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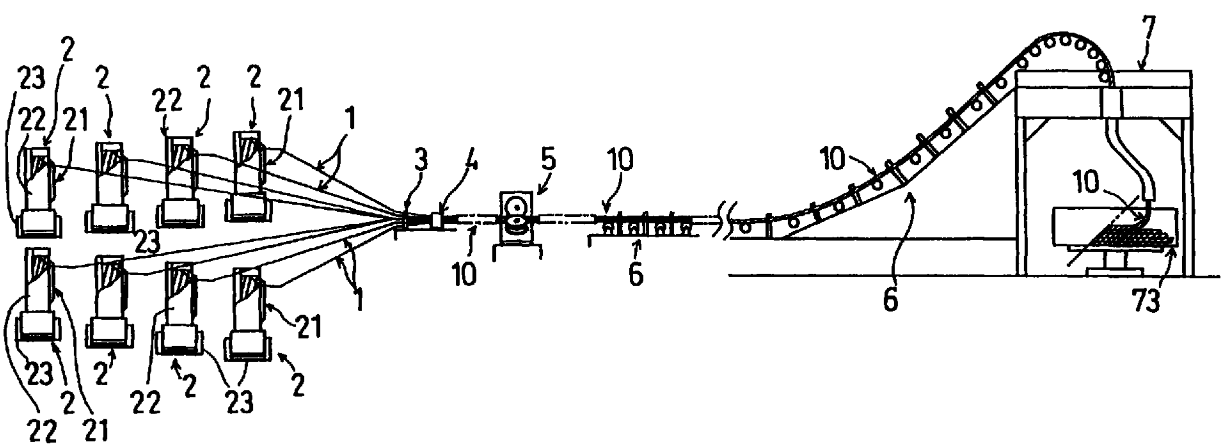
(54) Method and apparatus for manufacturing a cable

(57) A cable manufacturing apparatus is comprised of a specified number of strand winding frames 2 in which a plurality of strands 1 to be laid to form a cable 10 are wound, respectively; a guiding plate 3 for forming the cable 10 by laying the strands 1 pulled out from the strand winding frames 2 to the axial directions of the strand winding frames 2 in a specified arrangement; a die 4 for tightening the strands 1 in the specified arrangement; a feeder 5 for pulling out the respective strands 1 from the strand winding frames 2 through the guiding plate 3 and the die 4 as the cable 10; a supporting assembly 6 for supporting the cable 10 being conveyed to a winding table 73; and the winding table 73 for winding the conveyed cable 10 at a specified winding diameter by placing it on a horizontal table. Therefore, the cable can be manufactured by a simply constructed apparatus according to a simple method.

FIG. 1



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Description

[0001] This invention relates to a method and apparatus for manufacturing a cable of, e.g., steel strands for prestressed concrete.

[0002] The following methods are known as conventional methods for manufacturing a cable. A first method is such that a cable is manufactured by using a planetary type laying machine or a drum twister type laying machine. A second method is such that a specified number of strands, each of which is twisted beforehand to a predetermined degree, are bound together to form a bundle of strands, and then it is pulled out to have the leading end thereof rotated to manufacture a cable as a whole (see Examined Japanese Patent Publication No. 6(HEI)-72377). In these methods, the cable is wound on a winding drum rotating about an axis perpendicular to the moving direction of the cable.

[0003] With the conventional methods, the winding drum needs to have a large diameter so as not to cause the cable to be plastically deformed. Further, since a pulling force needs to be applied to the cable to wind the cable to the drum having a large diameter, the drum needs to have a large torque. This requires a large scale and, thus, expensive apparatus.

[0004] In view of the above problems residing in the prior art, an object of the present invention is to provide a simple cable manufacturing method and a cable manufacturing apparatus having a simple construction.

[0005] Accordingly, a first aspect of the invention is directed to a cable manufacturing method, comprising the steps of forming a cable by laying a plurality of strands; feeding the cable by a feeder while rotating it on its own axis; and winding up the cable on a winding table. The cable is wound at a specified winding diameter on the winding table by feeding the cable to the axial direction of the winding table by a feeding force of the feeder.

[0006] A second aspect of the invention is also directed to a cable manufacturing apparatus, comprising laying means for laying a plurality of strands; a feeder for feeding a cable while rotating it on its own axis; supporting means for supporting the cable being conveyed from the feeder to a winding device; and winding means for winding the conveyed cable at a specified winding diameter by placing it on a horizontal plane.

[0007] According to the above method and apparatus, the cable fed while being rotated on its own axis is supplied onto the winding table in the axial direction of the winding table. Thus, if the cable is wound at a winding diameter corresponding to a ratio of the feeding length to a rotating amount (lay length), the rotating force of the cable is absorbed as the cable is wound, even if at the condition that the winding table is held fixed. As a result, the cable can be wound without leaving a large stress within the cable.

[0008] In the method according to the first aspect, the cable is preferably supplied onto the winding table to be wound by passing through a rotatable arm made of a pipe and rotatable about a vertical axis with its upper end fixed.

[0009] With this method, the cable can be smoothly supplied onto the winding table by being passed through the rotatable arm, whose outlet at the bottom end faces the winding table.

[0010] Preferably, a specified number of strand winding frames are formed by respectively winding the plurality of strands to be laid to form the cable around winding frames, and the cable is formed by pulling the strands from the strand winding frames in the axial directions of the strand winding frames and passing them through a guiding plate and a die to lay them in a specified arrangement.

[0011] A specific construction of the cable manufacturing apparatus may comprise a specified number of strand winding frames in which a plurality of strands to be laid to form a cable are wound, respectively; a guiding plate for forming the cable by laying the strands pulled out from the strand winding frames in the axial directions of the strand winding frames in a specified arrangement; a die for tightening the strands in the specified arrangement; a feeder for drawing the respective strands from the strand winding frames through the guiding plate and the die as a cable; a supporting means for supporting the cable being conveyed to a winding device; a winding table for winding the conveyed cable at a specified winding diameter by placing it on a horizontal plane.

[0012] With the above method and apparatus, since the strands are pulled out from the strand winding frames in the axial directions thereof to be fed to the guiding plate, they can be laid by being pulled out. Accordingly, the cable can be formed without rotating the respective strand winding frames in a planetary manner or rotating them on their own axes on a flyer. Therefore, the cable manufacturing apparatus can be very compactly, simply and inexpensively constructed.

[0013] The cable manufacturing apparatus may further comprise driving means for rotating the winding table in the horizontal plane.

[0014] With this arrangement, the diameter at which the cable is wound can be freely changed by an inexpensive apparatus. Specifically, the winding diameter needs to correspond to the ratio of the feeding length to the rotating amount (lay length) in order to wind the cable on the winding table without leaving a large stress (rotational residual stress). The winding diameter can be freely changed by rotating the winding table. In this case, the winding table needs not have a large torque since it is not necessary to give a pulling force to wind the cable. Therefore, the apparatus can be simply and inexpensively constructed.

[0015] In the specific construction of the apparatus, the strand winding frames and the winding table are preferably provided on a lower base while the guiding plate, the die, the feeder, and the supporting means are preferably provided on an upper base located above the lower base so that the strands from the strand winding frames are pulled up to the guiding plate and the cable from the feeder descends onto the winding table.

[0016] With this construction, since the strands from the respective strand winding frames are pulled up and the cable descends toward the winding device, the length of the apparatus can be shortened by this vertical moving distance. Therefore, a long installation area, which is a problem with the conventional strand laying machines, can be considerably shortened.

[0017] These and other objects, features and advantages of the present invention will become more apparent upon a reading of the following detailed description and accompanying drawings in which:

FIG. 1 is a schematic front view showing an entire construction of a cable manufacturing apparatus according to one embodiment of the invention;
FIG. 2 is a front view partly in section of a strand winding frame of the apparatus of FIG. 1;
FIG. 3 is a side view partly in section of the frame of FIG. 2;
FIG. 4 is a schematic section of a cable;
FIG. 5 is a diagram showing a lay length, an angle of lay and a length of strand required for a lay length;
FIG. 6 is a side view of a guiding plate and a die;
FIG. 7 is a front view of the guiding plate;
FIG. 8 is a side view of a feeder;
FIG. 9 is a front view of the feeder of FIG. 8;
FIG. 10 is a plan view of a supporting assembly;
FIG. 11 is a side view of the supporting assembly of FIG. 10;
FIG. 12 is a plan view partly in section of a winding device;
FIG. 13 is a side view partly in section of the winding device of FIG. 12;
FIG. 14 is a front view of another embodiment of the winding device;
FIG. 15 is a plan view of the winding device of FIG. 14;
FIG. 16 is a front view of still another embodiment of the winding device;
FIG. 17 is a plan view of the winding device of FIG. 16;
FIG. 18 is a front view of further another embodiment of the winding device;
FIG. 19 is a plan view of the winding device of FIG. 18;
FIG. 20 is a schematic plan view showing an entire construction of a cable manufacturing apparatus according to another embodiment of the invention; and
FIG. 21 is a front view of the cable manufacturing apparatus of FIG. 20.

[0018] Referring to FIG. 1, it shows an entire construction of a cable manufacturing apparatus. This cable manufacturing apparatus is comprised of a specified number of strand winding frames 2 for winding a plurality of strands 1 to be laid into a cable 10, a guiding plate 3 and a die 4 for putting the strands 1 from the respective winding frames 2 to the axial direction of the winding frames 2 and laying them in a specified arrangement to form the cable 10, a feeder 5 for feeding the cable 10, a supporting assembly 6 for conveying the cable 10 to a winding device 7, and the winding device 7 for winding the conveyed cable 10. The cable 10 is made of, for example, 19 strands. In FIG. 1, only 8 strands (i.e. 8 winding frames 2) are shown to simplify the drawing. The respective strands 1 are pulled from the strand winding frames 2 to their axial directions and are laid in a specified arrangement by being passed through the guiding plate 3 and the die 4, thereby producing the cable 10. The cable 10 is subsequently conveyed by the supporting assembly 6 and wound on a winding table 73 of the winding device 7.

[0019] FIG. 2 is a front view partly in section of the strand winding frame 2; FIG. 3 is a side view partly in section thereof; FIG. 4 is a schematic section of the cable 10; and FIG. 5 is a diagram showing a lay length of the cable 10 and an angle of lay and a length of the strands required to obtain the lay length. As shown in FIGS. 2 and 3, each winding frame 2 is provided with a base table 23, a pair of rollers 24 rotatably supported on the base table 23, a winding frame main body 22 rotatably supported on the rollers 24. The main body 22 is made of a short hollow cylindrical body and is formed with an opening 21 for taking out a strand in the middle of one side portion thereof. Inside the main body 22, a specified strand 1 is wound at such a diameter as not to cause the strand 1 to be plastically deformed, and one end of the strand 1 is pulled out through the opening 21 for taking out the strand. Accordingly, the outer diameter of the main body 2 should be selected according to the diameter and material of the strand 1 used such that no plastic deformation is caused in the strand 1. Further, the base table 23 may be provided with an unillustrated driving device, so that the rollers 24 can be rotated at a desired rotating speed.

[0020] The material 1 is a strand made of 7 wires in this example as shown in FIG. 4. The cable 10 having a hexagonal cross section is made of one core strand 11 (material 1), six strands 12 (materials 1) in the first layer arranged around the core strand 11, and A-strands 13 (materials 1) and B-strands 14 (materials 1) in the second layer as described later. The six strands 12 in the first layer are located around the core strand 11 at an equal distance from the core strand 11;

the six A-strands 13 in the second layer are located around the core strand 11 and between the strands 12 at a longer equal distance therefrom; and the six B-strands 14 are located around the core strand 11 and outside the strands 12 at a longest equal distance therefrom.

[0021] FIG. 6 is a side view of the guiding plate 3 and the die 4; FIG. 7 is a front view of the guiding plate 3; FIG. 8 is a side view of the feeder 5; and FIG. 9 is a front view of the feeder 5 of FIG. 8. The guiding plate 13 has 19 through holes 30 for passing the respective strands 1 such that the strands 1 are held in a specified arrangement as shown in FIG. 4 and small clearances are left between the strands 1. The respective strands 1 having passed through the through holes 30 are passed through the die 4 to be forcibly put together, with the result that the cable 10 having a hexagonal cross section as shown in FIG. 4 is formed.

[0022] The feeder 5 is provided with bearings 52 projecting toward the center in three directions inside an outer frame 51 which is hexagonal in its front view. A roller 53 formed with a V-shaped groove is mounted on each bearing 52. A hexagonal through hole is formed by the V-shaped grooves of the rollers 53. The rollers 53 are rotated by an unillustrated driving device. The cable 10 is passed through this hexagonal through hole and is held by the rotating rollers 53, so that the cable 10 can be fed by the rotation of the respective rollers 53.

[0023] FIG. 10 is a plan view of the supporting assembly 6 and FIG. 11 is a side view thereof. In the supporting assembly 6, receiving rollers 61 for supporting the cable 10 being conveyed from below and pairs of side rollers 62 in contact with the opposite sides of the cable 10 are alternately arranged at specified intervals along the length of the supporting assembly 6. The receiving rollers 61 are obliquely arranged with respect to a direction normal to the length of the cable 10 when viewed from above. Thus, the rotation of the receiving rollers 61 during the conveyance of the cable 10 generates a force to move the cable 10 toward one side (side displacing force). On the other hand, since the cable 10 is moved while being rotated as described later, a force (side displacing force) trying to move in a direction opposite from the acting direction of the above side displacing force acts due to the rotation of the cable 10 on its own axis. A rotational resistance is made smaller by canceling the side displacing force caused by the rotation of the cable 10 on its own axis by the inclination of the receiving rollers 61.

[0024] FIG. 12 is a plan view partly in section of the winding device 7, and FIG. 13 is a side view partly in section of the winding device 7 of FIG. 12. The leading end of the supporting assembly 6 is guided to an upper part of a frame 71 of the winding device 7. The winding device 7 is provided with a rotatable arm 72 having its upper end supported on the frame 71, and a winding table 73 rotatable in a position opposite to the lower end of the rotatable arm 72. The rotatable arm 72 is made of a pipe so that the cable 10 passes therethrough, and the winding table 73 has its center portion supported on a support shaft 74. The rotatable arm 72 and the winding table 73 are provided with an unillustrated driving device, respectively.

[0025] FIG. 14 is a schematic front view of another embodiment of the winding device, and FIG. 15 is a schematic plan view thereof. A winding device 70 is provided with a guide pipe 711 vertically extending at the upper end of the frame 71, and a winding table 730 arranged below the guide pipe 711 and supported on a support shaft 740. A conic guide member 76 is provided on the winding table 730. The support shaft 740 is provided with a driving device 75, and an annular groove 760 is formed on the outer circumferential surface of the winding table 730 and on the outer circumferential surface of the bottom end of the guide member 76. Accordingly, the cable 10 descending along the outer surface of the guide member 76 after passing through the guide pipe 711 is supplied into the groove 760.

[0026] FIG. 16 is a schematic front view of still another embodiment of the winding device, and FIG. 17 is a schematic plan view thereof. A winding device 77 is provided with a similar rotatable arm 729 having its upper end supported on a frame 71, and a winding table 731 rotatable in a position opposite from the lower end of the rotatable arm 729. The winding table 731 has its center portion supported on a support shaft 740; a driving device 720 for rotating the winding table 731 is provided at the upper end of the rotatable arm 729; and the support shaft 740 is provided with a driving device 75. An annular groove 732 is formed on the outer circumferential surface of the winding table 731 and the leading end of the rotatable arm 729 faces the groove 732 sideways (faces directly below in the case of FIGS. 12 and 13), so that the cable 10 conveyed through the rotatable arm 729 is supplied into the groove 732.

[0027] FIG. 18 is a schematic front view of further another embodiment of the winding device, and FIG. 19 is a schematic plan view thereof. A winding device 78 is provided with a guide pipe 711 vertically extending at the upper end of a frame 71, and a rotatable base 79 arranged below the guide pipe 711 and supported on a support shaft 740 fitted with a driving device 75. The rotatable base 79 has a rotatable shaft 790 in a position displaced from the rotatable shaft 740, and a winding table 791 is supported on this rotatable shaft 790. The support shaft 790 is provided with a driving device 793 for the winding table 791, and an annular groove 792 is formed on the outer circumferential surface of the winding table 791. A part of the groove 792 is alternately located right below the guide pipe 711 and right above the support shaft 740, so that the cable 10 descending from the guide pipe 711 can be supplied into the groove 792.

[0028] FIG. 20 is a schematic plan view showing the entire construction of another embodiment of the cable manufacturing apparatus, and FIG. 21 is a front view of this embodiment. This cable manufacturing apparatus has the same construction as the apparatus of FIG. 1 in that it is comprised of a specified number of strand winding frames 2 for winding a plurality of strands 1 to be laid into a cable 10, a guiding plate 3 and a die 4 for pulling the strands 1 from the respective winding frames 2 to the axial directions of the frames 2 and laying them in a specified arrangement to produce the cable 10, a feeder 5 for feeding the cable 10, a supporting assembly 6 for conveying the cable 10 to a winding device 7, and a winding table 73 for winding the cable 10. In this cable manufacturing apparatus, the respective winding frames 2 are placed on a lower base 91; the winding table 73 is placed on a lower table 92 located below the lower base 91, and the other laying means such as the guiding plate 3, the die 4, the feeder 5 and the supporting assembly 6 are placed on an upper base 94 provided above the lower bases 91, 92 while being supported on a support column 93. Between the lower base 91 and the upper base 94 are provided strand guides 96 for positioning the strands 1 from the respective winding frames 2 in specified positions by passing the strands 1 through them and guiding the strands 1 upward while being held by a support plate 95. Further, guide rollers 99 are provided above the respective strand guides 96.

[0029] Guiding plates 31, 32, 33 having a construction similar to that of the guiding plate 3 are arranged on the upper base 94 so as to successively collect the strands 1 from the winding frames 2 at the far side. Specifically, six strands 1 are passed through the guiding plate 31. These strands together with additional five strands 1, i.e. a total of 11 strands 1 are passed through the guiding plate 32. These strands together with additional five strands 1, i.e. a total of 16 strands 1 are passed through the guiding plate 33. Three more strands 1 are added before the guiding plate 3, so that a total of 19 strands 1 are collected in the end. The strands are pulled up substantially vertically from the respective winding frames 2 through the strand guides 96. Further, the cable 10 fed from the feeder 5 descends substantially vertically toward the winding table 73 by being guided by the supporting assembly 6.

[0030] Next, a method for manufacturing a cable using the above apparatus is described. First, a plurality of strands 1 are pulled to the axial directions of the winding frames 2 from a specified number of winding frames 2 in which the strands 1 are wound, respectively. As a result, the strands 1 are unwound and rotated (revolved) on their own axes to the direction in which the coils thereof are unwound. These strands 1 are formed into the cable 10 by being passed through the guiding plate 3 and the die 4. This cable 10 rotates due to the rotating forces of the strands 1. In other words, the strands 1 are laid and fed while the core strand 11 rotates on its own axis and the remaining strands rotate on their own axes as well as round the core strand 11. Therefore, the cable 10 rotates on its own axis by the rotation of the respective strands 1.

[0031] As shown in FIG. 5, a lay length P of a portion of the cable 10 is a length the strands in the outer layer move forward when making a turn about the core strand 11. A length L of the strand (outer layer strand) corresponding to the lay length P is given by:

$$L = P/\cos A$$

where A denote an angle of lay.

[0032] If a circumferential length of the coil of the strand 1 within the strand winding frame 2 coincides with the length L, the strand 1 can be continuously pulled out with the winding frame 2 fixed. Specifically, the strand 1 makes one turn (revolves) when being pulled out by a circumferential length of the coil. If this circumferential length is equal to the length L of the strand corresponding to the lay length P of the cable 10, the rotation of the strand 1 caused by being pulled out is absorbed by the rotation of the cable 10. Accordingly, the cable 10 can be continuously formed by pulling out the strands 1 with the winding frames 2 fixed. In other words, the strands 1 are laid by the rotating forces of the strands 1 on their own axes by pulling the strands 1 from the winding frames 2 along the axial directions thereof.

[0033] For example, if a diameter of the coil of the strands 1 in the winding frames 2 is 1,274 mm (circumference: 4,002 mm) and a lay length of the cable 10 is 4,000 mm, the laying conditions of the strands 1 in the respective layers are as shown in TABLE-1. It should be noted that "Pitch Diameter" in TABLE-1 refers to a diameter of a circle obtained by tracing the respective center points of the strands 1 in the same layer in the cross section of the cable 10; that Rotational Angle" refers to an angle by which the strand 1 rotates on its own axis when being pulled by a lay length P from the winding frame 2; and that 'Rotational Discrepancy" refers to a discrepancy between an actual rotational angle and one turn (= 360°).

TABLE-1

Position of Strand	Pitch Diameter	A	CosA
Core Strand	0	0	1.0
Strand in 1st Layer	25.4	1.15	0.9998
Strand A in 2nd Layer	44.0	1.98	0.9994
Strand B In 2nd Layer	50.8	2.28	0.9992
Position of Strand	L	Rota. Angle	Rota. Discr.
Core Strand	4,000	359.8	-0.2
Strand in 1st Layer	4,000.8	359.2	-0.1
Strand A In 2nd Layer	4,002.4	360.0	0
Strand B In 2nd Layer	4,003.2	360.1	0.1

[0034] As shown in TABLE-1, if the strands 1 wound at a diameter of 1,274 mm are pulled by a length corresponding to 4,000 mm of the cable 10, there is only a slight discrepancy between the rotation of the respective strands 1 and 360°. In the case of a relatively long length P as in this example, the strand length L may be considered to be equal to the lay length P since a difference caused by the arrangement of the strands 1 is small. Therefore, in the case that a circumferential length of the coil of the strands 1 in the respective winding frames 2 is set substantially equal to the lay length P of the cable 10, the cable 10 which has no tendency of rotating can be manufactured even if the strands 1 are pulled out with the winding frames held stationary, i.e. without rotating them.

[0035] In the case that a circumferential length of the coil of the strand 1 is not equal to the strand length L of the strand 1 corresponding to the lay length P of the cable 10, the rotation of the strands 1 on their own axes is either excessive or insufficient in producing the cable 10. This may be dealt with by rotating the winding frames 2 by an amount corresponding to the excessive or insufficient rotation. As a result, the rotation of the strands 1 caused by being pulled can be coincided with a rotation necessary to produce the cable 10.

[0036] For example, in the case that the cable 10 with a lay length of 4 m is manufactured from 19 strands which are formed of 7 strands of PC steel having a diameter of 12.7 mm, a circumferential length of the coil of the strands 1 is 4 m if the diameter of the coil of the strand 1 in the winding frame 2 is 1,274 mm. Accordingly, if the strands 1 are pulled from the winding frames 2, they are fed while making one turn every time they are pulled by 4 m, and the cable 10 formed continuously from the strands 1 is fed while making one turn every 4 m. In this case, the winding frames 2 need not be rotated.

[0037] The winding frames 2 have to be rotated in the following cases:

(a) The case where a circumferential length of the coil of the strands in the winding frames 2 is made shorter than the strand length L in order to make the installation area of the winding frames 2 smaller, and

(b) The case where a circumferential length of the coil of the strands which does not cause the plastic deformation of the strands 1 in the winding frames 2 in consideration of conditions such as the large diameter of the strands 1 is longer than the lay length P.

[0038] In such cases, the winding frames 2 may be each provided with a driving device to be rotated, so that the strands 1 dispensed from the winding frames 2 may be caused to make one turn every lay length P of the cable.

[0039] If the diameter of the coil of the strands 1 in the winding frames and a lay length of the cable 10 are set at 1,000 mm (circumference 3,142 mm) and 4,000 mm, respectively, an example of the case (a), laying conditions of the strands 1 in the respective layer are as shown in TABLE-2.

TABLE-2

Position of Strand	Pitch Diameter	A	CosA
Core Strand	0	0	1.0
Strand in 1st Layer	25.4	1.15	0.9998
Strand A in 2nd Layer	44.0	1.98	0.9994
Strand B in 2nd Layer	50.8	2.28	0.9992
Position of Strand	L	Rota. Angle	Rota. Discr.
Core Strand	4,000	458.4	98.4
Strand in 1st Layer	4,000.8	458.5	98.5
Strand A in 2nd Layer	4,002.4	458.6	98.6
Strand B in 2nd Layer	4,003.2	458.7	98.7

[0040] As can be seen from TABLE-2, if the strands 1 wound at a winding diameter of 1,000 mm are pulled by a length corresponding to 4,000 mm of lay length of the cable 10, the strands 1 rotate on their own axes by more than 360° (458.4° to 458.7°), resulting in an excessive rotation. Therefore, the winding frames 2 may be rotated in a direction opposite from the rotating direction of the strands 1 by an excessive rotation (98.4° to 98.7°).

[0041] If the winding diameter of the coil of the strands 1 in the winding frames and the lay length of the cable 10 are set at 1,600 mm (circumference 5,027 mm) and 4,000 mm, respectively, an example of the case (b), laying conditions of the strands 1 in the respective layer are as shown in TABLE-3.

TABLE-3

Position of Strand	Pitch Diameter	A	CosA
Core Strand	0	0	1.0
Strand in 1st Layer	25.4	1.15	0.9998
Strand A in 2nd Layer	44.0	1.98	0.9994
Strand B in 2nd Layer	50.8	2.28	0.9992
Position of Strand	L	Rota. Angle	Rota. Discr.
Core Strand	4,000	286.5	-73.5
Strand in 1st Layer	4,000.8	286.5	-73.5
Strand A in 2nd Layer	4,002.4	286.6	-73.4
Strand B in 2nd Layer	4,003.2	286.7	-73.3

[0042] As can be seen from TABLE-3, if the strands 1 wound at a winding diameter of 1,600 mm are pulled by a length corresponding to 4,000 mm of lay length of the cable 10, the strands 1 rotate on their own axes by less than 360° (286.5° to 286.7°), resulting in an insufficient rotation. Therefore, the winding frames 2 may be rotated in the same direction as the rotating direction of the strands 1 by an insufficient rotation (73.3° to 73.5°).

[0043] The respective strands 1 are laid by being passed through the guiding plate 3 and the die 4 to be formed into the cable 10, which is then conveyed to the winding device 7 while rotating on its axis on the supporting assembly 6 and a feeding force is rendered thereto by the feeder 5. The conveyed cable 10 is supplied onto the winding table 73 through the rotatable arm 72 rotating about its upper end. Since the outlet at the bottom end of the rotatable arm 72 is rotating so as to face a winding position, the cable 10 can be smoothly supplied onto the winding table 73. The cable 10 is wound at a winding diameter corresponding to a circular trace of the bottom end of the rotatable arm 72 on the winding table 73. Since the cable 10 fed from the rotatable arm 72 makes one turn per unit length, a relationship between a winding diameter of the coil and the lay length of the cable 10 is also essential here.

[0044] For example, if the winding diameter of the coil on the winding table 73 is 3 m, the circumference thereof is 9.4

m. Thus, if the cable 10 is supplied by 4 m along an arc having a diameter of 3 m on the winding table 73 by causing the rotatable arm 72 to make one turn every lay length of 4 m of the cable 10, the rotating angle is

$$360° \times (4\ m/9.4\ m) = 153°.$$

In other words, 4 m length of the cable 10 corresponds to 153° on the winding table 73. Accordingly, the winding table 73 is rotated in the same direction as the rotating direction of the rotatable arm 72 by an angle discrepancy 207° (360° - 153° = 207°). The winding diameter of the coil of the cable 10 can be freely changed by rotating the winding table 73 in this manner. In such a case, it is not necessary to generate a large torque since the winding table 73 does not need to give a pulling force to wind the cable 10. Therefore, the cable manufacturing apparatus has a simple construction and is inexpensive. It should be noted that the winding table 73 does not need to be rotated if a circumferential length of the coil of the wound cable 10 on the winding table 73 is caused to coincide with the lay length P.

[0045] In the winding device 70 of FIGS. 14 and 15, the cable 10 is supplied onto the conic guide member 76 of the winding table 730 through the guide pipe 711, and descends along the outer surface of the guide member 76 to be introduced into the groove 760. The winding table 730 is rotated at a specified speed, so that the cable 10 is wound in the groove 760 without undergoing a plastic deformation.

[0046] In the winding device 77 of FIGS. 16, 17, the cable 10 is supplied into the groove 732 at the outer circumference of the winding table 731 through the rotatable arm 729. The winding table 731 and the rotatable arm 729 are rotated at specified speeds by driving devices 75, 720, so that the cable 10 is wound in the groove 760 without undergoing a plastic deformation.

[0047] In the winding device 78 of FIGS. 18 and 19, the cable 10 descends right downward through the guide pipe 711 while rotating on its own axis. The rotatable shaft 790 is arranged on the rotatable base 79 in a position displaced from the rotatable shaft 740. The winding table 791 rotates about the rotatable shaft 740 while rotating on its own axis. Further, as shown in FIG. 19, a part of the groove 792 is alternately positioned at the center of the rotatable base 79, i.e. right below the guide pipe 711 so that the cable 10 is supplied there. Since the position of the groove 792 where the cable 10 is supplied is determined by the speed at which the winding table 791 rotates on its own axis and the speed at which the winding table 791 rotates around the rotatable shaft 740 (the latter speed equals the rotating speed of the rotatable base 79), the cable 10 can be wound without undergoing a plastic deformation by adjusting these speeds.

[0048] In any of the above winding devices, the cable 10 is supplied by a feeding force given by the feeder 5 and no winding force of the winding device is utilized. Accordingly, no pulling force is given to the cable 10 being wound. Conventional strand laying machines have a large size because the cable is wound by applying a rotating force of the winding device having a large diameter thereto as a pulling force. However, according to the invention, a feeding force is given to the cable 10 immediately after the die 4 and the cable 10 is wound without applying a pulling force in the winding device. Therefore, the cable manufacturing apparatus is allowed to have a compact construction.

[0049] Further, in the apparatus of FIG. 20, the strands 1 from the respective winding frames 2 are pulled up substantially vertically and the cable 10 descends substantially vertically toward the winding table 73. Accordingly, the length of the apparatus can be shortened by as much as a vertical moving distance of the cable 10. Therefore, a long installation area, which is a problem with the conventional strand laying machines, can be considerably shortened.

[0050] Further, since the feeder 5 is arranged in a higher position to pull the strands 1 up and the cable 10 is supplied onto the winding table 730 arranged in a lower position, the weight of the strands 1 from the winding frames 2 to the upper base 94 acts as a resistance to the feeding force of the feeder 5 at the strand side, and the weight of the cable 10 from the upper base 94 to the winding device acts to reduce the feeding force of the feeder 5 at the winding side. Therefore, the feeding force of the feeder 5 can be made smaller by suitably setting a weight balance between the strand side and the winding side (e.g. by increasing or decreasing a height difference between the lower bases 91 and 92).

[0051] As described above, the cable rotating on its own axis is fed onto the winding table in the axial direction of the winding table according to the invention. Accordingly, if the cable is wound at the winding diameter corresponding to the feeding length decided by the rotating amount, the rotating force of the cable is absorbed as it is wound with the winding table fixed. As a result, the cable can be wound without leaving a large stress.

[0052] As the cable is wound by being passed through the rotatable arm rotating such that its outlet at the bottom end faces a winding table, the cable can be wound smoothly on the winding table.

[0053] As the strands are pulled out from the strand winding frames in the axial directions thereof to be fed to the guiding plate, they can be laid by being pulled out. Accordingly, the cable can be formed without rotating the respective strand winding frames as in a planetary manner or rotating them on their axes on a flyer. Therefore, the cable manufacturing apparatus can be very compactly, simply and inexpensively constructed.

[0054] Further, as the driving device is provided to rotate the winding table in the horizontal plane, the winding diameter at which the cable is wound can be freely changed by an inexpensive apparatus. Specifically, the winding diameter of the coil needs to correspond to the ratio of the feeding length to the rotating amount (lay length) in order to wind the cable on the winding table without leaving a large stress. The winding diameter of the coil can be freely changed by rotating the winding table. In this case, the winding table does not need to generate a large torque since it is not necessary to give a pulling force to wind the cable. Therefore, the apparatus can be simply and inexpensively constructed.

[0055] Furthermore, if the strand winding frames and the winding table are provided on the lower base, and the guiding plate, the die and the supporting assembly are provided on the upper base located above the lower base, so that the strands from the strand winding frames are pulled up to the guiding plate and the cable from the feed descends onto the winding table, the length of the apparatus can be shortened by this vertical moving distance. Therefore, a long installation area, which is a problem with the conventional strand laying machines, can be considerably shortened.

Claims

1. A cable manufacturing method, comprising the steps of:

    forming a cable (10) by laying a plurality of strands (1);
    feeding the cable (10) by a feeder (5) while rotating the cable on its own axis; and
    winding up the cable (10) by a winding table (73);
    wherein the cable (10) is wound at a specified winding diameter on the winding table (73) by feeding the cable (10) to the axial direction of the winding table (73) by a feeding force of the feeder (5).

2. A cable manufacturing method according to claim 1, wherein the cable (10) is supplied onto the winding table (73) to be wound by passing through a rotatable arm (72) made of a pipe and rotatable about a vertical axis with its upper end fixed.

3. A cable manufacturing method according to claim 1 or 2, wherein a specified number of strand winding frames (2) are formed by respectively winding the plurality of strands (1) to be laid to form the cable (10) inside winding frames (2), and the cable (10) is formed by pulling the strands (1) from the strand winding frames (2) to the axial directions of the strand winding frames (2) and passing them through a guiding plate (3) and a die (4) to lay them in a specified arrangement.

4. A cable manufacturing apparatus, comprising:

    laying means (2, 3, 4) for laying a plurality of strands (1);
    a feeder (5) for feeding a cable (10) while rotating the cable on its own axis;
    supporting means (6) for supporting the cable (10) being conveyed from the feeder (5); and
    winding means (7) for winding the conveyed cable (10) at a specified winding diameter by placing it on a horizontal plane.

5. A cable manufacturing apparatus according to claim 4, further comprising driving means (75) for rotating a winding table (73) of the winding means (7) in the horizontal plane.

6. A cable manufacturing apparatus according to claim 4 or 5, wherein:

    the laying means includes:

        a specified number of strand winding frames (2) in which a plurality of strands (1) to be laid to form a cable (10) are wound, respectively;
        a guiding plate (3) for forming the cable (10) by laying the strands (1) pulled out from the strand winding frames (2) to the axial directions of the strand winding frames (2) in a specified arrangement; and
        a die (4) for tightening the strands (1) in the specified arrangement;

    the feeder (5) which pulls out the respective strands (1) from the strand winding frames (2) through the guiding plate (3) and the die (4) as a cable (10).

7. A cable manufacturing apparatus according to claim 6, wherein the strand winding frames (2) and the winding table (73) are provided on a lower base while the guiding plate (3), the die (4), the feeder (5), and the supporting means (6) are provided on an upper base located above the lower base so that the strands (1) from the strand winding frames (2) are pulled up to the guiding plate (3) and the cable (10) from the feeder (5) descends onto the winding table (73).

FIG. 1

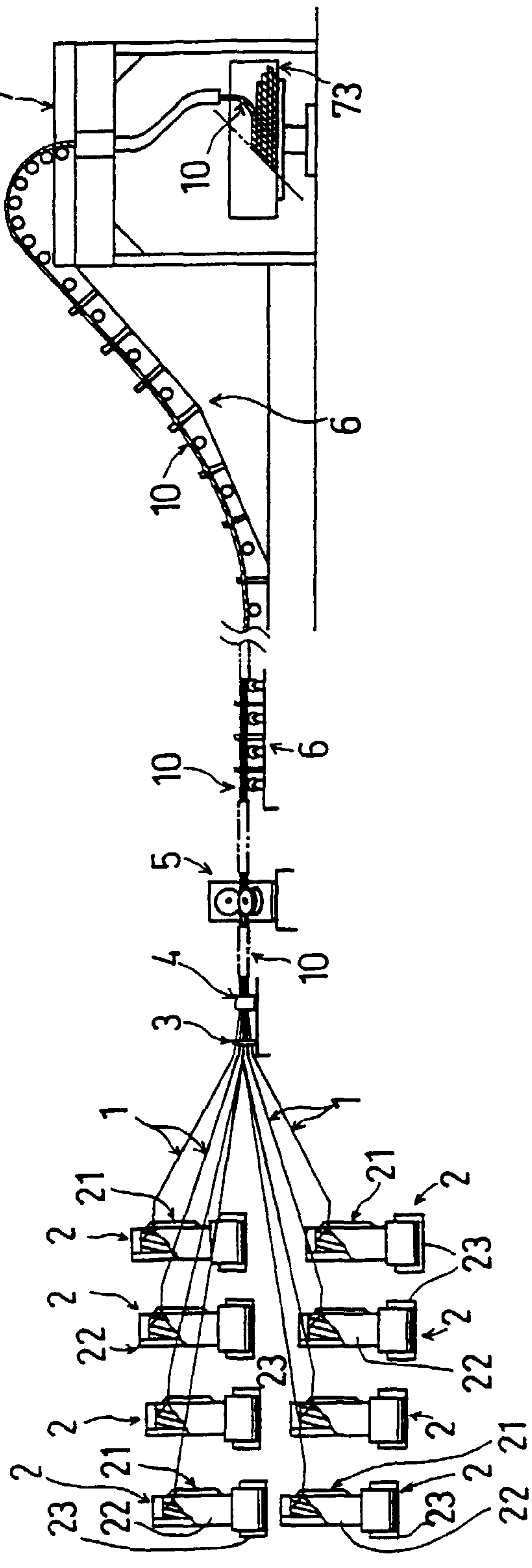


FIG. 2

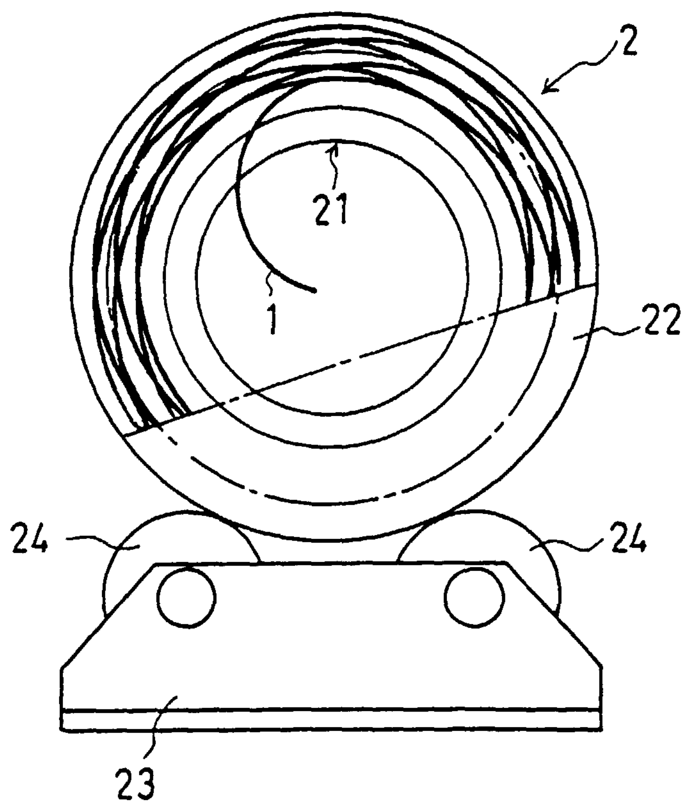


FIG. 3

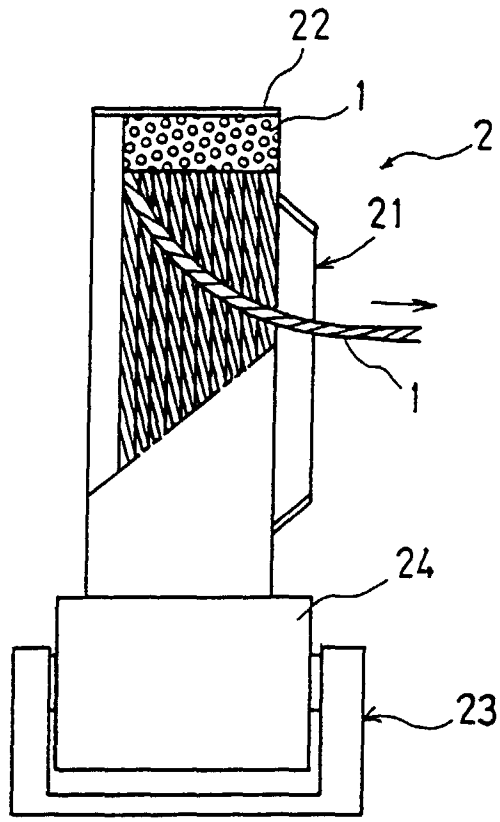


FIG. 4

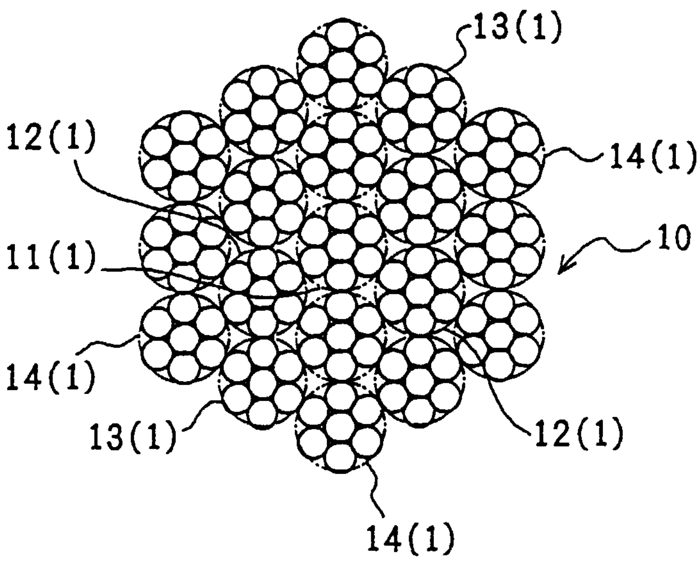
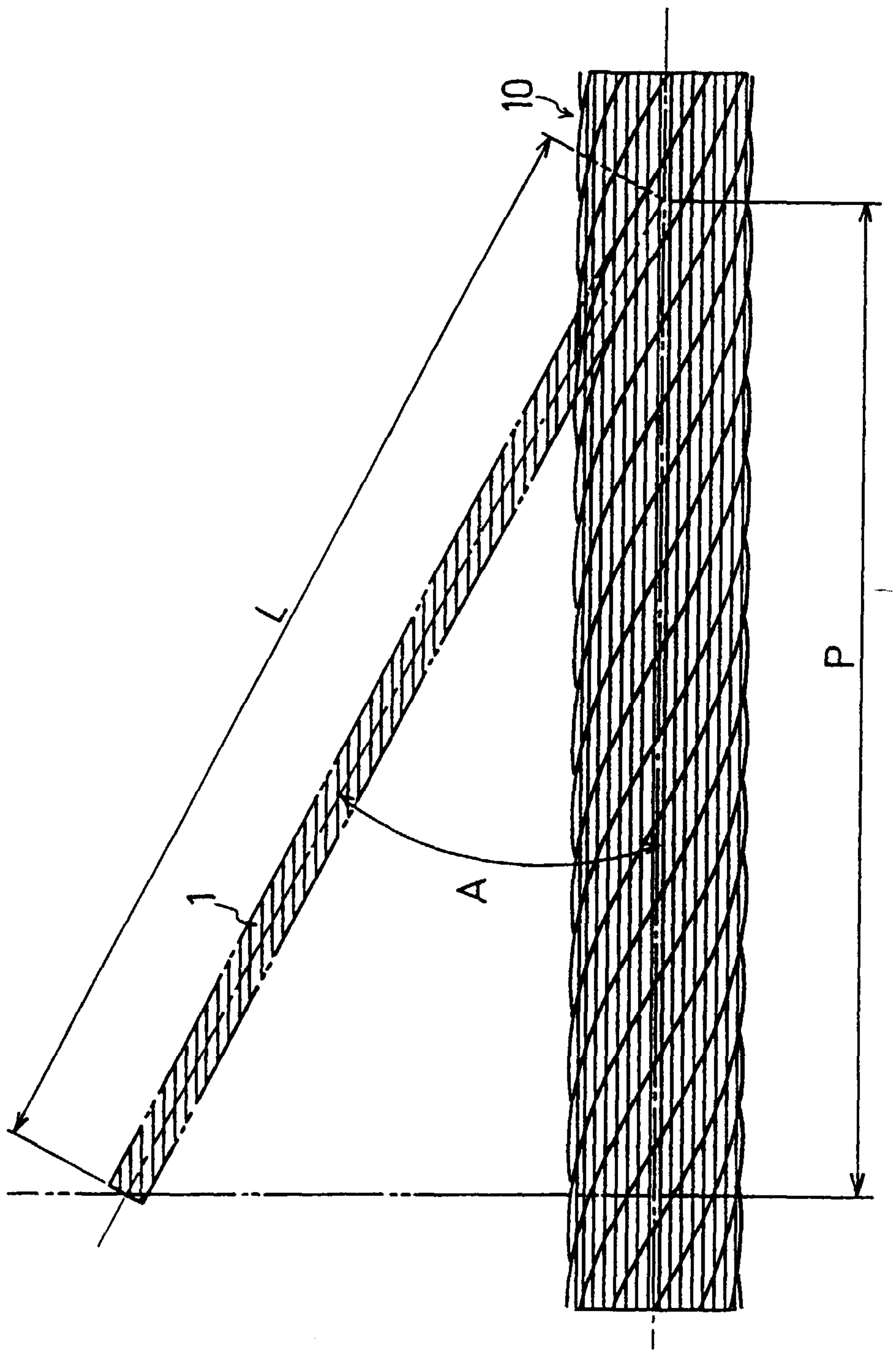


FIG. 5



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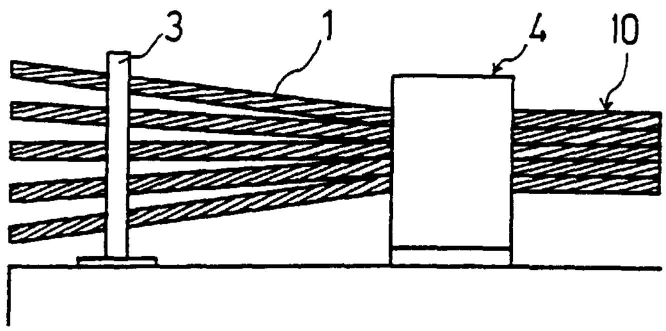

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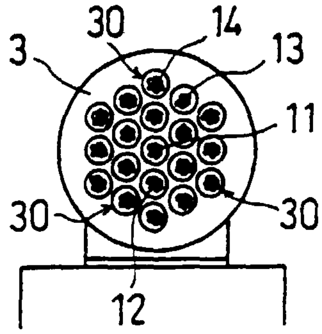

FIG. 8

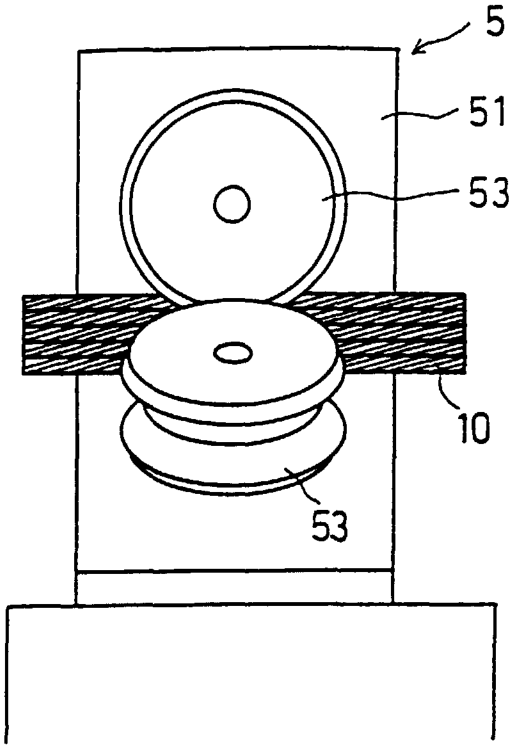

FIG. 9

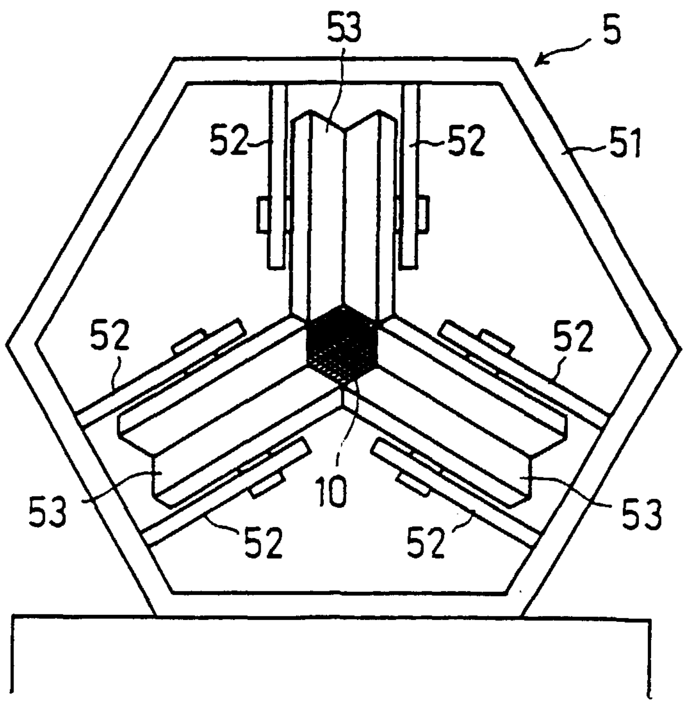

FIG. 10

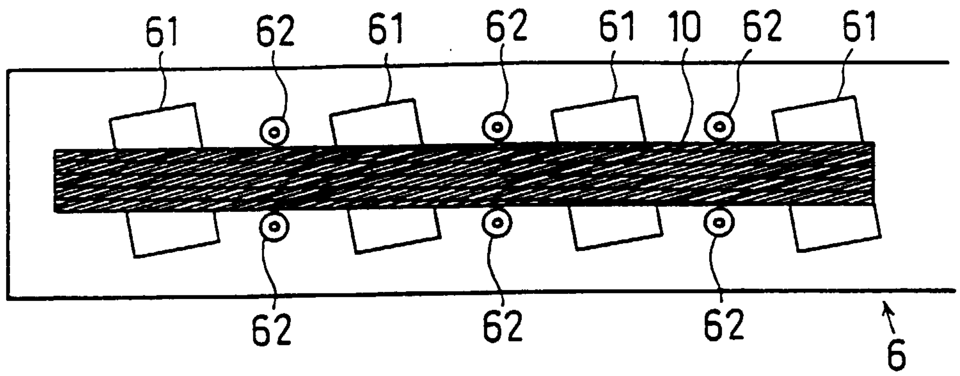

FIG. 11

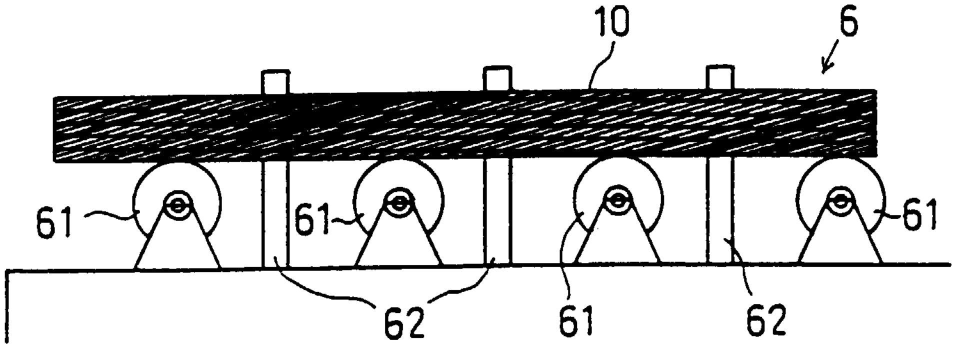

FIG. 12

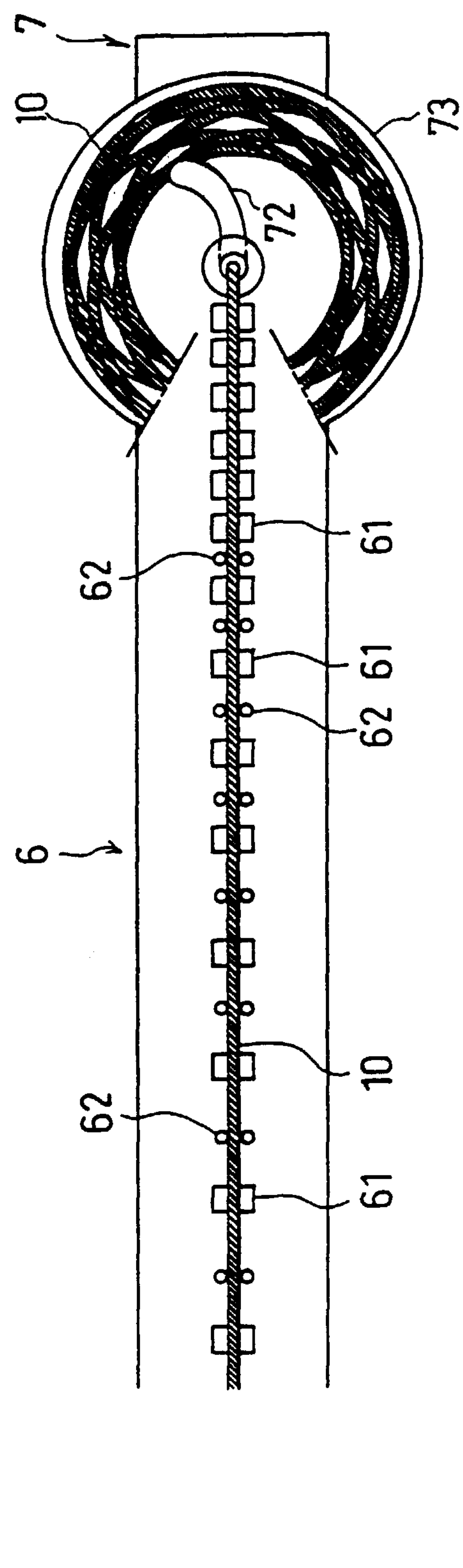

FIG. 13

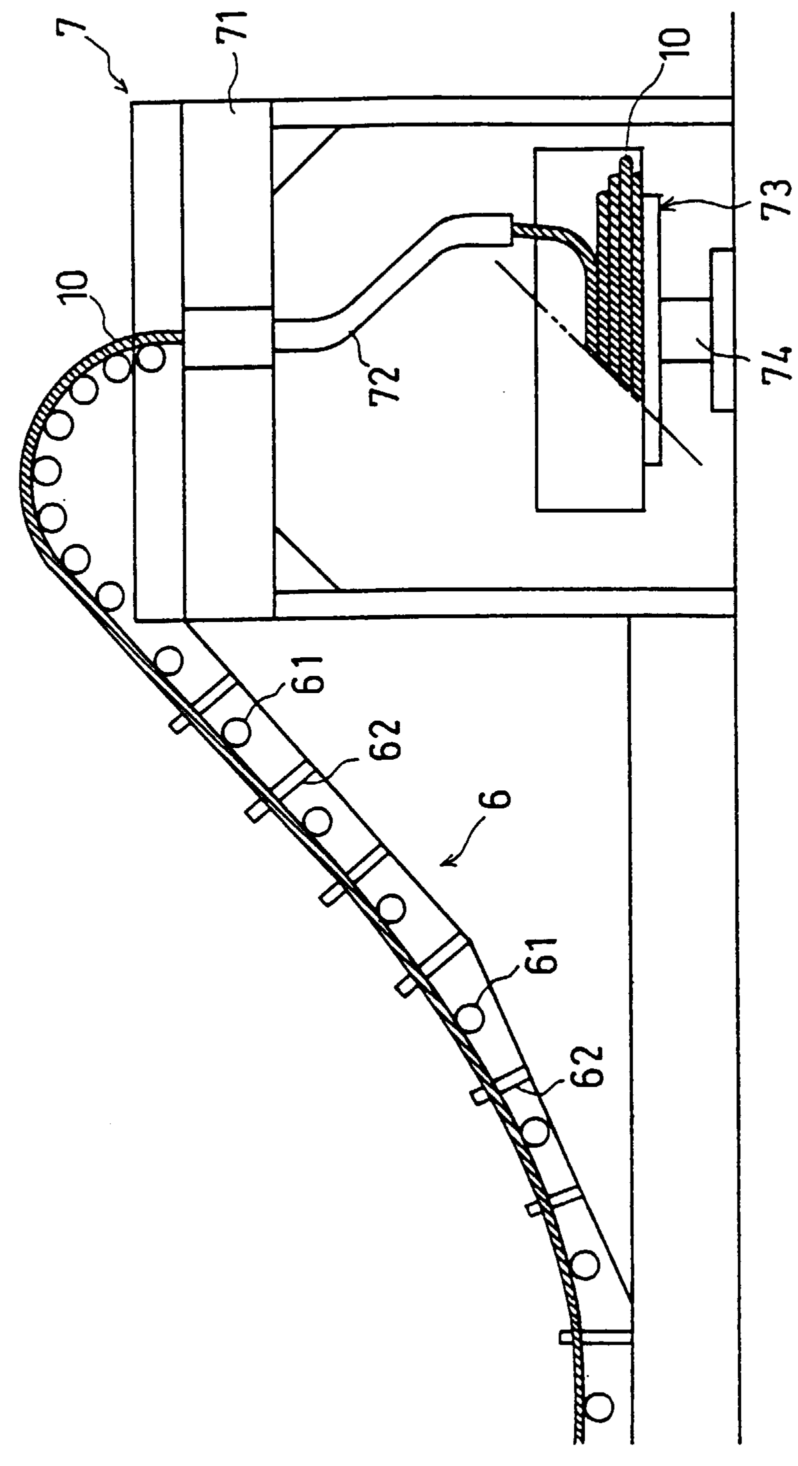

FIG. 14

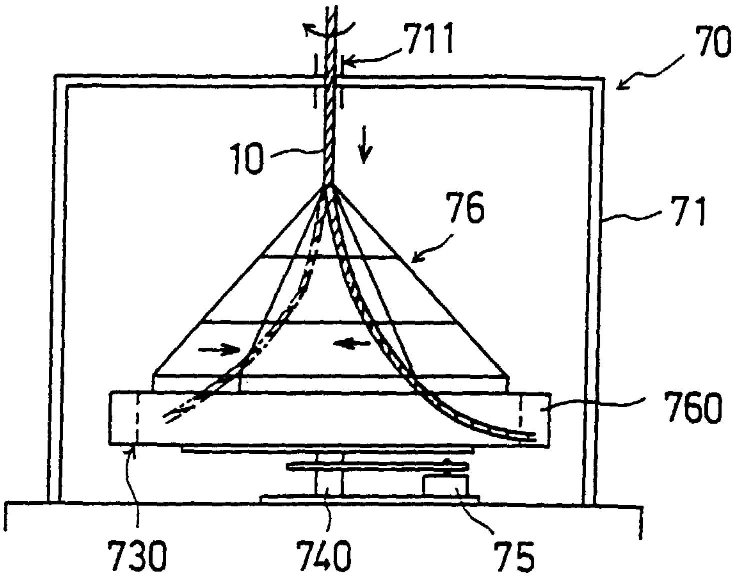

FIG. 15

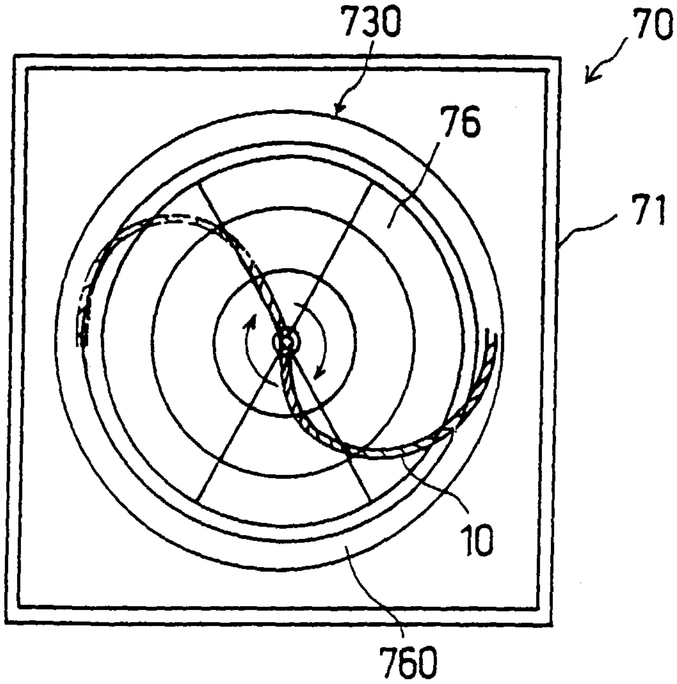

FIG. 16

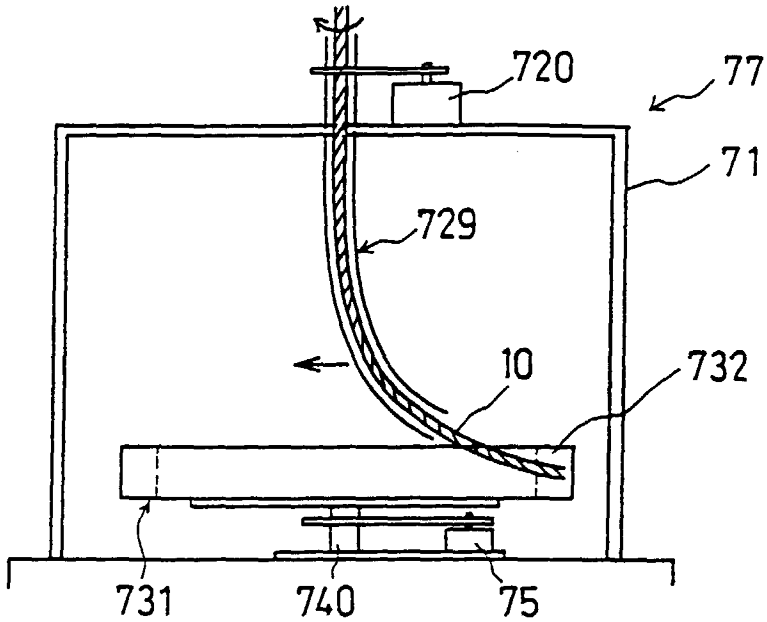

FIG. 17

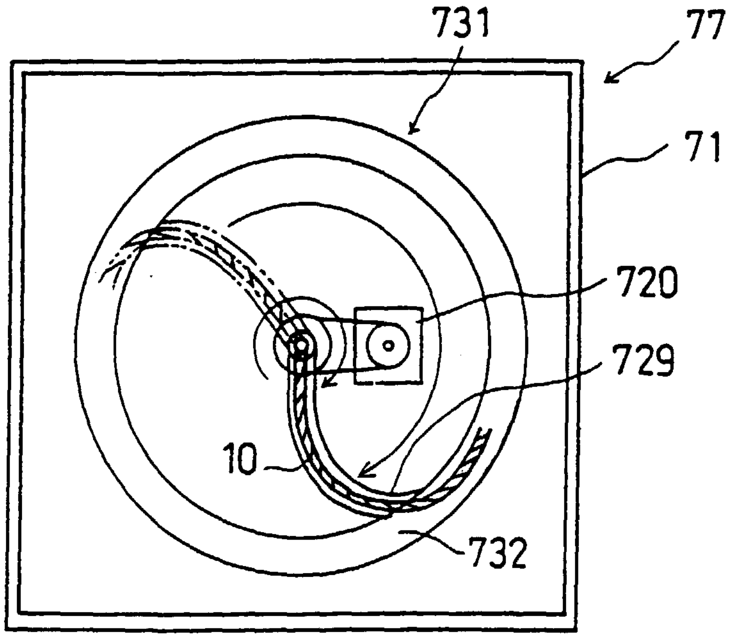

FIG. 18

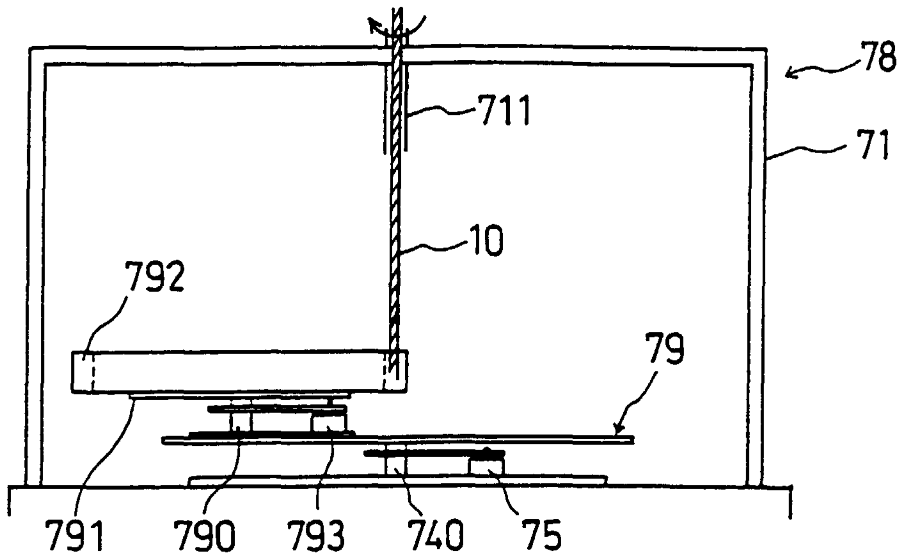
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FIG. 19

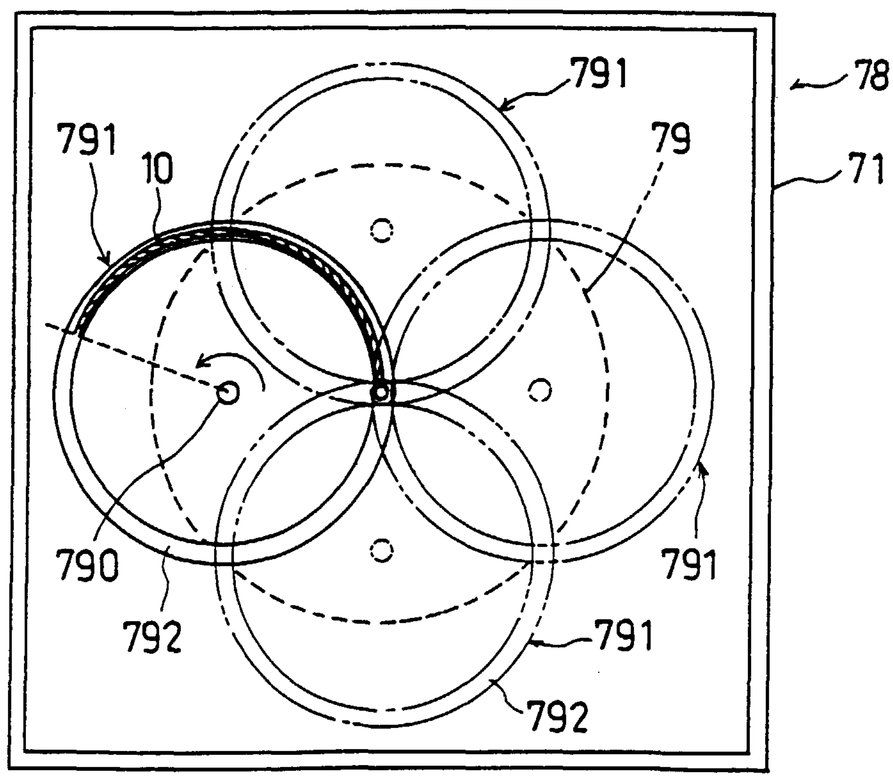
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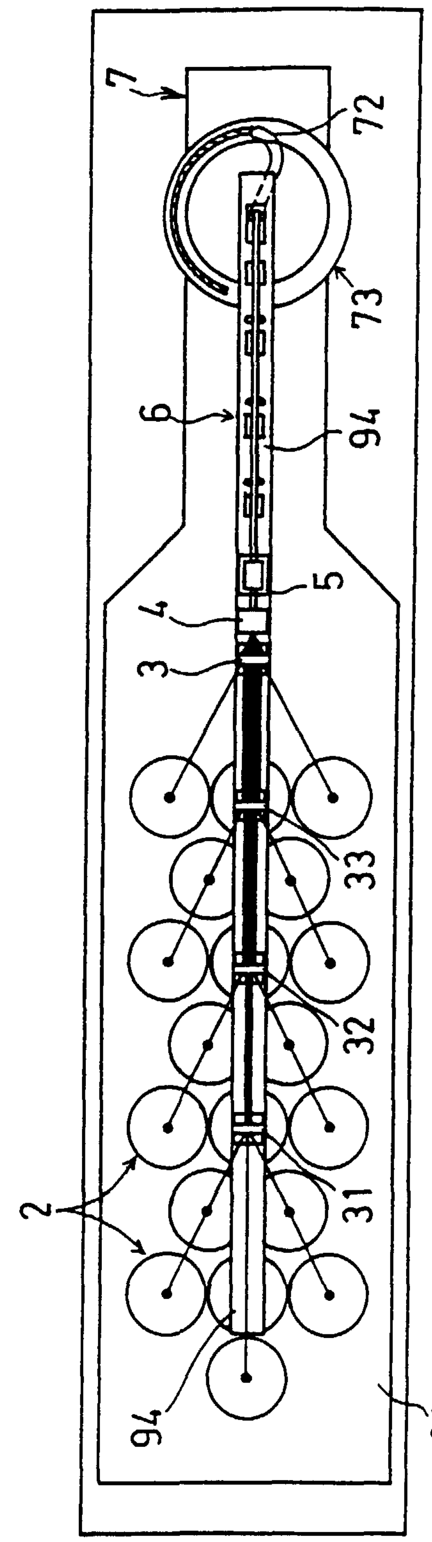
FIG. 20



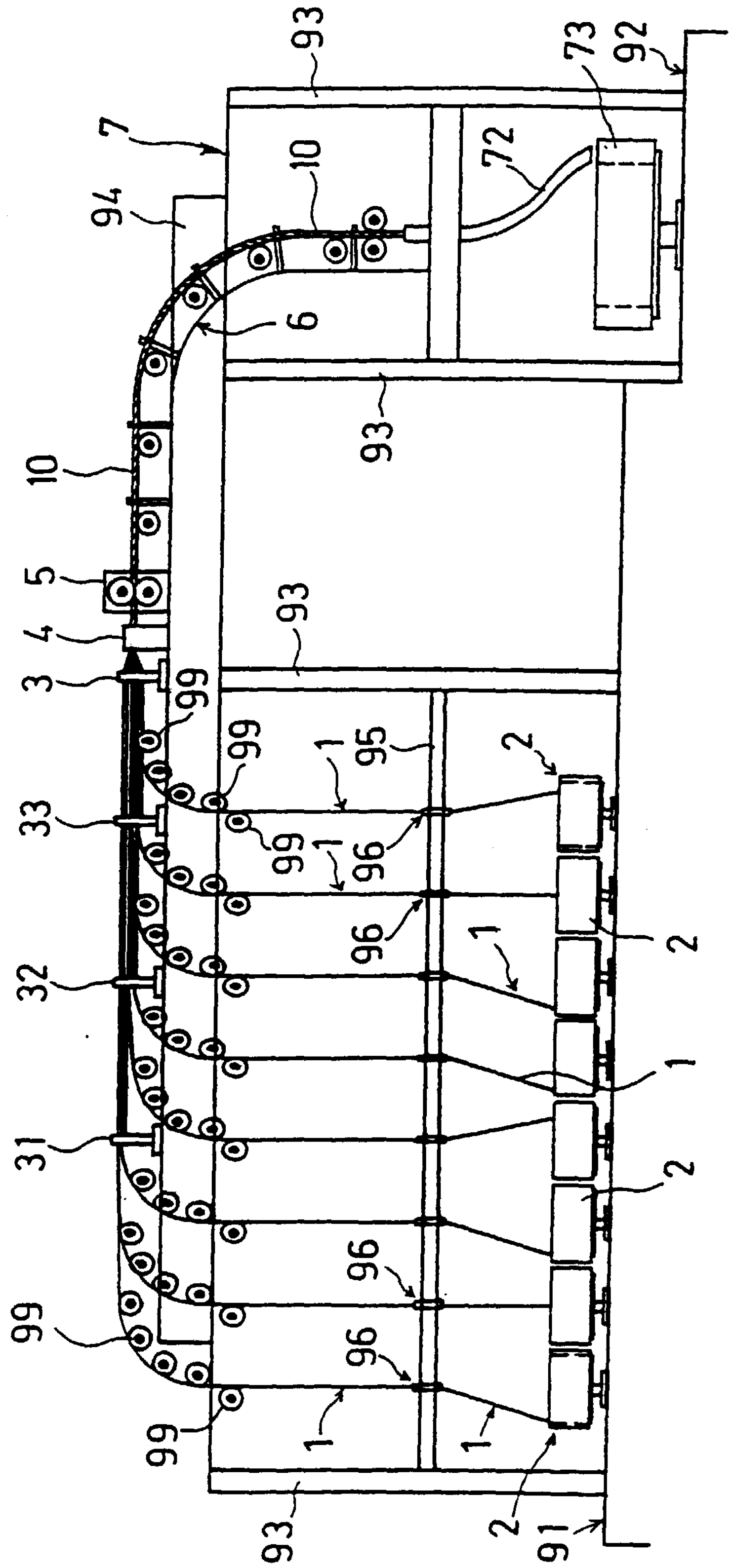

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FIG. 21

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 12 1539

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 2 944 380 A (J.J. KLAPPER ET AL) 12 July 1960 * column 2, line 3 - line 27 * * column 2, line 46 - column 3, line 38 *	1,3-6	D07B3/08 D07B7/10 B65H54/80
A	US 1 911 925 A (M.W. REED) 30 May 1933 * page 1, line 53 - page 2, line 24; figures 1-3 *	1,4	
A	EP 0 199 461 A (BRIDON PLC) 29 October 1986 * column 4, line 8 - line 47; figure 4 *	1,4	
A	GB 822 224 A (HUTTENWERK RHEINHAUSEN AG) 21 October 1959 * figure 1 *	2	
A	DE 34 44 496 A (W. HENRICH) 19 June 1986 * page 10, line 4 - line 14 *	7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

D07B
B65H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 February 1999	Goodall, C

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12-02-1999

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82