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(54) **CONICAL SPRING FORMING APPARATUS COMPRISING A SYSTEM FOR ADJUSTING THE LOAD CHARACTERISTICS OF A CONICAL SPRING**

VORRICHTUNG ZUR HERSTELLUNG KONISCHER FEDERN UMFASSEND EIN SYSTEM ZUR EINSTELLUNG DER BELASTUNGSEIGENSCHAFTEN EINER KONISCHEN FEDER

DISPOSITIF DE FABRICATION D'UN RESSORT CONIQUE COMPRENANT UN SYSTÈME D'AJUSTEMENT DES CARACTÉRISTIQUES DE CHARGE D'UN RESSORT CONIQUE

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Description

Technical Field of Invention

[0001] This invention relates to a conical spring forming apparatus comprising a system for adjusting the load characteristic of a conical spring (hereinafter referred to as load characteristic adjustment system) formed by a linear spring forming apparatus in a process of coiling a linear material into a conical spring by abutting a spring forming tool against the linear material

[0002] An apparatus for coiling a linear material to form a linear spring is disclosed in Patent Document 1 (JPA Laid Open 2004-237352). In this apparatus the linear material is forcibly fed from a quill to a spring forming stage, where the linear material is abutted against a coil forming tool and coiled by the coil forming tool carried forward to the spring forming stage perpendicularly to the axis of the linear material.

[0003] The diameter of the coil to be formed (hereinafter referred to as coil diameter) depends on the distance between the spring forming tool and the quill. That is, the shorter the distance, the smaller is the coil diameter, and the larger the distance, the larger is the coil diameter. Thus, if the coil forming tool is abutted against the linear material fed from the quill while moving the quill towards (or away from) the axis of the linear material at a constant speed perpendicularly to the axis by means of a quill moving means, the coil diameter can be gradually varied (increased), thereby resulting in a conical spring.

[0004] However, mainly due to manufacturing fluctuations in diameter of linear materials, it is often the case that the conical springs have a fluctuating load characteristic that depends on a particular manufacture lot. As a consequence, it is likely that conical springs formed from linear materials of different lots have fluctuating load characteristics beyond a permissible range if the apparatus is designed to form the conical springs of the same configuration. To obtain conical springs having the same load characteristic, it is therefore necessary to regulate the load characteristics of conical springs, depending on the manufacturing lot of the linear material used.

[0005] This can be done by delicately regulating the resultant shapes of conical springs to have a required load characteristic. For example, the load characteristic of a spring can be slightly changed if the inclination of the generatrix of the spring with respect to the spring axis (that is, the increasing rate of the coil diameter in the axial direction) is varied. The inclination of the generatrix varies between conical springs having different shapes, for example, substantial Mt. Fuji shaped (which is shaped like a bell of a horn, and hereinafter referred to as bell shaped), tapered shaped, and bowl shaped ones as shown in Fig. 7(b), by setting some of the control parameters of the spring forming apparatus to different magnitudes as shown in Fig. 7(a)

[0006] For example, the spring forming apparatus may be set up in such a way that the speed of the quill is constant while the feeding speed (or feed rate) of the lineal material fed from the quill is varied once during spring formation.

[0007] Fig. 7 illustrates relationships between different feed rates of conical spring forming apparatus (Fig. 7(a) and corresponding resultant shapes of conical springs (Fig. 7(b). The upper left and right diagrams of Fig. 7(a) respectively show the length X and feed rate V of linear material fed from the quill as a function of feeding time t. Symbol t1 represents time at which the feed rate is varied, and t2 the total feeding time The lower left diagram of Fig. 7(a) indicates the amount of move P (or position) of the quill as a function of time t (which is equal to the feeding time t).

[0008] As stated above, the spring forming apparatus is set such that the quill is moved at a constant speed away from the spring forming tool between P1 and P3. Further, the spring forming apparatus is set to feed the linear material from the quill at two different constant feed rates, as shown in the upper right diagram of Fig. 7(a).

[0009] Obviously, the circumferential length of a conical spring becomes larger towards the end of coil than that at the beginning. As a result, when the linear material is fed at constant feed rate V0 from the quill moving at constant speed from P1 to P3 as shown by a double dotted line in the upper right diagram of Fig. 7(a), the displacement of the quill per one revolution of the coiled linear material gradually increases towards the end of the spring, since the feed rate of the linear material is constant but the circumferential length of the conical spring gradually increases from the beginning to the end of the spring, as shown in the left diagram of Fig. 7(b). Thus, the inclination of the generatrix of the conic spring with respect to the axis L0 thereof becomes steeper towards the end of the spring than at the beginning, as shown in the left diagram of Fig. 7(b). In other words, the inclination of the generatrix of the conical spring with respect to the axis L0 is less steeper in the first half domain in which the quill moves from P1 to P2 than in the second half domain in which the quill moves from P2 to P3, as shown in Fig 7(b). As a consequence, the conical spring has a configuration which looks like a bell of a horn having a concave generatrix. (The configuration hereinafter referred to as bell type configuration.)

[0010] It is noted that the inclination of the generatrix becomes less steeper if the feed rate (feed rate) of the linear material is increased, and vise versa. Thus, if the feed rate of the linear material is set to a predetermined speed V1 lower than a predetermined constant speed V0 in the first half domain (0-t1 in time) and set to another predetermined speed V2 higher than V0 in the second half domain (t1-t2 in time) as indicated by solid lines in the upper right diagram of Fig. 7(a), the inclination of the generatrix becomes steeper in the first half domain, but less steeper in the second half domain as shown in the central diagram of Fig 7(b), as compared with the shape shown in the left diagram of Fig. 7(b). As a consequence, the resultant conical spring is slightly changed in config-

uration from bell type shown in the left diagram of Fig. 7(b) to one (hereinafter referred to as tapered type configuration) having a substantially constant inclination as shown in the central diagram of Fig. 7(b) Thus, the load characteristic is slightly changed.

[0011] On the other hand, if the feed rate is set to V3 which is still lower than V1 in the first half domain (0-t1) and set to V4 higher than V2 in the second half domain (t1-t2) as shown by a dotted line in the upper right diagram of Fig 7(a), the inclination of the generatrix becomes much steeper in the first half domain than in the second half domain as shown in the right diagram of Fig. 7(b), as compared with the one shown in the central diagram. Accordingly, the resultant conical spring looks like a slightly bulging bowl, as compared with the tapered one (this type of configuration will be referred to as bowl type configuration), so that its load characteristic is slightly changed still more than that of the tapered type.

[0012] As stated above, in the conventional conical spring formation, fine adjustment of load characteristics is made in such a way that a parameter "a" associated with the constant feed rate assumed in a first half domain from t=0 to t= t1 in which the quill is moved from P1 to P2 and a parameter "b" associated with the constant feed rate in a second half domain from t=t1 to t=t2 in which the quill is moved from P2 to P3 are set up in the spring forming apparatus by a worker, and trial conical springs made under different values of "a" and "b" having slightly different configurations that range from bell type to bowl type are tested until a conical spring having a preferred load characteristic is obtained

PRIOR ART DOCUMENT

Patent Document

[0013] Patent Document 1: JPA Laid Open 2004-237352

SUMMARY OF THE INVENTION

Objects of the Invention

[0014] To form a conical spring in a conventional approach, a worker must repeatedly change constant feed rate parameters ("a" and "b") until a preferred load characteristic is obtained. Thus, he must spend much energy and time to find an optimum set of constant feed rate parameters ("a" and "b"), since there are a large number of possible combinations of "a" and "b" to test.

[0015] Therefore, operations to determine such optimum set of "a" and "b" for a given linear material having a particular material characteristic is hopefully as simple as possible so that the operations can be done in a short time. In this connection, the inventors of the present invention came up with an idea that a great amount of time and repetitive work for forming conical springs can be reduced if a load characteristic of a conical spring can be adjusted using less number of control parameters while making trial conical springs of different shapes as usual.

[0016] In view of the problem stated above, the present invention is directed to an apparatus for forming a conical spring comprising a load characteristic adjustment system, the load characteristic adjustment system being capable of greatly reducing an amount of work and time conventionally required in setting up an optimum condition of the apparatus by reducing the number of control parameters (constant speed parameters "a" and "b" in conventional system) in the process of testing a multiplicity of trial conical springs having slightly different shapes and load characteristics.

MEANS FOR SOLVING THE PROBLEMS

[0017] This problem is solved by means of a conical spring forming apparatus with the features of claim 1, claim 2 or claim 3.

[0018] To solve the problems above, there is provided in accordance with claim 1 a load characteristic adjustment system for use with a spring forming apparatus that includes: a linear material feeder for feeding a linear material in the axial direction of the linear material; at least one spring forming tool arranged to face the linear material feeder and adapted to coil the linear material when abutted against the linear material; spiraling means for configuring the coiled linear material into a spiral form; and coil diameter varying means for gradually changing the diameter of the coiled linear material by dynamically changing the distance between the spring forming tool and the linear material feeder in operation. The load characteristic adjustment system is adapted to cause the linear material feeder to feed the linear material at a regulated constant acceleration to adjust the load characteristic of the conical spring formed.

[0019] (Function) By controlling the feed rate of the linear material, a multiplicity of conical springs different in shape and load characteristic can be formed.

[0020] Conventionally, shapes of conical springs and load characteristics of conical springs, including bell-type, tapered-type, and bowl-type springs, are controlled by a worker by varying values of combinatory control parameters ("a" and "b" for example) to be set up in the spring forming apparatus, associated with the linear material feed rates. To obtain an optimum combination of feed rates, however, this task requires great work and time, since there are a very large number of possible combinations.

[0021] However, according to the invention as recited in claim 1, the load characteristic adjustment system can similarly regulate the configuration of a spiral spring (including bell-type, tapered-type, and bowl-type ones), and hence the load characteristic, by simply varying the acceleration of the linear material fed from the linear material feeder (the acceleration hereinafter referred to as feeding acceleration), instead of varying constant feed

rates.

[0022] In other words, the load characteristic adjustment system of claim 1 controls only one control parameter, that is, feeding acceleration, to vary the configuration and load characteristic of the spiral spring formed by the spring forming apparatus. As a result, the inventive load characteristic adjustment system can obtain a desired spring configuration with less number of trials, as compared with conventional ones requiring trials as many as the second power of the number of control parameters Thus, in this invention, the amount of work and time needed to obtain an optimum value of the parameter (feeding acceleration in the present invention) for a given linear material is greatly reduced.

[0023] The load characteristic adjustment system defined in claim 2 is adapted for use with a conical spring forming apparatus that includes: a linear material feeder for feeding a linear material in the axial direction of the linear material; at least one spring forming tool arranged to face the linear material feeder and adapted to coil the linear material when abutted against the linear material; a pitch tool serving as a spiraling means for spiraling the linear material; and coil diameter varying means for gradually varying the coil diameter of the coiled linear material by dynamically varying the distance between the spring forming tool and the linear material feeder in operation. The load characteristic adjustment system is adapted to cause said means for gradually varying the coil diameter to move at a regulated constant acceleration at least one of the linear material feeder feeding the linear material and the spring forming tool to adjust the load characteristic of the conical spring formed

[0024] (Function) Instead of regulating the feeding acceleration by the load characteristic adjustment system according to claim 1, the configuration, and hence the load characteristic, of a conical spring, may be regulated by the load characteristic adjustment system according to claim 2 adapted to move at a regulated constant acceleration at least one of the linear material feeder and the spring forming tool so as to change the distance between them.

[0025] In other words, the acceleration for moving either the linear material feeder or the spring forming tool is the only control parameter needed for the load characteristic adjustment system to vary the configuration of a conical spring worked out by the spring forming apparatus, so that the load characteristic adjustment system enables the conical spring to have a desired configuration (and load characteristic) with less number of trials than conventional systems. Thus, the amount of work and time needed to find an optimum value of the control parameter (constant acceleration) for a given linear material is greatly reduced.

[0026] The load characteristic adjustment system defined in claim 3 is adapted for use with a conical spring forming apparatus that includes: a linear material feeder for feeding a linear material in the axial direction of the linear material; at least one spring forming tool arranged to face the linear material feeder and adapted to coil the linear material when abutted against the linear material; a pitch tool serving as a spiraling means for spiraling the linear material; and coil diameter varying means for gradually varying the diameter of the coiled linear material by dynamically changing the distance between the spring forming tool and the linear material feeder in operation. The load characteristic adjustment system is characterized in that:

the system is adapted to forcibly move the linear material in the direction of forming the conical spring (the direction hereinafter referred to as coil forming direction) so as to spiral the linear material at a given pitch in accord with the displacement of the spiraling means; and

the system is adapted to move the pitch tool at a regulated constant acceleration to gradually vary the pitch of the spiral, thereby adjusting the load characteristic of the conical spring formed.

[0027] (Function) The load characteristic of a conical spring can be adjusted by varying the pitch of the spring. The load characteristic adjustment system defined in claim 3 is adapted to cause the pitch tool to move at a regulated constant acceleration in the coil forming direction to gradually vary the pitch of the spiral, thereby varying the resultant shape, and hence the load characteristic, of the spring.

[0028] In other words, this load characteristic adjustment system regulates only the acceleration of the pitch tool as the control parameter for varying the shape of a resultant conical spring, requiring a fewer trials than ever in obtaining the same spring configuration as obtained by conventional adjustment system which requires trials as many as the second power of the number of control parameters. Thus, a number of trials and an amount of work required in conventional system to obtain optimum values of control parameters are greatly reduced.

RESULTS OF THE INVENTION

[0029] The load characteristic adjustment system of the invention requires only one parameter, instead of two or more than two parameters, for controlling the spring forming apparatus in the process of varying the shape of a conical spring, which means that the number of trials and time required of a worker to get an optimum value of the control parameter is not only simplified but also greatly reduced, thereby relieving the burden of the worker.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Fig. 1 is a front view of a coiling machine for use in the invention. Fig. 2 is a front view of a point tool unit in accordance with a first embodiment of the invention. Fig. 3 is a perspective view of the point tool unit of Fig 2,

as viewed from the rear end thereof. Fig. 4 is an enlarged perspective view of a linear material feeder near the point tool of the point tool unit. Fig. 5 is an enlarged front view of the linear material feeder near the point tool of Fig. 4. Fig. 6 is a plan view of the linear material feeder near the point tool, showing the coiling machine of the first embodiment in the process of forming a conical spring Fig. 7(a) shows diagrams illustrating how the material is fed from a prior art linear material feeder and how the movement of the feeder is controlled. Fig. 7(b) shows resultant configurations of conical springs formed under the controlled conditions shown in Fig. 7(a) Fig. 8(a) shows diagrams illustrating how the material is fed from an inventive linear material feeder and how the movement of the feeder is controlled. Fig. 8(b) shows resultant configurations of conical springs under the controlled conditions shown in Fig. 8(a). Fig. 9 is a front view, partially shown in cross section, of a coil spring forming apparatus in accordance with a second embodiment of the invention. Fig. 10 is an enlarged cross section of the coil spring forming tool shown in Fig 9. Fig. 11(a) shows positions of a right- and a left-handed coil spring forming tool mounted on a tool holder. Fig. 11(b) shows the right-handed coil spring forming tool as viewed from the direction II of Fig. 11(a). Fig. 11(c) shows the left-handed coil spring forming tool as viewed from the direction III of Fig. 11(a). Fig 12 is a plan view of a quill near the coil spring forming tool, showing how a conical spring is formed by the spring forming apparatus in accordance with the second embodiment of the invention

BEST MODE FOR CARRYING OUT THE INVENTION

[0031] The coiling machine in accordance with a first embodiment of the invention will now be described in detail by way of example with reference to Figs. 1 through 5

[0032] This coiling machine (linear spring forming apparatus) 150 has a linear material feeding unit 151 for feeding a linear material 1 to a spring forming stage 200, a point tool unit 152 to be abutted against the linear material 1 to forcibly bend the linear material 1 fed from the linear material feeding unit 151, a cored bar 153 for guiding the bent linear material 1, a pitch tool 154 for spiraling the linear material 1 into a coil by pressing the bent linear material 1 in the coil forming direction, and a cutting unit 155 for cutting the linear material 1 at the end of the coil

[0033] The linear material feeding unit 151 includes a linear material guide 156 having a guide groove 156a for guiding the linear material 1 along the axis X1 of the linear material 1, a pair of feed rollers (157a and 157b) for rotating the linear material 1 fixedly held on the linear material guide 156 towards the leading end of the linear material guide 156 (in the direction D1 of Fig. 1) by means of a feed motor (not shown), and a linear material feeder 158 for feeding the linear material to the spring forming stage 200 provided at the leading end of the linear material guide 156.

[0034] The point tool unit 152 has a point tool 160 having an abutting groove 159 for receiving therein in abutting condition the linear material 1 fed from the linear material feeder 158 to bend the linear material, a slide table 161 having on the surface thereof the point tool 160, and coil diameter regulation means 162 for dynamically regulating the distance between the leading end of the point tool 160 and the linear material feeder 158 by moving the slide table 161 in the axial direction X1 of the linear material. The leading end of the point tool 160 is arranged in opposition to the linear material feeder 158.

[0035] The cored bar 153 arranged between the linear material feeder 158 and the abutting groove 159 extends in the coil forming direction (CF direction as indicated in Fig. 4) and along line X2 (which is the axis of the coil shown in Fig. 6) perpendicular to the axis X1. The cored bar 153 has a semi-circular cross section, with its arcuate periphery facing the abutting groove 159 to guide the bent linear material 1 to the pitch tool 154.

[0036] The coil diameter of a coil formed increases in proportion to the distance between the linear material feeder 158 and the abutting groove 159. This distance can be regulated by coil diameter regulation means 162 adapted to move the point tool 160 towards or away from the linear material feeder 158.

[0037] The coil diameter regulation means 162 has a pair of slide rail units 163 securely fixed to the coiling machine 150 at a predetermined position with bolts 163f, for example, for holding the slide table 161 slidable in the axial direction X1 of the linear material, a cam receiving member 164 provided on the backside of the slide table 161, a cam member 165 rotated by a cam motor (not shown) to move the point tool 160 mounted on the slide table 161 in one direction along the axial direction X1 of the linear material by pushing the periphery of the cam receiving member 164, and a spring member 166 for urging a cam member 165 in the direction opposite to the moving direction of the cam member 165, thereby urging the slide table 161 in that opposite direction.

[0038] The slide rail unit 163 is provided on the upper and lower ends thereof with slide rails (163a and 163b), and at the rear end thereof with a mount 163c for mounting the spring member 166 and a stopper 163d. The slide table 161 is held by the slide rails 163a and 163b from above and below, respectively, and can slide either in TF direction (which is the feeding direction of the linear material feeder 158) along the axial direction X1 of the linear material or in TR direction (which is the direction towards the rear end 163e). The spring member 166 is connected at one end thereof to the mount 163c at the rear end 163e, and at the other end connected to the slide table 161. The slide table 161 is thus urged by the spring member 166 in TR direction. The stopper 163d is screwed to the rear end 163e such that it is movable forward and backward in the axial direction X1 of the linear material. As a consequence, the leading end 163g projection from the rear end 163e in TF direction may come into contact with the rear end 161a of the slide table 161 (which is

urged in TR direction by the spring member 166) without touching the rear end 163e, thereby serving as a stopper.

[0039] In the first embodiment, the outer circumference of the cam member 165 increases in the counterclockwise direction d2, as shown in Fig. 3 Thus, when the cam member 165 is rotated in the clockwise direction d1 by a cam motor (not shown), the cam receiving section 164 is pushed in TF direction along the slide rails (163a and 163b) together with the integral slide table 161, thereby causing the leading end of the point tool 160 on the slide table 161 to approach the linear material feeder 158. On the other hand, when the cam member 165 is rotated in the counterclockwise direction d2, the periphery of the cam member 165 abutting against the cam receiving member 164 is rotated by the urging force of the spring member 166 acting in TR direction, so that the slide table 161 is moved in TR direction along the slide rails (163a and 163b) and the point tool 160 comes off the linear material feeder 158.

[0040] It is noted that although there is only one point tool 160 in the first embodiment that can move back and forth in the axial direction X1 of the linear material, a multiplicity of point tools 160 (coil diameter regulation means 162) (not shown) may be radially arranged about the axis X2 of the coiling machine 150 such that the multiplicity of point tools 160 are movable in the radial direction about the axis X2 to regulate the coiling diameter of the spring formed.

[0041] The pitch tool 154 is arranged adjacent the cored bar 153 and in the direction in which the bent linear material 1 extends, such that the tip of the pitch tool 154 may abut against the bent linear material 1. The pitch tool 154 is provided at the leading end thereof with a pushing face 167, which is inclined in the direction from the material entering position to the coil forming direction (CF direction) so that it pushes the abutting linear material 1 in the coil forming direction (CF direction) When actuated by an actuator (not shown), the pitch tool 154 is not only movable back and forth in CF direction and in the opposite CR direction (Fig. 4) along line X3 that extends in the direction perpendicular to the axis X1, but is also rotatable about line X3.

[0042] As shown in Figs. 4 and 5, the linear material 1, fed from the linear material feeder 158 and bent by the abutting groove of the point tool 160 in the direction perpendicular to coil forming direction, is in contact with the pushing face 167 of the pitch tool 154 while it is guided by the curved interior of cored bar 153. Since the linear material 1 in contact with the pushing face 167 is pushed in the coil forming direction (CF direction) by the pushing face 167 as shown in Fig. 6, the linear material 1 is spiraled to form a coil spring. The coiled linear material 1 is cut by the cutting tool 55 that is movable to and away from the spring forming stage 200 and pushed against the linear material 1.

[0043] The pitch of the coil spring thus formed increases in proportion to the distance traveled by the pitch tool 154 in CF direction while the tool is in contact with the pushing face 167.

[0044] In forming a conical spring, the coiling spring diameter is gradually increased or decreased during coiling of the linear material 1. In the coiling machine 150 of the first embodiment, a conical spring is formed by moving the slide table 161 carried on the point tool 160 to the right (TR direction) along the axis X1 as shown in Fig. 6 for example, using a cam motor (not shown) to gradually separate the point tool 160 away from the linear material feeder 158 and bring the linear material 1 fed from the linear material feeder 158 at a predetermined constant acceleration into abutment with the abutting groove 159 of the point tool 160. Alternatively, a conical spring may be formed by moving the slide table 161 (point tool 160) at a predetermined constant acceleration and bringing the linear material 1 fed from the linear material feeder 158 at a regulated constant speed into contact with the abutting groove 159.

[0045] Thus, the final configuration of the conical spring formed may be easily and freely regulated between a bell-type, tapered type, and bowl type configuration by regulating the feed acceleration of linear material 1 in the case where the slide table 161 (point tool 160) is moved at a constant speed, or by regulating the constant acceleration of the slide table 161 in the latter case where the linear material is fed at a constant feed rate, as described in more detail below.

[0046] Referring to Fig. 8, there is shown specific methods of controlling the spring forming apparatus to form a conical spring. Fig. 8(a) shows control methods in accordance with the respective embodiments of the invention In the upper left and right diagrams of Fig. 8(a), abscissas represent time t of feeding a linear material from the linear material feeder 158. The ordinate of the upper left diagram represents the length X of the linear material fed from the linear material feeder 158, while the ordinate of the upper right diagram indicates the speed V of the linear material feeder 158. The abscissa of the lower left diagram of Fig. 8(a) represents time t of moving the slide table 161 carrying the point tool 160, and the ordinate the displacement P (P also represents the position for that displacement) of the slide table 161.

[0047] Through numerical control of a cam motor (not shown), the point tool 160 causes the linear material 1 fed from the linear material feeder 158 to be moved at a constant speed from P1 to P2 along the axis X1 over a period of time t2 as shown in the lower left diagram of Fig 8(a) while keeping the linear material in abutment against the abutting groove 159. If the speed of the linear material 1 fed from the linear material feeder 158 is numerically controlled by a feed motor (not shown) and set to a constant speed V0 throughout the feeding, a conventional bell type conical spring having a concaved generatrix as shown in the upper right diagram of Fig. 8(a) is formed.

[0048] In this embodiment, the spring forming apparatus is set up such that the linear material is fed from the linear material feeder 158 at a predetermined constant

acceleration, that is, the speed of the linear material 1 is set to V=a(t-t1)+V0 as shown in the upper right diagram of Fig 8(a), where "a" is a control parameter associated with the acceleration that can be manually varied by a worker in the integral range from 0 to 100 for example, "t" denotes time of feeding the linear material 1, "t2" a total time of feeding, "t1" a predetermined time smaller than t2, and "V0" a constant associated with the predetermined speed In trial spring formations of conical springs, a worker presets the values of t2, t1, and V0, and then varies the value of "a" in sequence, for example 0, 1, 2, ... and so on, to vary the feeding acceleration until a desired load characteristic is obtained.

[0049] If the value of "a" is increased, the slope of V, or the acceleration, of the fed linear material increases past the point (t1, V0). Then length X of the linear material fed changes as shown in the upper left diagram of Fig. 8(a). In other words, when a=0, length X is given by X=VO t. In this case, the inclination of the generatrix of the conical spring with respect to the axis L0 of the spring becomes gradually steeper from the beginning to the end the spring, thereby resulting in a bell shaped conical spring as shown in the upper left diagram of Fig. 8(b).

[0050] On the other hand, as the worker increases the value of "a" from a=0 to a=1, 2, 3, and so on, length X increases as

$$X=(a/2)\ t^2+(V0 \cdot a\ t1)\ t,$$

as indicated by a solid curve in the upper left diagram of Fig. 8(a). Thus, the linear material is fed slowly in the first half period and faster in the second half period as compared with the case where "a" is set to zero, so that the inclination of the generatrix with respect to the axis L0 becomes substantially constant throughout the respective half periods. As a result, the resultant conical spring formed has substantially a tapered configuration as shown in the central diagram of Fig. 8(b).

[0051] If "a" is set to a value still larger than a preset value, feeding is delayed or slowed in the first half period and faster in the second half period that the generatrix of the resultant conical spring is more steeper in the first half period but less steeper in the second half period, as indicated by a dotted line in the upper left diagram As a result, the resultant conical spring will have a bowl-like configuration as shown in the lower right diagram of Fig. 8(b)

[0052] In this way, the worker can delicately regulate the final shape of the conical spring having different pitch rates, and hence adjust the load characteristic of the conical spring, by simply varying only one control variable "a" associated with feed acceleration in the rage from a=0 to 100 for example as described above. When a conical spring having a desired load characteristic is included in the tested conical springs, the value of "a" for that conical spring is the optimum value for the lot. Thus, mass production of conical springs having a desired load characteristic can be done using the optimum value. The worker only need to vary one control parameter, feed acceleration say, and need not vary two or more than two variables as in conventional cases. Thus, the optimum value of "a" for a preferred load characteristic of conical springs can be easily determined, and the load characteristic is easily adjusted

[0053] In the example above, the moving speed of the point tool 160 (slide table 161) is fixed to a constant speed while the acceleration of feed rate of a linear material fed from the linear material feeder 158 is varied. Alternatively, similar conical springs including bell type, tapered type and bowl type springs may be formed if, in setting up the coiling machine 150, the feed rate of the linear material is fixed and the acceleration "a" of the slide table 161 is varied in different ways such that its displacement X and speed V satisfy X-t equation and V-t equation shown in the upper left and right diagrams of Fig 8. If a multiplicity of point tools 160 (not shown) movable back and forth are radially arranged about the axis X2 of a conical spring, each of the slide tables 161 associated with the respective point tool 160 be moved with a regulated constant acceleration in accord with the equations as indicated in the upper left and right diagrams of Fig. 8.

[0054] On the other hand, the load characteristic of a conical spring can be adjusted by varying its pitch. The load characteristic of a conical spring is weakened if the pitch is increased in the small diameter section and reduced in the larger diameter section, and conversely strengthen if the pitch is increased in the small diameter section and reduced in the large diameter section.

[0055] From this point of view, adjustment of the load characteristic of a conical spring may be achieved by regulating the constant acceleration of the pitch tool 154 moving in the coil forming direction (CF direction), instead of regulating the acceleration of the slide table 161 (point tool 160) and the feeding acceleration.

[0056] When the pitch tool 154 is moved by an actuator mechanism (not shown) at a constant acceleration in CF direction during forming a conical spring, the pitch of the conical spring increases in CF direction of Fig. 6 at an accelerated rate In this way, the resultant configuration, and hence the load characteristic, of the spring can be delicately adjusted, since the pitch of the spring is changed

[0057] Thus, the shape and load characteristic of a conical spring can be preferably regulated by setting up the coiling machine 150 in such a way that the pitch tool 154 is moved at a constant acceleration "a" (wherein the displacement X and speed V of the pitch tool 154 obey the respective defining equations indicated in the upper right and left diagrams of Fig. 8, with both of the feed rate (or feeding acceleration) of the linear material 1 fed from the linear material feeder 158 and the moving speed (or moving acceleration) of the slide table 161 set to fixed values.

[0058] In setting up the coiling machine 150, the worker

can delicately control the load characteristic of conical springs including bell shape, tapered shape, and bowl shape springs by varying only one control parametex, the acceleration "a", of the slide table 161 over the range from 0 to 100, for example (or the acceleration of the pitch tool in the case where the load characteristic is adjusted using the pitch tool 154). If a conical spring having a desired load characteristic is found among the conical springs tested for a particular value of "a" for a given lot, desirable conical springs can be mass-produced from the lot with that set value. It should be appreciated that the worker can again easily adjust the load characteristic by simply varying one control parameter associated with the acceleration of the coiling machine.

[0059] Next, referring to Figs. 9 through 12, a second load characteristic adjustment system of the invention will now be described.

[0060] As opposed to the first embodiment where the point tool 160 is moved with the linear material feeder 158 fixed, the quill 10 (which corresponds to the linear material feeder 158 of the first embodiment) is moved in the axial direction X1 of the linear material with a coil forming tool 120 (which corresponds to the point tool 160) fixed in the second embodiment.

[0061] As shown in those figures, a spring forming apparatus 300 utilizing such second load characteristic adjustment system includes: a linear material feeding means 20 having a pair of pressure rollers 22 for feeding a linear material 1 to a spring forming stage 100 (Fig. 9) via the quill 10 serving as a linear material guide; and a coil forming tool 120 movable towards, and away from, the spring forming stage 100; wherein the coil forming tool 120 is moved forward to the spring forming stage 100 to abut against the linear material 1 fed from the spring forming stage 100 provided at the leading end of the quill 10, thereby spiraling the linear material 1.

[0062] Reference numeral 3 indicates a fixed frame provided on a cradle 2. Mounted on the fixed frame 3 is a linear-way slide 50 (serving as a coil diameter regulating means of the claims) for dynamically varying the distance between the coil forming tool 120 and quill 10 by moving the quill 10 along the axis X1 of the linear material 1. Also mounted on the fixed frame 3 is a slide table 52, which is slidable on the frame 3 in the direction of the axis X1 of the linear material 1. The slide table 52 integrally bears thereon the quill 10 and the linear material feeding means 20 via a slide frame 4. The quill 10 integral with the slide table 52 can be moved in the forward direction (KF direction) and backward direction(KR direction) along the axis X1 of the linear material 1 as shown in Fig. 10, via a ball screw 54 which is rotated by a servomotor M50 mounted on the fixed frame 3. The pressure rollers 22 are subjected to a driving force of the M22 via a gear mechanism (not shown) The upper one of the rollers 22 is rotated in the counterclockwise direction, while the lower one is rotated in the clockwise direction, thereby feeding the linear material 1 held therebetween from the quill 10 to the spring forming stage 100.

[0063] Arranged above, and in the direction perpendicular to, the axis X1 of the linear material 1 is a linear slide 110. This linear slide 110 has a tool slide table 112 bearing thereon the coil spring forming tool 120. The tool slide table 112 is moved by a servo-motor M110 forward and backward relative to the spring forming stage 100 provided at the leading end of the quill 10. A crank mechanism 114 for converting the rotational motion of the servo-motor M110 to a linear motion is arranged between the output shaft of the servo-motor M110 and the tool slide table 112, which mechanism controls the forward and backward motion of the tool slide table 112.

[0064] The coil forming tool 120 has a tool rotation unit 131 and a servo-motor M132. The tool rotation unit 131 and the servo-motor 132 are mounted on a movable tool slide table 112. The tool unit 131 is provided on a rotatable tool holder thereof with a pair of right-handed and left-handed coil forming tools 134A and 134B, respectively, which are facing each other across the rotary shaft 133. The tool holder 132 is a rotary body having a rotational axis parallel to the direction of forward/backward movement of the tool slide table 112. Reference numerals 132a and 133b indicate a gear mounted on the output shaft of the servo-motor M132 and a gear mounted on the rotational shaft 133, respectively. The driving force of the motor is transmitted to the tool rotational unit 131 by these gears.

[0065] In this coil forming tool 120, the right- and left-handed coiling tools 134A and 134B, respectively, can be easily exchanged in position by operating the servo-motor M132, so that the tools 134A and 134B can be easily switched between them for abutment on the linear material 1.

[0066] As shown in Fig. 11(a)-(c), the tool holder 132 has a generally flattened square block configuration, and is provided at the right and left corners thereof with a right-and a left-handed coiling tool 134A and 134B, respectively, such that these tools have respective abutting faces 136 and 137 facing each other in their linear material engagement grooves 136a and 137a The engagement groove 136a for right-handed coiling of the linear material consists of a pair of parallel grooves downwardly inclined towards the right leading end of the right-handed coiling tool 134A as shown in Fig. 11(b). On the other hand, the engagement groove 137a for left-handed coiling of the linear material consists of a pair of parallel grooves downwardly inclined towards the left leading end of the left-handed coiling tool 134B as shown in Fig. 11(c)

[0067] In forming a coil spring, the coil forming tool 120 is moved towards the spring forming stage 100 in CF direction as indicated in Fig. 10 under the control of the tool slide table 112 so that the coiling tool 134A (or 134B) is arranged to face the quill 10 and is abutted on the linear material 1 fed from the leading end of the quill 10. When the coiling tool 134A is facing the quill 10, the linear material 1 is coiled in the right-handed coiling direction along the right declining abutment groove 136a of Fig. 11(b), as shown in Fig. 12 On the other hand, if the tool holder

132 is rotated through 180° by the servo-motor M132 so as to bring the left-handed coiling tool 134B to face the quill 10, the linear material 1 is coiled in the left-handed coiling direction by the left declining abutment groove 137a.

[0068] The coiling diameter of the coil spring thus formed increases in proportion to the distance from the coiling tool 134A (or 134B) to the quill 10. For instance, to form a conical spring as shown in Fig. 12, the slide table 52 carrying thereon the quill 10 feeding the linear material at a constant feeding acceleration is moved at a constant speed by the numerically controlled servo-motor M50 in the direction KR along the axis X1 shown in Fig. 10, so that the quill 10 is moved away from the coiling tool 134A (or 134B) while keeping the linear material 1 in abutment against the abutment groove 136a (or 137a) Alternatively, the quill 10 mounted on the slide table 52 and feeding the linear material 1 at a constant feed rate is moved by the servo-motor M50 at a constant acceleration in KR direction along the axis X1 as shown in Fig. 10 while keeping the linear material 1 in abutment against the abutment groove 136a (or 137a).

[0069] For example, in setting up the spring forming apparatus 300, the slide table 52 (quill 10) may be set to a constant speed while the feed acceleration of the linear material is set to a constant magnitude by regulating the value of "a" such that the feed length X and feed rate V of the linear material satisfies the defining equation indicated in the upper right and left diagrams of Fig 8. Alternatively, the feed rate of the linear material 1 fed from the quill 10 may be set to a constant speed and the value of "a" may be set so that the acceleration of the slide table 52 (quill 10) to remain constant and that displacement X and moving speed V of the slide table 52 (quill 10) satisfy the defining equation indicated in upper right and left diagrams of Fig. 8, as opposed to the preceding example.

[0070] In this case, the worker setting up the spring forming apparatus 300 to adjust the load characteristic of a conical spring by controlling the movement of the slide table 52 can delicately and easily regulate the resultant configuration (among bell type, tapered type, and bowl type configuration), or the pitch, of the conical spring to be formed by simply controlling only one parameter such as "a" associated with the acceleration of the slide table 52 in the range from 0 to 100.

SYMBOLS

[0071]

1	linear material
151	linear material feed unit (linear material feeding means)
154	pitch tool (spiraling means)
158	linear material feeding means
160	point tool (spring forming tool)
162	coil diameter regulating means
X1	axis of the linear material
"a"	acceleration parameter
10	quill (linear material feeder)
20	linear material feeding means
50	linear-way slide (coil diameter regulating means)
120	coil forming tool
136a	right declining linear material abutting groove (spiraling means)
137a	left declining linear material abutting groove (spiraling means)

Claims

1. A conical spring forming apparatus comprising a load characteristic adjustment system that includes: a linear material feeder (158) for feeding therefrom a linear material (1) in the axial direction of the linear material (1); at least one spring forming tool (160) arranged to face the linear material feeder (158) and adapted to be abutted against the linear material (1) to coil the linear material; spiraling means (154) for configuring the coiled linear material (1) into a spiral form; and coil diameter regulation means (162) for gradually changing the diameter of the coiled linear material (1) by dynamically changing the distance between the spring forming tool (160) and the linear material feeder (158) in operation, the conical spring forming apparatus is **characterized in that** the load characteristic adjustment system is adapted to cause the linear material feeder (158) to feed the linear material (1) at a regulated constant acceleration to adjust the load characteristic of the conical spring formed.

2. A conical spring forming apparatus comprising a load characteristic adjustment system that includes: a linear material feeder (10,158) for feeding therefrom a linear material (1) in the axial direction of the linear material (1); at least one spring forming tool (120,160), arranged to face the linear material feeder (10,158) and adapted to be abutted against the linear material (1) to spiral the linear material; a pitch tool serving as a spiraling means (136a,137a,154) for spiraling the linear material (1); and coil diameter regulation means (50,162) for gradually varying the coil diameter of the linear material (1) by dynamically varying the distance between the spring forming tool (120,160) and the linear material feeder (10,158) in operation, the conical spring forming apparatus is **characterized in that** the load characteristic adjustment system is adapted to cause said means for gradually varying the coil diameter of the linear material (1) to move, at a regulated constant acceleration, at least one of the linear material feeder (10,158) feeding the linear material (1) and the spring forming tool (120,160) to adjust the load characteristic of the

conical spring formed.

3. A conical spring forming apparatus comprising a load characteristic adjustment system that includes; a linear material feeder (1) for feeding therefrom a linear material (1) in the axial direction of the linear material (1); at least one spring forming tool (160), arranged to face the linear material feeder (158) and adapted to be abutted against the linear material (1) to spiral the linear material; a pitch tool serving as a spiraling means (154) for spiraling the linear material (1); and coil diameter regulation means (162) for gradually varying the diameter of the spiraled linear material (1) by dynamically changing the distance between the spring forming tool (160) and the linear material feeder (158) in operation, the conical spring forming apparatus is **characterized in that**:

   the load characteristic adjustment system is adapted to force and move the linear material (1) in the coil forming direction so as to spiral the linear material (1) at a pitch in accord with the displacement of the pitch tool (154); and
   the system is adapted to move the pitch tool at a regulated constant acceleration to gradually vary the spiral pitch, thereby regulating the load characteristic of the conical spring formed.

Patentansprüche

1. Formungsvorrichtung für konische Federn, umfassend ein Lastcharakteristik-Einstellsystem, das enthält: einen Linearmaterialzuführer (158) zum Zuführen eines linearen Materials (1) in der axialen Richtung des linearen Materials (1); mindestens ein Federformwerkzeug (160), das so angeordnet ist, dass es dem Linearmaterialzuführer (158) zugewandt ist und dazu ausgelegt ist, an dem linearen Material (1) anzuliegen, um das lineare Material zu wickeln; eine Spiraleinrichtung (154) zum Konfigurieren des gewickelten linearen Materials (1) in eine spiralförmige Form; und eine Wicklungsdurchmesser-Regeleinrichtung (162) zum allmählichen Ändern des Durchmessers des gewickelten linearen Materials (1) durch dynamisches Ändern des Abstands zwischen dem Federformwerkzeug (160) und dem Linearmaterialzuführer (158) im Betrieb, wobei die Formungsvorrichtung für konische Federn **dadurch gekennzeichnet ist, dass** das Lastcharakteristik-Einstellsystem dazu ausgelegt ist, die lineare Materialzuführung (158) zu veranlassen, das lineare Material (1) bei einer geregelten konstanten Beschleunigung zuzuführen, um die Belastungscharakteristik der gebildeten konischen Feder einzustellen.

2. Formungsvorrichtung für konische Federn umfassend ein Lastcharakteristik-Einstellsystem, das enthält: einen Linearmaterialzuführer (10, 158) zum Zuführen eines linearen Materials (1) in der axialen Richtung des linearen Materials (1); mindestens ein Federformwerkzeug (120, 160), das so angeordnet ist, dass es dem Linearmaterialzuführer (10, 158) zugewandt ist und dazu ausgelegt ist, gegen das lineare Material (1) zu stoßen, um das lineare Material spiralförmig zu wickeln; ein Steigungswerkzeug, das als Spiraleinrichtung (136a, 137a, 154) zum spiralförmigen Wickeln des linearen Materials (1) dient; und eine Wicklungsdurchmesser-Regeleinrichtung (50, 162) zum allmählichen Variieren des Wicklungsdurchmessers des linearen Materials (1) durch dynamisches Variieren des Abstands zwischen dem Federformwerkzeug (120, 160) und dem Linearmaterialzuführer (10, 158) im Betrieb, wobei die Formungsvorrichtung für konische Federn **dadurch gekennzeichnet ist, dass** das Lastcharakteristik-Einstellsystem dazu ausgelegt ist, die Einrichtung zum allmählichen Variieren des Wicklungsdurchmessers des linearen Materials (1) zu veranlassen, mindestens eines von der Linearmaterialzuführung (10, 158), die das lineare Material (1) zuführt, und dem Federformwerkzeug (120, 160) bei einer geregelten konstanten Beschleunigung zu bewegen, um die Belastungscharakteristik der gebildeten konischen Feder einzustellen.

3. Formungsvorrichtung für konische Federn umfassend ein Lastcharakteristik-Einstellsystem, das enthält; einen Linearmaterialzuführer (158) zum Zuführen eines linearen Materials (1) in axialer Richtung des linearen Materials (1); mindestens ein Federformwerkzeug (160), das so angeordnet ist, dass es dem Linearmaterialzuführer (158) zugewandt ist und dazu ausgelegt ist, an dem linearen Material (1) anzuliegen, um das lineare Material spiralförmig zu wickeln; ein Steigungswerkzeug, das als Spiraleinrichtung (154) zum spiralförmigen Wickeln des linearen Materials (1) dient; und eine Wicklungsdurchmesser-Regeleinrichtung (162) zum allmählichen Variieren des Durchmessers des spiralförmig gewickelten linearen Materials (1) durch dynamisches Ändern des Abstands zwischen dem Federformwerkzeug (160) und dem Linearmaterialzuführer (158) im Betrieb, wobei die Formungsvorrichtung für konische Federn **dadurch gekennzeichnet ist, dass**:

   das Lastcharakteristik-Einstellsystem dazu ausgelegt ist, das lineare Material (1) in die Wicklungsbildungsrichtung zu zwingen und zu bewegen, um das lineare Material (1) in einer Steigung in Übereinstimmung mit der Verschiebung des Steigungswerkzeugs (154) spiralförmig zu wickeln; und dass
   das System dazu ausgelegt ist, das Steigungswerkzeug bei einer geregelten konstanten Beschleunigung zu bewegen, um die Spiralstei-

gung allmählich zu variieren, wodurch die Belastungscharakteristik der gebildeten konischen Feder reguliert wird.

Revendications

1. Appareil de formation de ressort conique comprenant un système d'ajustement de caractéristique de charge comportant : un dispositif d'alimentation de matériau linéaire (158) pour alimenter, depuis celui-ci, un matériau linéaire (1) dans le sens axial du matériau linéaire (1) ; au moins un outil de formation de ressort (160) agencé pour faire face au dispositif d'alimentation de matériau linéaire (158) et apte à venir en butée contre le matériau linéaire (1) pour enrouler le matériau linéaire ; des moyens de spirale (154) pour configurer le matériau linéaire enroulé (1) sous forme de spirale ; et des moyens de régulation de diamètre d'enroulement (162) pour changer progressivement le diamètre du matériau linéaire enroulé (1) en changeant dynamiquement la distance entre l'outil de formation de ressort (160) et le dispositif d'alimentation de matériau linéaire (158) en fonctionnement, l'appareil de formation de ressort conique étant **caractérisé en ce que** le système d'ajustement de caractéristique de charge est apte à amener le dispositif d'alimentation de matériau linéaire (158) à alimenter le matériau linéaire (1) à une accélération constante régulée pour ajuster la caractéristique de charge du ressort conique formé.

2. Appareil de formation de ressort conique comprenant un système d'ajustement de caractéristique de charge comportant : un dispositif d'alimentation de matériau linéaire (10, 158) pour alimenter, depuis celui-ci, un matériau linéaire (1) dans le sens axial du matériau linéaire (1) ; au moins un outil de formation de ressort (120, 160) agencé pour faire face au dispositif d'alimentation de matériau linéaire (10, 158) et apte à venir en butée contre le matériau linéaire (1) pour mettre en spirale le matériau linéaire ; un outil de pas servant de moyens de mise en spirale (136a, 137a, 154) pour mettre en spirale le matériau linéaire (1) ; et des moyens de régulation de diamètre d'enroulement (50, 162) pour changer progressivement le diamètre d'enroulement du matériau linéaire (1) en changeant dynamiquement la distance entre l'outil de formation de ressort (120, 160) et le dispositif d'alimentation de matériau linéaire (10, 158) en fonctionnement, l'appareil de formation de ressort conique étant **caractérisé en ce que** le système d'ajustement de caractéristique de charge est apte à amener lesdits moyens de changement progressif du diamètre d'enroulement du matériau linéaire (1) à déplacer, à une accélération constante régulée, au moins l'un du dispositif d'alimentation de matériau linéaire (10, 158) alimentant le matériau linéaire (1) et de l'outil de formation de ressort (120, 160) pour ajuster la caractéristique de charge du ressort conique formé.

3. Appareil de formation de ressort conique comprenant un système d'ajustement de caractéristique de charge comportant : un dispositif d'alimentation de matériau linéaire (1) pour alimenter, depuis celui-ci, un matériau linéaire (1) dans le sens axial du matériau linéaire (1) ; au moins un outil de formation de ressort (160) agencé pour faire face au dispositif d'alimentation de matériau linéaire (158) et apte à venir en butée contre le matériau linéaire (1) pour mettre en spirale le matériau linéaire ; un outil de pas servant de moyens de mise en spirale (154) pour mettre en spirale le matériau linéaire (1) ; et des moyens de régulation de diamètre d'enroulement (162) pour changer progressivement le diamètre du matériau linéaire mis en spirale (1) en changeant dynamiquement la distance entre l'outil de formation de ressort (160) et le dispositif d'alimentation de matériau linéaire (158) en fonctionnement, l'appareil de formation de ressort conique étant **caractérisé en ce que** :

le système d'ajustement de caractéristique de charge est apte à forcer et déplacer le matériau linéaire (1) dans le sens de formation d'enroulement de manière à mettre en spirale le matériau linéaire (1) à un pas en accord avec le déplacement de l'outil de pas (154) ; et
le système est apte à déplacer l'outil de pas à une accélération constante régulée pour changer progressivement le pas de spirale, en régulant de ce fait la caractéristique de charge du ressort conique formé.

Fig. 1

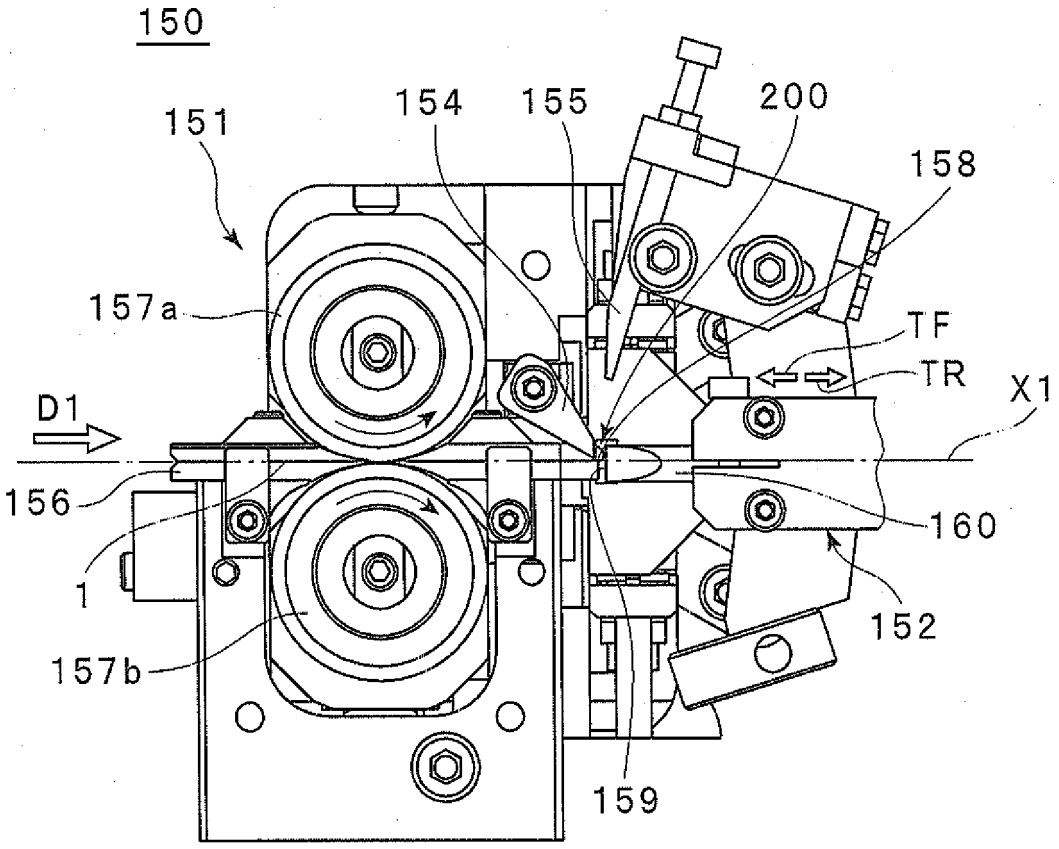


Fig. 2

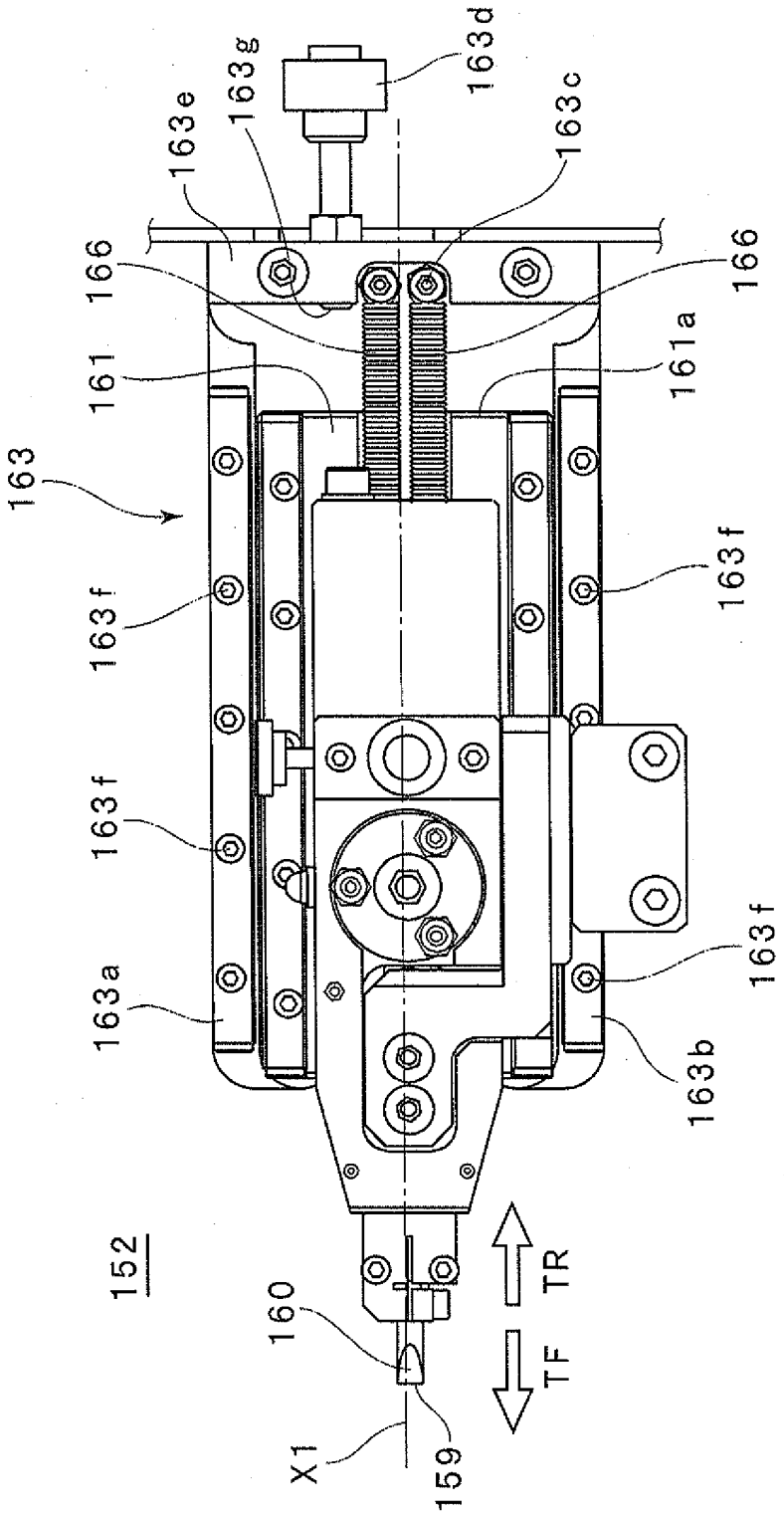

163d
163g
163e
163c
166
166
161
161a
163
163f
163f
163f
163f
163a
163b
152
160
TR
TF
X1
159

Fig. 3

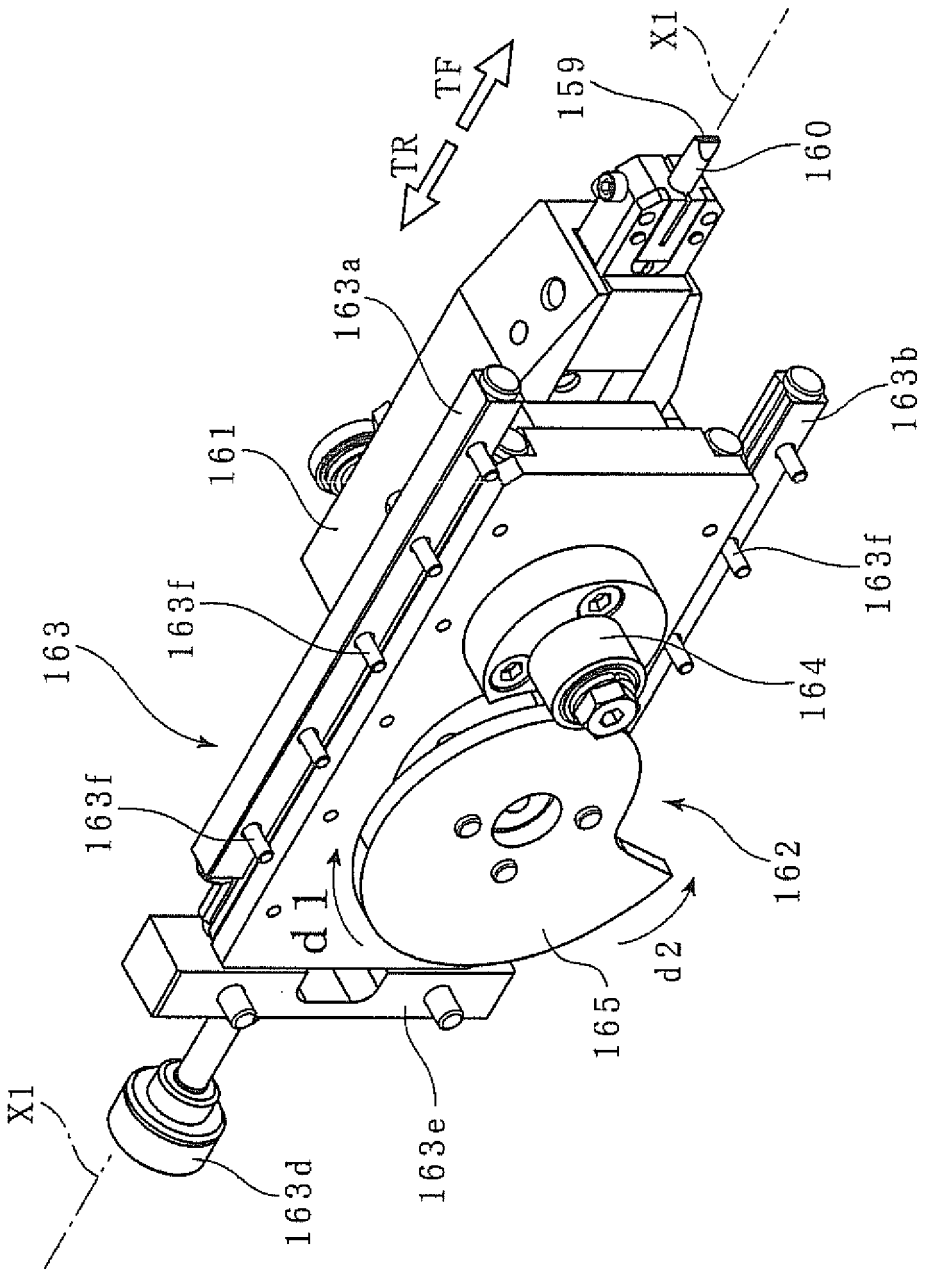

X1
TF
TR
159
160
163a
161
163b
163f
163
163f
164
163f
162
d1
d2
165
X1
163e
163d

Fig. 4

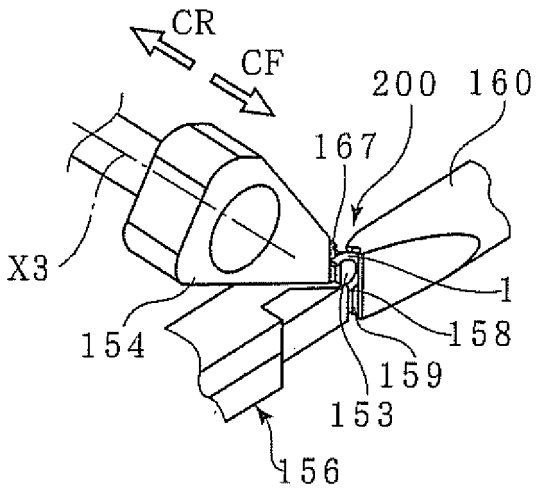

CR
CF
200
160
167
X3
1
158
154
159
153
156

Fig. 5

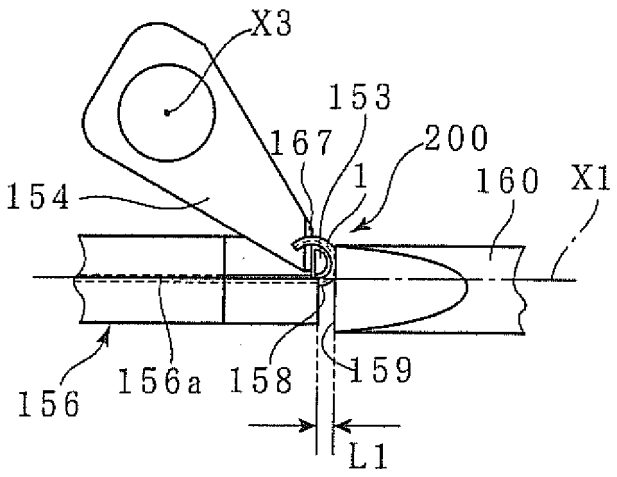

X3
153
167
200
1
160
X1
154
156
156a
158
159
L1

Fig. 6

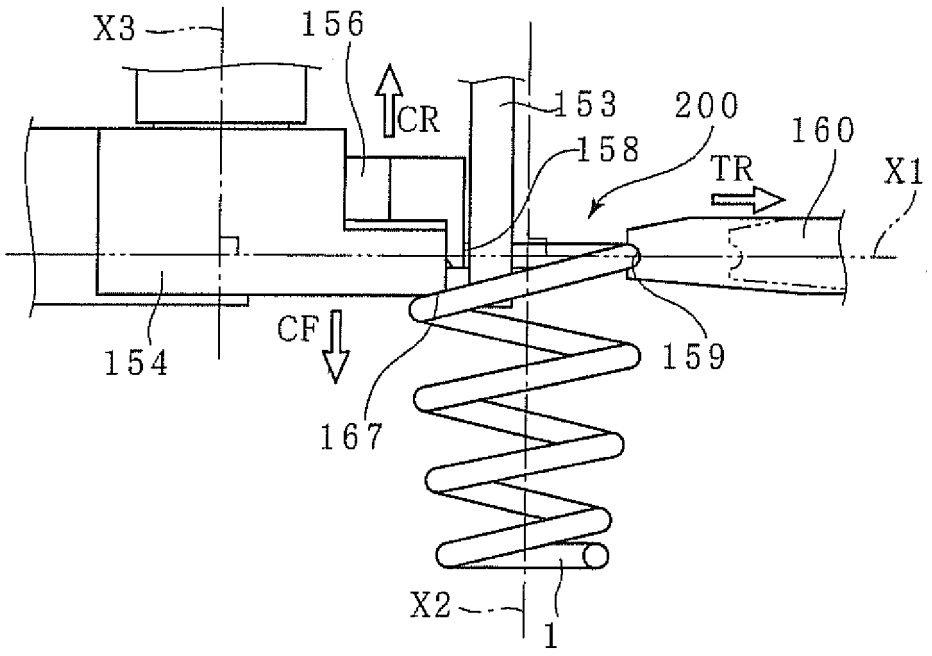
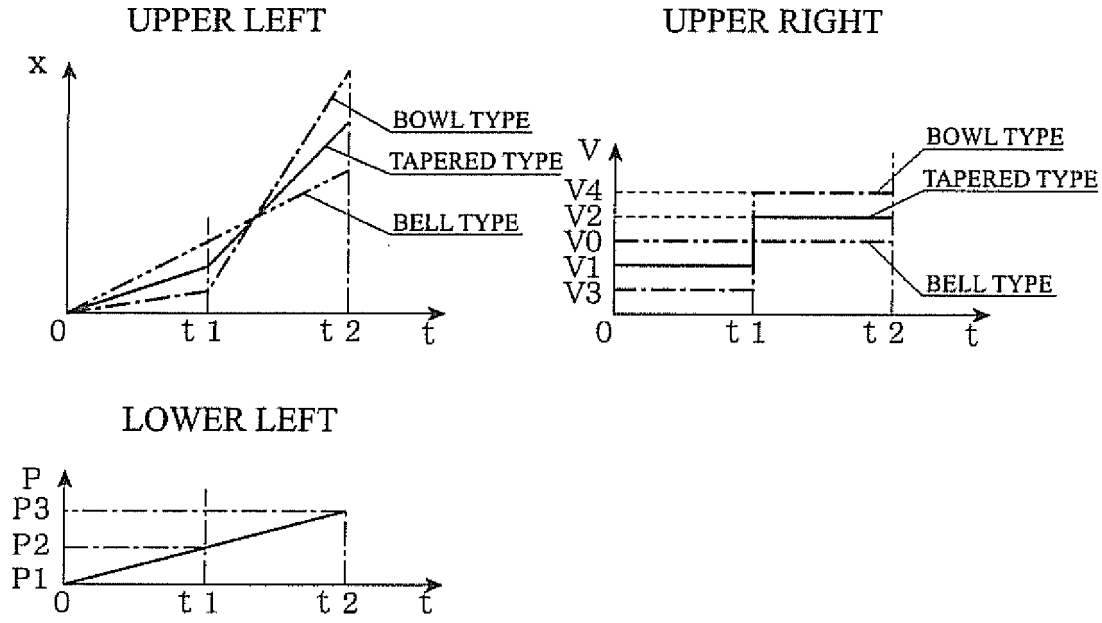


Fig. 7

(a)


UPPER LEFT
UPPER RIGHT
x
BOWL TYPE
TAPERED TYPE
BELL TYPE
0
t 1
t 2
t
V
V4
V2
V0
V1
V3
BOWL TYPE
TAPERED TYPE
BELL TYPE
0
t 1
t 2
t
LOWER LEFT
P
P3
P2
P1
0
t 1
t 2
t

(b)

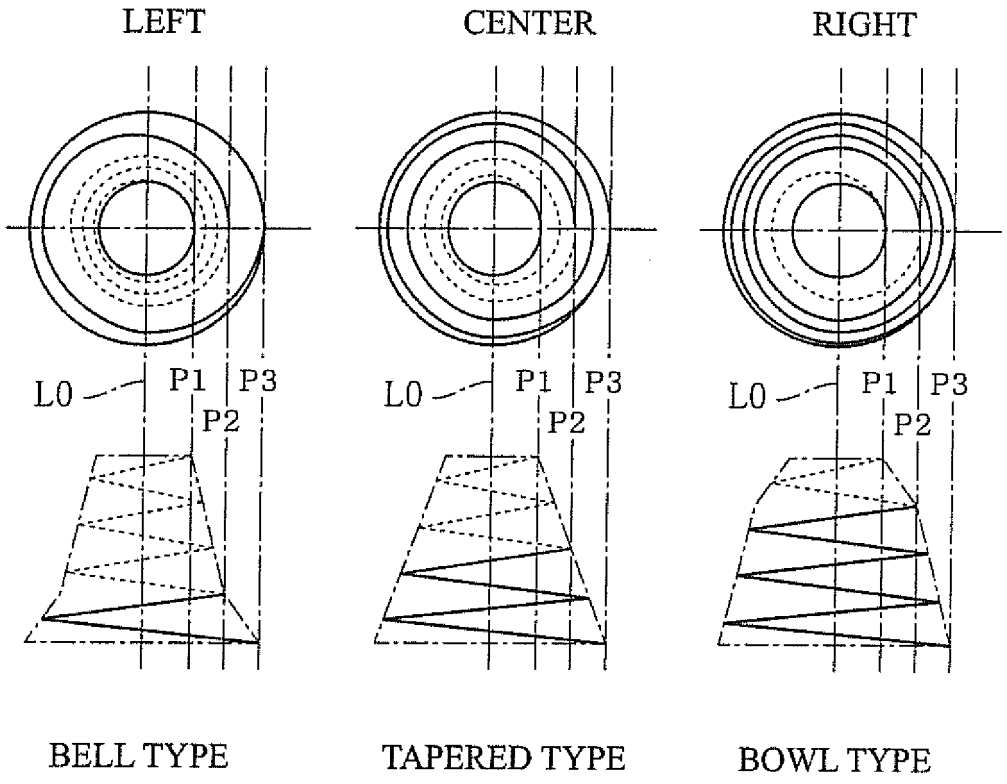
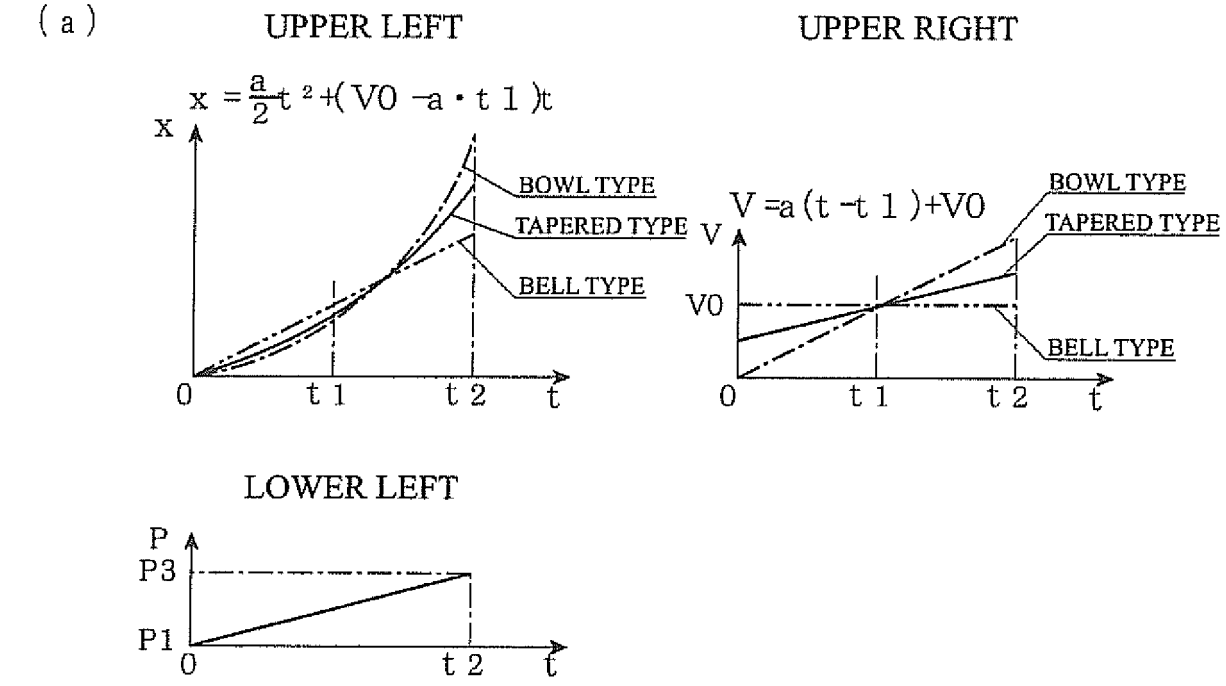

LEFT
CENTER
RIGHT
L0
P1
P3
P2
L0
P1
P3
P2
L0
P1
P3
P2
BELL TYPE
TAPERED TYPE
BOWL TYPE

Fig. 8


(a)
UPPER LEFT
$x = \frac{a}{2}t^2 + (V0 - a \cdot t1)t$
x
BOWL TYPE
TAPERED TYPE
BELL TYPE
0
t1
t2
t
UPPER RIGHT
V = a(t - t1) + V0
V
V0
BOWL TYPE
TAPERED TYPE
BELL TYPE
0
t1
t2
t
LOWER LEFT
P
P3
P1
0
t2
t

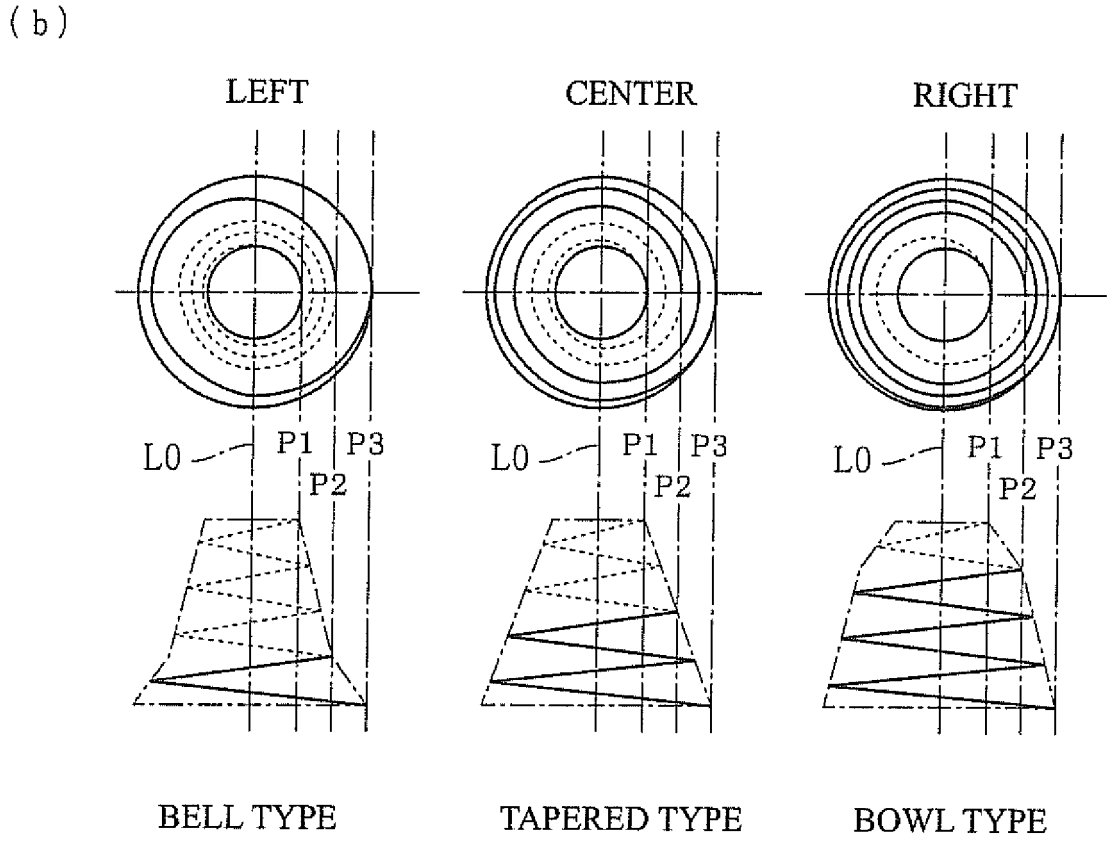

(b)
LEFT
CENTER
RIGHT
L0
P1
P3
P2
L0
P1
P3
P2
L0
P1
P3
P2
BELL TYPE
TAPERED TYPE
BOWL TYPE

Fig. 9

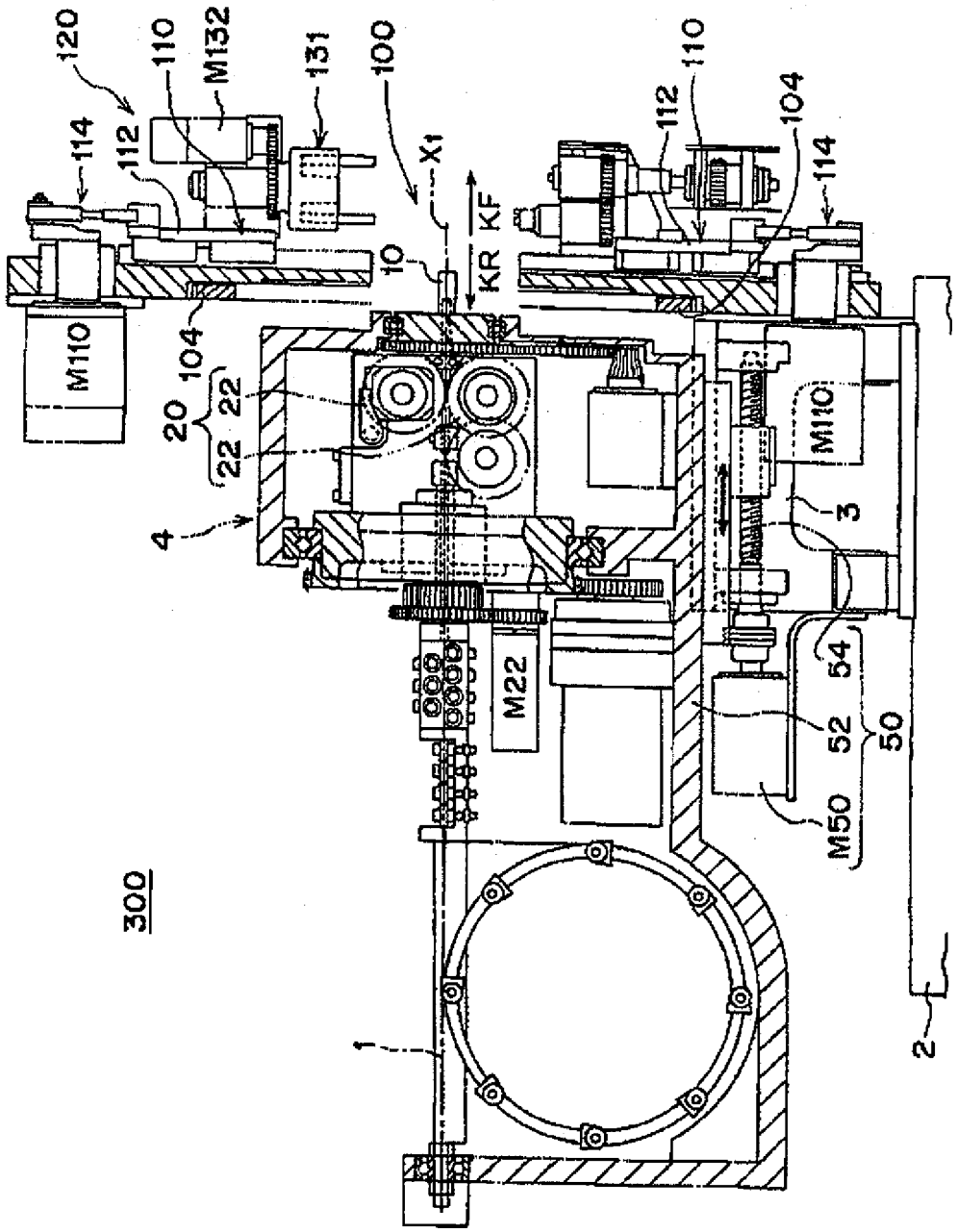

120
110
M132
131
100
X1
KF
KR
10
112
110
104
114
114
112
M110
104
20
22
22
4
M110
3
M22
54
52
50
M50
300
1
2

Fig. 10

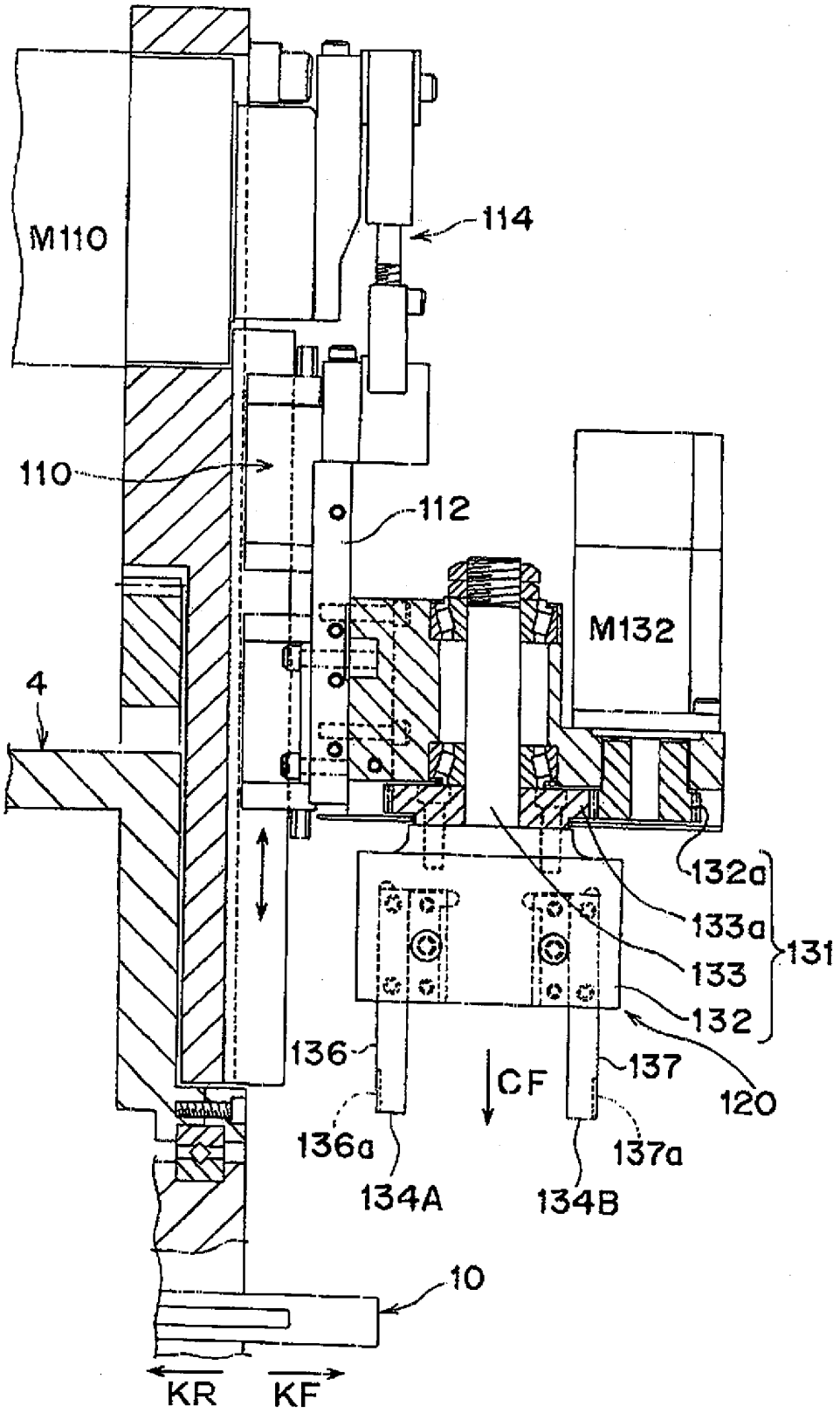

M110
114
110
112
M132
4
132a
133a
133
131
132
136
CF
137
120
136a
137a
134A
134B
10
KR
KF

Fig. 11

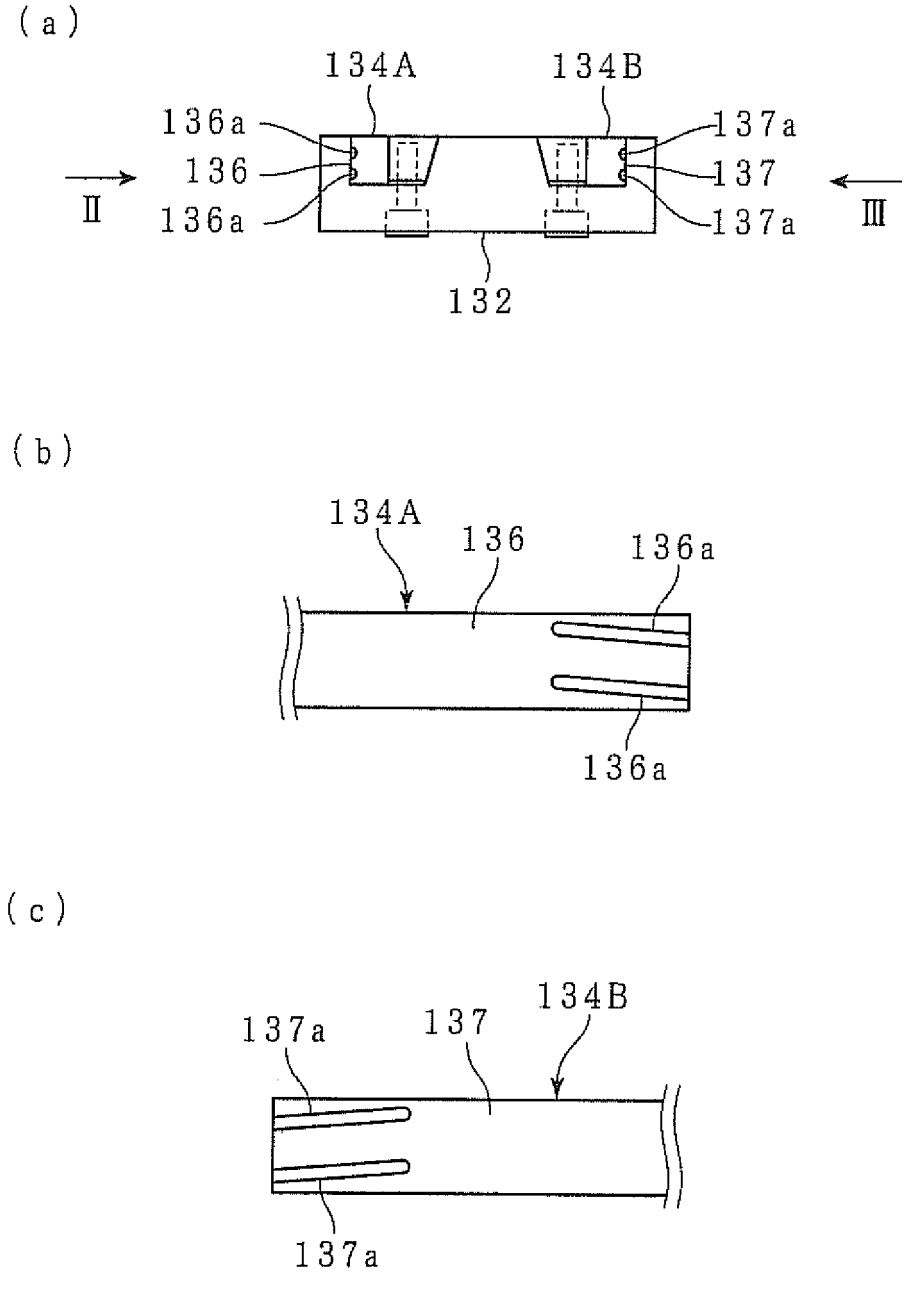
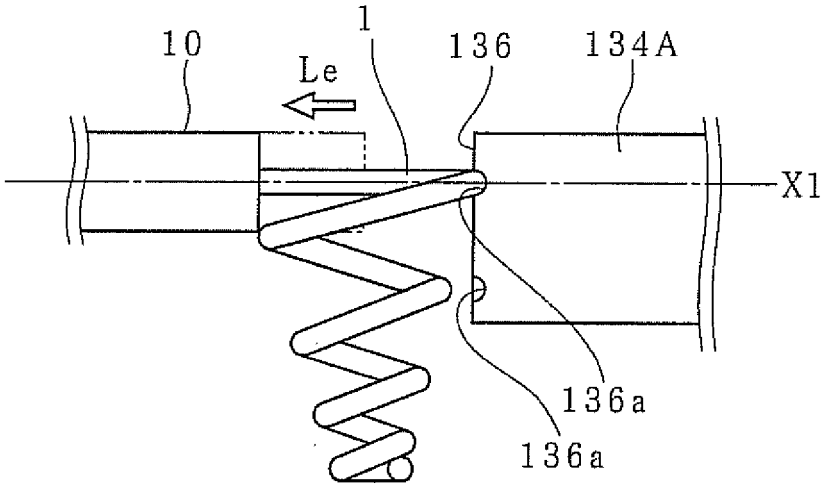

(a)
134A
134B
136a
136
136a
137a
137
137a
Ⅱ
Ⅲ
132
(b)
134A
136
136a
136a
(c)
137a
137
134B
137a

Fig. 12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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