the arrow Z in Figure 11A) forcing the passage thereof between the opposite wings 47 which, being arranged in a funnel, impose an elastic deformation in the radial direction of an end portion of the mandrel which takes on, consequently, a smaller external diameter with respect to the internal diameter of the portions of core 16' and, in this way, a core portion 16' placed at a vertex of the support shaft 23, through the rotation of the motor roller 50 and the action of thrust of the pusher 49, is fitted on the mandrel 30 (Figure 11A).

[0067] Taking account of the fact that the individual portions of core have an internal diameter smaller than the external diameter of the mandrel 30, the coupling between a first core portion 16' and an end portion of the mandrel forces said mandrel to maintain a deformed shape ready to accommodate the subsequent portions of core which, in order to be fitted on the mandrel 30, no longer require the use of the opposite wings 47 which, consequently, are decoupled with respect to the mandrel and moved away one from the other.

[0068] The thrust action of the pusher 49 in the direction of the linear actuator 46, as indicated by the arrow K in Figure 11B, imposes an axial sliding of the portions of core 16' arranged at the end of the first core portion 16' fitted on the mandrel 30 in accordance with what is detailed above, with said portions of core 16' which, due to the thrust of said pusher 49 and the rotation of the motor roller 50 and the action of the rubber inserts 41 of the conveyor belts 40' and 40" of the conveyor 40, are progressively fitted on the mandrel 30.

[0069] During this phase the linear actuator 46 carries out an end of travel action for the cores that are fitted on the mandrel by the thrust action of the pusher 49 in cooperation with the motor roller 50 and the rubber inserts 41.

[0070] Once all the portions of core have been loaded on the mandrel 30, the pusher 49 recedes (in the direction indicated by the arrow K' in Figure 11C) and likewise the linear actuator 46 recedes (in the direction indicated by the arrow Z' in Figure 11C) with the mandrel on which are fitted the portions of core that recedes due to the action of the rubber inserts 41 actuated by the rotation of the upper and lower conveyor belts of the conveyor 40.

[0071] The operation of the apparatus for the production of split cores with a flexible mandrel in a surface winder in accordance with the method of the invention is explained here below.

[0072] With reference to the diagram of Figure 13, the cores 16 coming from a core supply (block 54) are moved by means of a conveyor (block 56) in the direction of the apparatus 10 where they are loaded into the first processing station 12 (block 58) and translated to the second processing station 14 where they are loaded onto the rotating turret 20 in which, as previously detailed, the cutting is performed of the core 16 into the plurality of portions of cores 16' and, subsequently, the core portions 16' of the core 16 are fitted on the mandrel 30 (block 60), at the first processing station 12 with said mandrels coming from an extraction unit (block 62) and conducted back to the apparatus 10 by means of a conveyor (block 64). Assembled units, defined by the portions of core 16' of the core 16 and by the mandrel 30, are conducted from the apparatus 10 by means of a conveyor (block 66) to an accumulation or storage unit (block 68) from where they are conducted in a manner known to persons skilled in the art to the rewinder for winding of logs.

[0073] The processing steps detailed above are carried out in masked time; in fact, while, for example, portions of cores 16' obtained from a core 16 are fitted on a mandrel 30, at the same time a further core 16 is located at the second position of the rotating turret 20 for the cutting phase and, at the same time, a new and further core is loaded from the first processing station 12 to the first processing position of the rotating turret of the second processing station.

[0074] Once a log of sheet material is produced by the rewinder, the flexible mandrel 30 is extracted, as described, for example, in U.S. Patent Publication No. 2014/0084102 A1 the content of which is incorporated herein by reference. Subsequently this log is cut into rolls as described, for example, in EP 1669310 the content of which is also incorporated herein by reference.

[0075] In this way rolls 90 or 90' (Figs. 10A and 10B) are obtained, defined by sheet material 92 wound with respect to an internal core cut into two core segments 16 and 16'. In Fig. 10A the core segments 16 and 16' spaced apart along the axis of the roll, leaving an intermediate or central part empty, i.e., without a core segment. In Fig. 10B the core segments 16 and 16' are adjacent each other.

[0076] Figures 21-23 illustrate a flexible mandrel 30 of the invention and core segments 16 which are supported by a relatively rigid mandrel 92 of a conventional center rewinder or turret rewinder as previously described. The relatively rigid mandrel 92 supports and rotationally drives the flexible mandrel 30 and core segments 16 while a web of paper is wound over the core segments to form a roll.

[0077] As can be seen from the foregoing, there are obvious advantages achieved by the method and the apparatus for the production of rolls with split cores on a flexible mandrel in a surface winder according to the present invention.

[0078] As stated previously, thanks to the use of a flexible mandrel, split cores can advantageously be made, processed in a surface or central rewinder device suitable for forming rolls of paper which, once the elastic mandrel has been extracted and the log is cut into rolls, are provided with a central core formed by two portions of core separated or conveniently adjacent so as to economize the use of material and make the fall and collection of the cores at the time of exhaustion of the paper roll easier; in fact the rolls of paper are placed in appropriate containers or dispensers and, when they are exhausted, the core formed by two separate portions falls into a special collector or dispenser element, making the operations of

roll replacement faster and easier.

[0079] A further advantage of the method and of the apparatus of the invention is represented by the fact of allowing a reduction in waste material at the end of the production cycle, with a consequent reduction in the related costs of production.

[0080] Additionally advantageous is the fact that the method of the invention allows an optimization and reduction of cycle times with a consequent reduction in the associated costs.

[0081] A further advantage is represented by the use of a flexible mandrel on which are fitted the portions of core and which allows the moving of said portions of core for the different steps of processing avoiding the axial displacement of the same which is a potential cause of material waste at the end of the cycle.

[0082] Additionally advantageous is the fact that the apparatus of the method of the invention, being provided with a rotating turret, allows processing in masked time functional to a reduction in cycle times and, consequently, in the related costs.

[0083] The apparatus of the invention has features according to the following paragraphs:

1. An apparatus for the production of rolls of sheet material with split cores on a flexible mandrel in a winding machine, comprising:

- a first processing station and a second processing station longitudinally developed and arranged in line, with said first processing station comprising means for feeding of the cores to the second processing station , the second processing station comprising means for moving and cutting in masked time of said core into portions of core , with said first processing station and second processing station comprising, likewise, co-operating means of coupling between a flexible mandrel placed in said first processing station and the core portions of the core to form an assembly wherein said portions of core are arranged on said flexible mandrel;
- means for feeding said assembly to a winding machine for the production of a log;
- means for extracting of the flexible mandrel from the log;
- means for cutting the log into rolls.

2. The apparatus according to paragraph 1, wherein said means for feeding of the cores to the second processing station are defined by a conveyor belt subtended between two opposite shoulders of the support structure or frame of the first processing station.

3. The apparatus according to paragraph 1, wherein the means of moving and cutting in masked time comprise a turret rotating with respect to a longitudinal axis, arranged between two ends or opposite shoulders of the frame or support structure of said second processing station and comprising three positions of processing defined by a first position suitable for loading the central core coming from the first processing station with said core fitted on a support shaft, a second position or cutting position suitable for performing cutting of the core into portions of core and a third position or position of unloading for the moving of the portions of core in the direction of the first processing station.

4. The apparatus according to paragraph 3, wherein the second position or cutting position of the turret comprises a plurality of cutting heads restrained with respect to a cross member fixed between the opposite shoulders of the frame of the second processing station and arranged parallel to and equidistant one from the other.

5. The apparatus according to paragraph 3, wherein the means of coupling between the mandrel and the core portions of the core comprise a conveyor assembly longitudinally arranged between the opposite shoulders of the first processing station, a motor roller or wheel fixed to the second processing station, with said conveyor and motor roller co-operating to translate and extract the portions of core from the support shaft at the third processing position of the rotating turret and fit them equally distanced one from the other on the mandrel and, further, a means of linear actuation fixed to the frame or support structure of said first processing station and suitable for aligning axially the mandrel with respect to the core divided into portions of core.

6. The apparatus according to paragraph 5, wherein the conveyor assembly comprises two superimposed motorized belts, respectively, an upper motorized belt and a lower motorized belt, the upper conveyor belt fixed with respect to the frame of the first processing station and the lower motorized belt movable towards/away relatively to the upper motorized belt, each of said upper and lower conveyor belts being provided with elements or inserts in rubber suitable for embracing the core portions of the core winding them and taking them from the support shaft and to fit them on the mandrel placed in intermediate position between said upper conveyor belt and lower conveyor belt.

7. The apparatus according to paragraph 5, wherein said means of cutting of the log are suitable for cutting on the middle lines of the core portions in such a way as to obtain rolls having a split core with an empty central part.

8. The apparatus according to paragraph 1, wherein said flexible mandrel is made in polymeric material and has a substantially tubular development with an opening longitudinally developed for the entire length of the mandrel to define a "C" shape with an external diameter greater with respect to the internal diameter of the core.

9. The apparatus according to paragraph 1, wherein the flexible mandrel has a closed section, substantially circular.
10. The apparatus according to paragraph 1, wherein the mandrel has a section profile of the star type with three or more points.
11. The apparatus according to paragraph 1, wherein the flexible mandrel is made in two different materials to define, respectively, a rigid internal casing with support function and made in steel, aluminum or composite material and an external casing made of plastic material of the polyurethane type or similar foam material with the function of performing an action of pressure suitable for avoiding axial displacements of the core portions of the core.

[0084] Although the invention has been described above with particular reference to one of its embodiments and operation, numerous modifications and variations will be apparent to a person skilled in the art in light of the above description. The present invention aims, therefore, to embrace all modifications and variations that fall within the scope of the following claims.

Claims

1. A combination of an elongated flexible and elastic mandrel and a plurality of tubular core segments for use in a winding machine for winding a roll of sheet material over the core segments, said mandrel having an outer surface, said core segments being retained on the outer surface of the mandrel by elastic interference between the mandrel and the core segments.

2. The structure of claim 1 in which said mandrel is tubular.

3. The structure of claim 1 in which said mandrel is substantially tubular and is provided with a longitudinally extending opening which provides the mandrel with a generally C-shaped transverse cross section.

4. The structure of claim 3 in which the generally C-shaped cross section of the mandrel has a generally C-shaped wall, the thickness of the wall being greater adjacent said longitudinally extending opening.

5. The structure of claim 1 in which said mandrel is substantially tubular and is provided with a longitudinally extending split which provides a transverse cross section of the mandrel with a pair of end portions, the end portions overlapping.

6. The structure of claim 1 in which said mandrel has a generally star-shaped cross section which is provided by a plurality of curved flutes.

7. The structure of claim 1 in which said mandrel is substantially tubular and is formed by a coiled sheet having a pair of ends, the sheet being spirally wrapped so that the ends overlap other portions of the sheet.

8. The structure of claim 1 in which said mandrel has a generally tubular wall and a plurality of projections which extend outwardly from the wall and engage the core segments.

9. The structure of claim 1 in which the mandrel is formed from rigid PVC, or HDPE, or polypropylene.

10. A method for the production of rolls of sheet material with split cores on a flexible mandrel in a winding machine comprising the steps of:

    - providing tubular cores;
    - transversely cutting the cores to form portions of core;
    - feeding a flexible mandrel into the core portions;
    - coupling by elastic interference between said flexible mandrel and said core portions to form an assembly in which said core portions are arranged on said mandrel;
    - moving and feeding of said assembly to a winding machine to produce a log of sheet material;
    - extracting the flexible mandrel from the log; and
    - cutting the log into rolls.

11. The method according to claim 10 in which the core portions on the mandrel are adjacent to each other.

12. The method according to claim 10 in which the core portions on the mandrel are spaced apart.

13. The method according to claim 10, **characterized in that** the coupling between the mandrel and the core portions is performed by fitting said core portions on the mandrel along the entire longitudinal development of the mandrel by means of a relative flow of the core portions coaxially to the mandrel with said mandrel elastically deformed.

14. The method according to claim 10, **characterized in that** in the coupling between the mandrel and the core portions the radial force exerted by the elastic return of the mandrel determines an action of pressure on the internal side surface of the core portions suitable for preventing axial displacements of core portions.

15. The method according to claim 10, wherein the cutting of the log into rolls takes place by performing

the cut between core portions in such a way that each roll has spaced-apart core portions.

Fig. 1

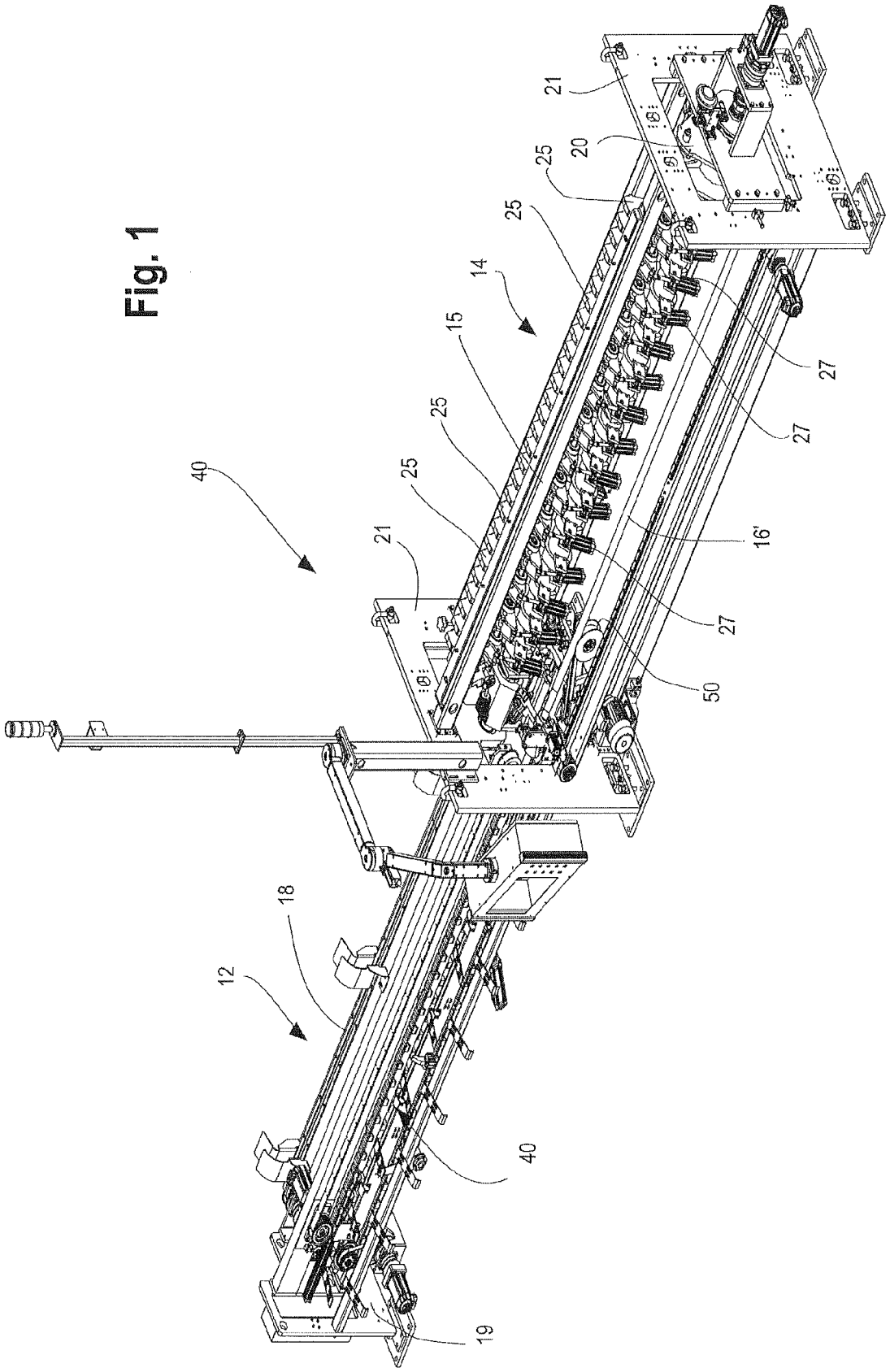
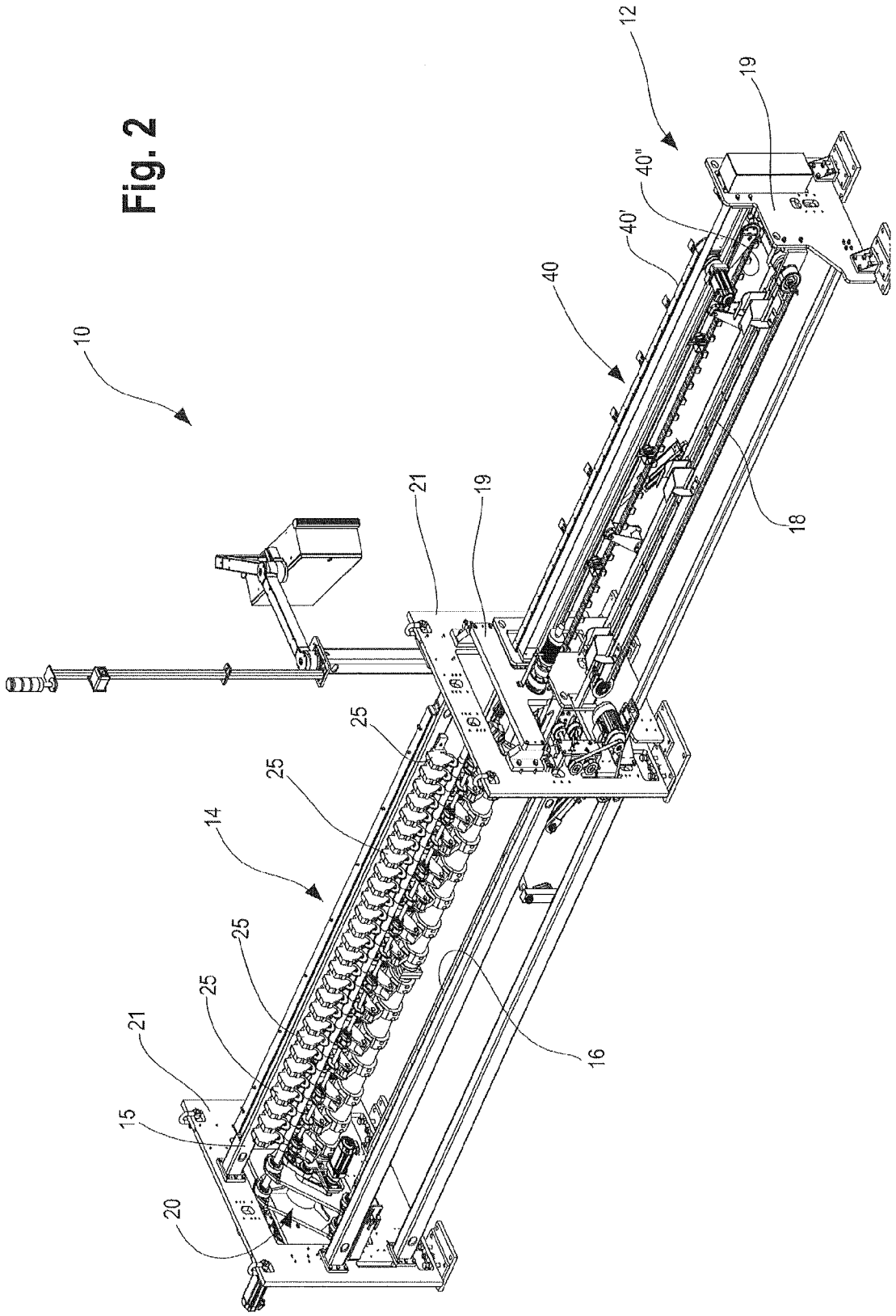


Fig. 2



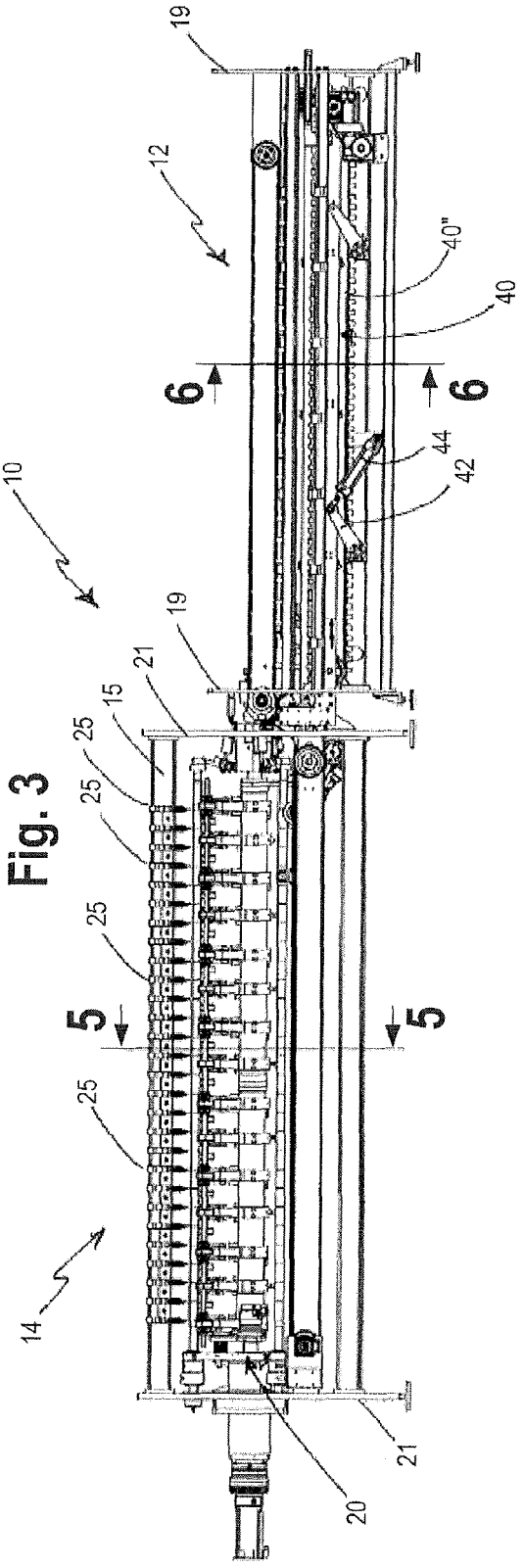

19
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40"
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20

Fig. 3

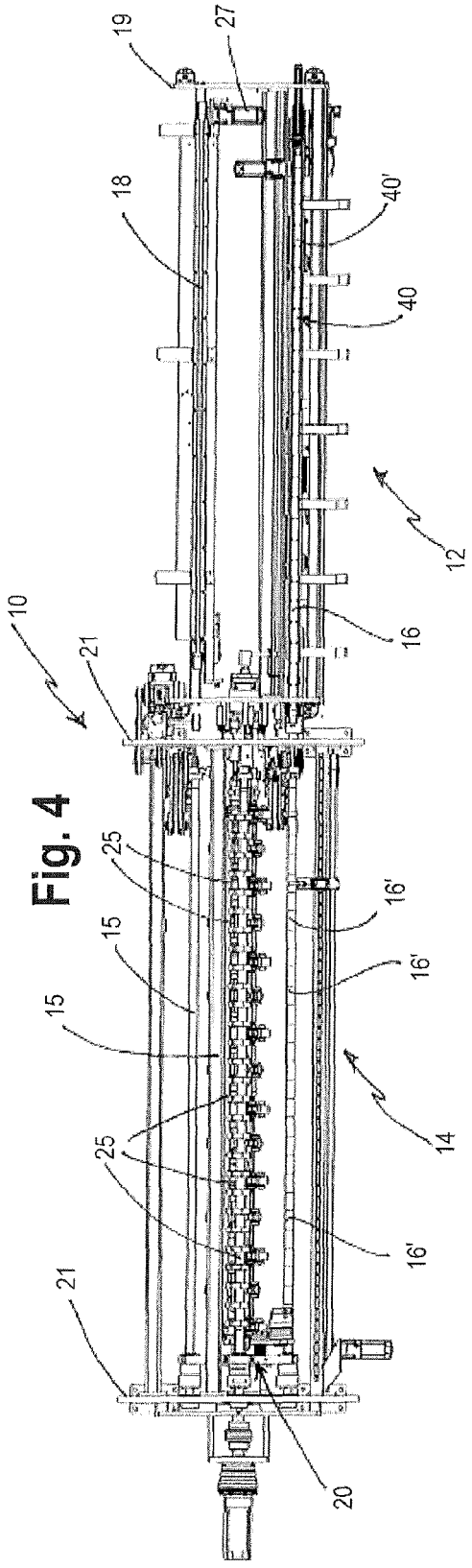

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18
40'
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16'
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16'
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Fig. 4

Fig. 5

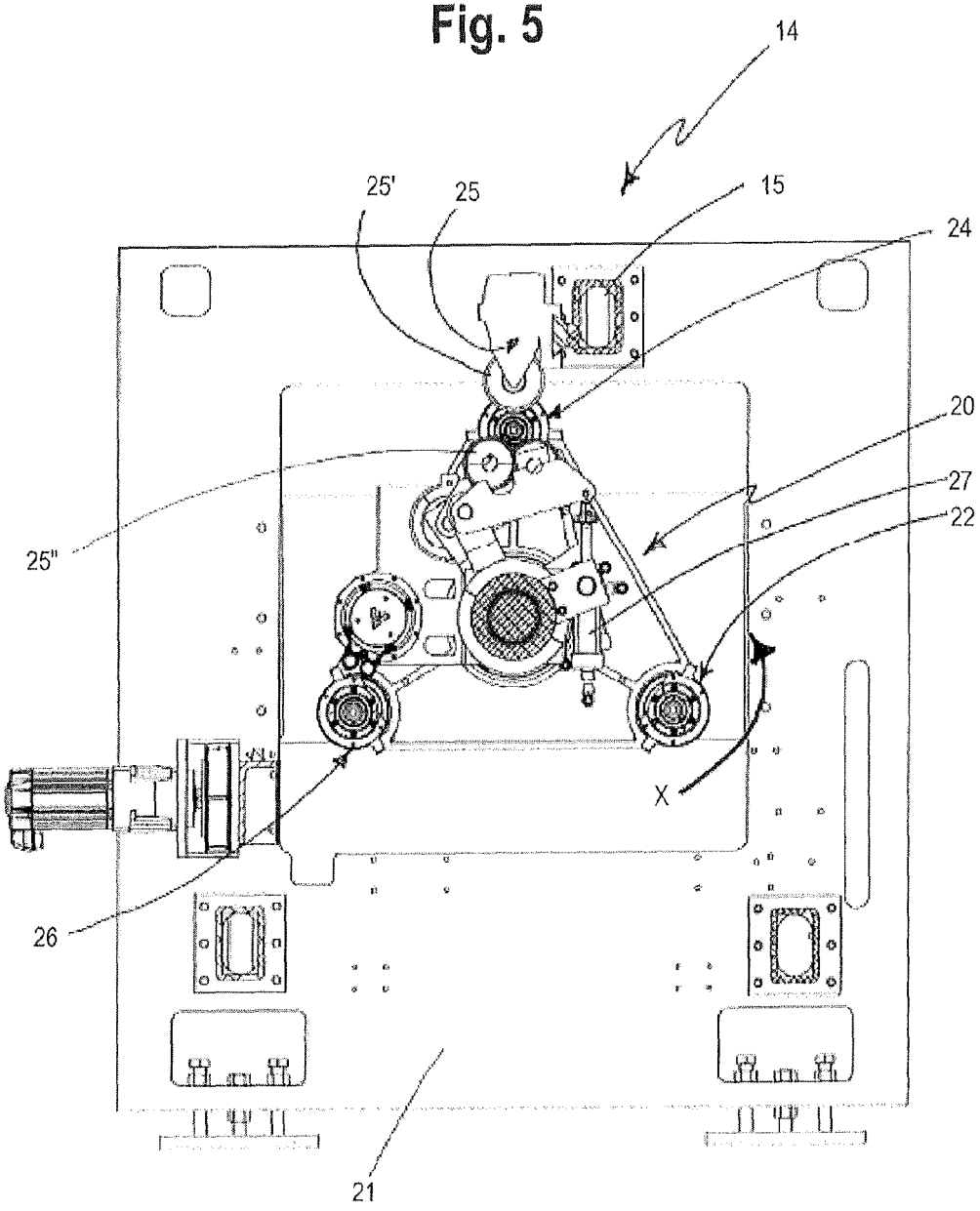


Fig. 6

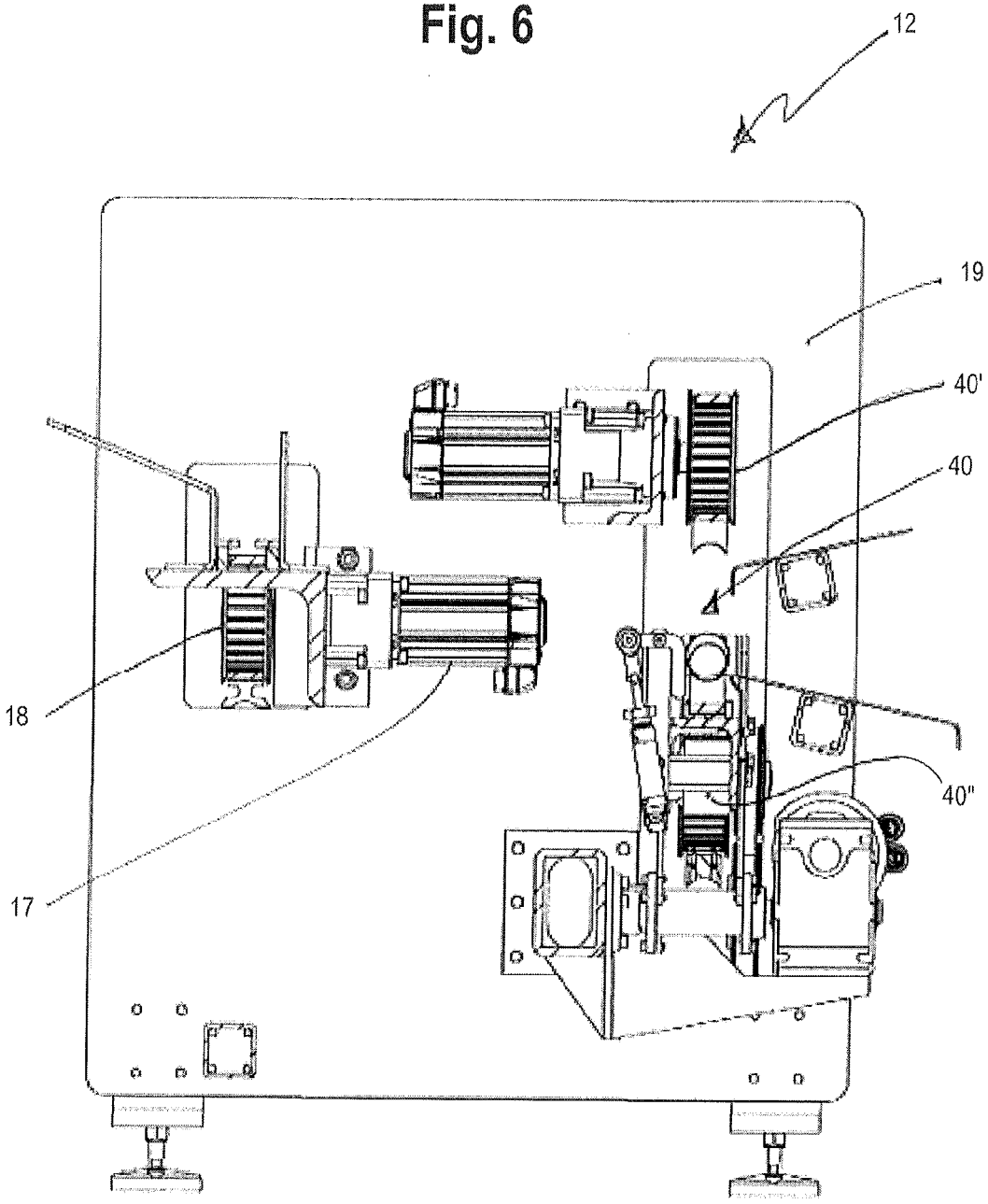


Fig. 7

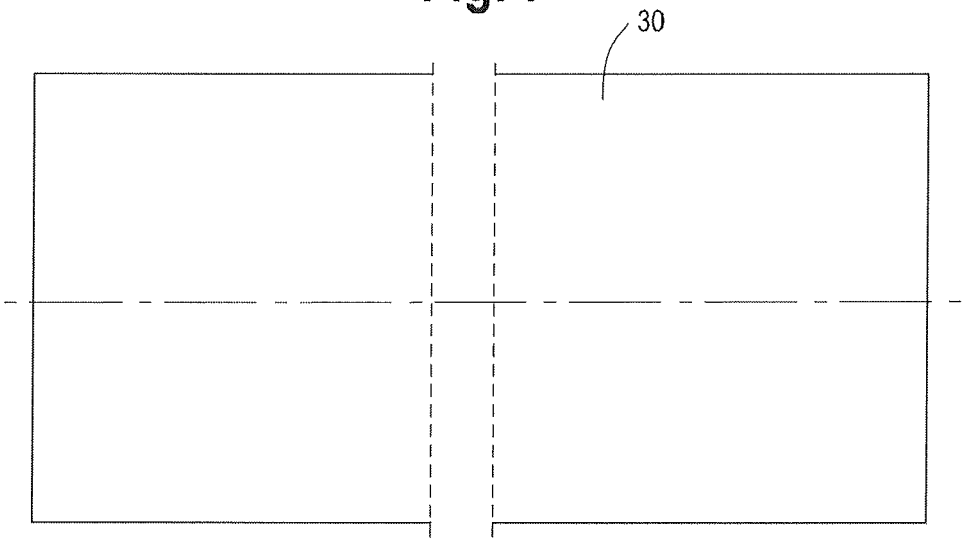


Fig. 8

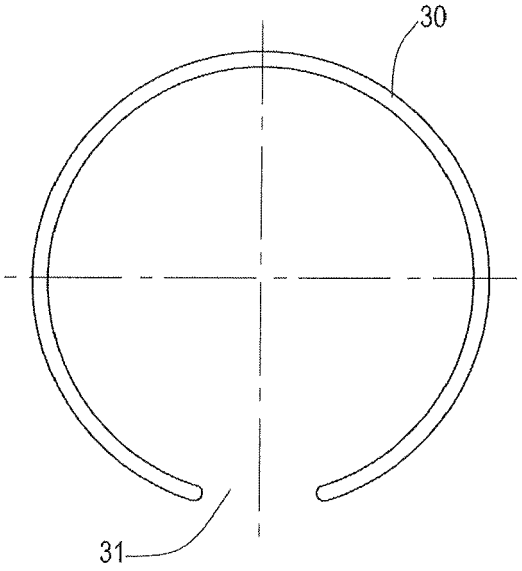


Fig. 9

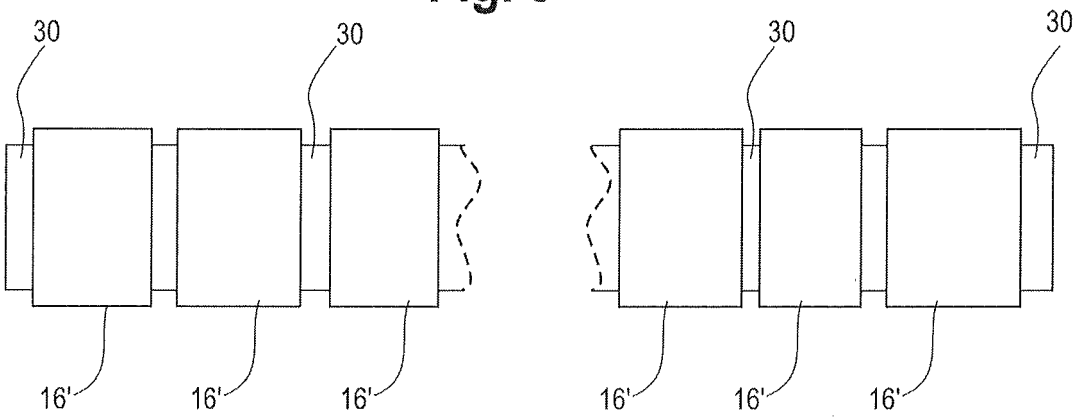


Fig. 10

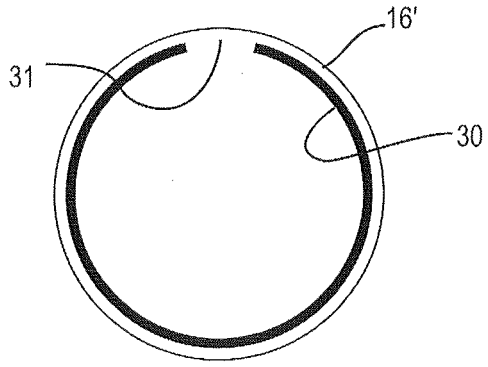


Fig. 10A

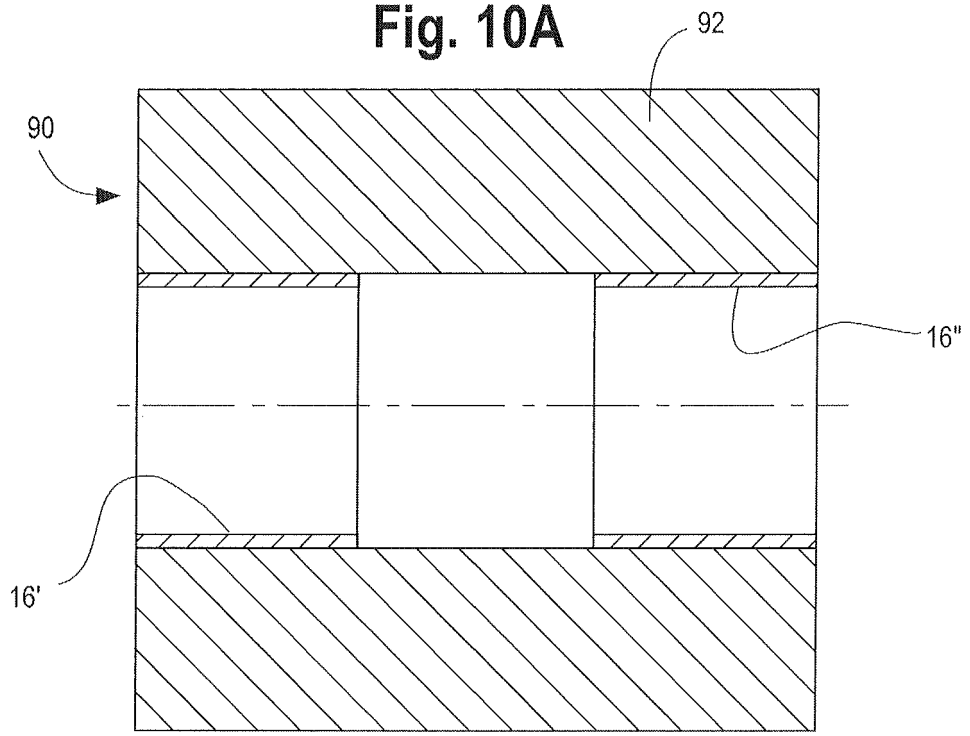
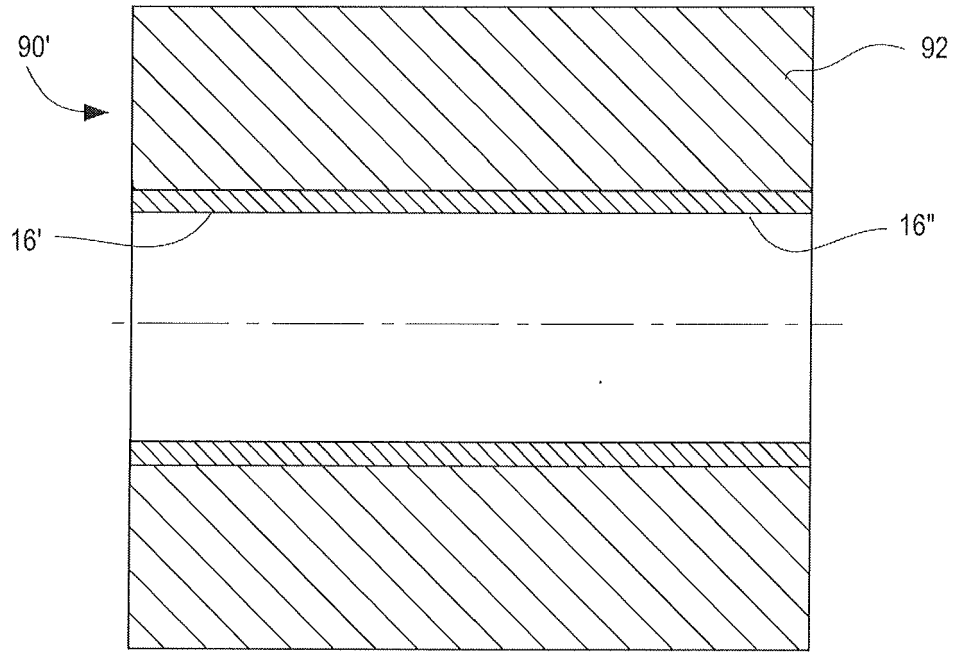


Fig. 10B



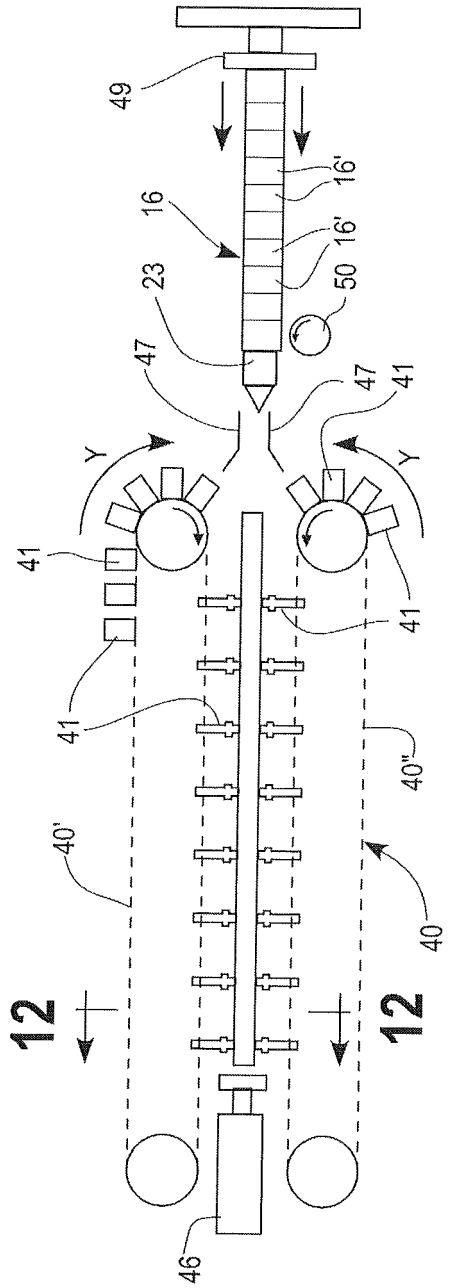


Fig. 11

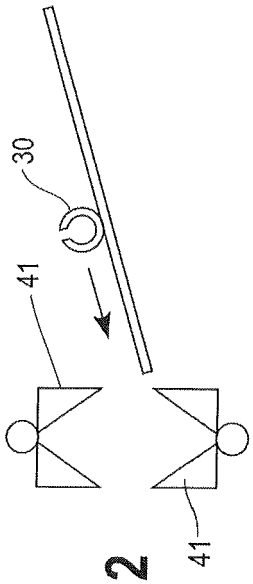


Fig. 12

Fig. 11A

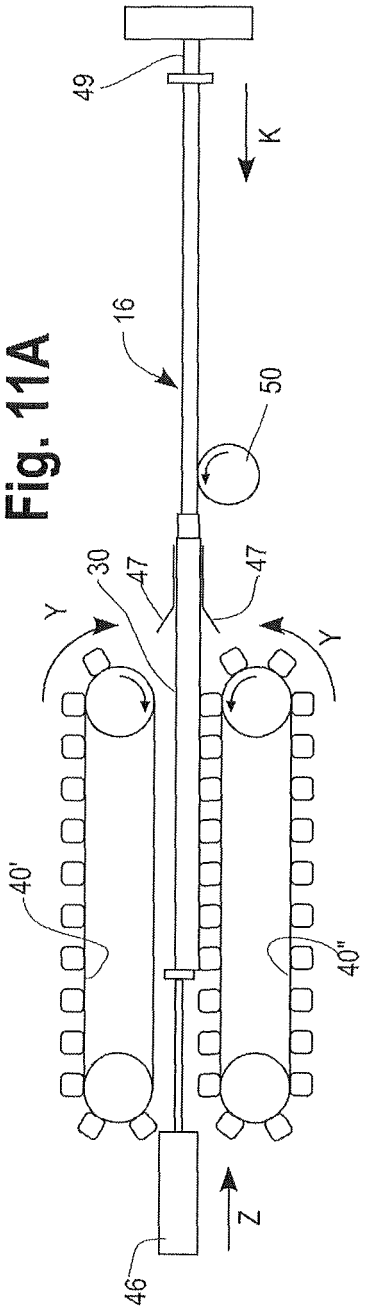


Fig. 11B

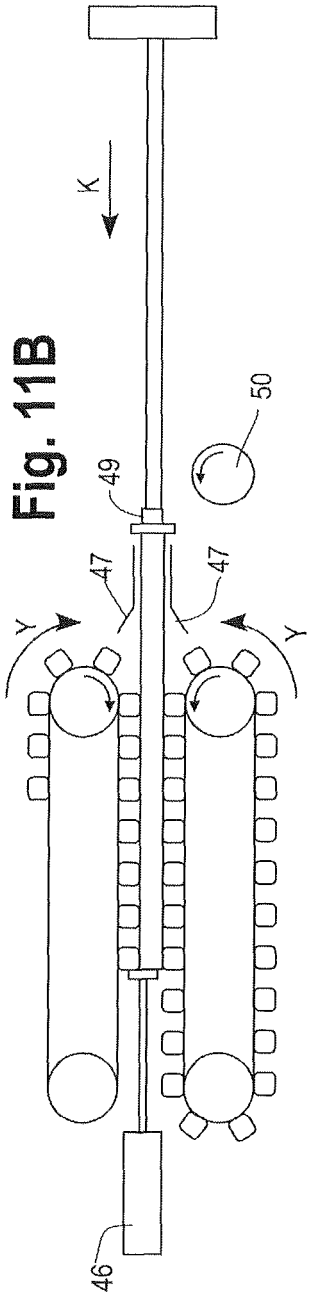


Fig. 11C

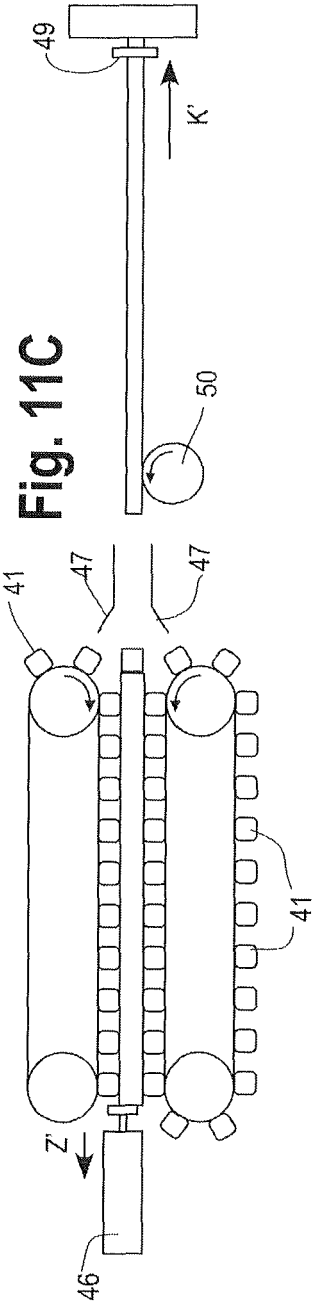
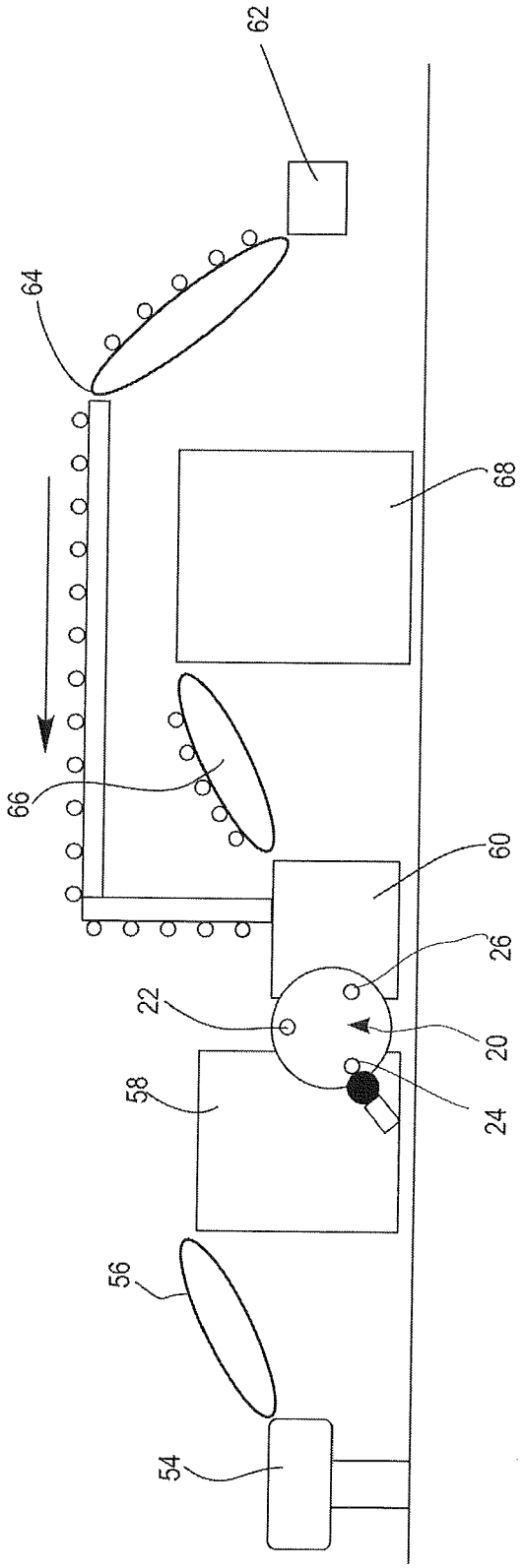


Fig. 13



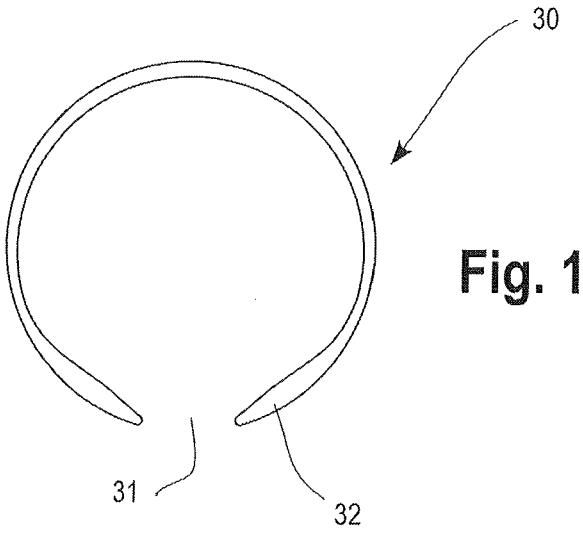


Fig. 14

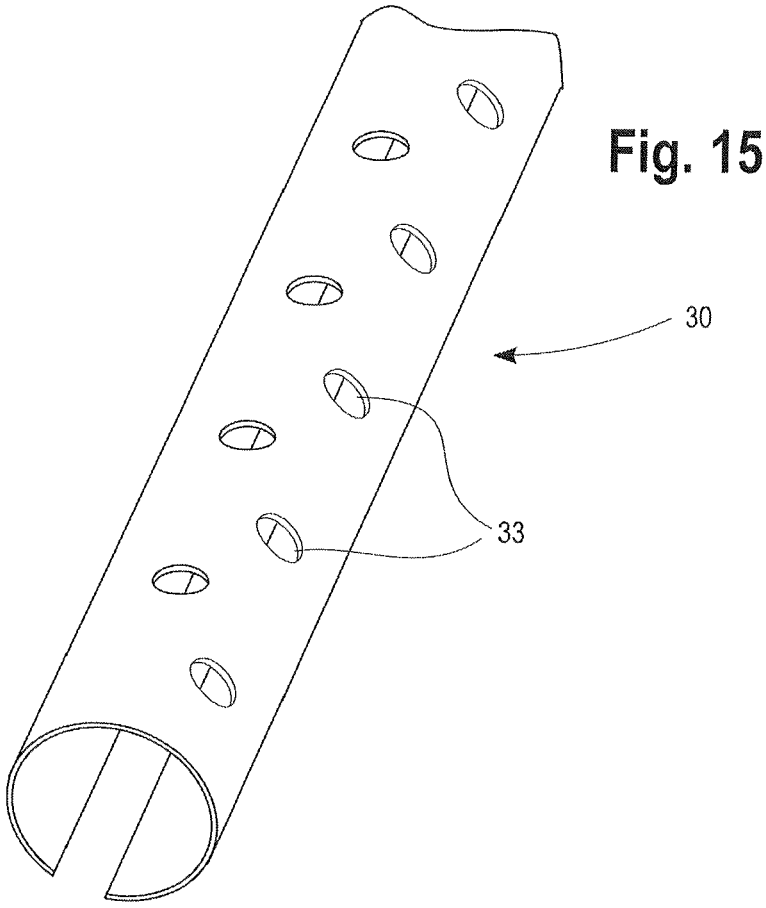


Fig. 15

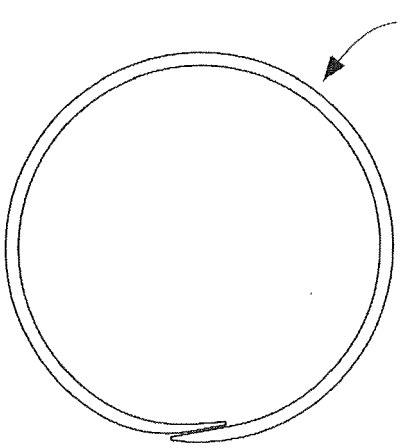


Fig. 16

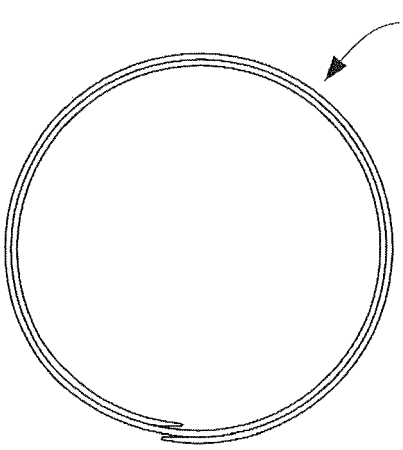


Fig. 17

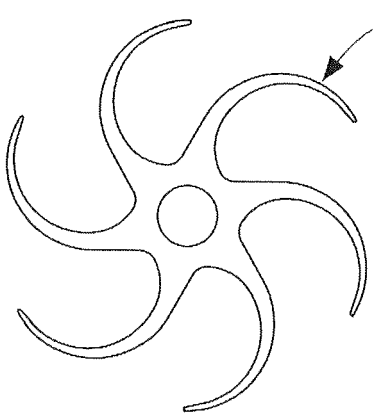


Fig. 18

Fig. 19

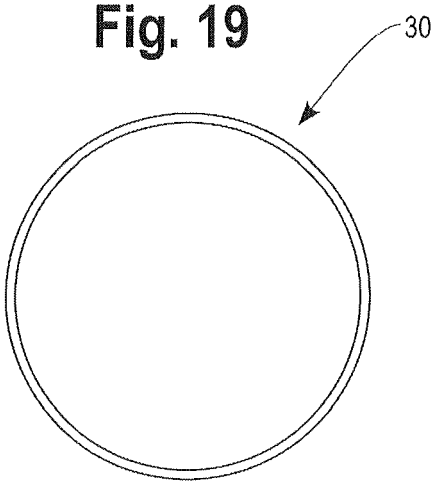


Fig. 20a

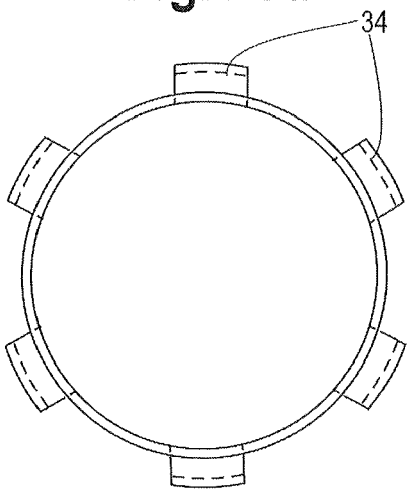


Fig. 20b

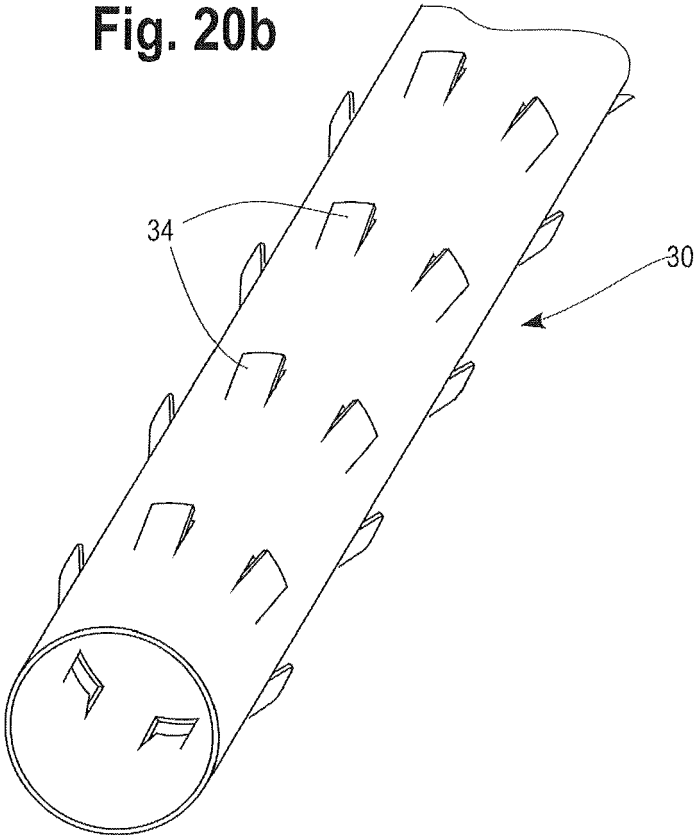


Fig. 21

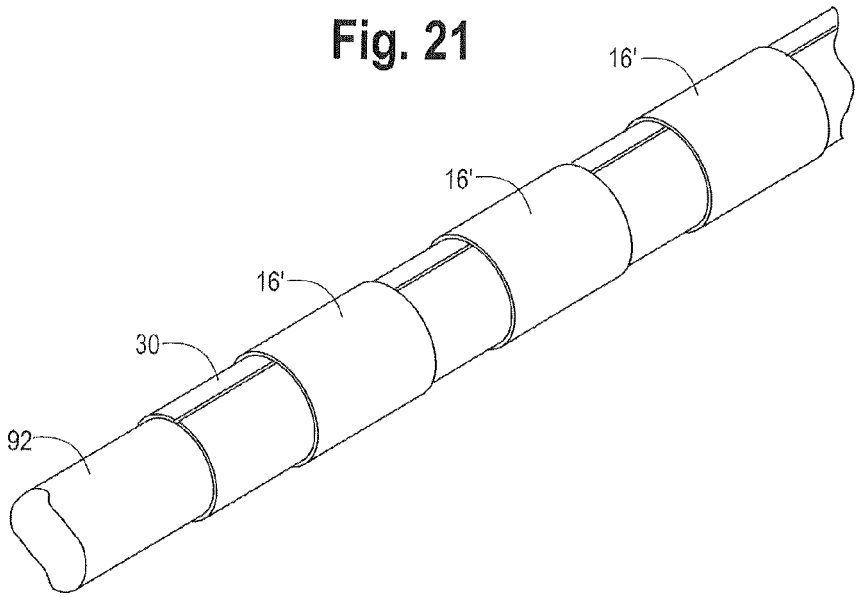


Fig. 22

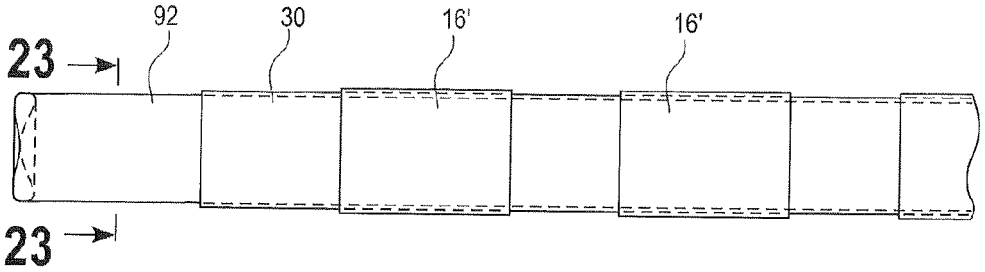
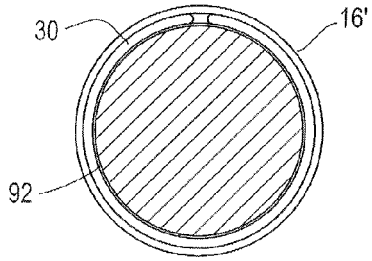


Fig. 23



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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 3154

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2009/004659 A1 (CELLI NONWOVENS SPA [IT]; ACCIARI GIUSEPPE [IT]) 8 January 2009 (2009-01-08)	1,2	INV. B65H75/24 B65H19/30
Y	* page 5, lines 16-24 * * page 7, lines 20-33 * * page 9, lines 17-19 * * page 12, line 14 - page 13, line 2 *	3-15	B65H19/22
Y	JP 2001 225998 A (SHIN NIPPON KASEI KK) 21 August 2001 (2001-08-21) * abstract; figures *	3,4,9	
Y	JP 2006 131344 A (BRIDGESTONE CORP) 25 May 2006 (2006-05-25) * figure 9 *	5,7	
Y	FR 2 904 816 A1 (TOKHEIM HOLDING BV [NL]) 15 February 2008 (2008-02-15) * page 5, lines 1-11; figures *	6	
Y	JP S64 43050 U (-) 15 March 1989 (1989-03-15) * figures *	8	TECHNICAL FIELDS SEARCHED (IPC) B65H
Y	JP H06 327584 A (ISHIZU SEISAKUSHO KK) 29 November 1994 (1994-11-29) * abstract; figures *	10-15	
X	WO 00/61480 A1 (CELLI SPA [IT]; ACCIARI GIUSEPPE [IT]) 19 October 2000 (2000-10-19) * page 9, lines 20-30 * * page 10, lines 3-6 * * page 13, lines 4-22 * * page 14, lines 8-12; figures *	1,2	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 August 2015	Lemmen, René

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 3154

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