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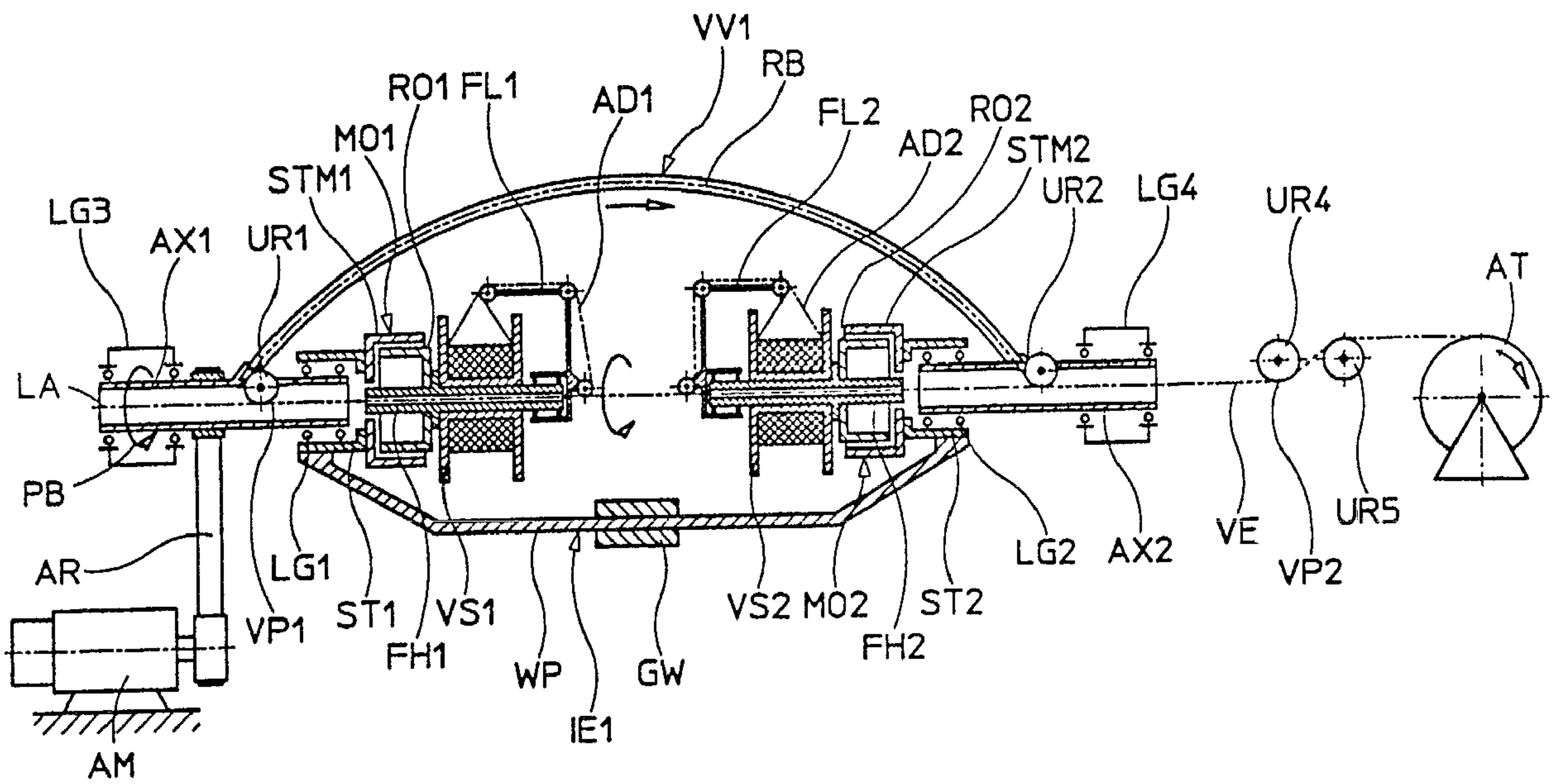
(54) Title: METHOD AND APPARATUS FOR LAYING UP ELECTRICAL AND/OR OPTICAL STRANDS



(57) Abrégé/Abstract:
The laying-up method works with a rotating bail (RB), the strands (AD1, AD2) being drawn off the supply spools (VS1, VS2) that are arranged within the space enclosed by the rotating bail (RB). The strands (AD1, AD2) are drawn off the supply spools (VS1, VS2) in such a way that they are laid up with little torsion.

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Abstract

A Method and Apparatus for Laying up Electrical and/or Optical Strands

The laying-up method works with a rotating bail (RB), the strands (AD1, AD2) being drawn off the supply spools (VS1, VS2) that are arranged within the space enclosed by the rotating bail (RB). The strands (AD1, AD2) are drawn off the supply spools (VS1, VS2) in such a way that they are laid up with little torsion.

Figure 1

A Method and Apparatus for Laying up Electrical and/or Optical Strands

The present invention relates to a method for laying up electrical and/or optical strands to form a laid-up unit; this apparatus incorporates a rotating bail to which the strands are fed, said strands being drawn off supply spools arranged within the space enclosed by the rotating bail.

A method of this kind is described in EP-B1 0 056 362. In this, the individual leads are drawn off a supply spool essentially tangentially and fed to a rotating bail, by which the conductors are laid up (bail lay-up). Bail-type laying-up machines of this kind are preferred for paired or quad lay-ups; each time the bail rotates through 360°, the pair or quad is rotated through two lays (2*360°), for which reason this method of laying-up is referred to as the "double-lay bail lay-up." An important disadvantage of bail layup is that the material being laid up is twisted together as it enters and as it leaves the bail, i.e., the individual strands are twisted together without any compensating twists. This can lead to variations in the pitch of the turns, and to restoring forces in the laid-up material. These restoring forces of the strands that have been twisted by the bail-type laying-up process act counter to the twist of the lay. If tensile stress is relaxed, or if there is twisting against the direction of the lay (for example, if the laid-up material is subsequently used to form the core of a cable), the restoring forces can cause the strands to be loosened from their tight twist so that a more or less large air space is formed between the strands. Because of the different spaces or air gaps, this leads to variations in the electrical characteristic impedance along the pair, which can lead to considerable difficulties, particularly in such cables as high-performance data cables or the like, which are meant to exhibit a high level of longitudinal homogeneity. In the case of this laying-up method, this can also result in variations in pitch because of twisting together [bunching], for example, in the event of fluctuations in the diameter of the leads and this, too, can affect the electrical properties of a cable that has been laid up in this way. In addition, the smallest differences in the symmetry of the individual strands (e.g., insulated leads that are off-centre) or dielectric values or the like that are distributed unequally in azimuth because of the line of contact of the strands that remains constant during twisting can accumulate and interfere with the electromagnetic wave passing through them. This means that the symmetry of the laid-up material produced in this way (e.g., a laid-up pair or quad) is interfered with to a very great extent. Such interference is manifested mainly as increased radiation of electromagnetic energy, by fluctuations in the characteristic impedance above the operating frequency, and by increased cable attenuation and cross-talk between the pairs of a cable core.

It is the task of the present invention to show how the properties of the laid-up product manufactured by the laying-up process can be improved. This problem has been solved by a method of the type described in the introduction hereto, in that the strands are drawn of the supply spool in such a way that they are rotated about their longitudinal axis, and in that the direction of this rotation is selected in the direction of the lay that is imparted to the strands by the laying-up process.

Because the strands are twisted in the same way, there is a reduction and, in some instances, widespread elimination of interference that is attributable to asymmetry in the cross section of the strands. Because of the fact that strands no longer touch each other on the identical, but rather on alternating lines of contact, radiation of electromagnetic energy is reduced, and fluctuations of line impedance are also lessened. The situation with respect to line attenuation and cross-talk can be greatly improved. Mechanical strains on the strands are similarly reduced by the counteracting twist (back twist) (in the case of partial back twist) or are eliminated entirely (in the case of complete back twist). This low-torsion layup is particularly important when optical strands, (e.g., fibre-optic leads, hollow leads, bundled leads, or the like) are laid up.

A broad aspect of the invention provides a method for laying up electrical and/or optical strands to form a laid-up unit, this incorporating a rotating bail to which the strands are delivered, the strands being drawn off supply spools that are arranged within the space enclosed by the rotating bail, characterized in that the supply spools are rotated; that the strands are drawn off the supply spools by overhead takeoff so that they are twisted about their longitudinal axis; and in that the direction of this twist is selected so as to be in the direction of the twist that is imparted to these strands by a laying-up process (back twist).

The present invention also relates to an apparatus for laying up electrical and/or optical strands to form a laid-up unit by using a rotating bail to which the strands are fed, said strands being drawn off supply spools arranged within the space enclosed by the rotating bail; this is characterized in that means by which the strands are twisted about their longitudinal axes as they are drawn off the supply spools are provided; the direction of this twist is selected so as to be identical to the twist that is imparted to the strands by the rotating bail as they are being laid up.

Another broad aspect of the invention provides an apparatus for laying up electrical and/or optical strands to form a laid-up unit, this incorporating a rotating bail to which the strands are delivered, the strands being drawn off supply spools that are arranged in inside the space enclosed by the rotating bail, characterized in that the supply spools are rotated; that the strands are drawn off the supply spools by overhead takeoff so that they are twisted about their longitudinal axis; and in that the direction of this twist is the same as the direction of the twist that is imparted to the strands by a laying-up process.

The present invention and developments to it are described below on the basis of the drawings appended hereto. These drawings show the following:

Figure 1: A first laying-up machine for implementing the method according to the present invention;

Figure 2: A second laying-up machine for implementing the method according to the present invention;

Figure 3: An arrangement of two supply spools;

Figure 4: An arrangement of four supply spools.

Figure 1 shows a laying-up machine VV1 That is secured in a frame or stand, (not shown herein). This machine incorporates two supply spools VS1 and VS2 for strands AD1, AD2 (shown by broken (..-) lines); these are to be stranded together to form a laid-up unit VE that is in the form of a bundle. These strands AD1 and AD2 can consist of separate, insulated electrical leads, from which a two-lead line (pair) can be made as laid-up element VE. It is also possible to use lead bundles that each consist of two electrical lines on the supply spools VS1 and VS2, so that when these are laid up, what is obtained as the finished laid-up element VE is a double bundle. Other combinations are possible. Finally, it is also possible for the strands AD1 and AD2 to be optical conductors, for example, hollow leads, bundle leads, separate fibre optics conductors, or the like.

Each of the supply spools VS1 and VS2 is flange-mounted onto a drive motor MO1 and MO2 that is provided with an access opening, or is connected thereto through a gear train. These drive motors MO1 and MO2 are mounted on the side that is remote from the supply spool VS2, VS2 with a tubular support ST1, ST2. The supports ST1 and ST2 are connected rigidly to each other by a yoke WP on which a weight GW is also mounted. The inner unit IE1 formed by the components described above is supported by bearings LG1 and LG2 located inside the supports ST1 and ST2, and these bearings are supported on hollow shafts AX1 and AX2. The elements that are connected by the yoke WP can make small swinging or compensating movements, although they are stabilized in their position by the weight GW together with the weight of the yoke WP. The group of components comprising the support ST1 or ST2, the motor MO1 or MO2 , and the supply spool VS1 or VS2 is aligned on the longitudinal axis LA. At their ends that are removed from the supply spools VS1 and VS2, the hollow shafts AX1 and AX2 are similarly supported, so as to be able to rotate, in bearing bushings LG3 and LG4; at least one of these shafts (in the present example, the shaft AX1) is driven by a drive motor AM, for example through a drive belt AR (e.g., a notched belt). A bail RB is attached rigidly to a hollow shafts AX1 and AX2 that are also tubular; this bail rotates about the longitudinal axis LA and thereby defines a space within which the components of the inner unit IE1 are arranged.

The strands AD1 and AD2 are taken off the supply spools VS1 and VS2 by a rotating stripper bail FL1 or FL2 (in the form of a flyer), respectively. The takeoff and the guidance of the strands can be configured, for example, as a takeoff cylinder. Because of the this takeoff process, a takeoff torsion is imparted to the strands AD1 and AD2, i.e., they are twisted once around their longitudinal axis for each periphery of the spool. The strands AD1 and AD2 pass through a guide sleeve FH1 that extends through the supply spool VS1 and the motor MO1 into the interior of the hollow shaft AX1.

The fixed outer parts (stators) STM1 and STM2 of the motors MO1 and MO2 are connected rigidly to the corresponding tubular support ST1 and ST2, respectively. The inner, rotating part (rotor) RO1 or RO2 of the motor MO1, MO2, respectively, has the guide tube FH1 or FH2, on which the supply spool VS1 or VS2 is rigidly mounted, as an axis of rotation. The guide tubes FH1 or FH2 are held so as to be able to rotate in bearings, not shown herein, in the stators STM1 and STM2. This means that the supply spools VS1 and VS2 are rotated about their longitudinal axis by the particular rotor RO1 or RO2, respectively; this means that the leads AD1 and AD2 that are drawn off are similarly twisted about their longitudinal axis. In addition to the takeoff torsion, a further turn is applied to the lead that is being drawn, depending on the speed of the motor.

The strands AD1 and AD2 move out of the hollow shaft AX1 to a guide roller UR1, from which they pass through an opening in the hollow shaft AX1 to the rotating bail RB. The guide roller UR1 forms a first twisting point VP1. This guide roller is connected rigidly to the shaft AX1 and rotates about its axis, the strands AD1 and AD2 that are to be laid up resting on its outside surface. The rotating bail RB carries the strands along on its rotating path, that thereby imparts a twist to them. The bail RB can be constructed in different ways, for instance in the form of a tube, the strands AD1 and AD2 running in the interior of this, or it can be in the form of a bail, when holding elements (eyelets, rollers, or the like) for the strands can be arranged along its length.

It is expedient that an additional guide roller UR2 be provided at the outlet from the rotating bail RB; this is supported so as to be able to rotate in the hollow shaft AX2. Because of this guide roller UR2, the strands AD1 and AD2 that have now been laid up to form a bundle are conducted through the hollow shaft AX2 in the direction of the longitudinal axis LA, at which point they leave the laying up machine and pass over additional transport and delivery systems (the drawing shows delivery rollers UR4 and UR5, although conveyor tracks or similar systems that provide for longitudinal movement can also be used) to a takeup drum AT. The entry of the laid up pair VE which is rotating about its longitudinal axis at the speed at which the bail is turning, into the torsion stop UR4 and UR5 forms an addition twisting point VP on the guide roller UR4, where the second part of this double twist is imparted to the previously laid up material VE. The strand VE can also be passed directly to the next processing step, e.g., to a subsequent bundle laying up machine.

The direction in which the bail RB rotates (indicated by the arrow PB) is the same as the direction of rotation PF that is imparted to the strands AD1 and AD1 in the area of the longitudinal axis LA by the rotation of the supply spools VS1 and VS2, and by the overhead takeoff. This means that during takeoff of the strands AD1 and AD2 from the rotating spools VS1 and VS2, these are subjected to twisting (torsion) according to PF, which is equal to the twist that is brought about by the rotating bail (as indicated by the arrow PB). This causes a "back twist" in the strands, which is to say that the residual torsion within the individual strands AD1 and AD2 in the finished strand VE is smaller than if the strands were to be moved to the bail RB without being twisted in the same direction on being taken off ahead of the supply spools VS1 and VS2.

As far as the back twisting itself is concerned, this can be either a partial back twist (i.e., some residual torsion remains in the strands), or it can be a complete back twist (i.e., either in fact or for all practical purposes, there is no torsion in the strands within the laid-up unit VE). The amount of back twist can be adjusted within a very wide range, depending on the ratio of the speed of rotation of the lead spools for the strands AD1 and AD2 to the speed of rotation of the bail RB. If, for example, the speed of rotation of the lead spools VS1 and VS2 for the strands AD1 and AD2 is selected so as to be equal to the speed of rotation of the bail RB, there will be a 100% back twist at the first twisting point VP1 (which is to say at the transition of the parallel leads to the rotating bail system at the entry point to the guide roller UR1. After being twisted together repeatedly, the laid-up unit VE that is obtained moves to the second twisting point VP at the guide roller UR4 that is fixed in the space (i.e., outside the laying-up frame). This means that the strand VE that is rotating about its longitudinal axis at the speed of rotation of the bail will have its back twist reduced to 50 per cent once it leaves the bail RB, because the previously laid-up material will be twisted together once again at that point.

A back-twist take-off can be designed as a space-saving overhead take off with a rotating lead spool, as is shown in Figure 1. If it is incorporated in a bail-type laying up machine, care must be taken that the rotation of the strands AD1, AD2 can be managed effectively, without changing direction, as far as the first twisting point VP1, i.e., the individual strands AD 1 and AD2 should, as far as possible, pass in a straight line to the first twisting point VP1 at the guide roller UR1.

The degree to which the leads are free of torsion depends on the speeds at which the supply spools VS1 and VS2 are rotating relative to the speed of rotation of the rotating bail RB, increased or reduced--depending on the direction of rotation--by the takeoff torsion imposed by the flyers FL1 and FL2 that are moved by the particular lead, and this freedom from tension can be adjusted by appropriate selection of the speeds of rotation. If the resulting speed of rotation of the takeoff device FL1, FL2 exceeds the speed of rotation of the rotating bail RB, this will result in over-compensation of the lead twist at the first twisting point VP1, which is only partially applied at this first twisting point and which is still present in the second twisting point VP after leaving the bail. In the ideal case, i.e., if there is a pre-twist of 200 per cent in the area of the twisting point VP1 (since this twist is reduced by about one-half by the action of the laying up bail RB), there will be a resulting back twist of 100 per cent at the output, i.e., after twisting point VP, i.e., the mechanical tensions in the laid-up element VE are zero, for all practical purposes, or at least minimal. This method requires strands that are of such material, e.g., steel, plastic, for the bundle leads or fibre-optic lines, as can retain the pre-twist that is applied to them elastically as they pass through the bail. Should they undergo any plastic deformation, there will be a plastic reformation at the second twisting point, and the resulting back-twist will be reduced.

As has been described above, a back-twist take-off can be designed as a space-saving overhead take off with a rotating lead spool VS1, VS2, as is shown in Figure 1. If it is incorporated into a bail-type laying-up machine VV1, care must be taken to ensure that the lead can be twisted as far as the first twisting point VP1, i.e., as has been discussed above, after it has been taken off by the flyer FL1, the lead should track in a straight line as far as this twisting point VP1, since any guide rollers could act as torsion blocks and cause plastic pre-torsion of the particular element AD1 and AD2. As a rule, this will result in unfavourable electrical properties in the particular strand VE. If there are not any changes in the direction of the rotating elements AD1 and AD2, this can be formed in a particularly advantageous manner with the coaxial structure shown in Figure 1, wherein the supply spools VS1 and VS2 for the cable material are aligned with each other. The leads are twisted for the first time after leaving the guide rollers of the flyers FL1 and FL2, i.e., as they make the transition from the spinning take-off system to the relatively static rotating system.

The following examples of rotational speeds and the back-twist that results from each of these are quoted in order to further clarify the present invention:

1.)

Speed of rotation of the flyers FL1, FL2: $100\ min^{-1}$

Speed of rotation of the rotating bail RB $100\ min^{-1}$

Back twist 50 %

2.)

Speed of rotation of the flyers FL1, FL2: $200\ min^{-1}$

Speed of rotation of the rotating bail RB $100\ min^{-1}$

Back twist 100 %

3.)

Speed of rotation of the flyers FL1, FL2: $100\ min^{-1}$

Speed of rotation of the rotating bail RB $250\ min^{-1}$

Back twist 20 %

The following applies in general terms:

$$RD[\%] = \frac{U_{FL} \cdot 100}{2 \cdot U_B}$$

wherein RD[%] stands for the back twist in %, U_{FL} stands for the speed of rotation of the flyers FL1 and FL2, and U_B stands for the speed of rotation of the bail RB.

If the bail RB rotates at particularly high speed, it is expedient to have a flat bail and a correspondingly compact coaxial construction, as is shown in Figure 1. If, in contrast to this, more space is available, then a design like that shown in Figure 2 is more useful. If the supply spools VS21 and VS22 are arranged with their axes parallel and adjacent to each other, and thus symmetrically about the longitudinal axis LA, this will result in a more convex rotating bail RB that can, in general, only be driven at a lower speed. The advantage of such an arrangement is essentially that the arrangement of the supply spools and the way the strands AD21 and AD22 are guided can be made more open and thus easier to inspect. In addition, it becomes possible to arrange compensating rollers so that they are aligned with the longitudinal axis LA such that there is one such compensating roller for each strand AD1 and AD2 that is as close to the longitudinal axis LA as possible. This provides a simple way to adjust the lead tension at the twisting point VP1 without forming an undesirable torsion block.

In the design of the laying-up machine that is shown in Figure 2, the arrangement outside the inside element IE2 is identical to that in Figure 1, and so the outside elements have not been assigned reference numbers. Unlike that shown in Figure 1, the machine shown in Figure 2 is shown in plan view, so that the yoke WP and the weight GW can be seen between the take-off spools.

The supply spools VS21 and VS22 are flanged onto the associated motors MO21 and MO22 with their shafts parallel. These motors MO21 and MO22 are secured by their stators STM21 and STM22 to the mounting arms HA21 and HA22, whilst their rotors RO21 and RO22 are connected by way of a guide pin FZ21 and FZ22, each of these being supported so as to be rotatable within the associated stator. The supply spools VS1 and VS22 are made to rotate by the guide pins FZ21 and FZ22. The flyers FL21 and FL22 are both supported on the guide pins FZ21 and FZ22 so as to be able to rotate thereon. It is preferred that they be driven by the leads AD21 and AD22 that move from the spool flange from the particular flyer FL21, FL22 into the most favourable take-off position. In order to prevent the arm continuing to rotate automatically if the speed at which the leads are taken off is reduced, the arm of the particular flyer must by supported on the guide pin FZ21, FZ22 with a certain amount of friction. These friction-loaded bearings bear the reference numbers RL1, RL2. This also applies in the same way to the supply spools VS21 and VS22, as well as to the flyers FL1 and FL2 in Figure 1. The two sleeve-shaped support pieces ST21 and ST22 at the ends are joined together, as in Figure 1, by a yoke WP and are held so as to be able to swing in a horizontal position by a weight GW (as mentioned, Figure 2 is a plan view).

The strands AD21 and AD22 that are taken off are guided towards the axis of the guide pins FZ21 and FZ22 and from there, over the guide rollers UB21 and UB22 at an incline to the interior, towards the longitudinal axis LA, where there are two additional guide rollers UB31 and UB32, preferably in the form of flyers that are arranged symmetrically about the axis LA and between which the strands AD21 and AD22 continue to the guide roller UR1. As is indicated by the arrows PB and PF21 and PF22, all of the movable components (supply spools, flyers, bail) rotate in the same direction, and this results in a complete or partial back twist, or a complete or partial freedom from torsion, respectively, in the strand VE.

As is shown in Figure 3, the paths of the flyers FL21 and FL22 must be so selected that the associated elements do not come into contact with them.

It is also possible, for example, in order to make a star quad in the interior of the space that is enclosed in each instance by the rotating bail RB, to arrange four supply spools VS41 to VS 44 in a symmetrical structure, as is shown in Figure 4. When this is done, the axes of the supply spools are parallel to and symmetrical with the longitudinal axis LA that is perpendicular to the plane of the drawing. The associated flyers are numbered FL41 to FL44, and it is expedient that these rotate in such a way that they do not come into contact with the closest points, but rather run off-set to these. Since the flyer arms are guided by the leads that are being taken off, they can assume any positions relative to each other during operation, depending on the thickness of the winding packet, precision of the winding layers, and so on.

Appropriate drives (not shown herein), similar to those shown in Figure 2, will be required for the four supply spools VS41 to VS44 and the associated flyers FL41 to FL44.

A star quad can also be produced with a coaxial arrangement as in Figure 1, when the four takeoff spools are arranged one behind the other. A dedicated drive has to be provided for each of these supply spools.

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CLAIMS:

1. A method for laying up electrical and/or optical strands (AD1, AD2) to form a laid-up unit (VE), this incorporating a rotating bail (RB) to which the strands (AD1, AD2) are delivered, the strands (AD1, AD2) being drawn off supply spools (VS1, VS2) that are arranged within the space enclosed by the rotating bail (RB), characterized in that the supply spools (VS1, VS2) are rotated; that the strands (AD1, AD2) are drawn off the supply spools (VS1, VS2) by overhead takeoff so that they are twisted about their longitudinal axis; and in that the direction of this twist is selected so as to be in the direction of the twist that is imparted to these strands (AD1, AD2) by a laying-up process (back twist).

2. A method as described in Claim 1, characterized in that two supply spools (VS1, VS2) are used.

3. A method as described in Claim 2, characterized in that supply spools (VS1, VS2) that have their longitudinal axes aligned are used.

4. A method as described in Claim 2, characterized in that supply spools (VS1, VS2) whose axes are parallel to each other but offset relative to the continuous longitudinal axis (LA) of the bail (RB) are used.

5. A method as described in Claim 2, characterized in that four supply spools (VS41 to VS44) are used in a symmetrical layout.

6. An apparatus for laying up electrical and/or optical strands (AD1, AD2) to form a laid-up unit (VE), this incorporating a rotating bail (RB) to which the strands (AD1, AD2) are delivered, the strands (AD1, AD2) being drawn

off supply spools (VS1, VS2) that are arranged in inside the space enclosed by the rotating bail (RB), characterized in that the supply spools (VS1, VS2) are rotated; that the strands (AD1, AD2) are drawn off the supply spools (VS1, VS2) by overhead takeoff so that they are twisted about their longitudinal axis; and in that the direction of this twist (PF) is the same as the direction (PB) of the twist that is imparted to the strands (AD1, AD2) by a laying-up process.

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FIG 1

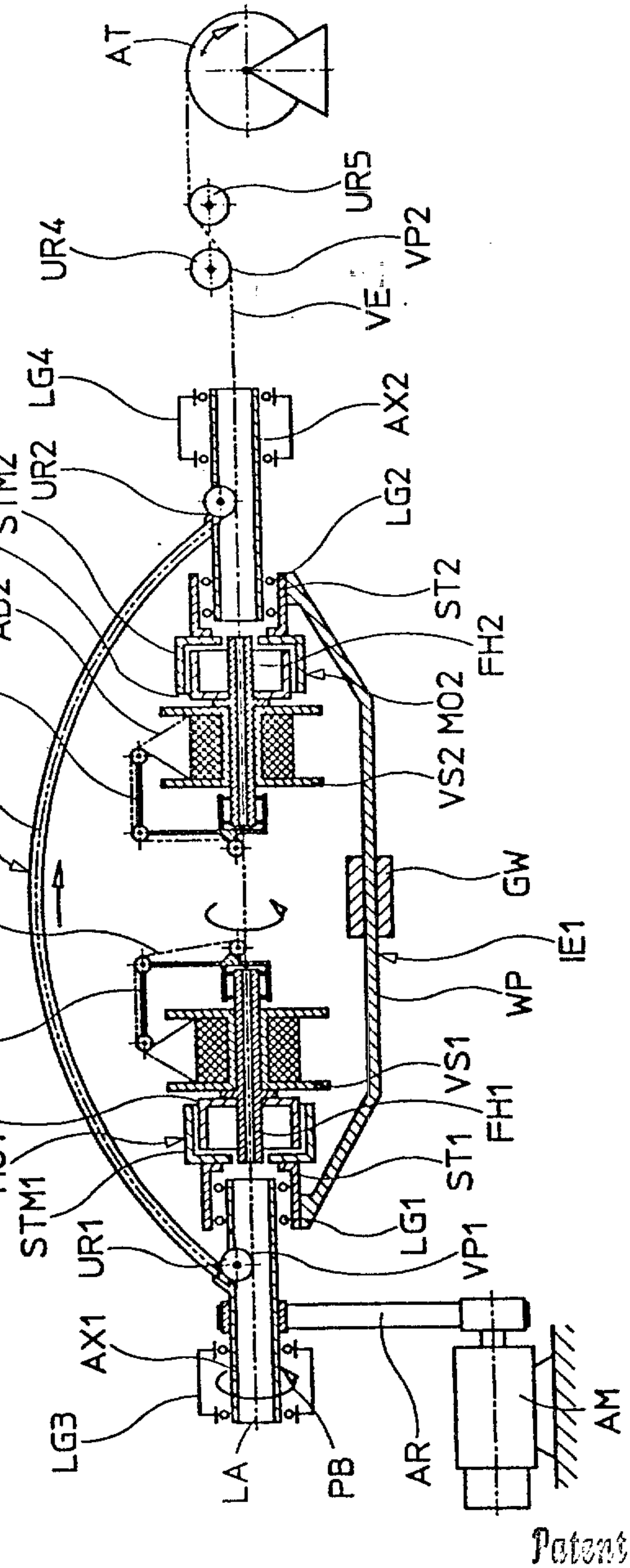

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FIG 2

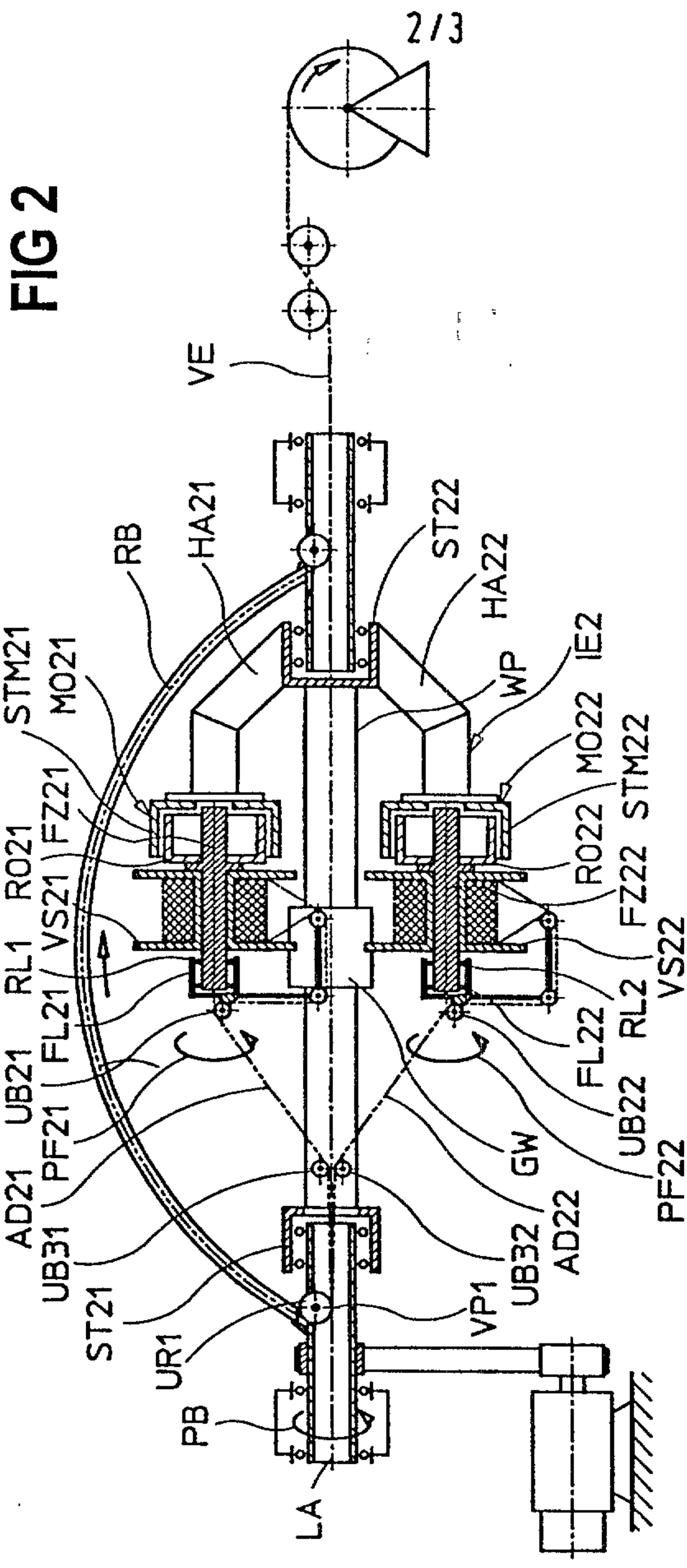

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FIG 3

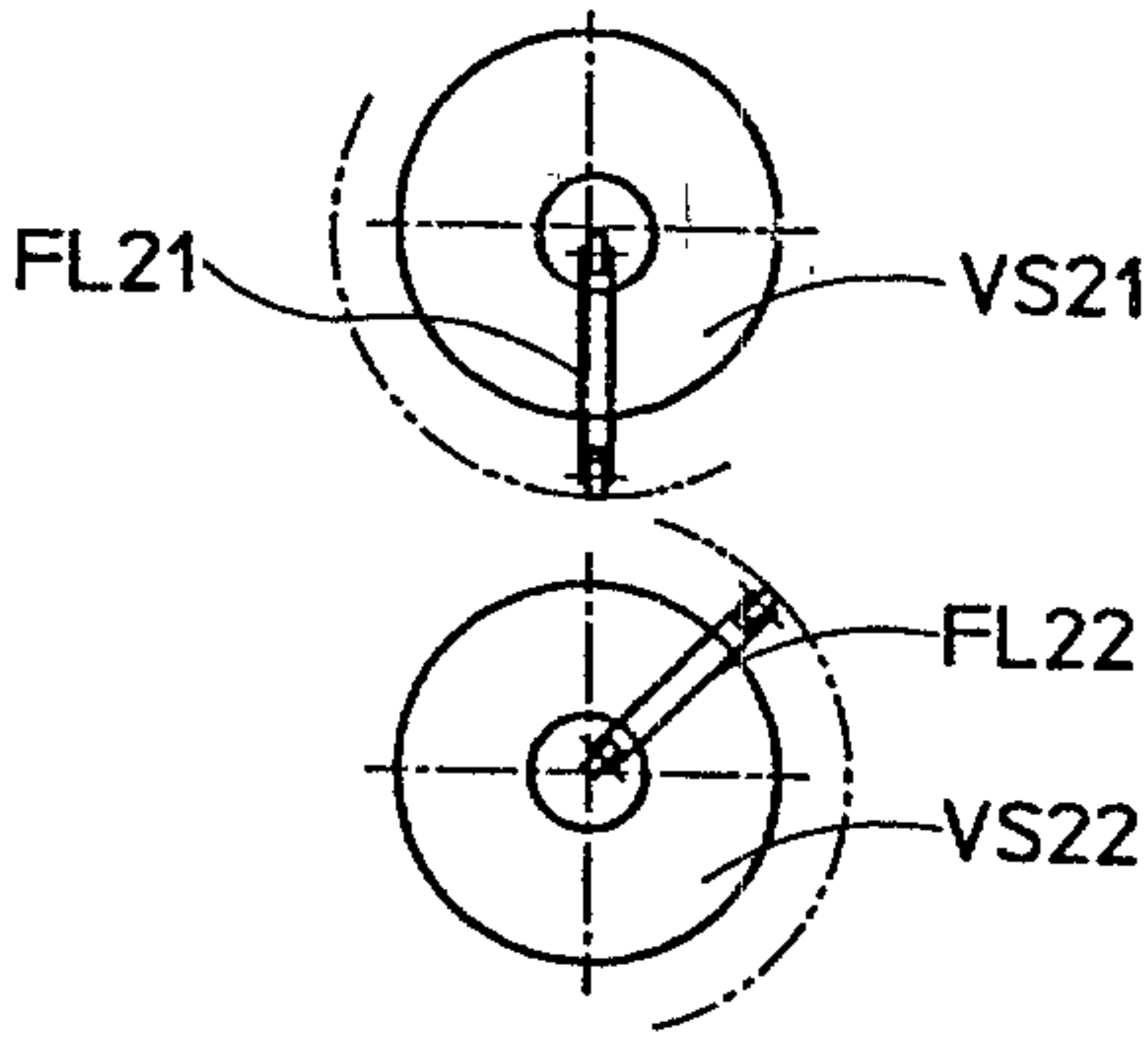
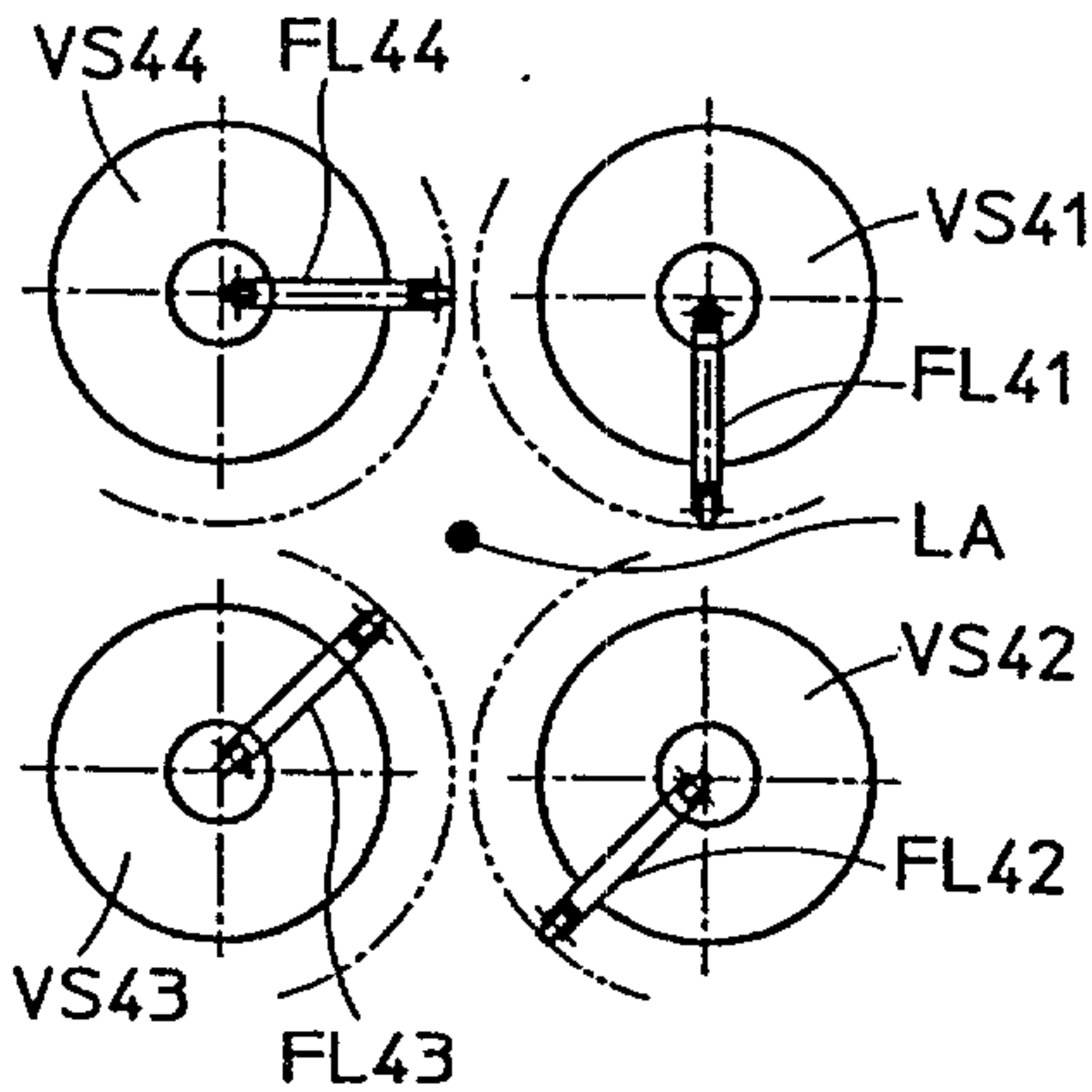


FIG 4



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VV1
RB
RO1 FL1
AD1
FL2
RO2
MO1
AD2
STM2
STM1
UR2
LG4
LG3
UR4
AX1
UR1
AT
LA
PB
AR
LG1
VP1
ST1
VS1
FH1
WP
IE1
GW
VS2 MO2
FH2
ST2
LG2
AX2
VE
VP2
UR5
AM