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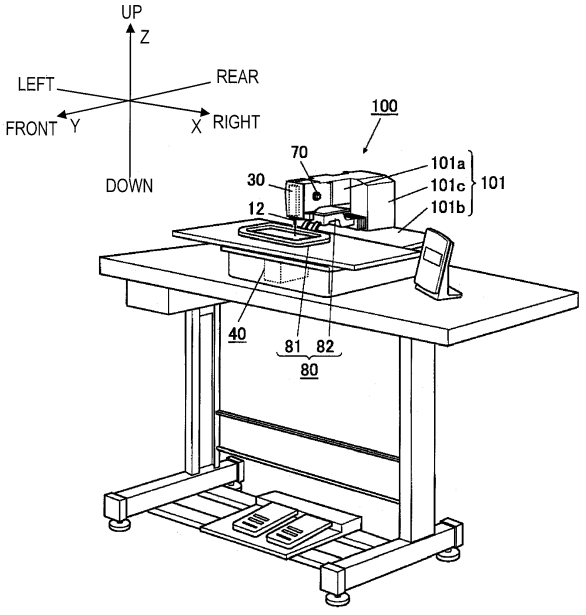
(54) Sewing machine

(57) The invention relates to a sewing machine (100) including a needle bar turning mechanism (30, 30A, 30B) configured to turn a needle bar (12) about an axis of the up-down movement of the needle bar (12), a thread pulling mechanism (50, 50A, 50B, 50C) configured to pull a lower thread (D) below a throat plate (14), a cloth moving mechanism (80) configured to move a workpiece, and a controller (90) configured to control the cloth moving mechanism (80) based on sewing data defining a stitch point or a movement amount of the workpiece per stitch for forming a sewing pattern. The controller (90) includes determining means for determining a movement direction in which the cloth moving mechanism (80) moves the workpiece, and control means for controlling the thread pulling by the thread pulling mechanism (50, 50A, 50B, 50C) or the turning of the needle bar (12) by the needle bar turning mechanism (30, 30A, 30B) in accordance with the movement direction determined by the determining means.

FIG. 1



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Description

[0001] The present invention relates to a sewing machine capable of forming perfect stitches.

[0002] When forming lockstitches by a sewing machine, for example, depending on a relationship between an advancing direction of cloth feeding and the relative position relationship between a sewing needle and a shuttle, perfect stitches may be formed by interlacing an upper thread with a lower thread in a well-balanced manner as shown in Fig. 37A, or hitch stitches may be formed in a state where only an upper thread is twisted spirally as shown in Fig. 37B.

[0003] The perfect stitches have excellent balance between the tension of the upper thread and the tension of the lower thread, and are visually beautifully finished to have the surface side and the back surface side matching each other, and improve the sewing quality of a workpiece. On the other hand, in the case of the hitch stitches, the tension of the upper thread easily becomes weak, and the balance with the tension of the lower thread is poor, the seam thereof is uneven, and the surface side and the back surface side become different from each other and the appearance is undesirable, so that the hitch stitches deteriorate the sewing quality of a workpiece.

[0004] Therefore, in a conventional sewing machine, for example, as disclosed in JP09-220391A, a rotary type thread tensioner using a hysteresis brake is installed, and by controlling a brake torque to increase the tightness of the threads, deterioration of the thread tightness caused in the case of hitch stitches is prevented, and a tight seam is formed.

[0005] In a sewing machine capable of forming a sewing pattern by moving a cloth to a position on a horizontal plane based on sewing data, for example, as disclosed in JP2008-023261A, by controlling the lower thread path so that the lower thread path is switched between the left side and the right side with respect to an eye for each stitch formation according to a cloth feeding direction, occurrence of hitch stitches can be avoided.

[0006] However, the conventional sewing machine described in JP09-220391A only enables avoidance of deterioration in thread tightness due to hitch stitches, and cannot prevent hitch stitches itself although the sewing machine can improve the visual finish of sewing. In addition, depending on the workpiece and thread, an appropriate thread tension differs, so that an appropriate thread tension is determined and adjusted in accordance with sewing condition changes.

[0007] Hitch stitches are caused not only by the relative positional relationship of the stitch point with respect to the lower thread path but also by whether the upper thread moving toward a cloth from the sewing needle for stitching is entwined on the right side or the left side of the sewing needle. However, the conventional sewing machine described in JP2008-023261A cannot address hitch stitches that are caused depending on the entwining direction of the upper thread with the sewing needle.

[0008] In the sewing machine described in JP2008-023261A, the lower thread path is corrected to either the left or the right by thread pulling, so that the tension of the lower thread is always in a high state. Therefore, the upper thread is drawn and the knot of the upper thread and the lower thread becomes a hang-down state, the thread tightness deteriorates, and the quality of a sewn product deteriorates.

[0009] Further, when switching the lower thread path, the rotation speed of the sewing machine needs to be reduced, and this lowers the sewing efficiency.

[0010] It is an object of the present invention is to more effectively prevent hitch stitches. Another object of the present invention is to prevent thread tightness from deteriorating during sewing while avoiding hitch stitches. Still another object of the present invention is to realize high-speed sewing while avoiding hitch stitches.

[0011] According to an aspect of the present invention, a sewing machine comprises a needle bar holding a sewing needle and arranged to move up and down, a shuttle configured to turn to interlace an upper thread with a lower thread, a sewing machine motor serving as a drive source for the up-down movement of the needle bar and the turning of the shuttle, a needle bar turning mechanism configured to turn the needle bar about the axis of the up-down movement of the needle bar, a thread pulling mechanism configured to pull the lower thread below a throat plate by a thread pulling member, a cloth moving mechanism configured to move a workpiece along a horizontal plane, and a controller configured to control the cloth moving mechanism based on sewing data defining a stitch point or a movement amount of the workpiece per stitch for forming a sewing pattern, and to optionally control the needle bar turning mechanism and the thread pulling mechanism. The controller includes determining means for determining a movement direction in which the cloth moving mechanism moves the workpiece, and control means for controlling execution or withholding of the thread pulling by the thread pulling mechanism or the turning of the needle bar by the needle bar turning mechanism in accordance with the movement direction determined by the determining means, or for selectively executing the thread pulling by the thread pulling mechanism or the turning of the needle bar by the needle bar turning mechanism in accordance with the movement direction determined by the determining means.

[0012] According to another aspect of the present invention, the controller is configured to execute the steps comprising determining a movement direction in which the cloth moving mechanism moves the workpiece, and controlling execution or withholding of the thread pulling by the thread pulling mechanism or the turning of the needle bar by the needle bar turning mechanism in accordance with the determined movement direction.

[0013] The controller may comprise a storage unit that stores a command to instruct execution of the thread pulling by the thread pulling mechanism or the turning of the needle bar by the needle bar turning mechanism, wherein

the entire angular range of cloth feeding direction around an up-down movement path of the sewing needle associated with the up-down movement of the needle bar is divided into a plurality of segments, and the commend is stored for each the segments, and in accordance with the movement direction determined by the determining means, the controller may read the command that corresponds to the segment including the movement direction, and operate the thread pulling mechanism or the needle bar turning mechanism based on the read command.

[0014] The segments may be defined by specifying angular ranges based on a probability of occurrence of hitch stitches and a factor for hitch stitches.

[0015] The control means may comprise identifying means for identifying the segment that includes the movement direction determined by the determining means, and in accordance with the segment identified by the identifying means, the control means controls an operation of the thread pulling mechanism or the needle bar turning mechanism (for example, the execution or the withholding of the thread pulling by the thread pulling mechanism or the turning of the needle bar by the needle bar turning mechanism).

[0016] For example, the controller may execute a step of identifying a segment in which the determined movement direction is included, and control the execution or the withholding of the thread pulling by the thread pulling mechanism or the turning of the needle bar by the needle bar turning mechanism in accordance with the identified segment.

[0017] The thread pulling mechanism may comprise a thread pulling motor, a thread pulling cam member actuated by the thread pulling motor, a thread pulling follower to which a motion is applied from the thread pulling cam member, and a thread pulling link mechanism configured to transmit a lower thread pulling operation from the thread pulling follower to the thread pulling member, wherein the thread pulling cam member comprises a cam portion including a non-operating section that does not apply the thread pulling operation to the thread pulling member and an operating section that applies the thread pulling operation to the thread pulling member, the non-operating section and the operating section being continuously formed, and wherein the controller controls the thread pulling motor such that the thread pulling motor accelerates while the thread pulling follower engages with the non-operating section of the thread pulling cam member.

[0018] The non-operating section of the thread pulling cam member may be formed on each side of the operating section such that the operating section is interposed in the non-operating section.

[0019] The thread pulling mechanism may comprise a thread pulling motor and a thread pulling link mechanism configured to transmit a motion from the thread pulling motor to the thread pulling member such that a distal end portion of the thread pulling member moves in a revolving manner, wherein the thread pulling member is provided such that the distal end portion of the thread pulling member contacts the lower thread and pulls the lower thread when the distal end portion of the thread pulling member is an operating section of a locus of the revolving motion.

[0020] When executing the thread pulling, the controller may control the thread pulling motor such that the thread pulling motor starts to drive when the distal end portion of the thread pulling member is outside the operating section of the locus of the revolving motion, and such that the thread pulling motor accelerates before the distal end portion of the thread pulling member reaches the operating section.

[0021] The thread pulling mechanism may comprise a thread pulling cam member actuated by the sewing machine motor, a thread pulling follower to which a motion is applied from the thread pulling cam member, and a thread pulling link mechanism including a plurality of thread pulling link bodies configured to transmit a lower thread pulling operation from the thread pulling follower to the thread pulling member, wherein the thread pulling link mechanism is configured such that the transmission from the thread pulling follower to the thread pulling member is disabled by shifting a turning joint portion at which one of the plurality of thread pulling link bodies is joined turnably to another member to a position concentric with a turning joint portion of another one of the thread pulling link bodies, and wherein the controller executes the thread pulling by controlling an actuator that shifts the turning joint portion of said one of the thread pulling link bodies to the position concentric with the turning joint portion of said another one of the thread pulling link bodies.

[0022] The needle bar turning mechanism may comprise a needle bar turning motor, a needle bar turning cam member actuated by the needle bar turning motor, a needle bar turning follower to which a motion is applied from the needle bar turning cam member, and a transmission member that transmits a turning operation from the needle bar turning follower to the needle bar, wherein the needle bar turning cam member comprises a cam portion including a non-operating section that does not apply the turning operation to the needle bar and an operating section that applies the turning operation to the needle bar, the non-operating section and the operating section being continuously formed, and the controller controls the needle bar turning motor such that the needle bar turning motor accelerates while the needle bar turning follower engages with the non-operating section of the needle bar turning cam member.

[0023] The non-operating section of the needle bar turning cam member may be formed on each side of the operating section such that the operating section is interposed in the non-operating section.

[0024] The needle bar turning mechanism may comprise a needle bar turning cam member actuated by the sewing machine motor, a needle bar turning follower to which a motion is applied from the needle bar turning

cam member, and a needle bar link mechanism including a plurality of needle bar link bodies configured to transmit a turning operation from the needle bar turning follower to the needle bar, the needle bar link mechanism is configured such that the transmission from the needle bar turning follower to the needle bar is disabled by shifting a turning joint portion at which one of the plurality of needle bar link bodies is joined turnably to another member to a position concentric with a turning joint portion of another one of the needle bar link bodies, and the controller executes the turning of the needle bar by controlling an actuator that shifts the turning joint portion of said one of the needle bar link bodies to the position concentric with the turning joint portion of said another one of the needle bar link bodies.

[0025] The sewing machine may comprise a thread tensioner configured to apply a thread tension to the upper thread, and a thread tension adjusting actuator configured to change and to adjust the thread tension to be applied by the thread tensioner, wherein the controller controls the thread tension adjusting actuator to reduce the thread tension at the time of forming a stitch during which the thread pulling is executed or at the time of forming a plurality of stitches including said stitch.

[0026] The needle bar turning mechanism may comprise a needle bar turning cam member, a needle bar turning follower to which a motion is applied from the needle bar turning cam member, and a needle bar link mechanism configured to transmit a turning operation from the needle bar turning follower to the needle bar, wherein the needle bar turning cam member is a grooved cam with which needle bar turning follower engages, or a circumferential cam provided in a rotatable manner to apply a displacement to the needle bar turning follower along the entire circumference of the needle bar turning cam member.

[0027] The needle bar turning cam member may comprise a cam portion including an operating section that applies the displacement to the needle bar turning follower and a non-operating section that does not apply the displacement to the needle bar turning follower, wherein the operating section and the non-operating section being formed alternately and repetitively.

[0028] The needle bar turning mechanism may comprise a needle bar base provided in a turnable manner and configured to support the needle bar such that the needle bar moves up and down, a needle bar turning cam member, a needle bar turning follower to which a motion is applied from the needle bar turning cam member, and a needle bar link mechanism configured to transmit a turning operation from the needle bar turning follower to the needle bar via the needle bar base, wherein the needle bar link mechanism comprises an arm member extending from the needle bar base in a radially outward direction of the turning of the needle bar base, and a needle bar link body configured to transmit the turning operation to a turning distal end portion of the arm member, and wherein the arm member and the needle bar link body are coupled without being restrained in the up-down direction.

[0029] The turning distal end portion of the arm member may be formed with a groove along the horizontal plane, wherein a sliding member is supported at an end portion of the needle bar link body such that the sliding member is slidable along the groove and is rotatable about an axis along the up-down direction, and wherein the arm member and the needle bar link body are coupled via the groove and the sliding member.

[0030] According to an aspect of the present invention, a direction of movement of a workpiece by the cloth moving mechanism is determined, and according to the determined movement direction, thread pulling by the thread pulling mechanism and needle bar turning by the needle bar turning mechanism are selectively executed. Not only a hitch stitch caused by a stitch point with respect to the lower thread but also a hitch stitch caused by a direction in which the upper thread is entwined with the sewing needle can be prevented, so that occurrence of hitch stitches can be more effectively reduced. The sewing machine can cope with a plurality of factors, so that even when various shuttles such as a horizontal hook, a vertical hook, a full rotary hook, and a semi-rotary hook are used, occurrence of hitch stitches can be prevented.

[0031] When the cam portion of the thread pulling cam member of the thread pulling mechanism has a non-operating section that does not apply a thread pulling operation to the thread pulling member and an operating section that applies a thread pulling operation to the thread pulling member, the thread pulling operation can be performed after the thread pulling motor is sufficiently accelerated in the non-operating section of the thread pulling cam member, so that even during high-speed sewing, thread pulling is realized.

[0032] When the needle bar turning cam member of the needle bar turning mechanism has a cam portion including continuous formation of a non-operating section that does not apply turning to the needle bar and an operating section that applies turning, the needle bar turning can be performed after the needle bar turning motor is sufficiently accelerated in the non-operating section of the needle bar turning cam member, so that even during high-speed sewing, needle bar turning is realized.

[0033] When the controller is configured to control the thread tension adjusting actuator so as to reduce and adjust the thread tension at the time of formation of a stitch involving execution of thread pulling or formation of a plurality of stitches including the stitch, the tension of the lower thread drawn-out by thread pulling and the tension of the upper thread can be made well-balanced, a knot can be drawn into a cloth, so that thread tightness can be made excellent.

[0034] Other aspects and advantages of the invention will be apparent from the following description, the drawings and the claims.

[0035] The following description of embodiments of the invention serves to explain the invention in greater detail

in conjunction with the drawings including:

Fig. 1: a perspective view of a sewing machine according to a first embodiment;
Fig. 2: a perspective view of a structure inside a front end portion of an arm portion;
Fig. 3: a perspective view of a needle bar base;
Fig. 4: a perspective view of an upper end portion of the needle bar base;
Fig. 5: a perspective view of a lower end portion of the needle bar base;
Fig. 6: a perspective view of a connecting structure of a crank rod and a needle bar;
Fig. 7: another perspective view of the connecting structure of the crank rod and the needle bar, viewed in different direction;
Fig. 8: a plan view of an operation system of a needle bar turning mechanism;
Fig. 9: an operation explanatory view of the needle bar turning mechanism;
Fig. 10: an operation explanatory view of the needle bar turning mechanism;
Fig. 11: a plan view of a needle bar turning cam member;
Fig. 12: a diagram showing speed characteristics of a motor;
Fig. 13: an explanatory view showing a relationship between a reference standby position and a stop position of a roller on a cam portion of the needle bar turning cam member;
Fig. 14: a plan view of a thread pulling mechanism;
Fig. 15: a perspective view of the thread pulling mechanism;
Fig. 16: a plan view of a thread pulling cam member;
Fig. 17: an explanatory view showing a relationship between a reference standby position and a stop position of a roller on a cam portion of the thread pulling cam member;
Fig. 18: a sectional view of a thread tensioning device;
Fig. 19: a block diagram showing a control system of the sewing machine;
Fig. 20A: a sectional view showing a state where an upper thread passing through an eyelet is entwined with a sewing needle in a leftward winding direction when the sewing needle enters a cloth;
Fig. 20B: a sectional view showing a state where an upper thread is entwined with the sewing needle in a rightward winding direction;
Fig. 21A: a plan view showing a state where a lower thread passes from a corner portion of a bobbin case of a shuttle to an eye of a throat plate;
Fig. 21B: a front view thereof;
Fig. 22: an explanatory view showing a relationship between a cloth movement direction and a factor that causes hitch stitches in a sewing machine using a semi-rotary hook;
Fig. 23: an explanatory view showing table data storing which should be executed, by either thread pulling or needle bar turning, according to an angle segment of a cloth feeding direction;
Fig. 24: a diagram showing a relationship between an upper shaft angle and a sewing needle height;
Fig. 25: a diagram showing relationships between motion diagrams of the sewing needle, shuttle, and thread take-up and thread pulling in the sewing machine;
Fig. 26: a plan view showing a position relationship between a thread pulling member and an eye in a state where thread pulling is not executed;
Fig. 27: a plan view showing a position relationship between the thread pulling member and the eye in a state where thread pulling is executed;
Fig. 28: an explanatory view showing a lower thread drawn-out state when thread pulling is executed;
Fig. 29: a flowchart of hitch stitch avoidance control;
Fig. 30: a plan view of a second example of a needle bar turning mechanism, showing a state where turning is not applied to the needle bar;
Fig. 31: a plan view of the second example of the needle bar turning mechanism,
showing a state where turning can be applied to the needle bar;
Fig. 32: a perspective view of a roller arm of the needle bar turning mechanism;
Fig. 33: a plan view of a second example of a thread pulling mechanism, showing a retracted state where a thread pulling operation is not executed;
Fig. 34: a plan view of the second example of the thread pulling mechanism, showing an actuating state where a thread pulling member executes thread pulling;
Fig. 35: a diagram showing relationships between motion diagrams of the sewing needle, shuttle, and thread take-up and thread pulling cam displacement in the sewing machine, simultaneously;
Fig. 36: a plan view of a third example of a thread pulling mechanism;
Fig. 37A: an explanatory view showing perfect stitches;
Fig. 37B: an explanatory view showing hitch stitches;
Fig. 38: a perspective view of a third example of a needle bar turning mechanism;
Fig. 39: a plan view of the third example of the needle bar turning mechanism;
Fig. 40: a plan view of a needle bar turning cam member in the third example of the needle bar turning mechanism;
Fig. 41A: an enlarged perspective view of a needle bar base upper end portion of the needle bar turning mechanism
Fig. 41B: an exploded perspective view;
Fig. 42: a plan view of a fourth example of a thread pulling mechanism;
Fig. 43: a perspective view of the fourth example of the thread pulling mechanism; and

Fig. 44: a plan view of a thread pulling cam member in the fourth example of the thread pulling mechanism.

[0036] A first embodiment of the present invention is described with reference to Fig. 1 to Fig. 29.

[0037] A sewing machine 100 described hereinafter as the present embodiment is a so-called electronic cycle sewing machine, and includes a holding frame 81 as a cloth holding portion that holds a cloth as a workpiece to be sewn, and forms a sewing pattern based on predetermined sewing data on a cloth held by the holding frame 81 by moving the holding frame 81 relative to a sewing needle.

[0038] Here, the vertical direction in which the sewing needle 11 moves up and down is defined as a Z-axis direction or up-down direction. In addition, a horizontal direction is defined as an X-axis direction or left-right direction, and a horizontal direction orthogonal to the X-axis direction is defined as a Y-axis direction or front-rear direction. In addition, "front" in the following description indicates the direction in which an operator who performs sewing is positioned with respect to the sewing machine 100, "left" indicates the left side in a state where the operator in front of the sewing machine 100 faces the sewing machine 100, and "right" indicates the right side in a state where the operator in front of the sewing machine 100 faces the sewing machine 100.

[0039] As shown in Fig. 1, the sewing machine 100 includes a needle bar 12 that moves up and down along the Z-axis direction while holding a sewing needle 11 on the lower end portion, a needle up-down movement mechanism 20 that moves the needle bar 12 up and down by using a sewing machine motor 21 as a drive source, a needle bar turning mechanism 30 that turns the needle bar 12 around the central axis along the Z-axis direction, a shuttle 13 that interlaces a lower thread D with an upper thread U passing through the eyelet of the sewing needle 11, a thread pulling mechanism 50 that pulls the lower thread D, a thread tensioning device 70 that varies and adjusts the thread tension of the upper thread U, a cloth moving mechanism 80 that holds a cloth and arbitrarily moves and positions the cloth along the X-Y plane, a control device 90 (controller) that controls operations of the respective components, and a sewing machine main body 101 that supports the respective components of the sewing machine 100.

[0040] Sewing Machine Frame

[0041] As shown in Fig. 1, the sewing machine 100 includes the sewing machine main body 101 assuming a substantially U external shape as viewed from the X-axis direction. This sewing machine main body 101 includes an arm portion 101a that forms an upper portion of the sewing machine 100 and extends in the Y-axis direction, a bed portion 101b that forms a lower portion of the sewing machine 100 and extends in the X-Y-axis directions, and a vertical drum portion 101c that joins the arm portion 101a and the bed portion 101b positioned above and below.

[0042] Needle Up-Down Movement Mechanism

[0043] As shown in Fig. 1 and Fig. 2, the needle up-down movement mechanism 20 includes an upper shaft 22 disposed along the Y-axis direction inside the arm portion 101a and supported rotatably, a sewing machine motor 21 shown in Fig. 19 that is joined to one end portion of the upper shaft 22 and applies a rotating force thereto, a needle bar crank 23 provided on the other end portion of the upper shaft 22 on the distal end side of the arm portion 101a, a crank rod 24 whose end portion is joined eccentrically to the rotation center of the needle bar crank 23, and a guide 25 that guides the end portion on the needle bar 12 side of the crank rod 24 so that the end portion reciprocates along the up-down direction.

[0044] The upper shaft 22 is directly connected to an output shaft of the sewing machine motor 21 and driven to rotate, and the rotation of the upper shaft 22 is converted into up-down reciprocating movement by the needle bar crank 23 and the crank rod 24 and transmitted to the needle bar 12.

[0045] A pivot 26 along the Y-axis direction is provided to penetrate through the end portion on the needle bar 12 side of the crank rod 24, and the pivot 26 axially supports rotatably two square pieces 27 and 28 so as to sandwich the crank rod 24 by both end portions.

[0046] The square piece 27 provided on the surface on the needle bar 12 side of the crank rod 24 engages with the needle bar 12 via needle bar holders 331 and 332 described later and transmits the up-down movement to the needle bar 12. The square piece 28 provided on the surface on the side opposite to the needle bar 12 of the crank rod 24 fits a groove-shaped guide 25 formed along the Z-axis direction on the wall surface of the arm portion 101a. Specifically, the square piece 28 fits the groove-shaped guide 25 slidably, so that it allows the end portion on the needle bar 12 side of the crank rod 24 to reciprocate only along the Z-axis direction while restricting the end portion from moving in the X-axis direction.

[0047] Accordingly, reciprocation in the up-down direction synchronized with rotation of the sewing machine motor 21 is applied to the needle bar 12.

[0048] Shuttle

[0049] In the present embodiment, an example in which a semi-rotary hook is adopted as the shuttle 13 is illustrated. The semi-rotary hook includes an inner shuttle that reciprocatively turns in synchronization with the up-down movement of the needle bar 12 inside a large shuttle, a bobbin case housed inside the inner shuttle, a bobbin which is housed inside the bobbin case and around which a thread is wound, a driver that applies reciprocative turning to the inner shuttle, a crank rod whose one end portion is joined to a crank portion formed on the upper shaft 22, a reciprocative turning shaft having an arm portion joined to the other end portion of the crank rod, and a lower shaft that is increased in speed by the reciprocative turning shaft and reciprocatively turns. The lower shaft holds the driver and reciprocatively turns the

inner shuttle via the driver. The sewing machine motor 21 becomes a drive source for up-down movement of the needle bar 12 and turning of the shuttle 13, and an upper thread is interlaced with a lower thread by the up-down movement of the sewing needle 11 and turning of the shuttle 13. The structure and configuration of the semi-rotary hook are known, so that detailed description thereof is omitted.

[0050] Needle Bar Turning Mechanism

[0051] As shown in Fig. 3 to Fig. 5, the needle bar turning mechanism 30 includes a needle bar base 31 that is supported turnably around the Z-axis (around the central axis of the up-down movement of the needle bar 12) on the front end portion of the arm portion 101a, and supports the needle bar 12 movably up and down, and an operation system that applies turning around the Z-axis with respect to the needle bar 12 through the needle bar base 31.

[0052] The needle bar base 31 is formed to have a cylindrical shape so that the upper end portion 311 and the lower end portion 312 thereof are concentric with each other, and the end portions are joined integrally by a rectangular frame portion 313. Inside the lower end portion 312 and the frame portion 313, cylindrical metal bearings 321 and 322 are held, respectively, and a round-bar-shaped needle bar 12 is inserted inside the two metal bearings 321, 322. Accordingly, the needle bar 12 is supported in a state along the Z-axis direction movably up and down.

[0053] On the outer peripheries of the upper end portion 311 and the lower end portion 312 of the needle bar base 31, bearings 323, 324 are provided, respectively, and the outer peripheries of the bearings 323, 324 are held on the wall surface of the arm portion 101a. Accordingly, the needle bar base 31 and the needle bar 12 supported by the needle bar base 31 become turnable about the Z-axis with respect to the arm portion 101a.

[0054] The washers 325, 326 maintain slidability between the outer rings of the bearings 323, 324 and the needle bar base 31 side.

[0055] To the upper end portion 311 of the needle bar base 31 and below the bearing 323, an arm member 327 into which a turning torque is input from the operation system is threadably fixed. The arm member 327 has an arm portion formed that is extended outward in a radial direction around the needle bar 12, and a distal end portion of this arm portion is joined to one of the link bodies constituting the operation system by a shoulder screw, and through this arm portion, turning is input.

[0056] The frame portion 313 of the needle bar base 31 has a rectangular plane portion along the Z-axis direction, and to the upper portion of the plane portion, a detection body 328 is fixed. A proximity state of the detection body 328 is detected by a needle bar angle sensor 329 that is a proximity sensor provided on the wall surface of the arm portion 101a. Specifically, the needle bar angle sensor 329 outputs a detection signal corresponding to a distance to the detection body 328, and accordingly, a proximity state or a separated state of the detection body 328 with respect to the needle bar angle sensor 329 can be identified. For example, when a state where the detection body 328 is most proximal is defined as an origin position in the turning direction of the needle bar 12, it can be identified whether the needle bar 12 is at the origin or turns away from the origin.

[0057] On the plane portion of the frame portion 313 of the needle bar base 31, a long guide plate 330 is threadably mounted. On the guide plate 330, a slit 330a along the Z-axis direction is formed. On the plane portion of the frame portion 313, an opening larger than the slit 330a of the guide plate 330 is formed on the back surface side of the guide plate 330.

[0058] To the needle bar 12, a needle bar holder 331 is fixed as shown in Fig. 6 and Fig. 7, and on this needle bar holder 331, a rectangular projection 331a extending outward in a radial direction around the needle bar 12 is formed. The projection 331a is inserted in the slit 330a from the back surface side of the guide plate 330 toward the outside, and when the needle bar 12 moves up and down, the projection 331a also moves up and down inside the slit 330a. The horizontal width of the projection 331a is set to be substantially equal to the width of the slit 330a, and accordingly, when the needle bar base 31 turns around the Z-axis, the needle bar 12 also turns together.

[0059] As shown in Fig. 6 and Fig. 7, a square piece 27 is axially supported on the surface on the needle bar 12 side of the lower end portion of the crank rod 24 turnably around the Y-axis.

[0060] To the needle bar 12, two needle bar holders 331 and 332 arranged vertically are fixed so as to hold the needle bar while leaving a predetermined gap. Between the needle bar holder 331 and the needle bar holder 332 arranged vertically, the square piece 27 is interposed via washers 333 and 334.

[0061] The washers 333 and 334 are made of a material with excellent friction performance, and the friction surface of the square piece 27 has excellent slidability. To the washers 333 and 334, pins projecting from the needle bar holders 331 and 332, respectively, are fitted, and the washers turn together with the needle bar holders 331 and 332 when the needle bar 12 turns.

[0062] On the upper needle bar holder 331, a projection 331a is provided to project from the front side in the Y-axis direction, and the guide plate 330 turns the needle bar 12 around the Z-axis together with the needle bar base 31. At this time, the needle bar holders 331 and 332 turn together with the needle bar 12, however, the square piece 27 supported by the crank rod 24 can be maintained in a state where the square piece is positioned between the needle bar holders 331 and 332 via the washers 333 and 334, and even when the needle bar turns, the power of the up-down movement from the sewing machine motor 21 can be transmitted to the needle bar 12.

[0063] As shown in Fig. 8 to Fig. 10, the operation system of the needle bar turning mechanism 30 includes a needle bar turning motor 34 that serves as a drive source,

a needle bar turning cam member 35 (hereinafter, referred to as a needle bar cam member) to be actuated by the needle bar turning motor 34, a roller 36 (needle bar turning follower) to which an operation is applied from the needle bar cam member 35, and a transmission member that transmits turning from the roller 36 to the needle bar 12. The transmission member includes a roller arm 361, a link body 362, and an arm 327.

[0064] The needle bar turning motor 34 is supported in a state where its output shaft is directed vertically upward by a motor mounting base 341 attached to the left side surface of the arm portion 101a, and on this output shaft, a drive sprocket 342 is provided. On the upper surface of the motor mounting base 341, a driven sprocket 343 with a small diameter is provided adjacent to the drive sprocket 342, and a timing belt 344 is laid around the sprockets 342 and 343, and increased-speed rotation is transmitted from the drive sprocket 342 to the driven sprocket 343.

[0065] The driven sprocket 343 is joined to the needle bar cam member 35 via a turning shaft 345, and turning of the driven sprocket 343 is transmitted to the needle bar cam member 35 to rotate the needle bar cam member 35.

[0066] In Fig. 11, the needle bar cam member 35 has a substantially fan shape centered on the turning shaft 345, and a substantially arc-shaped outer edge portion thereof is a cam portion 351 and comes into contact with the roller 36 and applies displacement thereto. This cam portion 351 has a cam shape having two arc-shaped non-operating sections 352 and 353 that keep a constant distance from the turning center position, and an operating section 354 provided between the two non-operating sections 352 and 353. The cam shape is bilaterally symmetric so that the operating section 354 is continuous to the non-operating sections 352 and 353 and gradually decreases the diameter from the non-operating sections 352 and 353.

[0067] Specifically, the needle bar member 35 has a cam portion formed so that the non-operating sections 352 and 353 that does not apply turning to the needle bar 12 and an operating section 354 that applies turning to the needle bar 12 are continuous to each other.

[0068] The needle bar turning mechanism 30 reciprocatively turns the needle bar 12 in a predetermined angular range around its own axis at a timing within a constant rotation angular range in a 360° rotation of the upper shaft as shown in Fig. 24. Therefore, the higher the sewing speed becomes, the more the needle bar 12 must also be reciprocatively turned at a high speed.

[0069] However, as shown in Fig. 12, generally, the motor has speed characteristics in which the acceleration of the motor is small immediately after the start of driving, a low-speed state V1 continues for a predetermined period, and then, the motor accelerates and reaches a high-speed state V2. Therefore, when turning is applied to the needle bar cam member 35 by the needle bar turning motor 34, when starting driving of the needle bar turning motor 34, the needle bar cam member 35 turns at a low speed, so that the turning of the needle bar 12 may not keep up with the needle bar 12 and the shuttle 13 driven by the sewing machine motor that continuously rotates at a high speed.

[0070] Therefore, the needle bar cam member 35 is designed so that the cam portion 351 of the needle bar cam member 35 is provided with the non-operating section 352 or 353, and this non-operating section 352 or 353 is set as a standby position of the roller 36, and until a high-speed state is reached after the start of driving of the needle bar turning motor 34, the roller 36 moves relatively along the non-operating section 352 or 353, and when the needle bar turning motor 34 sufficiently accelerates, the roller 36 moves relatively along the operating section 354. Accordingly, the needle bar 12 can be turned by utilizing only the high-speed range of the needle bar turning motor 34, so that the needle bar 12 can be turned at a high speed.

[0071] The control device 90 controls the needle bar turning motor 34 so that the needle bar turning motor 34 starts to drive in the non-operating section 352 or 353 of the needle bar cam member 35, and turning is applied to the needle bar in the operating section 354 after the needle bar turning motor 34 sufficiently accelerates.

[0072] The needle bar cam member 35 has non-operating sections 352 and 353 formed on both sides sandwiching the operating section 354, so that when the needle bar 12 is reciprocatively turned once, it is not necessary to reciprocatively turn the needle bar cam member 35, and it is sufficient to turn the needle bar cam member 35 to one side so that the roller 36 moves relatively from one non-operating section 352 to the other non-operating section 353. At the next reciprocative turning of the needle bar 12, the roller 36 has already come into contact with the other non-operating section 353, so that running-up until the motor 34 reaches a high speed can be performed in the non-operating section 353.

[0073] An origin sensor 355 is provided along with the needle bar cam member 35. The origin sensor 355 can detect a reference standby position of the roller 36 on the cam portion 351 of the needle bar cam member 35 by detecting a sensor 346 fixed to the turning shaft 345. By turning the needle bar cam member 35 from a state where the roller 36 is positioned at the reference standby position, when the needle bar turning motor 34 reaches a high speed, the roller 36 can be made to reach the operating section 354, so that needle turning at a high speed is enabled.

[0074] The roller 36 is held rotatably on one arm portion 361a of the roller arm 361 (bell crank) of the transmission member, and the other arm portion 361b of the roller arm 361 is joined to a turning distal end portion of the arm member 327 via the link body 362 of the transmission member.

[0075] The base end portion sides of two arm portions 361a and 361b of the roller arm 361 are supported turnably on a roller arm base 366 fixed to the wall surface of

the arm portion 101a by using a shoulder screw 363 as a pivot.

[0076] The roller arm 361 is energized by a triton coil spring 364 so that the roller 36 is always in contact with the cam portion 351 of the needle bar cam member 35.

[0077] Along with the roller arm 361, a stopper 365 is provided to prevent the needle bar cam member 35 from being more excessively turned by a torsion coil spring 364 when the needle bar cam member 35 excessively turns and the roller 36 comes off from the cam portion 351.

[0078] With the above-described configuration, in the needle bar turning mechanism 30, after the origin sensor 355 detects the state shown in Fig. 9 where the roller 36 is at the reference standby position on the cam portion 351 of the needle bar cam member 35, when the needle bar turning motor 34 starts to drive, the needle bar cam member 35 starts to turn via the drive sprocket 342, the timing belt 344, and the driven sprocket 343.

[0079] In the low-speed state when the needle bar turning motor 34 starts driving, the roller 36 moves relatively along the non-operating section 352 of the needle bar cam member 35, so that turning is not applied to the needle bar 12 and the needle bar base 31, and when the needle bar turning motor 34 gradually accelerates and reaches a high speed, as shown in Fig. 10, the roller 36 reaches the operating section 354 of the needle bar cam member 35 and moves relatively. Accordingly, the roller arm 361 turns to turn the needle bar base 31 via the link body 362. Accordingly, the needle bar 12 also turns.

[0080] Driving of the needle bar turning motor 34 is continued until the roller 36 comes off of the operating section 354 and reaches a stop position S2 in the other non-operating section 353. As shown in Fig. 13, when $\theta 1$ is a turning angle from the reference standby position S1 in the non-operating section 352 of the cam portion 351 detected by the origin sensor 355 to a boundary K1 between the non-operating section 352 and the operating section 354, the stop position S2 is preferably controlled so that a turning angle $\theta 2$ from a boundary K2 between the operating section 354 and the non-operating section 353 to the stop position S2 becomes equal to the angle $\theta 1$.

[0081] Specifically, at the next turning of the needle bar 12, the stop position S2 is a standby position as a turning start position and the needle bar cam member 35 is turned in the opposite direction, so that by setting the turning angle $\theta 2$ from the boundary K2 between the operating section 354 and the non-operating section 353 to the stop position S2 to be the same angle as $\theta 1$, the needle bar turning motor 34 can reach a high speed when the roller 36 enters the operating section 354 from the non-operating section 353.

[0082] In the case where the needle bar cam member 35 is used, in the running-up period during which the roller 36 moves relatively in the non-operating section 352 or 353, the needle bar 12 is in a stopped state and cannot be operated, so that when turning of the needle bar 12 must be started at a certain upper shaft angle as a more accurate timing, the needle bar turning motor 34 is controlled so as to start driving earlier by the running-up period than the turning start timing.

[0083] Thread Pulling Mechanism

[0084] As shown in Fig. 14 and Fig. 15, the thread pulling mechanism 50 is provided lower than the throat plate 14 inside the bed portion 101b, and pulls the lower thread by the thread pulling member 51. This thread pulling mechanism 50 includes the thread pulling member 51 that pulls a lower thread passing from the bobbin case to the eye 15 of the throat plate 14 to change its path, a thread pulling motor 52 that serves as a drive source for a thread pulling operation of the thread pulling member 51, a thread pulling cam member 53 to be actuated by the thread pulling motor 52, a roller 54 (thread pulling follower) to which an operation is applied from the thread pulling cam member 53, and a thread pulling link mechanism 55 that transmits a lower thread pulling operation from the roller 54 to the thread pulling member 51. The link mechanism 55 includes a roller arm 541 and a pivot 542.

[0085] The thread pulling motor 52 is supported in a state where its output shaft is directed vertically upward by a motor mounting base 521 attached inside the bed portion 101b, and on the output shaft, a drive gear 522 is provided. On the upper surface of the motor mounting base 521, a driven gear 523 with a small diameter is provided adjacent to the drive gear 522, and these gears mesh with each other, and increased-speed rotation is transmitted from the drive gear 522 to the driven gear 523.

[0086] The driven gear 523 is joined to the thread pulling cam member 53 via a turning shaft 524, and turning of the driven gear 523 is transmitted to the thread pulling cam member 53.

[0087] As shown in Fig. 16, the thread pulling cam member 53 has a substantially fan shape, and a substantially arc-shaped outer edge portion becomes a cam portion 531 that comes into contact with the roller 54 and displaces the roller. This cam portion 531 has arc-cam-shaped non-operating sections 532 and 533 that keep constant distances from the turning center position, and between the two non-operating sections 532 and 533, an operating section 534 continuous to these non-operating sections is formed. The two non-operating sections 532 and 533 both have cam shapes that keep constant distances from the turning center, however, the diameter of the non-operating section 533 is set to be larger than that of the non-operating section 532.

[0088] The operating section 534 has a cam shape which gradually increases in diameter from the boundary with one non-operating section 532 and becomes the same in diameter with the non-operating section 533 at the boundary with the other non-operating section 533.

[0089] Specifically, the thread pulling cam member 53 has a cam portion 531 including continuous formation of the non-operating sections 532 and 533 that do not apply

a thread pulling operation to the thread pulling member 51 and the operating section 534 that applies a thread pulling operation to the thread pulling member 51.

[0090] The thread pulling mechanism 50 turns the thread pulling member 51 in a predetermined angular range in a constant direction at a timing in a constant upper shaft angular range during sewing, and turns the thread pulling member 51 in the same angular range as the previous range in the opposite direction at a timing in another upper shaft angular range. Therefore, the higher the sewing speed becomes, the more the turning of the thread pulling member 51 in each direction must be performed at a higher speed.

[0091] Therefore, as with the needle bar turning mechanism 30, the thread pulling cam member 53 is designed so that the cam portion 531 of the thread pulling cam member 53 is provided with non-operating sections 532 and 533, the non-operating section 532 or 533 is set as a standby position of the roller 54, and after the thread pulling motor 52 sufficiently accelerates in a period in which the roller 54 moves relatively in the non-operating section 532 or 533 as a running-up period, the roller 54 moves relatively along the operating section 534. Accordingly, high-speed turning of the thread pulling member 51 can be performed by utilizing only the high-speed range of the thread pulling motor 52.

[0092] The thread pulling member 51 reciprocatively turns, however, unlike the needle bar 12, the thread pulling member 51 temporarily stops between forward turning and backward turning. Further, unlike the needle bar cam member 35, the thread pulling cam member 53 is not designed so that the thread pulling member 51 reciprocatively turns according to turning of the thread pulling cam member 53 to one side, and to reciprocatively turn the thread pulling member 51, the thread pulling cam member 53 must also reciprocatively turn.

[0093] Therefore, one non-operating section 532 is used for a running-up period when the thread pulling cam member 51 turns forward, and the other non-operating section 533 is used for a running-up period when the thread pulling cam member 51 turns backward.

[0094] Accordingly, forward turning and backward turning of the thread pulling member 51 can be made higher in speed, respectively.

[0095] Like the needle bar cam member 35, the thread pulling mechanism 50 may also be configured so that the mechanism is provided with an origin sensor that detects a reference standby position of the thread pulling cam member 53, and the thread pulling cam member 53 is started to turn from the reference standby position to make the thread pulling cam member 51 turn when the thread pulling motor 52 reaches a high-speed state.

[0096] The roller 54 that is in contact with the cam portion 531 of the thread pulling cam member 53 is held rotatably on one arm portion 541a of the roller arm 541 (bell crank), and the thread pulling member 51 is held on the other arm portion 541b of the roller arm 541.

[0097] The base end portion sides of the two arm portions 541a and 541b of the roller arm 541 are supported turnably by a pivot 542 provided on the motor mounting base 521.

[0098] The roller arm 541 is energized by a torsion coil spring 543 so that the roller 54 is always in contact with the cam portion 531 of the thread pulling cam member 53.

[0099] Along with the roller arm 541, a stopper 544 is provided to prevent the thread pulling cam member 53 from being more excessively turned by the torsion coil spring 543 when the thread pulling cam member 53 excessively turns and the roller 54 comes off from the cam portion 531.

[0100] The base end portion of the thread pulling member 51 is held on the turning distal end portion of the arm portion 541b of the roller arm 541, and the distal end portion of the thread pulling member 51 is extended toward the eye 15 direction below the throat plate 14. The distal end portion side of the thread pulling member 51 is a free end, and is formed into an acute shape. The thread pulling member 51 usually stands-by at a position at which the distal end portion thereof is ahead and away from the eye 15, and for thread pulling, the distal end portion moves to pass just below the eye 15 and engages with the lower thread passing through the eye 15 from the bobbin case to pull the lower thread rearward.

[0101] On the left side portion of the throat plate 14, a guide 511 that supports the plate-shaped thread pulling member 51 so as to interpose the thread pulling member in a gap between two upper and lower plate-shaped bodies before and after turning is provided, and prevents the thread pulling member 51 from vibrating in the up-down direction when it turns.

[0102] With the above-described configuration, in the thread pulling mechanism 50, when the thread pulling motor 52 starts to drive from the state where the roller 54 is at a predetermined standby position in the non-operating section 532 of the cam portion 531 of the thread pulling cam member 53, the thread pulling cam member 53 starts to turn via the drive gear 522 and the driven gear 523.

[0103] In a low-speed state of the thread pulling motor 52 when it starts driving, the roller 54 moves relatively along the non-operating section 532 of the thread pulling cam member 53, so that turning is not applied to the thread pulling member 51, and when the thread pulling motor 52 gradually accelerates and reaches a high speed, the roller 54 reaches the operating section 534 of the thread pulling cam member 53 and moves relatively. Accordingly, the roller arm 541 turns to turn the thread pulling member 51. Thereby, the thread pulling member 51 turns forward, and the distal end portion thereof passes just below the eye 15 and pulls the lower thread rearward.

[0104] The thread pulling motor 52 continues driving until the roller 54 comes off of the operating section 534 and reaches a predetermined stop position in the other non-operating section 533.

[0105] Specifically, the control device 90 controls the

thread pulling motor 52 so that the thread pulling motor 52 accelerates while the follower 54 engages with the non-operating section 532 of the thread pulling cam member 53, and the thread pulling motor 52 is driven at a high speed in the operating section 534.

[0106] The thread pulling member 51 must turn backward and return to the original position, so that in the thread pulling mechanism 50, when the thread pulling motor 52 starts to drive in reverse from the state where the roller 54 is at the standby position that is a stop position in the non-operating section 533, the roller 54 moves relatively along the non-operating section 533 in a low-speed state of the thread pulling motor 52 when it starts driving, and the roller 54 reaches the operating section 534 and moves relatively when the thread pulling motor 52 reaches a high speed. Accordingly, the roller arm 541 turns in the opposite direction, and the thread pulling member 51 turns backward.

[0107] The thread pulling motor 52 continues driving until the roller 54 comes off of the operating section 534 and reaches the original standby position in the non-operating section 532.

[0108] Specifically, the non-operating sections 532 and 533 of the thread pulling cam member 53 are respectively formed on both sides sandwiching the operating section 534. The control device 90 controls the thread pulling motor 52 so that the thread pulling motor 52 starts to drive in the non-operating section 532 or 533 of the thread pulling cam member 53, and applies a thread pulling operation to the thread pulling member 51 in the operating section 534 after the thread pulling motor 52 sufficiently accelerates.

[0109] As shown in Fig. 17, preferably, when S3 is a predetermined standby position of the roller 54, a turning angle $\theta 3$ from the standby position S3 to a boundary K3 between the non-operating section 532 and the operating section 534 is set so that the thread pulling motor 52 reaches a high-speed state at the boundary K3 when the thread pulling motor 52 starts driving from the standby position S3.

[0110] A roller stop position S4 in the non-operating section 533 when the thread pulling member 51 turns forward becomes a standby position as a backward turning start position of the thread pulling member 51, so that the turning angle $\theta 4$ from the standby position S4 to the boundary K4 between the non-operating section 533 and the operating section 534 is preferably set to be the same as the turning angle $\theta 3$.

[0111] In the thread pulling mechanism 50, by considering a running-up period during which the roller 54 moves relatively on the non-operating section 532 or 533, the thread pulling motor 52 must start driving earlier by the running-up period than the planned driving start timing.

[0112] Cloth Moving Mechanism

[0113] As shown in Fig. 1, the cloth moving mechanism 80 includes a holding frame 81 that holds a workpiece (cloth) on the upper surface of the bed portion 101b, a support arm 82 that supports the holding frame 81 movably up and down, an X-axis motor 83 shown in Fig. 19 that moves the holding frame 81 in the X-axis direction via the support arm 82, and a Y-axis motor 84 shown in Fig. 19 that moves the holding frame 81 in the Y-axis direction via the support arm 82.

[0114] With this configuration, the cloth moving mechanism 80 can move and position the cloth on an X-Y plane via the holding frame 81 to move the needle down at a certain position on the cloth for each stitch (each stitch formation), so that free seams can be formed. Specifically, the cloth moving mechanism 80 (a cloth moving mechanism) moves the cloth along the horizontal plane to perform stitching at stitch points on the cloth.

[0115] Thread Tensioning Device

[0116] As shown in Fig. 18, the thread tensioning device 70 includes a thread tensioner 79 that applies a thread tension to the upper thread and a thread tensioning solenoid 71 as a thread tension adjusting actuator that varies and adjusts a thread tension applied by the thread tensioner 79.

[0117] The thread tensioner 79 is provided on the right side surface of the arm portion 101a, and sandwiches the upper thread in the path from the thread supply source to the thread take-up and applies a thread tension thereto. The thread tensioner 79 includes two thread tensioning discs 72 that sandwich the upper thread, a hollow pivot 73 that supports these thread tensioning discs 72 movably along the X-axis direction in which the thread tensioning discs 72 approach each other and separate from each other, a pressing shaft 74 that penetrates through the inside of the hollow pivot 73 and can press one thread tensioning disc 72 against the other thread tensioning disc 72, a thread take-up spring 75, and a main body case 76 that houses and holds these components.

[0118] On the other hand, on the left of the thread tensioner, the thread tensioning solenoid 71 is disposed so that an output shaft 71a that generates a thrust in an projecting direction according to a supplied current value is aligned with the pressing shaft 74.

[0119] The output shaft 71a is coupled to a transmission shaft 78 inserted through a coil spring 77, and this transmission shaft 78 is inserted through the coil spring 77 that presses the output shaft 71a to push the output shaft in a push back direction.

[0120] Therefore, when an electric current is not supplied to the thread tensioning solenoid 71, the output shaft 71a is pushed back by the coil spring 77, and a pressing force for pressing the pressing shaft 74 toward the thread tensioning disc 72 cannot be obtained, so that the two thread tensioning discs 72 become free, and a thread tension is not applied.

[0121] When an electric current is supplied to the thread tensioning solenoid 71, the output shaft 71a is projected by a thrust corresponding to the supplied current value, the transmission shaft 78 presses one thread tensioning disc 72 via the pressing shaft 74 against the

coil spring 79, and according to this pressing force, a tension can be applied to the upper thread interposed between the two thread tensioning discs 72.

[0122] A current supply amount of the thread tensioning solenoid 71 is controlled by the control device 90, and an appropriate thread tension can be applied to the upper thread in the thread tensioning device 70.

[0123] The control device 90 controls the thread tensioning solenoid 71 as a thread tension adjusting actuator so as to reduce and adjust the thread tension when a calculated sewing direction belongs to segment A or B at the time of formation of a stitch with thread pulling or formation of a plurality of stitches including the stitch.

[0124] Control Device

[0125] As shown in Fig. 19, the sewing machine 100 includes a control device 90 that controls operations of the respective portions and members described above. The control device 90 includes a ROM 92 storing a program for controlling operations for sewing, a RAM 93 that serves as a work area for arithmetic processing, a non-volatile data memory 94 as a storage means that stores sewing data, and a CPU 91 that executes the program in the ROM 92.

[0126] The CPU 91 is connected to the sewing machine motor 21, the X-axis motor 83, the Y-axis motor 84, the thread pulling motor 52, the needle bar turning motor 34, and the thread tensioning solenoid 71, respectively, via a sewing machine motor drive circuit 21a, an X-axis motor drive circuit 83 a, a Y-axis motor drive circuit 84a, a thread pulling motor drive circuit 52a, a needle bar turning motor drive circuit 34a, and a thread tensioning solenoid drive circuit 71b, and controls driving of the motors 21, 83, 84, 52, 34 and the thread tensioning solenoid 71.

[0127] The sewing machine motor 21 includes an encoder NP, and detects a rotation phase of the sewing machine motor 21, that is, a rotation phase of the upper shaft of the sewing machine main body 101 and transmits and outputs a detection signal to the CPU 91. The above-described motors 83, 84, 52, 34 are stepping motors, and means for searching origins of these motors, not illustrated, are connected to the CPU 91, and based on outputs therefrom, the CPU 91 can recognize the origin positions of the motors.

[0128] In sewing data stored in a data memory 94, operation amounts of the X-axis motor 83 and the Y-axis motor 84 per stitch for sewing a predetermined sewing pattern are stored in order, and the CPU 91 reads the operation amounts of the X-axis motor 83 and the Y-axis motor 84 per stitch when sewing, and performs operation control to drive the X-axis motor 83 and the Y-axis motor 84 according to the operation amounts. Specifically, the control device 90 controls the cloth moving mechanism 80 based on sewing data defining a stitch point or a cloth movement amount per stitch for forming a predetermined sewing pattern.

[0129] Hitch Stitch Occurrence Factor

[0130] The CPU 91 executes hitch stitch avoidance control along with execution of sewing control based on sewing data. Here, a factor that causes hitch stitches is described with reference to Figs. 20A to 21B. For convenience, illustration of the upper thread U is omitted.

[0131] When a cloth is moved by the cloth moving mechanism 80 for each stitch formation based on sewing data, depending on the cloth feeding direction, that is, the stitch forming direction, the entwining direction in which the upper thread U passing through the eyelet 11a of the sewing needle 11 is entwined with the sewing needle 11 when the sewing needle 11 enters the cloth becomes leftward winding direction as shown in Fig. 20A or rightward winding direction as shown in Fig. 20B, and depending this entwining direction, it is determined whether a perfect stitch or a hitch stitch is to be formed.

[0132] As shown in Figs. 21A and 21B, depending on whether the sewing needle 11 moves down on the left side L or the right side R of the path with respect to the lower thread D, it is also determined whether a perfect stitch or a hitch stitch is to be formed.

[0133] Next, a relationship between the cloth movement direction and a hitch stitch occurrence factor in the case using a semi-rotary hook as in the sewing machine 100 according to the embodiment will be described with reference to Fig. 22. In Fig. 22, in the entire angular range (360 degrees) around the eye 15 in which the cloth is fed by the cloth moving mechanism 80, angular ranges are identified in terms of probability of occurrence of hitch stitches and a factor for hitch stitches.

[0134] First, the angular range I of the feeding direction is a region in which it is uncertain whether the sewing needle 11 falls (moves down) to the right side or falls to the left side of the lower thread passing through the eye 15 because when the cloth is fed in the direction in this angular range, the direction substantially matches the direction of the lower thread toward the eye 15 from the bobbin case, and is a region in which either a perfect stitch or a hitch stitch may occur. On the other hand, in this region, the direction in which the upper thread is entwined with the sewing needle 11 is constant according to the feeding direction, so that this region is not influenced by this factor.

[0135] Next, with regard to the angular range II, when the cloth is fed in the direction in this angular range, the sewing needle 11 reliably moves down to the left side of the path of the lower thread extending from the shuttle (bobbin case) to the eye 15, and the direction in which the upper thread is entwined with the sewing needle 11 is rightward according to the cloth feeding direction, so that a hitch stitch is certainly formed in this region.

[0136] Next, with regard to the range III, when the cloth is fed in the direction in this angular range, the sewing needle 11 reliably moves down to the left side of the path of the lower thread extending from the shuttle (bobbin case) to the eye 15, however, since the direction in which the upper thread is entwined with the sewing needle 11 is uncertain, either a perfect stitch or a hitch stitch may occur in this region.

[0137] With regard to the range IV, when the cloth is fed in the direction in this angular range, the sewing needle 11 reliably moves down to the right side of the path of the lower thread extending from the shuttle (bobbin case) to the eye 15, and the direction in which the upper thread is entwined with the sewing needle 11 is leftward, so that a perfect stitch is reliably formed in this region.

[0138] Hitch Stitch Avoidance Control

[0139] Thus, in the sewing machine 100, whether a perfect stitch or a hitch stitch is to be formed is determined by two factors, that is, the side to which the sewing needle 11 falls with respect to the lower thread path connected from the shuttle (bobbin case) to the eye 15 and the direction in which the upper thread is entwined with respect to the sewing needle 11, and in a region in which both of these factors are uncertain, the kind of stitch also tends to become an uncertain element.

[0140] Therefore, in the sewing machine 100, four segments of angular ranges I to IV identified and set based on probabilities of hitch stitches and factors for hitch stitches are registered in the data memory 94. Further, as shown in Fig. 23, for each segment of the angular ranges I to IV, data showing which should be executed, thread pulling by the thread pulling mechanism 50 or needle bar turning by the needle bar turning mechanism 30, is stored as table data in the data memory (storage unit) 94.

[0141] Specifically, the control device 90 includes a storage unit that stores a command to instruct execution of the thread pulling by the thread pulling mechanism 50 or the needle bar turning by the needle bar turning mechanism 30 for each of the segments I to IV, wherein the entire angular range of cloth feeding direction around the up-down movement path of the sewing needle 11 associated with the up-down movement of the needle bar 12 is divided into the segments by specifying the respective angular ranges based on probabilities of hitch stitches and factors for hitch stitches.

[0142] The control device 90 executes the following hitch stitch avoidance control during the sewing operation. Specifically, to form a sewing pattern, when operation amounts of the X-axis motor 83 and the Y-axis motor 84 for one stitch are read from the sewing data, and from the movement amounts in the X-axis direction and the Y-axis direction, one of the angular ranges I to IV is identified as a segment to which the cloth movement direction belongs. Then, in accordance with the identified segment, it is determined whether to execute the thread pulling or the needle bar turning from the table data, and the thread pulling motor 52 of the thread pulling mechanism 50 or the needle bar turning motor 34 of the needle bar turning mechanism 30 is controlled to execute each operation at an upper shaft rotation angle (upper shaft angle) corresponding to each execution timing.

[0143] The control device 90 calculates a direction of cloth movement by the cloth moving mechanism 80 when the needle enters the cloth (at the stitching timing) from a stitch point (position at which the needle enters the cloth) or a cloth movement amount determined in the sewing data, and identifies one of the angular ranges I to IV as the segment to the cloth movement direction belongs.

[0144] The control device 90 executes thread pulling by thread pulling mechanism 50 when the movement direction belongs to the angular range I or II (a first angular range), executes needle bar turning by the needle bar turning mechanism 30 when the movement direction belongs to the angular range III (a second angular range), and does not execute thread pulling by the thread pulling mechanism 50 and needle bar turning by the needle bar turning mechanism 30 when the movement direction belongs to the angular range IV (a third angular range).

[0145] The control device 90 calculates a direction of cloth movement by the cloth moving mechanism 80 for each stitch based on a stitch point or a cloth movement amount determined in sewing data. Instead of this, it is also possible that angular range data defining the first angular ranges I and II, the second angular range III, and the third angular range IV are set in the sewing data in advance, and based on the data, the control device 90 controls execution of needle bar turning and thread pulling.

[0146] Specifically, the control device 90 executes the thread pulling by the thread pulling mechanism 50 when a direction of cloth movement by the cloth moving mechanism 80 per stitch belongs to the first angular range I or II, and executes the needle bar turning by the needle bar turning mechanism 30 when the movement direction belongs to the second angular range III.

[0147] Timing of Needle Bar Turning

[0148] Next, a proper timing to execute needle bar turning in hitch stitch avoidance control is described with reference to Fig. 24.

[0149] In Fig. 24,

[0150] Section a: moving-up section until the needle tip reaches a needle bar upper dead point after moving out from a workpiece,

[0151] Section b: moving-down section until the needle tip reaches the workpiece from the needle bar upper dead point,

[0152] Section c: moving-down section until the needle tip reaches a needle bar lower dead point after reaching the workpiece,

[0153] Section d: moving-up section until the needle matches the shuttle hook from the needle bar lower dead point, and

[0154] Section e: moving-up section until the needle comes out from the workpiece after the needle and the shuttle hook matches each other.

[0155] As needle bar turning, it is required that the orientation of the sewing needle 11 turns by a necessary angle before the needle entering angle shown in Fig. 24 is reached, that is, in the section a. Therefore, the needle bar turning motor 34 of the needle bar turning mechanism 30 is controlled to start driving earlier by at least a necessary time until a middle position of the operating section

354 is reached from the reference standby position of the non-operating section 352 or 353 of the needle bar cam member 35 than the timing to reach the needle entering angle.

[0156] The upper shaft angle is monitored based on outputs from the encoder provided in the sewing machine motor 21.

[0157] The orientation of the sewing needle 11 must be rotated to return to the original orientation at least before reaching the upper shaft angle at which the needle and the shuttle match each other, that is, before reaching the upper shaft angle of the needle bar lower dead point in the section c. The needle bar turning motor 34 runs up in the non-operating section 352 or 353 of the needle bar cam member 35, and high-speed reciprocative turning of the needle bar 12 is realized, so that by setting a driving start timing so that the orientation of the sewing needle 11 turns by a necessary angle before reaching the needle entering angle, delay of the timing to return to the original orientation of the sewing needle 11 can be avoided.

[0158] Timing of Thread Pulling

[0159] Next, a proper timing to execute thread pulling in hitch stitch avoidance control is described with reference to Fig. 25 to Fig. 27. In Fig. 25, the line connecting black triangles indicates a needle bar curve, the line connecting black squares indicates a shuttle curve, and the line connecting black diamonds indicates a thread take-up curve.

[0160] As shown in Fig. 26 and Fig. 27, the thread pulling member 51 crosses the eye 15 where the stitch point is, and for executing thread pulling, forward turning of the thread pulling member 51 is preferably completed before an upper shaft rotation angle (upper shaft angle) of 113 degrees that is the needle entering angle. Therefore, the thread pulling motor 52 of the thread pulling mechanism 50 is controlled to start driving earlier by at least a necessary time until the stop position in the non-operating section 533 is reached from the standby position in the non-operating section 532 of the thread pulling cam member 53 than the timing to reach the needle entering angle.

[0161] Backward turning of the thread pulling member 51 is preferably executed at an upper shaft angle of 270 degrees that is an upper thread open angle at which the upper thread is made most distant from the needle center by the shuttle. Therefore, the thread pulling motor 52 of the thread pulling mechanism 50 is controlled to start so that the timing of shifting from the non-operating section 533 to the operating section 534 of the thread pulling cam member 53 and the upper thread open angle (upper shaft angle of 270 degrees) match each other.

[0162] As shown in Fig. 35, the displacement H of the thread pulling cam 53 becomes maximum displacement before the needle entering angle of 113 degrees, and accordingly, forward turning is applied to the thread pulling member 51. The state where the displacement of the thread pulling cam 53 is maximum continues until the upper thread open angle of 270 degrees, and thereafter, the displacement H of the thread pulling cam 53 decreases. Specifically, the thread pulling member 51 turns backward when the upper thread open angle is 270 degrees, and is returned to the original standby position when the upper thread open angle is 0 degrees.

[0163] Specifically, by thus setting the displacement of the thread pulling cam 53A, lower thread pulling can be performed at the above-described proper timing without interference with the sewing needle 11 and the upper thread. The line type definition in Fig. 35 is the same as in Fig. 25.

[0164] Both of the timing of forward turning and backward turning of the thread pulling member 51 are required to be short, and the operating section 534 is reached in a high-speed state of the thread pulling motor 52 after the thread pulling motor runs up in the non-operating section 532 or 533, so that the thread pulling member 51 can be turned at a high speed, and the requirement for short-time operation can be sufficiently satisfied. For convenience, illustration of the upper thread U is omitted.

[0165] Thread Tension Adjusting Control during Thread Pulling

[0166] As shown in Fig. 28, when thread pulling is executed, the lower thread D is pulled by the thread pulling member 51 and its path length becomes longer, and the lower thread D is drawn out from the bobbin side. For convenience, illustration of the upper thread U is omitted.

[0167] Therefore, even when the upper thread tension is set to be smaller than normal, the knot between the upper and lower threads can be drawn to the upper side of the cloth, so that a stitch with a low tension and excellent tightness can be formed.

[0168] Therefore, at the time of sewing a stitch with respect to which the thread pulling is determined to be executed, the thread tensioning solenoid 71 is controlled to reduce the thread tension.

[0169] At this time, the thread tension of the thread tensioning solenoid 71 is automatically calculated by subtracting a predetermined amount by automatic arithmetic operation from a thread tension set value set in the sewing data or reducing it by a predetermined ratio, or a thread tension value suitable for thread pulling is set in advance, and the thread tensioning solenoid 71 is controlled so that a thread tension value suitable for thread pulling is constantly obtained during execution of thread pulling.

[0170] Thus, by performing control to reduce the thread tension at the time of thread pulling, a stitch that executes thread pulling and a stitch that does not execute thread pulling can be made even in tightness.

[0171] Operations for Hitch Stitch Avoidance Control

[0172] The operations will be described with reference to Fig. 29.

[0173] The control device 90 of the sewing machine 100 reads movement amounts in the X-axis direction and the Y-axis direction for the next stitch formation from sewing data in a case where a rotation angle (phase) per rotation of the upper shaft is a predetermined read angle

when executing sewing based on the sewing data (Step S1).

[0174] Then, the control device 90 calculates a direction of cloth movement, that is, sewing direction from the movement amounts in the X-axis direction and the Y-axis direction (Step S2). Therefore, the control device 90 functions as a determining means for determining a direction of cloth movement (sewing direction) by the cloth moving mechanism 80 by executing Step S2.

[0175] Next, the control device 90 judges whether the calculated sewing direction belongs to the segment of the angular range I or II (a first angular range) by referring to the table shown in Fig. 23 (Step S3). Specifically, the control device 90 functions as identifying means for identifying a segment in which the movement direction determined by the determining means is included by executing Step S3.

[0176] As a result, when the sewing direction belongs to the segment of the angular range I or II, the control device controls the thread tensioning solenoid 71 to make the thread tension lower than the set value or equal to a predetermined low tension value (Step S4). Further, by monitoring the upper shaft angle based on detection signals of the encoder NP, the control device starts driving of the thread pulling motor 52 at a proper timing to execute thread pulling (Step S5). Accordingly, even when the sewing direction belongs to the segment of the angular range I or II, the needle is moved down on the right side of the lower thread, and a perfect stitch is executed. The proper timing differs depending on the upper shaft rotation speed, and in the present example, the upper shaft rotation angle is set to 100 degrees.

[0177] In Step S3, if the sewing direction does not belong to the segment of the angular range I or II, it is judged whether it belongs to the segment of the angular range III (Step S6).

[0178] Accordingly, when the sewing direction belongs to the segment of the angular range III, by monitoring the upper shaft angle based on detection signals of the encoder NP, driving of the needle bar turning motor 34 is started to execute turning of the needle bar 12 at a proper timing (Step S7).

[0179] Accordingly, the upper thread can be entwined with the sewing needle 11 on the left side of the sewing needle 11, and sewing of a perfect stitch is executed.

[0180] In Step S6, when the sewing direction does not belong to the segment of the angular range III, either, the sewing direction belongs to the segment of the angular range IV, so that without thread pulling and needle bar turning, normal stitch formation is executed.

[0181] Therefore, the control device 90 functions as a control means that controls execution or withholding of thread pulling by the thread pulling mechanism 50 (thread pulling motor 52) or needle bar turning by the needle bar turning mechanism 30 (needle bar turning motor 34) depending on the movement direction determined by the determining means (Steps S2 and S3), by executing Steps S4 to S7, that is, a control means that selectively executes thread pulling by the thread pulling mechanism 50 (thread pulling motor 52) or needle bar turning by the needle bar turning mechanism 30 (needle bar turning motor 34) depending on the movement direction determined by the determining means (Steps S2 and S3).

[0182] Advantages

[0183] As described above, in the sewing machine 100, a sewing direction of each stitch is obtained, and according to the sewing direction, thread pulling or needle bar turning is selectively executed. Therefore, not only a hitch stitch caused by a stitch point with respect to the lower thread but also a hitch stitch caused by a direction in which the upper thread is entwined with the sewing needle 11 can be prevented, and occurrence of hitch stitches can be more effectively reduced. In addition, the sewing machine copes with a plurality of factors, so that occurrence of hitch stitch can be prevented even when various shuttles such as a vertical hook, a horizontal hook, a full-rotary hook, and a semi-rotary hook are used.

[0184] In the sewing machine 100, along with execution of thread pulling, control to reduce the thread tension is performed, so that the tensions of the lower thread drawn out by thread pulling and the upper thread can be well-balanced, and the knot can be drawn into the cloth, and thread tightness can be improved.

[0185] In the sewing machine 100, the thread pulling cam member 53 that applies turning to the thread pulling member 51 and the needle bar cam member 35 that applies turning to the needle bar 12 have non-operating sections, and before reaching the operating section, running-up of the motor can be executed, so that operations of thread pulling and needle bar turning can be performed at a high speed, and these operations can be executed without reducing the speed of the sewing machine motor 21.

[0186] Second Example of Needle Bar Turning Mechanism

[0187] A second example of a needle bar turning mechanism is described with reference to Fig. 30 to Fig. 32.

[0188] The same components of the needle bar turning mechanism 30A in the second example as those of the above-described needle bar turning mechanism 30 are provided with the same reference numerals, and overlapping description is omitted.

[0189] The needle bar turning mechanism 30A includes a needle bar cam member 35A as an end cam that is rotated by the sewing machine motor 21, a roller 36A (needle bar turning follower) to which an operation is applied from the needle bar cam member 35A, a needle bar link mechanism that transmits turning from the roller 36A to the needle bar 12 and the needle bar base 31, and a direct acting type actuator 34A (for example, air cylinder or solenoid) for switching between a state where the operation is transmitted from the roller 36A to the needle bar 12 side and a cut-off state.

[0190] The link mechanism includes a roller arm 37A,

a first link body 382A, a second link body 383A, an arm portion 384A, an arm portion 386A, and a transmission link body 387A.

[0191] The needle bar cam member 35A is provided on the upper shaft 22, and rotates around the upper shaft 22. The roller 36A comes into contact with an end face of the needle bar cam member 35A and is displaced according to the shape of the end face.

[0192] The roller 36A is held by a first arm portion 371A of the roller arm 37A that is turnable around a shoulder screw 374A as a pivot with respect to a foundation 39A fixed to the wall surface of the arm portion 101a.

[0193] The roller arm 37A has first to third arm portions 371A to 373A extending in three directions around the shoulder screw 374A as shown in Fig. 32. A tension spring 361A is joined to the first arm portion 371A so that the roller 36A is always in contact with the cam surface of the needle bar cam member 35A.

[0194] An end portion of the first link body 382A is joined to an end portion of the second arm portion 372A of the roller arm 37A, and turning by the roller 36A is transmitted to the needle bar 12 side.

[0195] The other end portion of the first link body 382A is joined to an operation switching link body 381A joined to a plunger of the actuator 34A, and also joined to an end portion of the second link body 383A.

[0196] The second link body 383A is joined to one arm portion 384A of a bell crank axially supported on the foundation 39A by the shoulder screw 385A, and the other arm portion 386A of the bell crank is joined to the needle bar base 31 via the transmission link body 387A.

[0197] In Fig. 30, the actuator 34A is in a state where the plunger is retracted. In this state, when the needle bar turning cam 35A rotates according to rotation of the upper shaft 22, the roller 36A changes in position along the Y-axis direction according to displacement of the cam surface, and the entire roller arm 37A turns around the shoulder screw 374A. Then, when the roller arm 37A turns, the first and second link bodies 382A and 383A transmits turning to the bell crank. Accordingly, the needle bar base 31 and the needle bar 12 can be turned via the transmission link 387A.

[0198] On the other hand, the second arm portion 372A of the roller arm 37A and the first link body 382A have lengths set to be equal to each other, and when the direct acting shaft of the actuator 34A is projected forward, as shown in Fig. 31, the turning joint portion of the first link body 382A and the second link body 383A overlaps the shoulder screw 374A that is the turning center (turning joint portion) of the roller arm 37A. In this case, even if the roller arm 37A is turned around the shoulder screw 374A by the roller 36A in contact with the needle bar turning cam 35A, operation is not transmitted beyond the first link body 382A, so that the needle bar 12 becomes stationary.

[0199] Specifically, the link mechanism is configured such that the transmission from the roller 36A to the needle bar 12 is disabled by shifting the turning joint portion of the first link body 382A joined turnably to the second link body 383A (the turning joint portion of one of the needle bar link bodies) to a position concentric with the turning joint portion of the roller arm 37A (the turning joint portion of another one of the needle bar link bodies).

[0200] Advancing and retracting of the direct acting shaft of the actuator 34A can be controlled by the control device 90, and by controlling the actuator 34A, the needle bar 12 can be arbitrarily turned or made stationary.

[0201] Specifically, the control device 90 turns or makes stationary the needle bar by controlling the actuator 34A that shifts one turning joint portion to a position concentric with the other turning joint portion.

[0202] The needle bar turning mechanism 30A uses the upper shaft 22 as a drive source for turning the needle bar 12, so that turning of the needle bar 12 can be completely synchronized with the entire operation of the sewing machine 100 without delay.

[0203] Second Example of Thread Pulling Mechanism

[0204] A second example of a thread pulling mechanism is described with reference to Fig. 33 and Fig. 34.

[0205] The same components of the thread pulling mechanism 50A of the second example as those in the above-described thread pulling mechanism 50 are provided with the same reference numerals, and overlapping description is omitted.

[0206] The thread pulling mechanism 50A includes a thread pulling cam member 53A as an end cam provided on a rotary shaft 531A that is rotated (actuated) by the sewing machine motor 21, a roller 54A (thread pulling follower) to which an operation is applied from the thread pulling cam member 53A, a thread pulling link mechanism that transmits turning from the roller 54A to the thread pulling member 51, and a direct acting type actuator 52A (for example, air cylinder or solenoid) that switches a state where the operation is transmitted from the roller 54A to the thread pulling member 51 side and a cut-off state.

[0207] The thread pulling cam member 53A is provided on the rotary shaft 531A, and rotates around the rotary shaft 531A. The roller 54A comes into contact with an end face of the thread pulling cam member 53A and is displaced according to the shape of the end face.

[0208] The roller 54A is held by a first arm portion of the roller arm 551A (bell crank) turnable around a pivot with respect to the wall surface of the bed portion 101b.

[0209] The roller arm 551A includes a first arm portion and a second arm portion around a pivot as shown in Fig. 34. To the first arm portion of the roller arm 551A, a tension spring is joined so that the roller 54A is always in contact with the cam surface of the thread pulling cam member 53A.

[0210] To the end portion of the second arm portion of the roller arm 551A, one end portion of a first link body 552A is joined to transmit turning caused by the roller 54A to the thread pulling member 51 side.

[0211] The other end portion of the first link body 552A is joined to an operation switching link body 553A joined

to the plunger of the actuator 52A, and also joined to one end portion of a second link body 554A.

[0212] The second link body 554A is joined to one arm portion of a bell crank 555A axially supported on the wall surface of the bed portion 101b, and the other arm portion of the bell crank 555A holds the thread pulling member 51.

[0213] In Fig. 34, the actuator 52A is in a state where the plunger is retracted. In this state, when the thread pulling cam 53A rotates according to rotation of the rotary shaft 531A, the roller 54A changes in position along the Y-axis direction according to displacement of the cam surface, and the entire roller arm 551A turns around the pivot. Then, when the roller arm 551A turns, the first and second link bodies 552A and 554A transmit turning to the bell crank 555A. Accordingly, the thread pulling member 51 turns toward the eye 15 side, and thread pulling can be executed.

[0214] On the other hand, the second arm portion 551Aa of the roller arm 551A and the first link body 552A have lengths set equal to each other, and when the direct acting shaft of the actuator 52A is projected forward, as shown in Fig. 33, the turning joint portion 556A of the first link body 552A and the second link body 554A overlaps the turning center 551Ab of the roller arm 551A. In this case, even when the roller arm 551A is turned around the pivot by the roller 54A that comes into contact with the thread pulling cam 53A, the operation is not transmitted beyond the first link body 552A, and the thread pulling member 51 is kept at the position shown in Fig. 33.

[0215] Specifically, the link mechanism includes the roller arm 551A, the first link body 552A, the second link body 554A, and the bell crank 555A.

[0216] The link mechanism is configured such that the transmission from the roller 54A to the thread pulling member 51 is disabled by shifting the turning joint portion 556A of the first link body 552A and the second link body 554A (the turning joint portion of one of the thread pulling link bodies) to a position concentric with the turning center 551Ab of the roller arm 551A (the turning joint portion of another one of the thread pulling link bodies).

[0217] The control device 90 executes thread pulling by controlling the actuator 52A that shifts one turning joint portion 556A to a position concentric with the other turning joint portion 551Ab.

[0218] As shown in Fig. 35, the displacement H of the thread pulling cam 53A becomes maximum displacement before the needle entering angle of 113 degrees, and accordingly, forward turning is applied to the thread pulling member 51. The state where the displacement of the thread pulling cam 53A is maximum continues until the upper thread open angle of 270 degrees, and thereafter, the displacement H of the thread pulling cam 53A decreases. Specifically, the thread pulling member 51 turns backward when the upper thread open angle is 270 degrees, and is returned to the original standby position when the upper thread open angle is 0 degrees.

[0219] Specifically, by thus setting the displacement of the thread pulling cam 53A, the lower thread can be pulled at the above-described proper timing without interference with the sewing needle 11 and the upper thread.

[0220] In the case of this thread pulling mechanism 50A, the actuator 52A can also control advancing and retracting of the direct acting shaft thereof by the control device 90, and by controlling the actuator 52A, the thread pulling member 51 can be arbitrarily turned or made stationary.

[0221] The needle bar turning mechanism 50A uses the sewing machine motor 21 as a drive source for turning the thread pulling member 51, so that turning of the thread pulling member 51 can be completely synchronized with the entire operation of the sewing machine 100 without delay.

[0222] Third Example of Thread Pulling Mechanism

[0223] A third example of a thread pulling mechanism is described with reference to Fig. 36.

[0224] The same components of the thread pulling mechanism 50B of the third example as those of the above-described thread pulling mechanism 50 are provided with the same reference numerals, and overlapping description thereof is omitted.

[0225] The thread pulling mechanism 50B includes a thread pulling motor 52B serving as a drive source for thread pulling, a first link body 531B to be turned by the thread pulling motor 52B, a second link body 532B whose one end portion is joined to a turning distal end portion of the first link body 531B, and a third link body 533B whose one end portion is joined to a motor mounting base 521B by a shoulder screw 534B. The other end portion of the second link body 535B and the other end portion of the third link body 533B are joined.

[0226] To the other end portion of the second link body 532B, the thread pulling member 51 is fixed and held.

[0227] In this structure, one end portion side of the second link body 532B revolves along a circle due to the first link body 531B, however, the other end portion of the second link body 532B moves in an arc whose radius is the third link body 533B. Accordingly, the distal end portion of the thread pulling member 51 revolves in a deformed oval shape (see the reference numeral M).

[0228] Specifically, the thread pulling mechanism 50B includes the first link body 531B, the second link body 532B, and the third link body 533B as a thread pulling link mechanism that transmits an operation from the thread pulling motor 52B to the thread pulling member 51 so that the distal end portion of the thread pulling member 51 revolves.

[0229] The thread pulling member 51 is disposed so that the eye 15 is included in the revolving range, and the distal end portion of the thread pulling member 51 contacts the lower thread and executes the thread pulling in the operating section of the locus M of revolving motion.

[0230] Thus, in the case where the distal end portion of the thread pulling member 51 revolves, only when the distal end portion of the thread pulling member 51 ap-

proaches the eye 15, the thread pulling member 51 engages with and pulls the lower thread. When the thread pulling member 51 moves away from the eye 15, the lower thread comes off from the thread pulling member 54. Specifically, the thread pulling mechanism 50B performs thread pulling by utilizing only a range that is a part of the revolution movement locus of the thread pulling member 51. Accordingly, unlike in the case where thread pulling is performed by reciprocative turning, the thread pulling member 50B does not have to pass below the eye 15 both when it turns forward and when it turns backward, and the need for operating the thread pulling member at a timing to avoid interference with the surrounding is reduced, and as compared with other examples, thread pulling can be realized by control with fewer limitations on operation timing and operation speed.

[0231] When the revolution locus of the thread pulling member 51 is determined in advance, as for the upper shaft angle, a timing at which the thread pulling member comes into contact with the lower thread and starts thread pulling is determined. Therefore, when the upper shaft angle corresponding to this thread pulling start is known, the thread pulling motor 52B is controlled to start driving at a predetermined angle before the upper shaft angle for starting thread pulling, and the thread pulling motor 52B is sufficiently accelerated in a period from the driving start to the thread pulling start as a running-up period, and accordingly, without using the thread pulling cam member 53 having the non-operating section described above, thread pulling operation itself can be performed at a high speed. Accordingly, thread pulling adapted to high-speed sewing can be easily realized.

[0232] Specifically, the control device 90 controls the thread pulling motor 52B such that, when performing thread pulling, the thread pulling motor 52B starts to drive when the distal end portion of the thread pulling member 51 is outside the operating section of the locus M of the revolving motion, and such that the thread pulling motor 52B accelerates until the distal end portion of the thread pulling member 51 reaches the operating section.

[0233] Third Example of Needle Bar Turning Mechanism

[0234] A third example of a needle bar turning mechanism is described with reference to Fig. 38 to Fig. 41B.

[0235] The same components of the needle bar turning mechanism 30B in the third example as those of the above-described needle bar turning mechanism 30 are provided with the same reference numerals, and overlapping description thereof is omitted.

[0236] In the needle bar turning mechanism 30B, the structure of the needle bar cam member 35B and the joint structure between the cam arm 361B of the needle bar link mechanism that transmits turning from the needle bar cam member 35B to the needle bar base 31 and the needle bar base 31 are different from those in the needle bar turning mechanism 30.

[0237] Specifically, the needle bar turning mechanism 30B includes a circular needle bar cam member 35B to be rotated by belt driving from the needle bar turning motor 34, a columnar boss-shaped portion 36B (needle bar turning follower) that fits in a cam groove 351B formed on the lower surface of the needle bar cam member 35B, a cam arm 361B that includes the boss-shaped portion 36B on one arm portion 361Ba and includes a square piece 362B (sliding member) on the other arm portion 361Bb, an arm member 327B fixed near the upper end portion 311 of the needle bar base 31, and a thrust cup 335B fixed to the upper end portion 311 of the needle bar base 31 above the arm member 327B.

[0238] The cam arm 361B has a bell crank structure, and turning is input therein from the needle bar cam member 35B through the boss-shaped portion 36B. The cam arm 361B thus turns and transmits the turning to the needle bar base 31.

[0239] Unlike the roller arm 361 described above, a torsion coil spring that always applies energization in a constant turning direction is not provided along with the cam arm 361B.

[0240] On the lower surface of the needle bar cam member 35B, as shown in Fig. 40, a cam groove 351B is formed whose depth direction is in the up-down direction.

[0241] The cam groove 351B is formed into an endless annular shape by connecting five operating sections 352B that apply one-round reciprocative turning to the needle bar base 31. Specifically, one operating section 352 of the needle bar cam member 35B is formed to be a 72-degree angular range.

[0242] One operating section 352B is formed in a shape so that its displacement gradually increases from a starting point 352Ba set at a minimum displacement position at the smallest distance from the rotation center and becomes a maximum displacement at a middle point 352Bb of this section, and then gradually decreases to a starting point 352Ba of the next operating section 352B.

[0243] In the needle bar cam member 35B, when the needle bar 12 is not turning, the boss-shaped portion 36B of the cam arm 361B is positioned at the starting point 352Ba, and by driving and rotating the needle bar cam member 35B so that the boss-shaped portion 36B moves from this point to the starting point 352Ba of the next operating section 352B, the needle bar base 31 is reciprocatively turned through the cam arm 361B.

[0244] At this time, the needle bar cam member 35B is a grooved cam, so that even when it is rotated at a high speed, the boss-shaped portion 36B is prevented from coming off from the needle bar cam member 35B due to a centrifugal force, and a stable operation is maintained.

[0245] In the needle bar cam member 35B, the cam groove 351B thereof is a circumferential cam that is an endless annular shape, and has a plurality of operating sections 352B formed connected without discontinuity, so that when the needle bar needs to be turned for formation of a plurality of continuous stitches, the needle bar cam member 35B does not need to be intermittently

driven in each operating section 352B, and by rotating the needle bar cam member continuously, the needle bar can be turned a plurality of times. Therefore, unlike intermittent rotation during which rotation is repeatedly stopped, during continuous turning, abrupt acceleration from a stop state to a high-speed state is not necessary, and stable continuous turning is possible.

[0246] Thus, the cam groove 351B of the needle bar cam member 35B is a circumferential cam, so that the durability of the timing belt 344 that transmits rotation from the needle bar turning motor 34 to the needle bar cam member 35B can be improved.

[0247] Specifically, in the needle bar turning mechanism 30, the needle bar cam member 35 reciprocatively turns only in a limited angular range, so that the timing belt 344 meshes with only portions of sprockets 342 and 343, and only these portions are worn and easily deteriorated. On the other hand, the needle bar cam member 35B has a cam groove 351B on the entire circumference, so that it is rotated in a constant direction, and the timing belt 344 meshes and is worn entirely uniformly, so that durability is maintained for a long period of time.

[0248] Without limiting to the timing belt, even when the needle bar cam member 35B is actuated by a gear, the durability of the gear can also be improved in the same manner.

[0249] In the needle bar turning mechanism 30B, the origin sensor 355B is provided along with the needle bar turning motor 34. Specifically, the output shaft of the needle bar turning motor 34 is equipped with a sensor 346B, and by detecting the presence or absence of the sensor 346B by the origin sensor 355B, the origin position of the needle bar turning motor 34 is detected. In the control device 90, by counting a pulse number from the origin position of the needle bar turning motor 34, the starting point 352Ba of each operating section 352B of the needle bar cam member 35B can be recognized.

[0250] As shown in Figs. 41A and 41B, on the arm portion 361Bb on the needle bar base 31 side of the cam arm 361B as a link body to which turning is applied by the needle bar cam member 35B, a square piece 362B is supported turnably around the Z-axis by a pivot 362Ba. This square piece 362B has a rectangular parallelepiped shape that is square in a plan view, and fits the arm member 327B having a guide groove 327Ba formed as a groove portion with a width equal to the width of one side of the square piece 362B.

[0251] The needle bar link mechanism that transmits turning from the boss-shaped portion 36B (needle bar turning follower) to the needle bar via the needle bar base 31 includes the cam arm (needle bar link body) 361B, the pivot 362Ba, the square piece 362B (sliding member), and the arm member 327B.

[0252] The square piece 362B is slidable along the guide groove 327Ba, and is coupled to the guide groove 327Ba without being restrained in the up-down direction. Specifically, the square piece 362B is supported turnably by the pivot 362Ba along the up-down direction while a predetermined gap is formed to prevent the square piece from coming into contact with the lower surface of the arm portion 361Bb.

[0253] The guide groove 327Ba is formed along a horizontal plane on the turning distal end portion side of the arm member 327B. By forming the guide groove so that the center line of the guide groove 327Ba passes through the turning center of the needle bar base 31, the rotation of the needle bar base 31 becomes smooth.

[0254] The arm member 327B is fixed to the upper end portion 311 of the needle bar base 31 by holding it, and accordingly, when the cam arm 361B turns, the turning is transmitted to the needle bar base 31 through the arm member 327B.

[0255] At this time, the square piece 362B slides along the guide groove 327Ba of the arm member 327B to maintain the joined state between the cam arm 361B and the arm member 327B.

[0256] In the case where this turning is performed at a high speed, when the portion between the cam arm 361B and the arm member 327B are mutually locked in the up-down direction, friction between the members causes vibration, abnormal noise, and noise, etc., however, the square piece 362B is not locked in the up-down direction with respect to the guide groove 327Ba, that is, the cam arm 361B and the arm member 327B are coupled without being mutually restrained in the up-down direction, so that the cause of vibration, etc., is eliminated and the mechanism can be made silent.

[0257] Just above the arm member 327B, a thrust cup 335B is fixed to the upper end portion 311 of the needle bar base 31. The thrust cup 335B is brought into contact with a bearing 323 via a washer 325 and fixed to the upper end portion 311 of the needle bar base 31 by holding it, and accordingly, the needle bar base 31 is prevented from rattling in the up-down direction with respect to the washer 325.

[0258] In the above-described needle bar turning mechanism 30, the arm member 327 also performs the function of the thrust cup 335B, so that the positions of the arm member 327 and the link body 362 cannot be adjusted in the up-down direction, and friction may occur and cause abnormal noise. However, in the needle bar turning mechanism 30B, the thrust cup 335B and the arm member 327B are separate members, so that the position of the arm member 327B can be adjusted to a proper height with respect to the cam arm 361B, and this also prevents occurrence of abnormal noise.

[0259] Like the needle bar cam member 35 described above, the cam groove 351B of the needle bar cam member 35B may be configured such that a non-operating section whose distance from the rotation center is constant is formed between the adjacent ones of the operating sections. In this case, as in the case of the needle bar cam member 35, the non-operating section can be utilized as a running-up section when the needle bar turning motor 34 starts to rotate.

[0260] By adjusting a ratio of the non-operating section

to the operating section, continuous needle bar turning can be performed in synchronization with up-down movement of the sewing needle 11 by continuously rotating the needle bar cam member 35B at a constant speed.

[0261] In this case, preferably, after the control device 90 reads in advance data of stitch points or a workpiece movement amount for a plurality of stitches from sewing data stored in the data memory 94, and judges whether the needle bar turning continues for the plurality of stitches, the control device 90 controls the needle bar cam member 35B so as to continuously rotate it.

[0262] The depth direction of the cam groove of the needle bar cam member 35B is orthogonal to a direction in which the needle bar cam member 35B applies displacement to the boss-shaped portion 36B (the needle bar cam member 35B applies displacement along its radial direction), and for example, a cam groove whose depth direction is downward may be formed on the upper surface of the needle bar cam member 35B.

[0263] Like the needle bar cam member 35A (Fig. 30), when the needle bar cam member 35B is formed as a grooved cam structured to rotate around the upper shaft 22, a cam groove is preferably formed on the outer peripheral surface of the needle bar cam member 35B so that the depth direction of the cam groove is the rotation radial direction.

[0264] Instead of the boss-shaped portion 36B provided on one arm portion 361Ba of the cam arm 361B, a roller member supported rotatably around the Z-axis with respect to the arm portion 361Ba may be provided as a follower.

[0265] Fourth Example of Thread Pulling Mechanism

[0266] A fourth example of a thread pulling mechanism is described with reference to Fig. 42 to Fig. 44.

[0267] The same components of the thread pulling mechanism 50C in the fourth example as those of the above-described thread pulling mechanism 50 are provided with the same reference numerals, and overlapping description thereof is omitted.

[0268] In the thread pulling mechanism 50C, the structure of the thread pulling cam member 53C is different from that in the thread pulling mechanism 50.

[0269] In Fig. 44, the thread pulling cam member 53C has a substantially fan shape centered on a turning shaft 524, and a cam groove 531C is formed on the upper surface along a substantially arc-shaped outer edge portion. This cam groove 531C has arc-cam-shaped non-operating sections 532C and 533C that keep constant distances from the turning center position, and between the two non-operating sections 532C and 533C, an operating section 534C continuous to the non-operating sections is formed. As compared with one non-operating section 532C, the other non-operating section 533C is set to be larger in diameter.

[0270] The operating section 534C has a cam shape that gradually increases in diameter from the boundary with one non-operating section 532C and reaches the same diameter as the diameter of the other non-operating section 533C at the boundary with the other non-operating section 533C.

[0271] A roller 54C supported rotatably around the Z-axis by a roller arm 541C fits in the cam groove 531C, and the cam groove 531C applies displacement to the roller arm 541C according to its shape. The direction of displacing the roller 54C by the cam groove 531C is a radial direction around the turning shaft 524 of the thread pulling cam member 53C. The depth direction of the cam groove 531C is the up-down direction that is orthogonal to the direction of displacement applied to the roller 54C.

[0272] The roller arm 541C is axially supported by a pivot 542, and these constitute a link mechanism 55C. The roller arm 541C is structurally the same as the roller arm 541 except that the roller arm 541C supports the roller 54C below one arm portion 541a so as to correspond to the cam groove 531C opened above the roller arm. The cam groove 531C of the thread pulling cam member 53C is shaped so as to apply turning that is completely the same as the turning applied by the cam portion 531 of the thread pulling cam member 53 to the roller arm 541, to the roller arm 541C.

[0273] In the thread pulling mechanism 50C, the operation of the roller arm 541C is locked by the cam groove, so that the torsion coil spring 543 and the stopper 544 are not necessary.

[0274] With the above-described configuration, in the thread pulling mechanism 50C, when the thread pulling motor 52 starts to drive, the thread pulling cam member 53C starts to turn, the roller 54C accelerates in the non-operating section 532C of the cam groove 531C, passes through the operating section 534C in a high-speed state, and stops at a predetermined position in the non-operating section 533C. Accordingly, the distal end portion of the thread pulling member 51 passes below the eye 15 and stops.

[0275] Next, the thread pulling cam member 53C turns in the opposite direction, and the roller 54C accelerates in the non-operating section 533C, passes through the operating section 534C in a high-speed state, and stops again in the non-operating section 532C. Accordingly, the thread pulling member 51 is returned to the original position.

[0276] Forward turning of the thread pulling member 51 is executed before the downward movement of the sewing needle 11, and backward turning is executed after the downward movement of the sewing needle.

[0277] Thus, the thread pulling cam member 53C is a grooved cam, so that even when high-speed turning is performed, the roller 54C (thread pulling follower) is prevented from coming off from the thread pulling cam member 53C due to a centrifugal force, so that a stable operation is maintained.

[0278] The thread pulling cam member 53C may be a circular cam member formed into an endless annular shape by connecting a plurality of cam grooves for making one-round reciprocative turning of the thread pulling member 51 like the above-described needle bar cam

member 35B. In this case, the thread pulling cam member 53C is driven to rotate in a constant direction.

[0279] When the thread pulling cam member is structured by connecting cam grooves as described above, a cam groove in which the roller passes through an operating section 534C that gradually increases in diameter from a non-operating section 532C with a small radius and reaches a non-operating section 533C with a large radius, and further returns again to the non-operating section 532C with a small radius through the operating section that gradually decreases in diameter, is set as a one-round thread pulling operation unit, and by connecting a plurality of the operation units, an endless annular shape cam member may be formed.

[0280] As described above, when a circumferential cam is formed by forming an endless annular shape cam groove on the thread pulling cam member, a plurality of cam grooves each of which is a one-round thread pulling operation unit are continuously formed without discontinuity, so that when the thread pulling operation is necessary for a plurality of continuous stitches, the thread pulling cam member 53C does not need to be intermittently reciprocatively turned, and by continuously rotating the thread pulling cam member 53C, a plurality of thread pulling operations can be performed. Therefore, executing continuous thread pulling, abrupt acceleration is not necessary for each operation, so that a stable continuous operation is enabled.

[0281] In addition, when the thread pulling cam member 53C is a circumferential cam, the problem of use of only partial teeth of the drive gear 522 and the driven gear 523 as in the case of the fan-shaped cam is eliminated, and all teeth of the gears 522 and 523 mesh with each other and are worn uniformly, so that durability is maintained for a long period of time.

[0282] Even when the thread pulling cam member 53C is actuated by a timing belt, the durability of the belt can be improved in the same manner.

[0283] When thread pulling operations are continuously performed for a plurality of stitches, preferably, the control device 90 controls the thread pulling cam member 53C so as to continuously rotate it after the control device reads data of stitch points or a workpiece movement amount for the plurality of stitches from sewing data in the data memory 94 in advance and judges whether the thread pulling continues for a plurality of stitches.

[0284] Like the thread pulling cam member 53A described above, when a thread pulling cam member that is a grooved cam is provided on the rotary shaft 531A that is disposed along the horizontal direction and fully rotates, a cam groove whose depth direction is a rotation radial direction is preferably formed on the outer peripheral surface of the thread pulling cam member 53A.

Claims

1. A sewing machine (100) comprising:

a needle bar (12) holding a sewing needle (11) and arranged to move up and down;
a shuttle (13) configured to turn to interlace an upper thread (U) with a lower thread (D);
a sewing machine motor (21) serving as a drive source for the up-down movement of the needle bar (12) and the turning of the shuttle (13);
a needle bar turning mechanism (30, 30A, 30B) configured to turn the needle bar (12) about the axis of the up-down movement of the needle bar (12);
a thread pulling mechanism (50, 50A, 50B, 50C) configured to pull the lower thread (D) below a throat plate (14) by a thread pulling member (51);
a cloth moving mechanism (80) configured to move a workpiece along a horizontal plane; and
a controller (90) configured to control the cloth moving mechanism (80), and to optionally control the needle bar turning mechanism (30, 30A, 30B) and the thread pulling mechanism (50, 50A, 50B, 50C), based on sewing data defining a stitch point or a movement amount of the workpiece per stitch for forming a sewing pattern,

wherein the controller (90) comprises:

determining means for determining a movement direction in which the cloth moving mechanism (80) moves the workpiece, and
control means for controlling execution or withholding of the thread pulling by the thread pulling mechanism (50, 50A, 50B, 50C) or the turning of the needle bar (12) by the needle bar turning mechanism (30, 30A, 30B) in accordance with the movement direction determined by the determining means, or for selectively executing the thread pulling by the thread pulling mechanism (50, 50A, 50B, 50C) or the turning of the needle bar (12) by the needle bar turning mechanism (30, 30A, 30B) in accordance with the movement direction determined by the determining means.

2. The sewing machine (100) according to claim 1, wherein the controller (90) comprises a storage unit (94) that stores a command to instruct execution of the thread pulling by the thread pulling mechanism (50, 50A, 50B, 50C) or the turning of the needle bar (12) by the needle bar turning mechanism (30, 30A, 30B),
wherein the entire angular range of cloth feeding direction around an up-down movement path of the sewing needle (11) associated with the up-down movement of the needle bar (12) is divided into a plurality of segments (I, II, III, IV), and the commend is stored for each the segments (I, II, III, IV), and
wherein, in accordance with the movement direction determined by the determining means, the controller

(90) reads the command that corresponds to the segment including the movement direction, and operates the thread pulling mechanism (50, 50A, 50B, 50C) or the needle bar turning mechanism (30, 30A, 30B) based on the read command.

3. The sewing machine (100) according to claim 2, wherein the segments (I, II, III, IV) are defined by specifying angular ranges based on a probability of occurrence of hitch stitches and a factor for hitch stitches.

4. The sewing machine (100) according to claim 2 or 3, wherein the control means comprises identifying means for identifying the segment that includes the movement direction determined by the determining means, and
wherein, in accordance with the segment identified by the identifying means, the control means controls an operation of the thread pulling mechanism (50, 50A, 50B, 50C) or the needle bar turning mechanism (30, 30A, 30B).

5. The sewing machine (100) according to any one of the preceding claims, wherein the thread pulling mechanism (50, 50C) comprises:

a thread pulling motor (52);
a thread pulling cam member (53, 53C) actuated by the thread pulling motor (52);
a thread pulling follower (54, 54C) to which a motion is applied from the thread pulling cam member (53, 53C); and
a thread pulling link mechanism (55, 55C) configured to transmit a lower thread pulling operation from the thread pulling follower (54, 54C) to the thread pulling member (51),
wherein the thread pulling cam member (53, 53C) comprises a cam portion (531, 531C) including a non-operating section (532, 533, 532C, 533C) that does not apply the thread pulling operation to the thread pulling member (51) and an operating section (534, 534C) that applies the thread pulling operation to the thread pulling member (51), the non-operating section (532, 533, 532C, 533C) and the operating section (534, 534C) being continuously formed, and
wherein the controller (90) controls the thread pulling motor (52) such that the thread pulling motor (52) accelerates while the thread pulling follower (54, 54C) engages with the non-operating section (532, 533, 532C, 533C) of the thread pulling cam member (53, 53C).

6. The sewing machine (100) according to claim 5, wherein the non-operating section (532, 533, 532C, 533C) of the thread pulling cam member (53, 53C) is formed on each side of the operating section (534, 534C) such that the operating section (534, 534C) is interposed in the non-operating section (532, 533, 532C, 533C).

7. The sewing machine (100) according to any one of claims 1 to 4, wherein the thread pulling mechanism (50B) comprises:

a thread pulling motor (52); and
a thread pulling link mechanism configured to transmit a motion from the thread pulling motor (52) to the thread pulling member (51) such that a distal end portion of the thread pulling member (51) moves in a revolving manner,
wherein the thread pulling member (51) is provided such that the distal end portion of the thread pulling member (51) contacts the lower thread (D) and pulls the lower thread (D) when the distal end portion of the thread pulling member (51) is an operating section of a locus (M) of the revolving motion.

8. The sewing machine (100) according to claim 7, wherein, when executing the thread pulling, the controller (90) controls the thread pulling motor (52) such that the thread pulling motor (52) starts to drive when the distal end portion of the thread pulling member (51) is outside the operating section of the locus (M) of the revolving motion, and such that the thread pulling motor (52) accelerates before the distal end portion of the thread pulling member (51) reaches the operating section.

9. The sewing machine (100) according to any one of claims 1 to 4, wherein the thread pulling mechanism (50A) comprises:

a thread pulling cam member (53A) actuated by the sewing machine motor (21);
a thread pulling follower (54A) to which a motion is applied from the thread pulling cam member (53A); and
a thread pulling link mechanism including a plurality of thread pulling link bodies (551A, 552A, 554A, 555A) configured to transmit a lower thread (D) pulling operation from the thread pulling follower (54A) to the thread pulling member (51),
wherein the thread pulling link mechanism is configured such that the transmission from the thread pulling follower (54A) to the thread pulling member (51) is disabled by shifting a turning joint portion (556A) at which one of the plurality of thread pulling link bodies (552A, 554A) is joined turnably to another member (553A) to a position concentric with a turning joint portion (551Ab) of another one of the thread pulling link bodies (551A), and

wherein the controller (90) executes the thread pulling by controlling an actuator (52A) that shifts the turning joint portion (556A) of said one of the thread pulling link bodies (552A, 554A) to the position concentric with the turning joint portion (551Ab) of said another one of the thread pulling link bodies (551A).

10. The sewing machine (100) according to any one of the preceding claims, wherein the needle bar turning mechanism (30) comprises a needle bar turning motor (34);
a needle bar turning cam member (35) actuated by the needle bar turning motor (34);
a needle bar turning follower (36) to which a motion is applied from the needle bar turning cam member (35); and
a transmission member (361, 362, 327) that transmits a turning operation from the needle bar turning follower (36) to the needle bar (12),
wherein the needle bar turning cam member (35) comprises a cam portion (351) including a non-operating section (352, 353) that does not apply the turning operation to the needle bar (12) and an operating section (354) that applies the turning operation to the needle bar (12), the non-operating section (352, 353) and the operating section (354) being continuously formed, and
wherein the controller (90) controls the needle bar turning motor (34) such that the needle bar turning motor (34) accelerates while the needle bar turning follower (36) engages with the non-operating section (352, 353) of the needle bar turning cam member (35).

11. The sewing machine (100) according to claim 10, wherein the non-operating section (352, 353) of the needle bar turning cam member (35) is formed on each side of the operating section (354) such that the operating section (354) is interposed in the non-operating section (352, 353).

12. The sewing machine (100) according to any one of claims 1 to 9, wherein the needle bar turning mechanism (30A) comprises:

a needle bar turning cam member (35A) actuated by the sewing machine motor (21),
a needle bar turning follower (36A) to which a motion is applied from the needle bar turning cam member (35A); and
a needle bar link mechanism including a plurality of needle bar link bodies (37A, 382A, 383A, 384A, 386A, 387A) configured to transmit a turning operation from the needle bar turning follower (36A) to the needle bar (12),
wherein the needle bar link mechanism is configured such that the transmission from the needle bar turning follower (36, 36A, 36B) to the needle bar (12) is disabled by shifting a turning joint portion at which one of the plurality of needle bar link bodies (382A, 383A) is joined turnably to another member (381A) to a position concentric with a turning joint portion of another one of the needle bar link bodies (37A), and
wherein the controller (90) executes the turning of the needle bar (12) by controlling an actuator (34A) that shifts the turning joint portion of said one of the needle bar link bodies (382A, 383A) to the position concentric with the turning joint portion of said another one of the needle bar link bodies (37A).

13. The sewing machine (100) according to any one of the preceding claims, further comprising:

a thread tensioner (79) configured to apply a thread tension to the upper thread (U); and
a thread tension adjusting actuator (71) configured to change and to adjust the thread tension to be applied by the thread tensioner (79),
wherein the controller (90) controls the thread tension adjusting actuator (71) to reduce the thread tension at the time of forming a stitch during which the thread pulling is executed or at the time of forming a plurality of stitches including said stitch.

14. The sewing machine (100) according to any one of claims 1 to 9, wherein the needle bar turning mechanism (30B) comprises:

a needle bar turning cam member (35B);
a needle bar turning follower (36B) to which a motion is applied from the needle bar turning cam member (35B); and
a needle bar link mechanism configured to transmit a turning operation from the needle bar turning follower (36B) to the needle bar (12),
wherein the needle bar turning cam member (35B) is a grooved cam (35B) with which needle bar turning follower (36B) engages, or a circumferential cam provided in a rotatable manner to apply a displacement to the needle bar turning follower (36B) along the entire circumference of the needle bar turning cam member (35B).

15. The sewing machine (100) according to claim 14, wherein the needle bar turning cam member (35B) comprises a cam portion (351B) including an operating section (354) that applies the displacement to the needle bar turning follower (36B) and a non-operating section that does not apply the displacement to the needle bar turning follower (36B),
wherein the operating section (354) and the non-operating section are formed alternately and repetitive-

ly.

16. The sewing machine (100) according to any one of claims 1 to 9, wherein the needle bar turning mechanism (30B) comprises:

a needle bar base (31) provided in a turnable manner and configured to support the needle bar (12) such that the needle bar (12) moves up and down;
a needle bar turning cam member (35B);
a needle bar turning follower (36B) to which a motion is applied from the needle bar turning cam member (35B); and
a needle bar link mechanism configured to transmit a turning operation from the needle bar turning follower (36B) to the needle bar (12) via the needle bar base (31),
wherein the needle bar link mechanism comprises an arm member (327B) extending from the needle bar base (31) in a radially outward direction of the turning of the needle bar base (31), and a needle bar link body (361B) configured to transmit the turning operation to a turning distal end portion of the arm member (327B), and
wherein the arm member (327B) and the needle bar link body (361B) are coupled without being restrained in the up-down direction.

17. The sewing machine (100) according to claim 16, wherein the turning distal end portion of the arm member (327B) is formed with a groove (327Ba) along the horizontal plane,
wherein a sliding member (362B) is supported at an end portion of the needle bar link body (361B) such that the sliding member (362B) is slidable along the groove and is rotatable about an axis along the up-down direction, and
wherein the arm member (327B) and the needle bar link body (361B) are coupled via the groove (327Ba) and the sliding member (362B).

FIG. 1

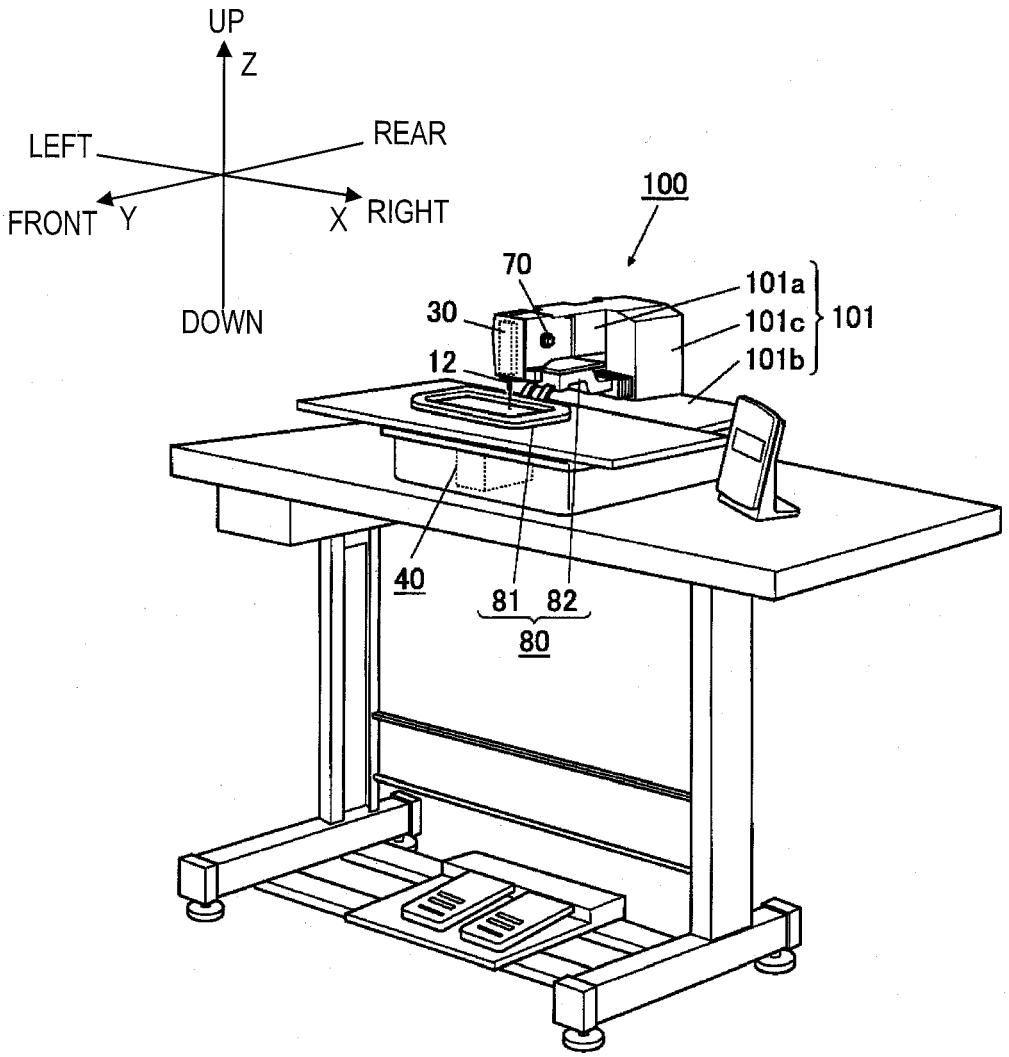

UP
Z
LEFT
REAR
FRONT
Y
X
RIGHT
DOWN
100
70
30
12
101a
101c
101b
101
40
81
82
80

FIG. 2

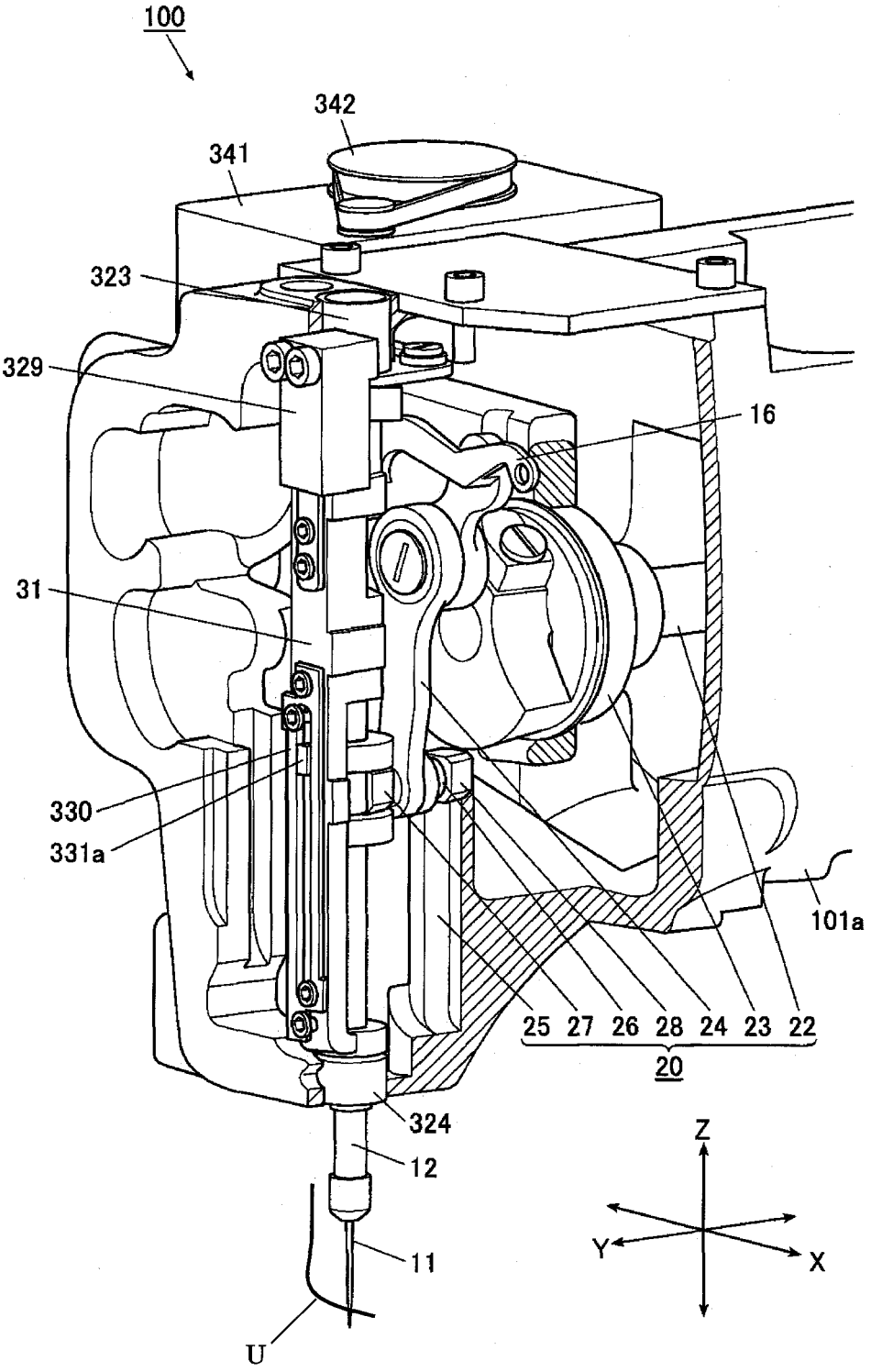

100
342
341
323
329
16
31
330
331a
101a
25 27 26 28 24 23 22
20
324
12
11
U
Z
Y
X

FIG. 3

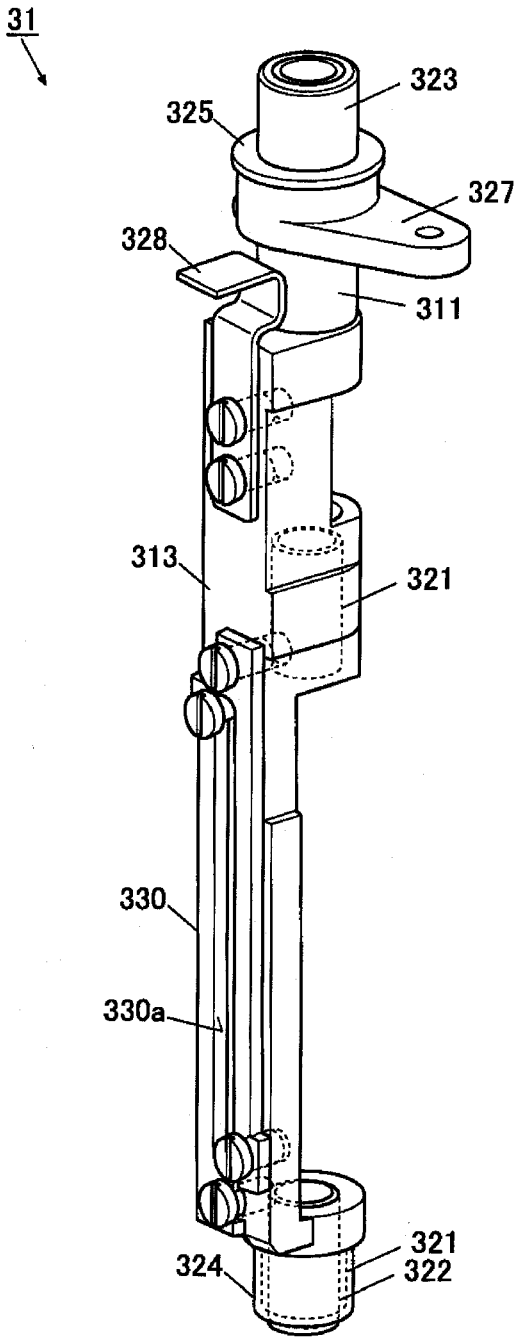


FIG. 4

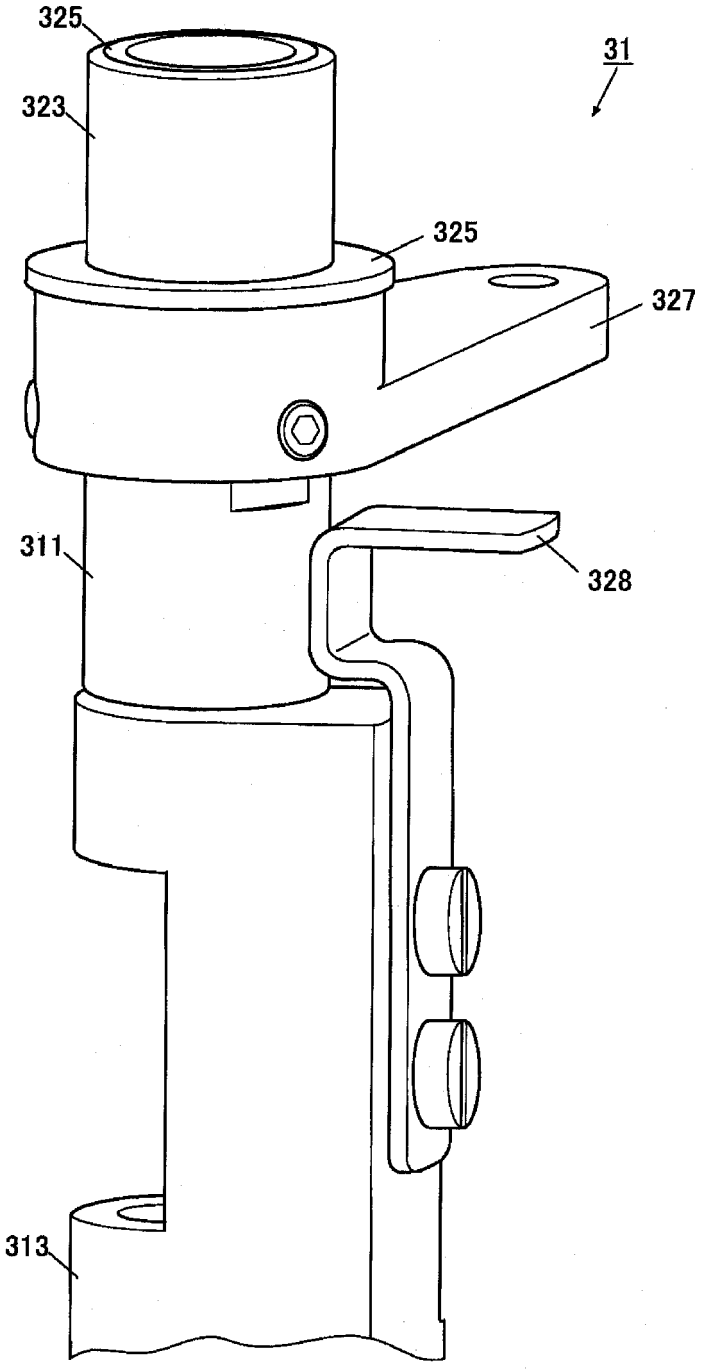


FIG. 5

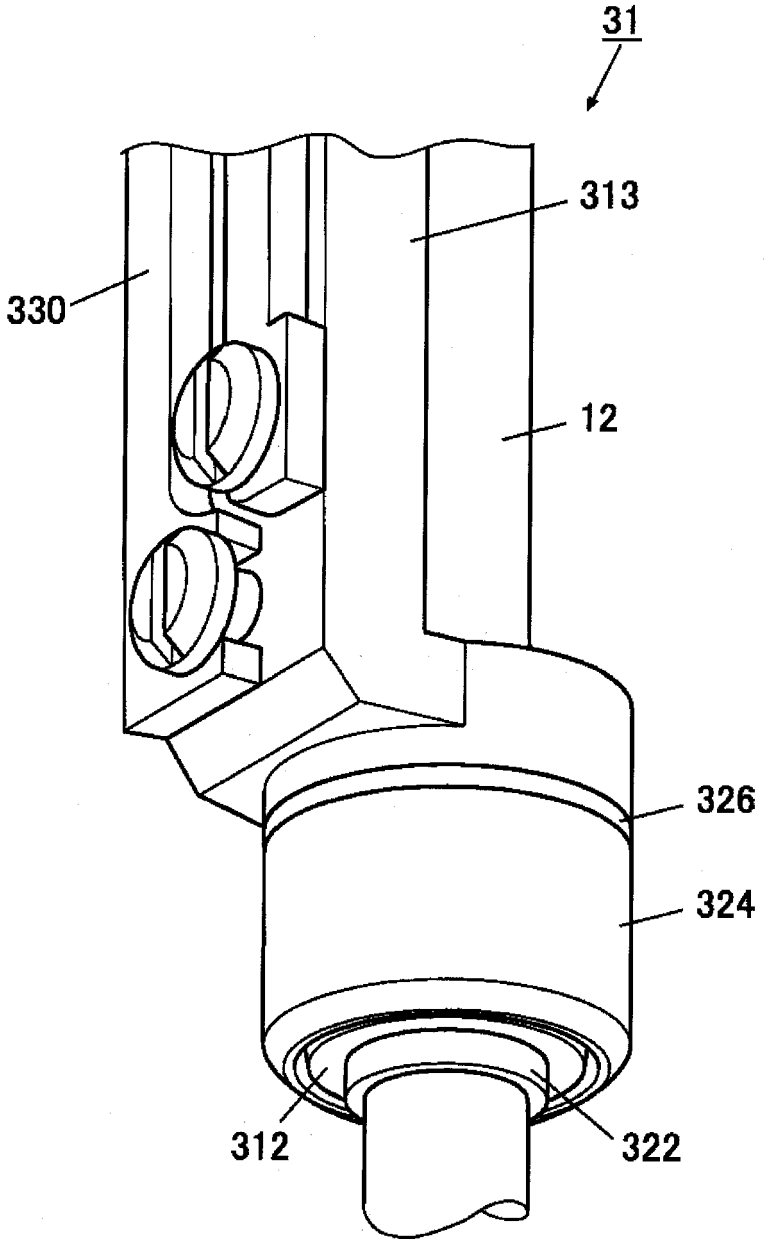


FIG. 6

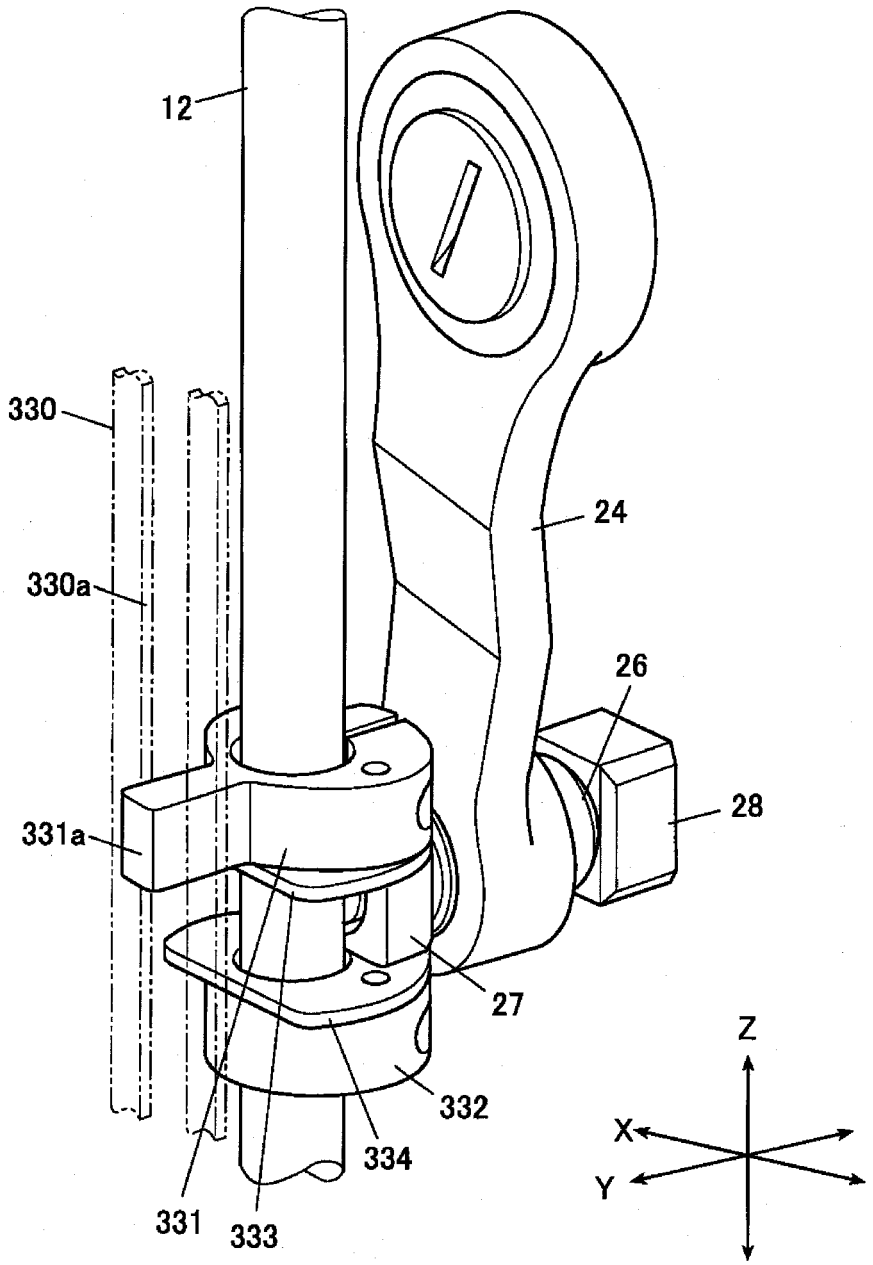


FIG. 7

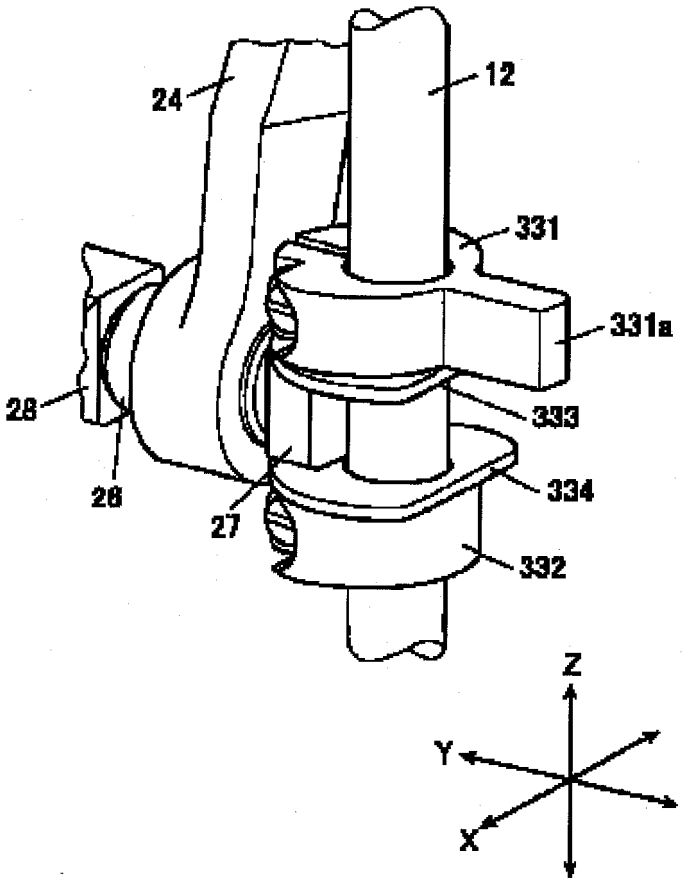


FIG. 8

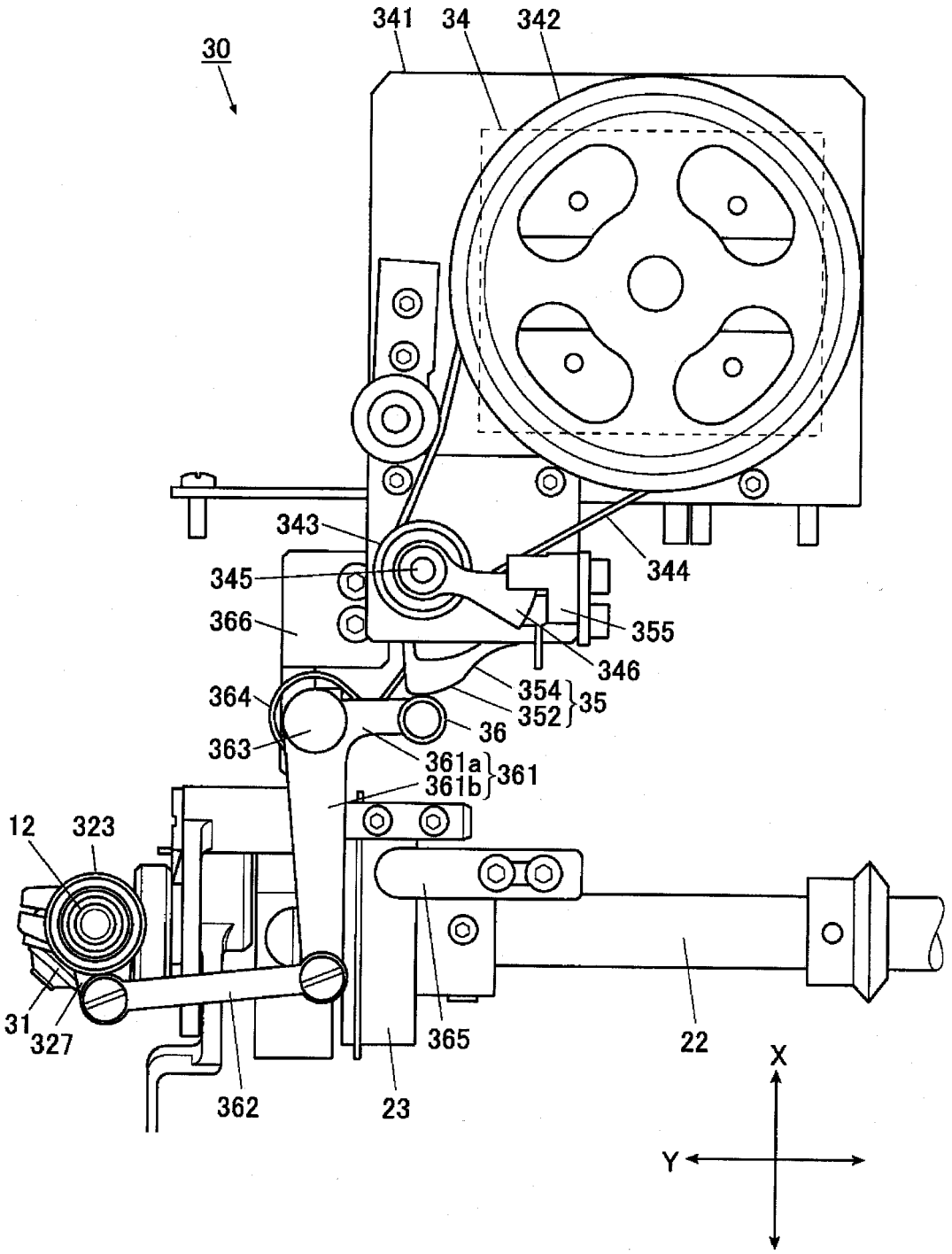

341
34
342
30
343
344
345
366
355
346
354
352
35
364
36
363
361a
361b
361
12
323
31
327
362
23
365
22
X
Y

FIG. 9

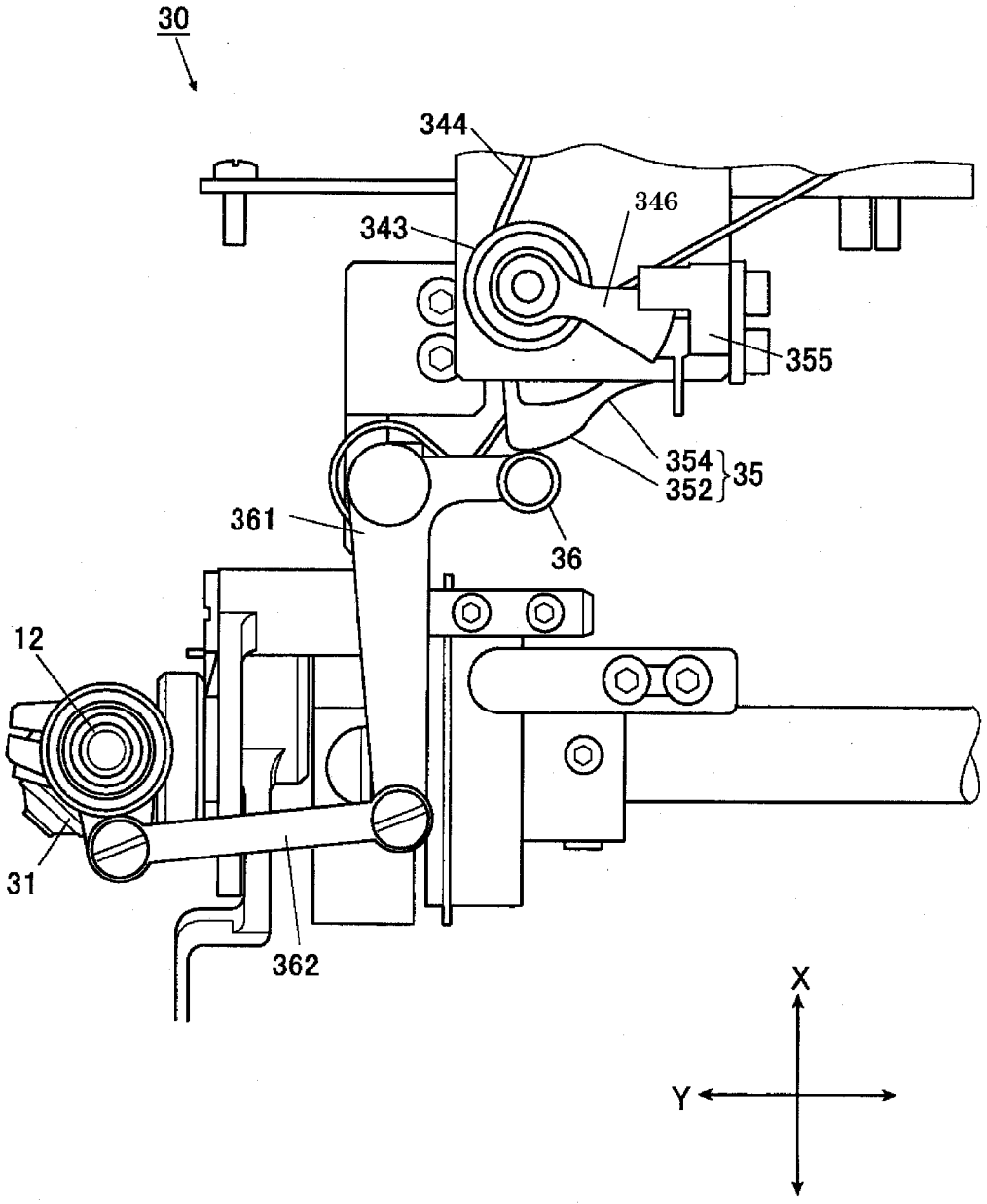


FIG. 10

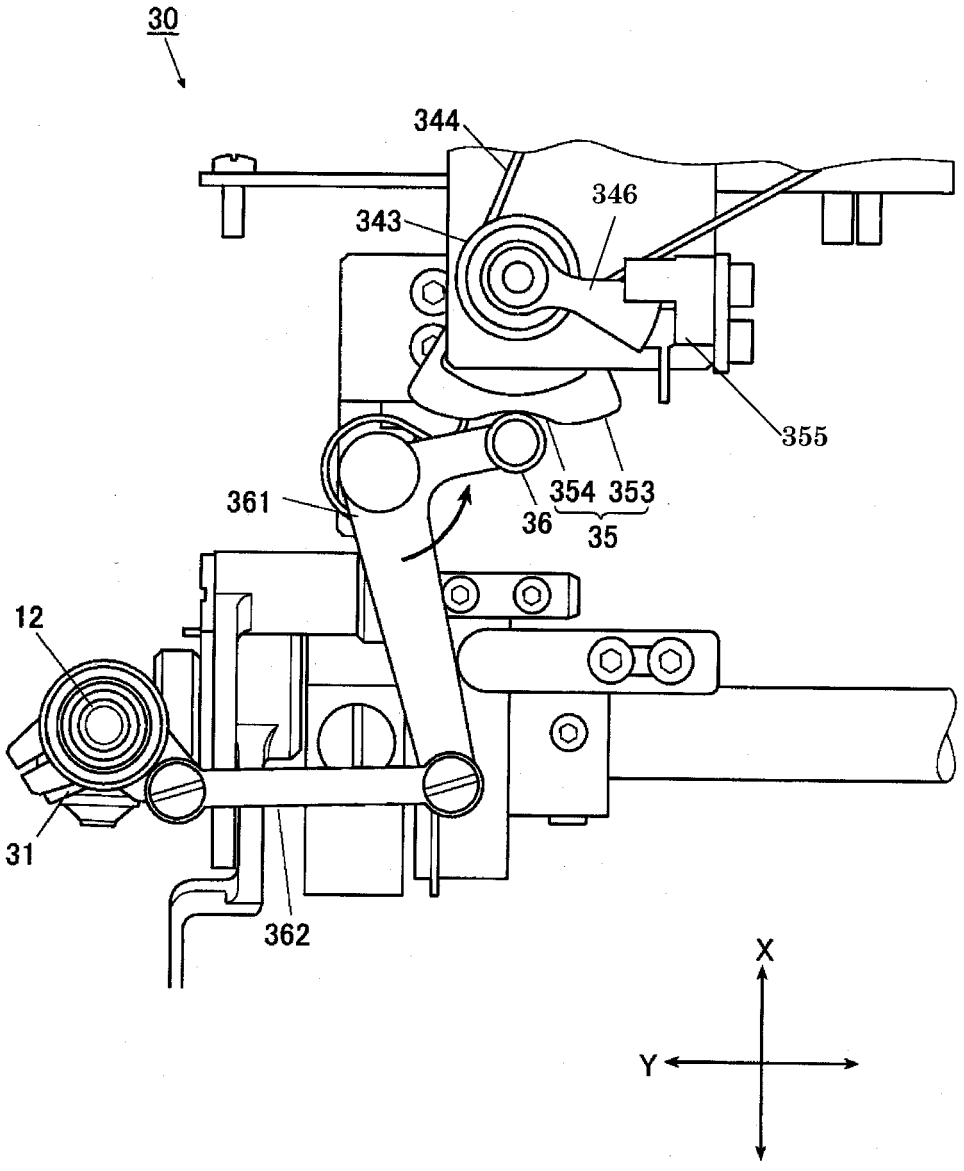


FIG. 11

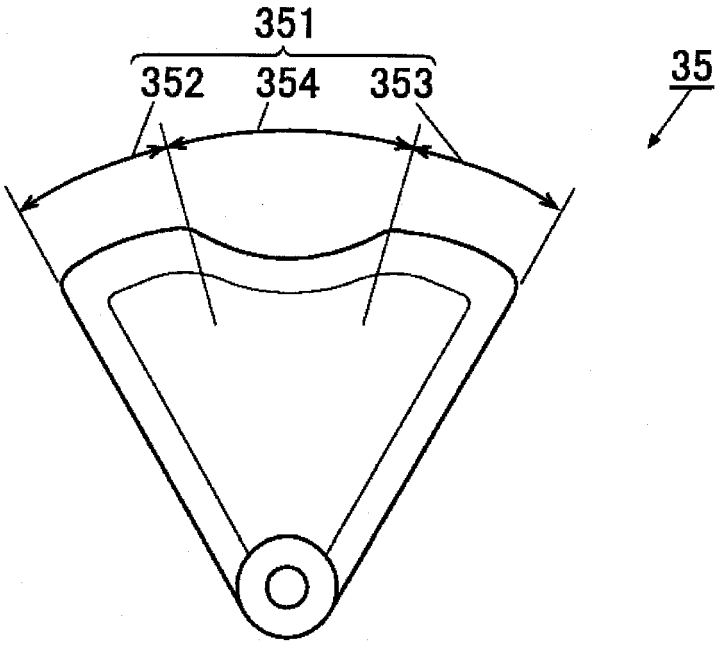


FIG. 12

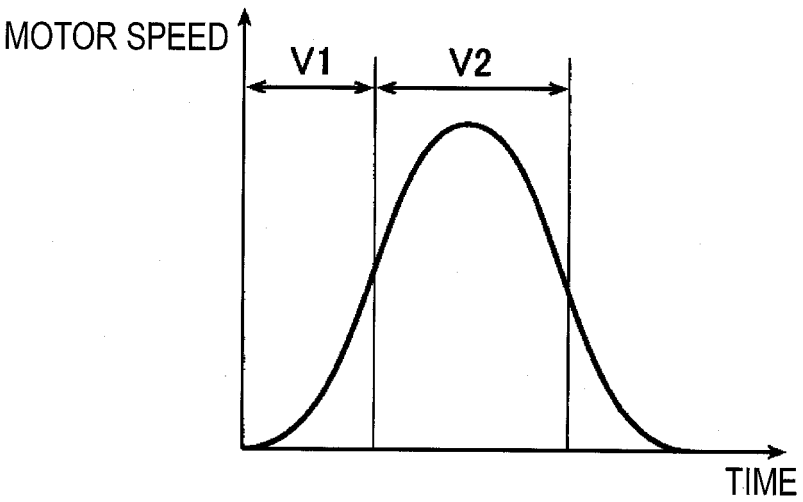


FIG. 13

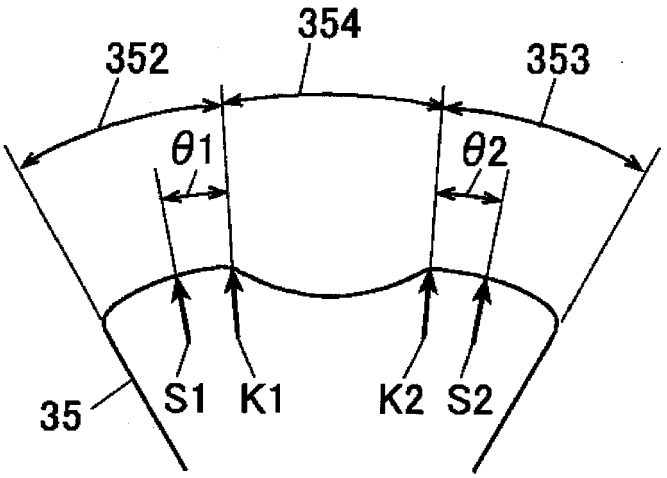


FIG. 14

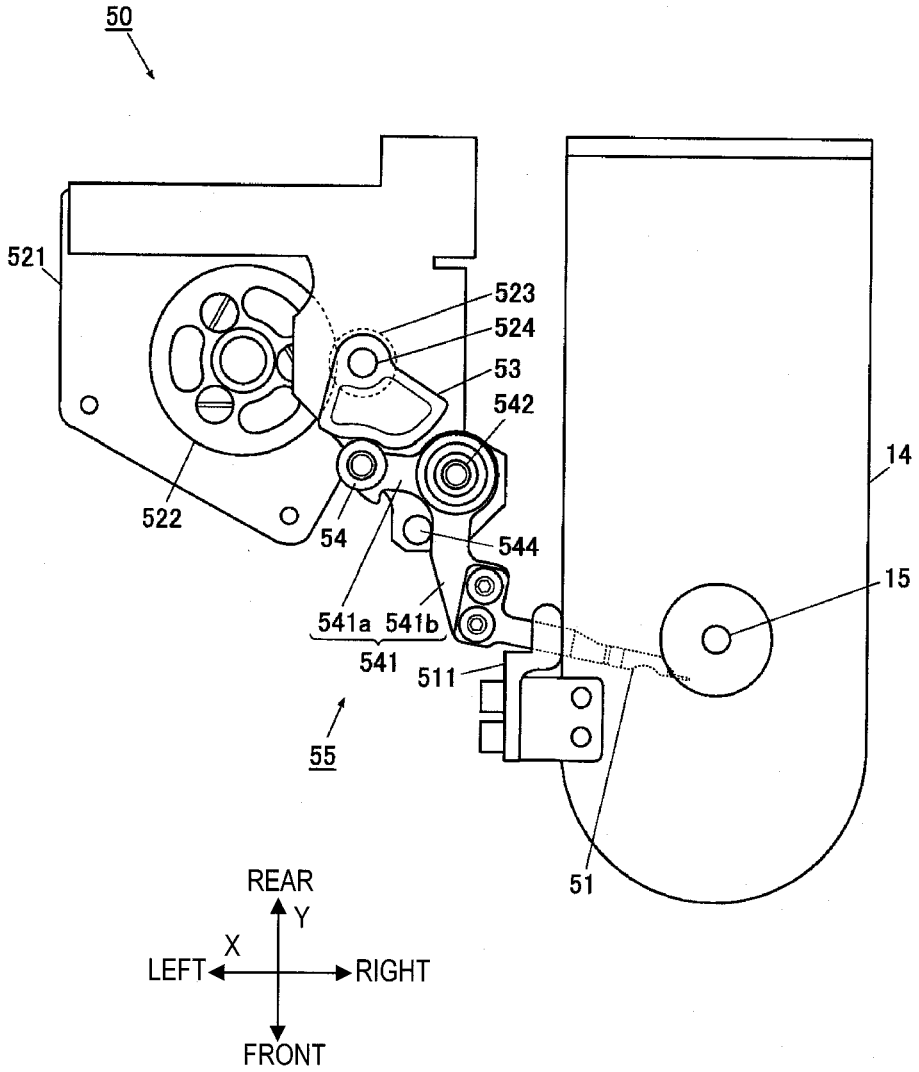

50
521
523
524
53
542
14
522
54
544
15
541a
541b
541
511
55
51
REAR
Y
X
LEFT
RIGHT
FRONT

FIG. 15

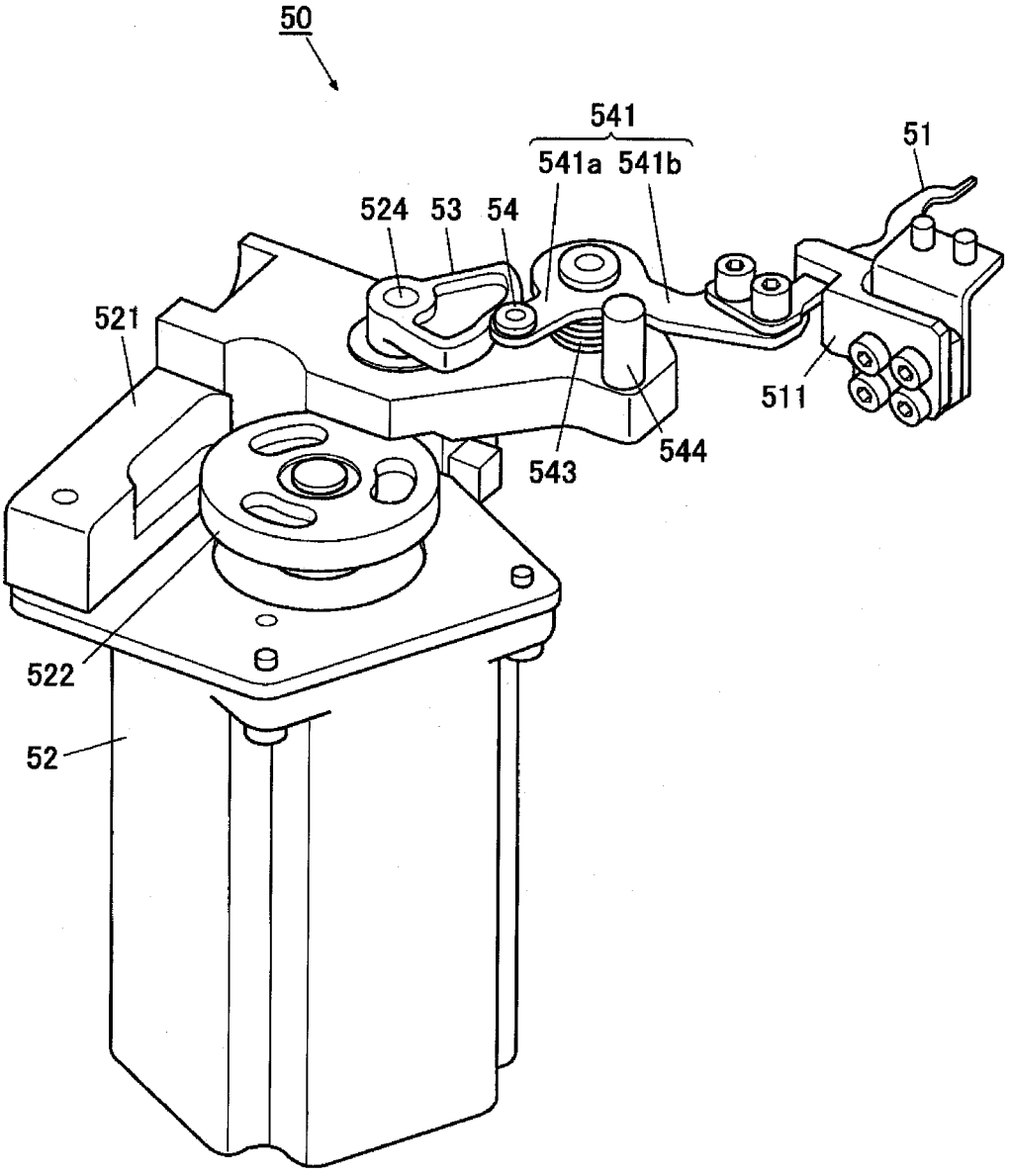


FIG. 16

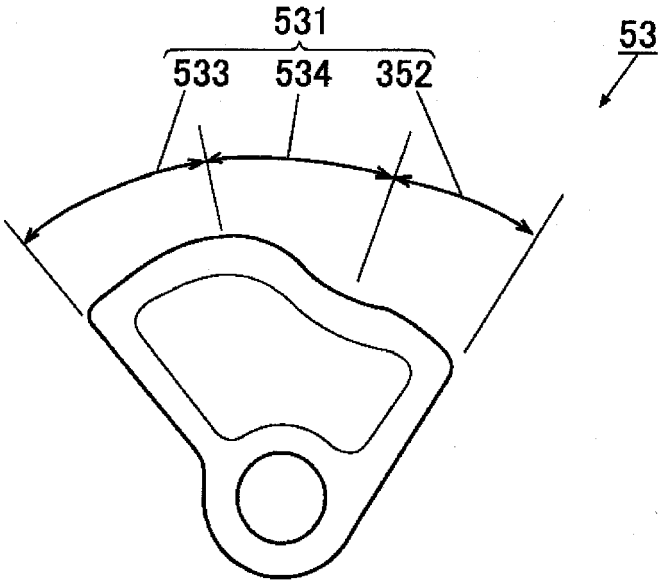


FIG. 17

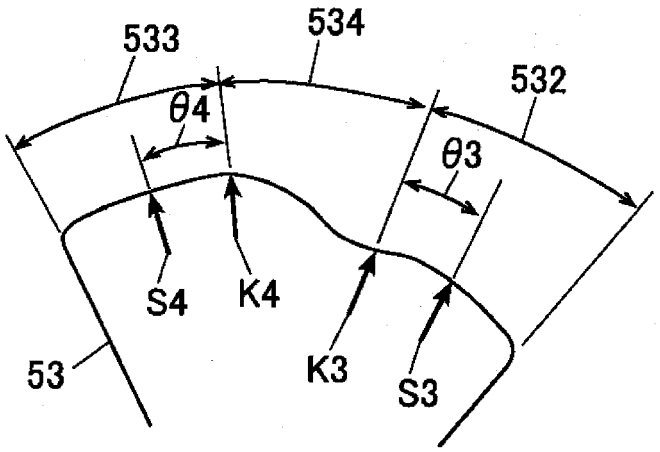


FIG. 18

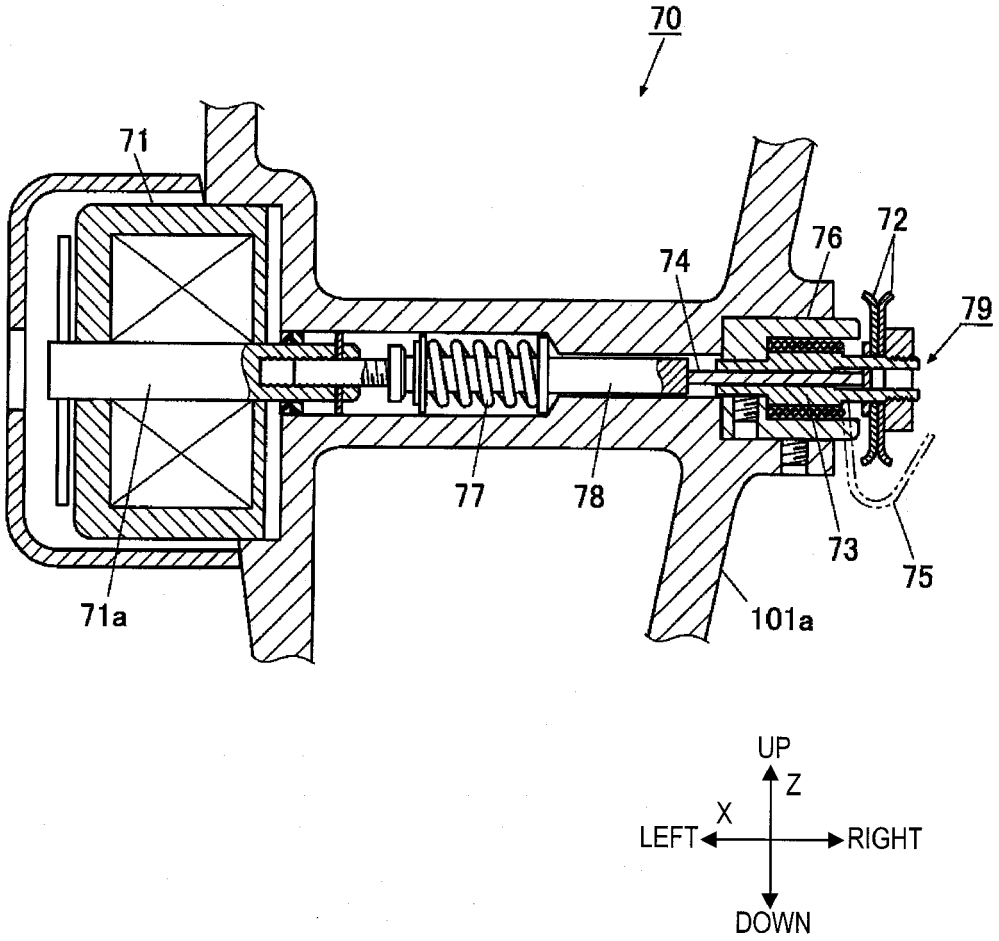


FIG. 19

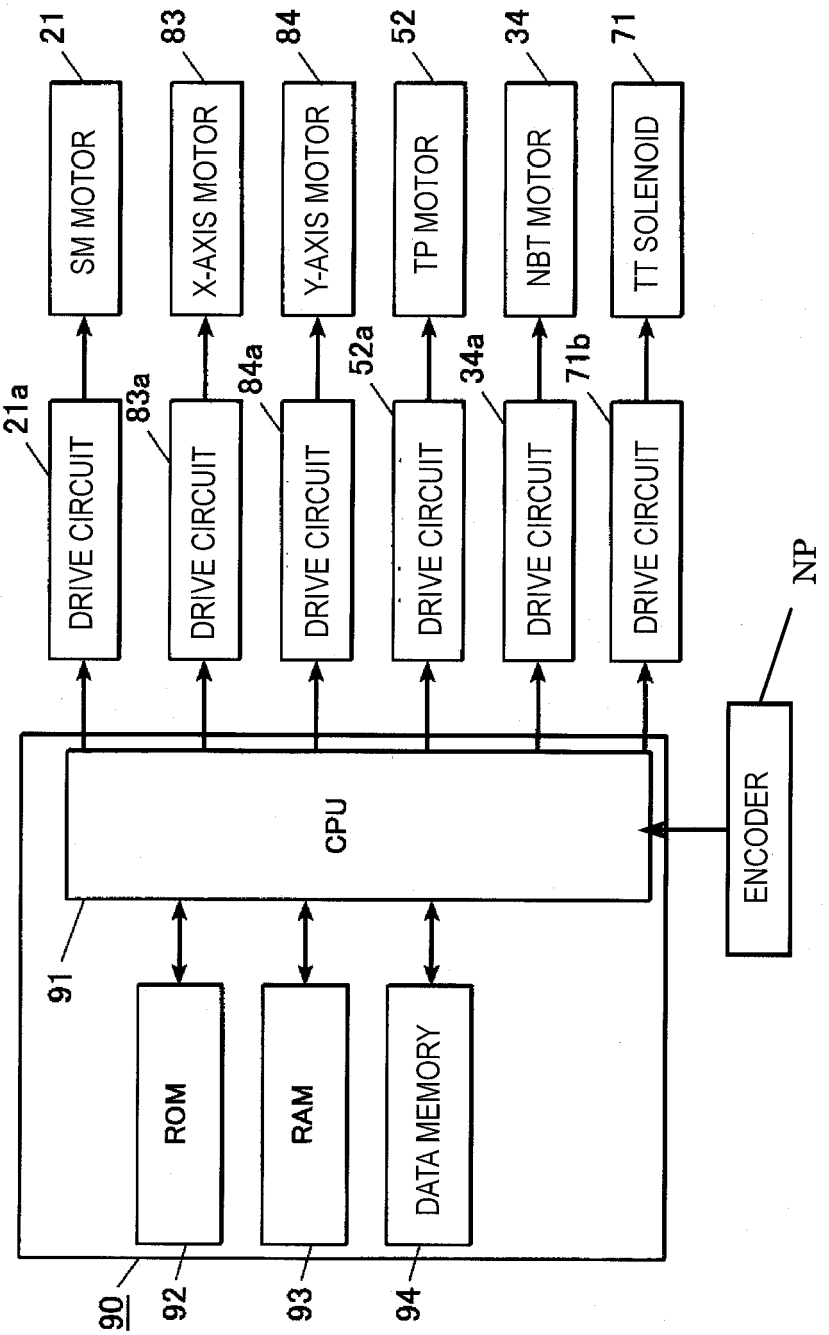

100
21
SM MOTOR
83
X-AXIS MOTOR
84
Y-AXIS MOTOR
52
TP MOTOR
34
NBT MOTOR
71
TT SOLENOID
21a
83a
84a
52a
34a
71b
DRIVE CIRCUIT
CPU
91
ROM
RAM
DATA MEMORY
90
92
93
94
ENCODER
NP

FIG. 20A

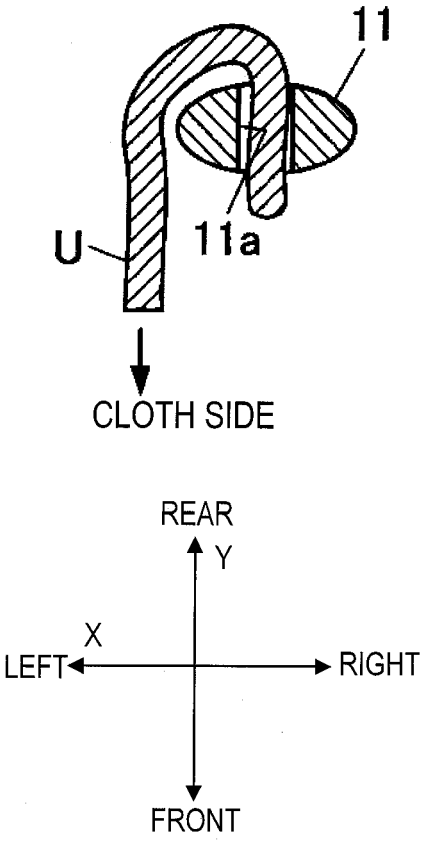


FIG. 20B

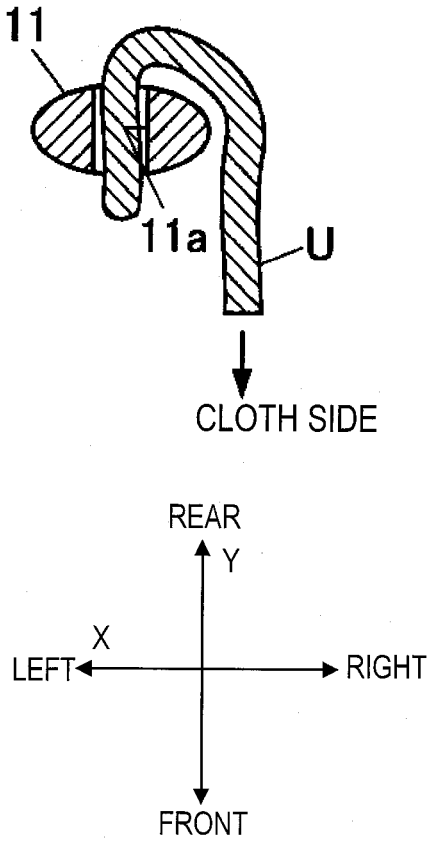


FIG. 21A

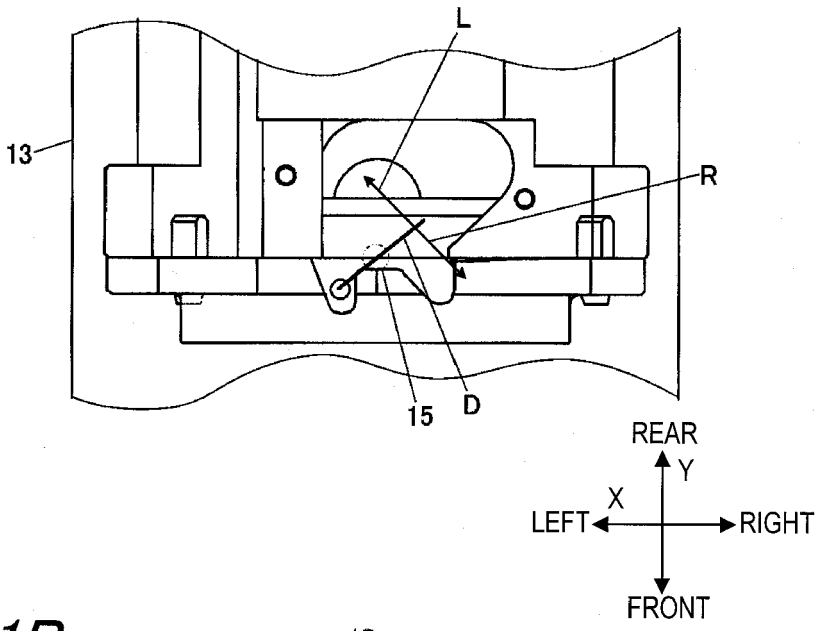


FIG. 21B

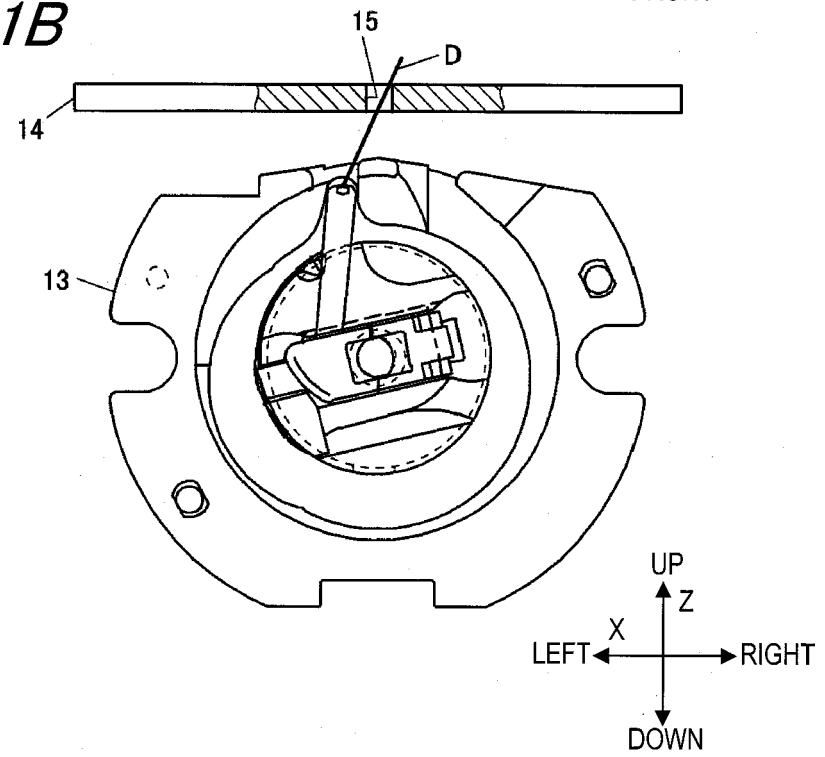


FIG. 22

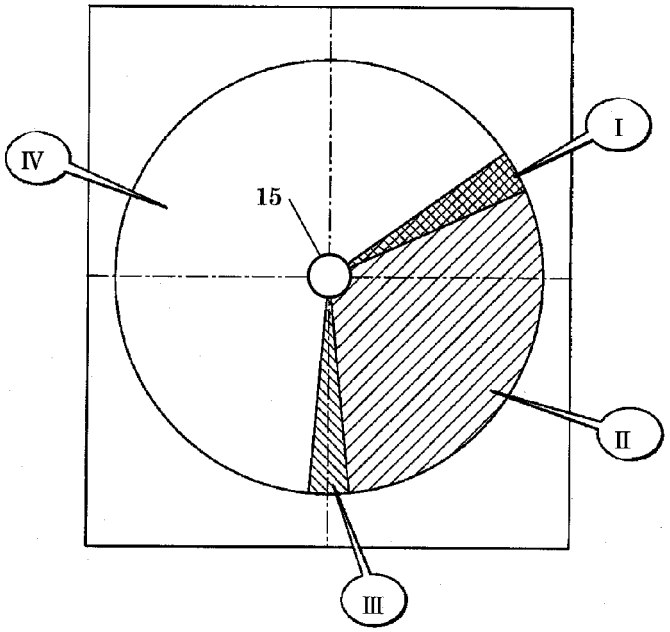


FIG. 23

	STITCH POINT WITH RESPECT TO LOWER THREAD	UPPER THREAD ENTWINING DIRECTION WITH RESPECT TO SEWING NEEDLE	STITCH	THREAD PULLING	NEEDLE BAR TURNING
I	RIGHT OR LEFT	RIGHT	PERFECT	Y	N
II	LEFT	RIGHT	PERFECT OR HITCH	Y	N
III	LEFT	RIGHT OR LEFT	PERFECT OR HITCH	N	Y
IV	RIGHT	LEFT	PERFECT	N	N

FIG. 24

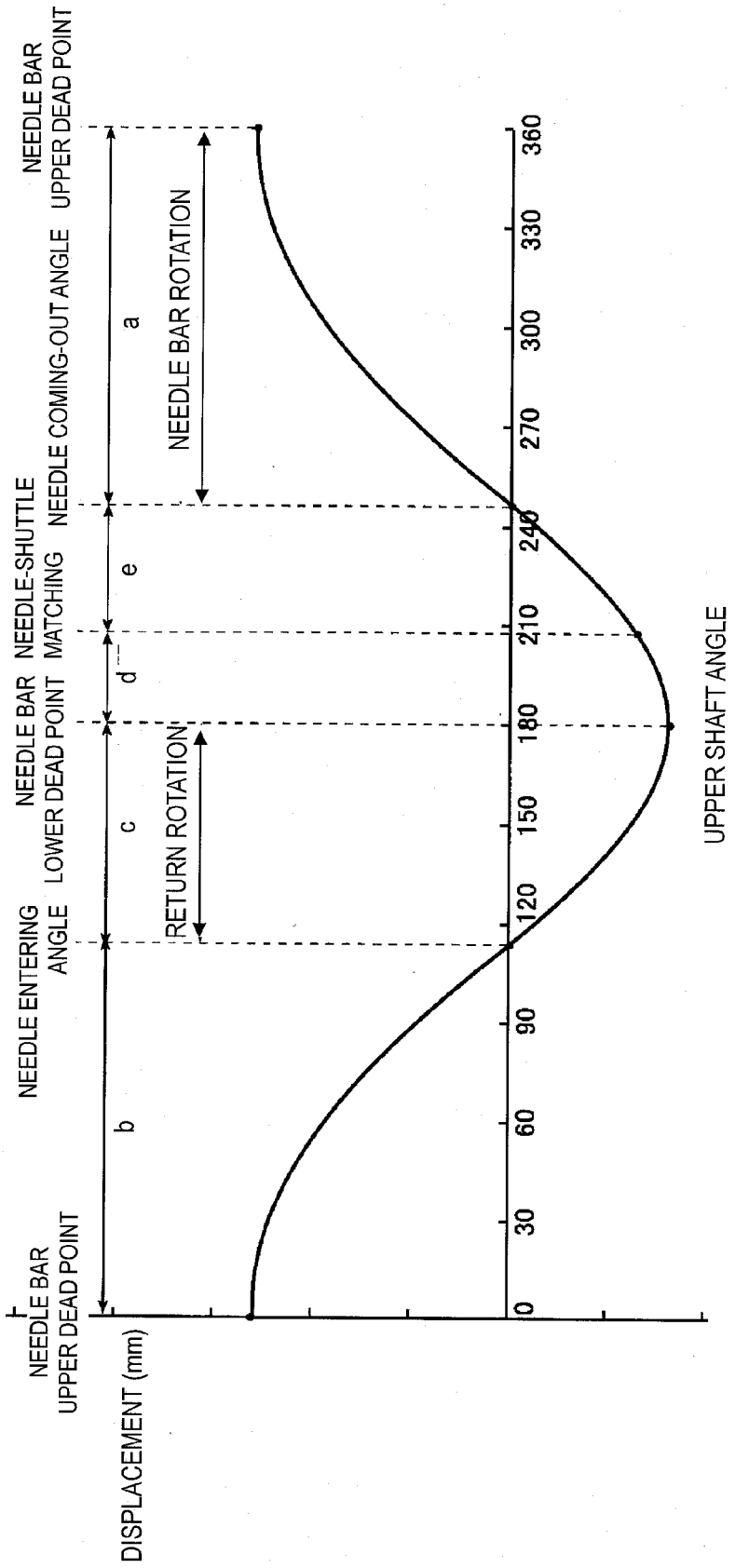

NEEDLE BAR UPPER DEAD POINT
NEEDLE COMING-OUT ANGLE
NEEDLE-SHUTTLE MATCHING
NEEDLE BAR LOWER DEAD POINT
NEEDLE ENTERING ANGLE
NEEDLE BAR ROTATION
RETURN ROTATION
a
b
c
d
e
0
30
60
90
120
150
180
210
240
270
300
330
360
UPPER SHAFT ANGLE
DISPLACEMENT (mm)

FIG. 25

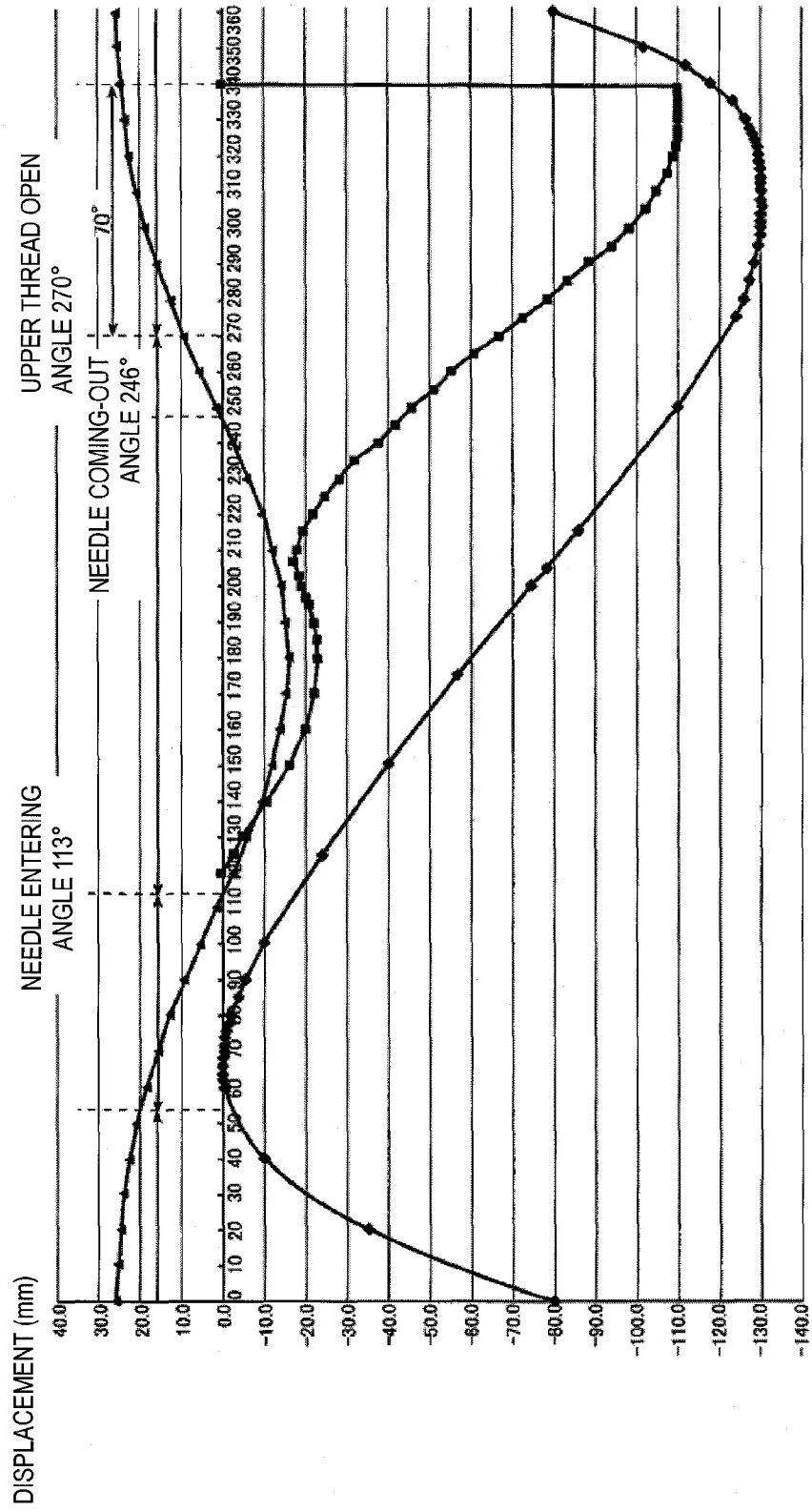

DISPLACEMENT (mm)
NEEDLE ENTERING ANGLE 113°
NEEDLE COMING-OUT ANGLE 246°
70°
UPPER THREAD OPEN ANGLE 270°
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360

FIG. 26

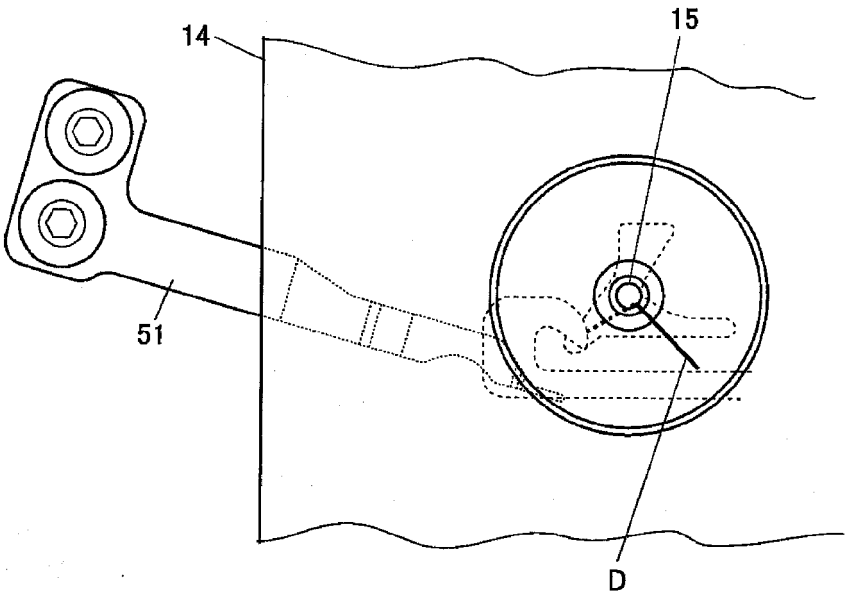


FIG. 27

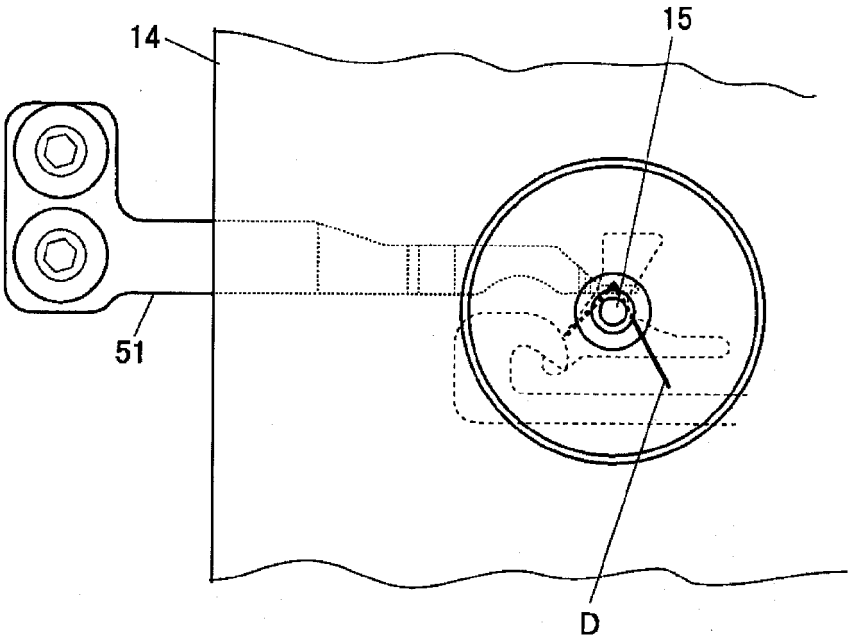


FIG. 28

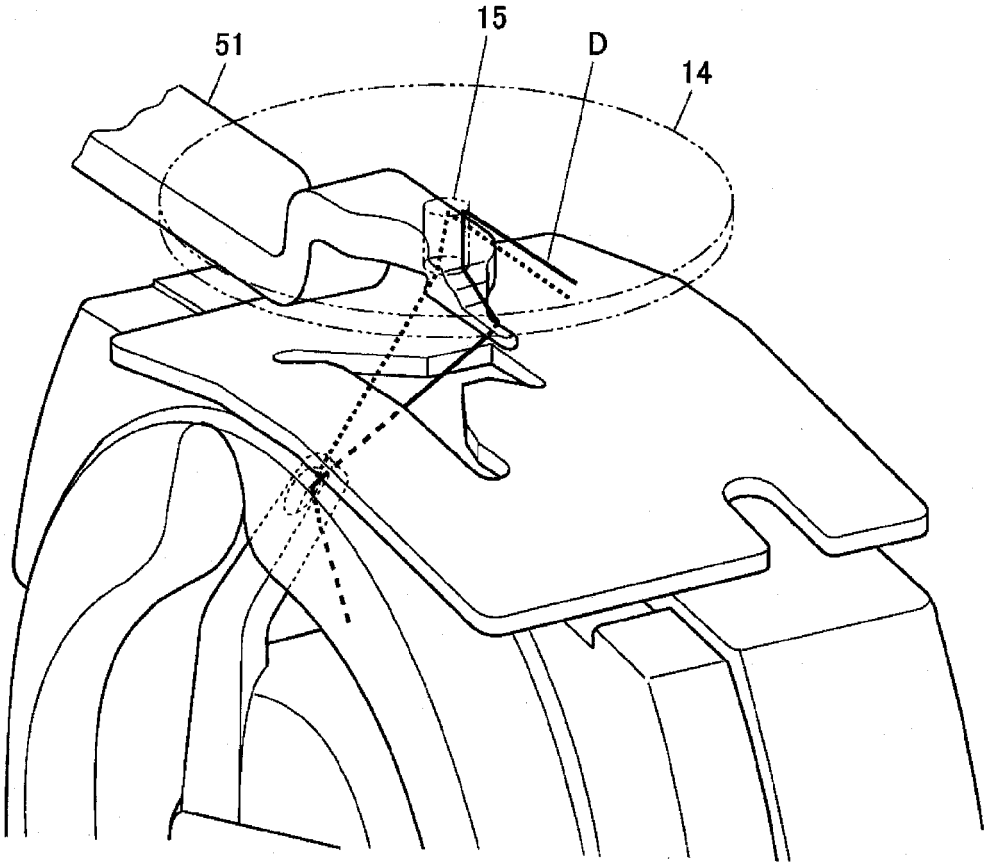


FIG. 29

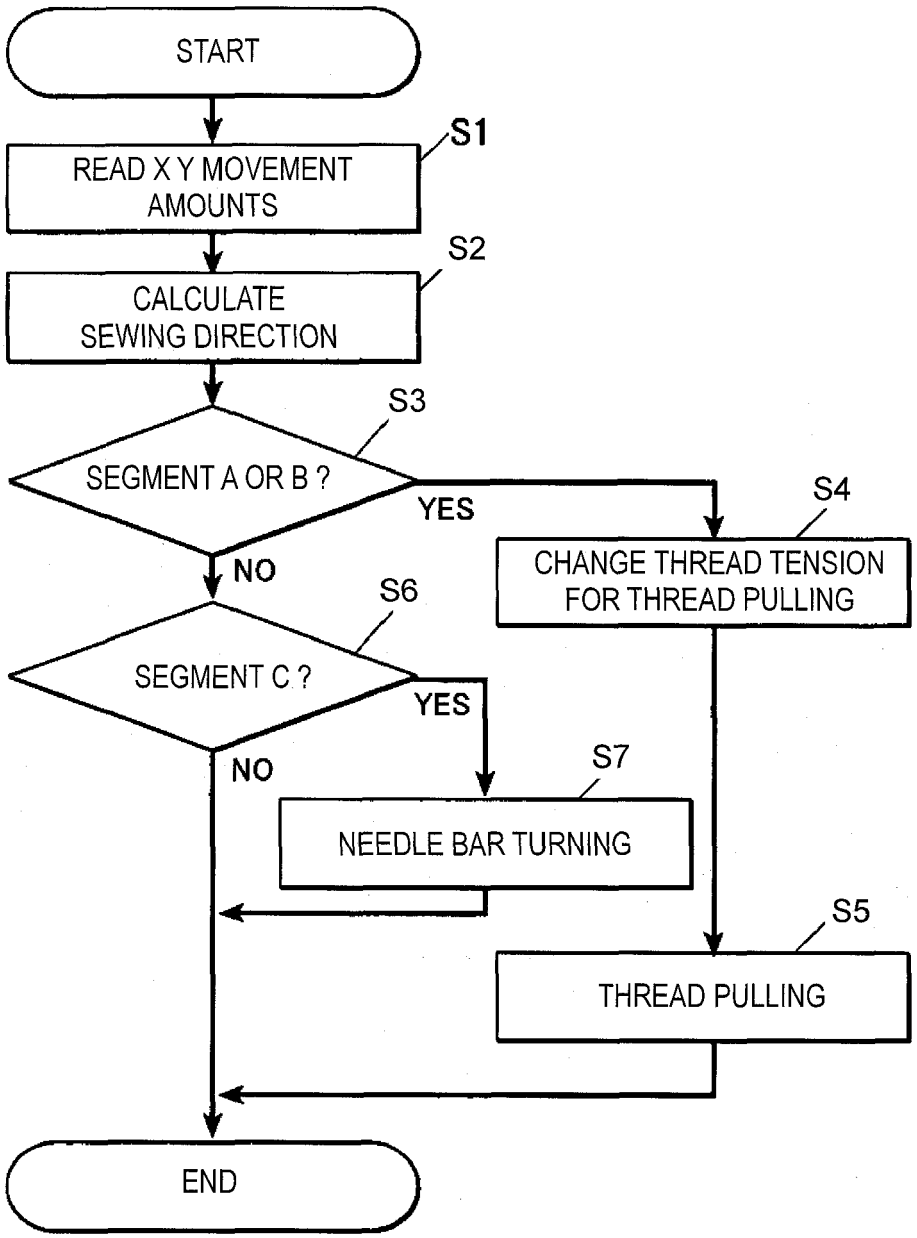

START
S1
READ X Y MOVEMENT AMOUNTS
S2
CALCULATE SEWING DIRECTION
S3
SEGMENT A OR B ?
YES
NO
S4
CHANGE THREAD TENSION FOR THREAD PULLING
S6
SEGMENT C ?
YES
NO
S7
NEEDLE BAR TURNING
S5
THREAD PULLING
END

FIG. 30

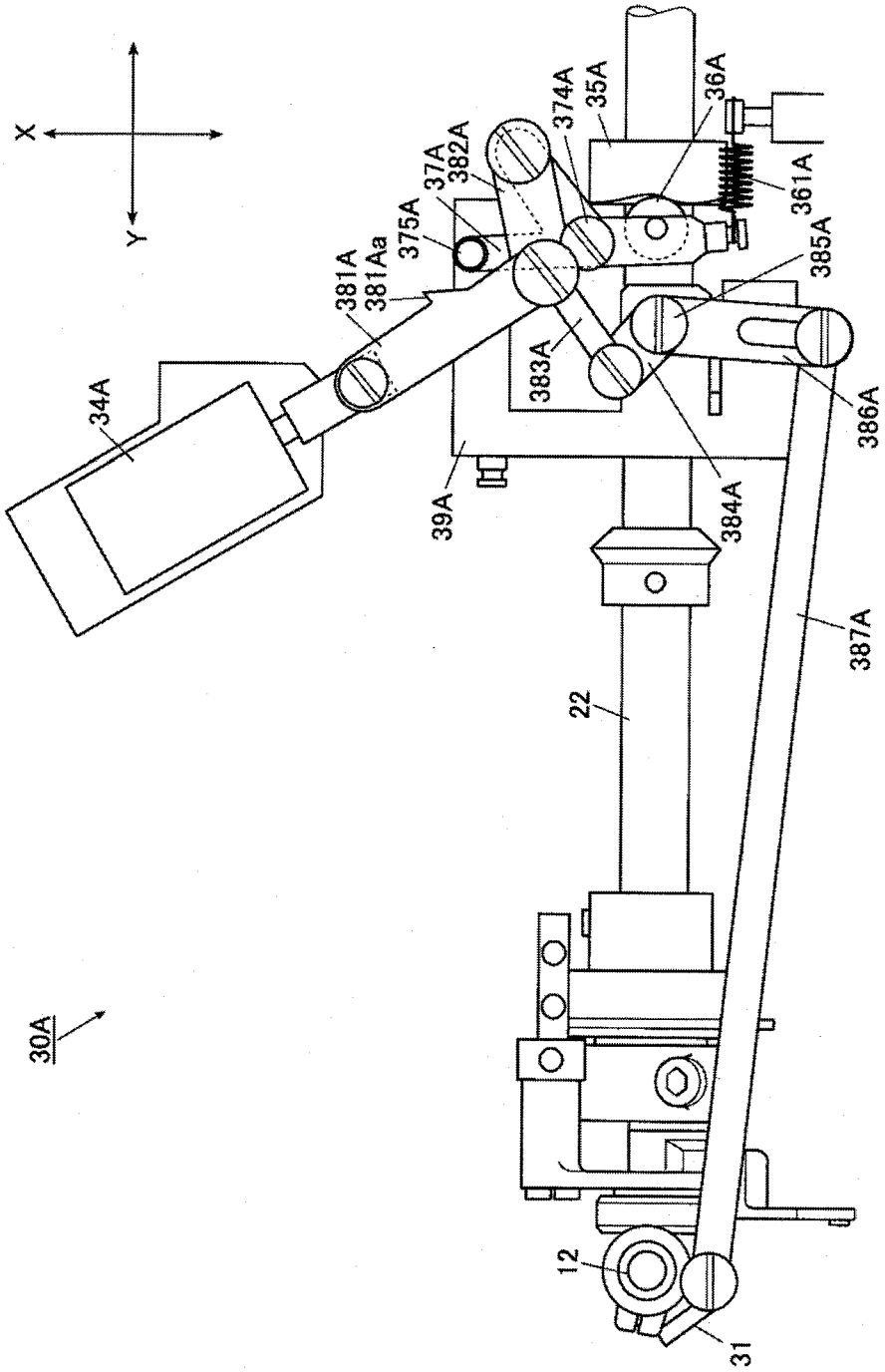

X
Y
30A
34A
381A
381Aa
375A
37A
382A
374A
35A
36A
361A
385A
383A
386A
39A
384A
387A
22
12
31

FIG. 31

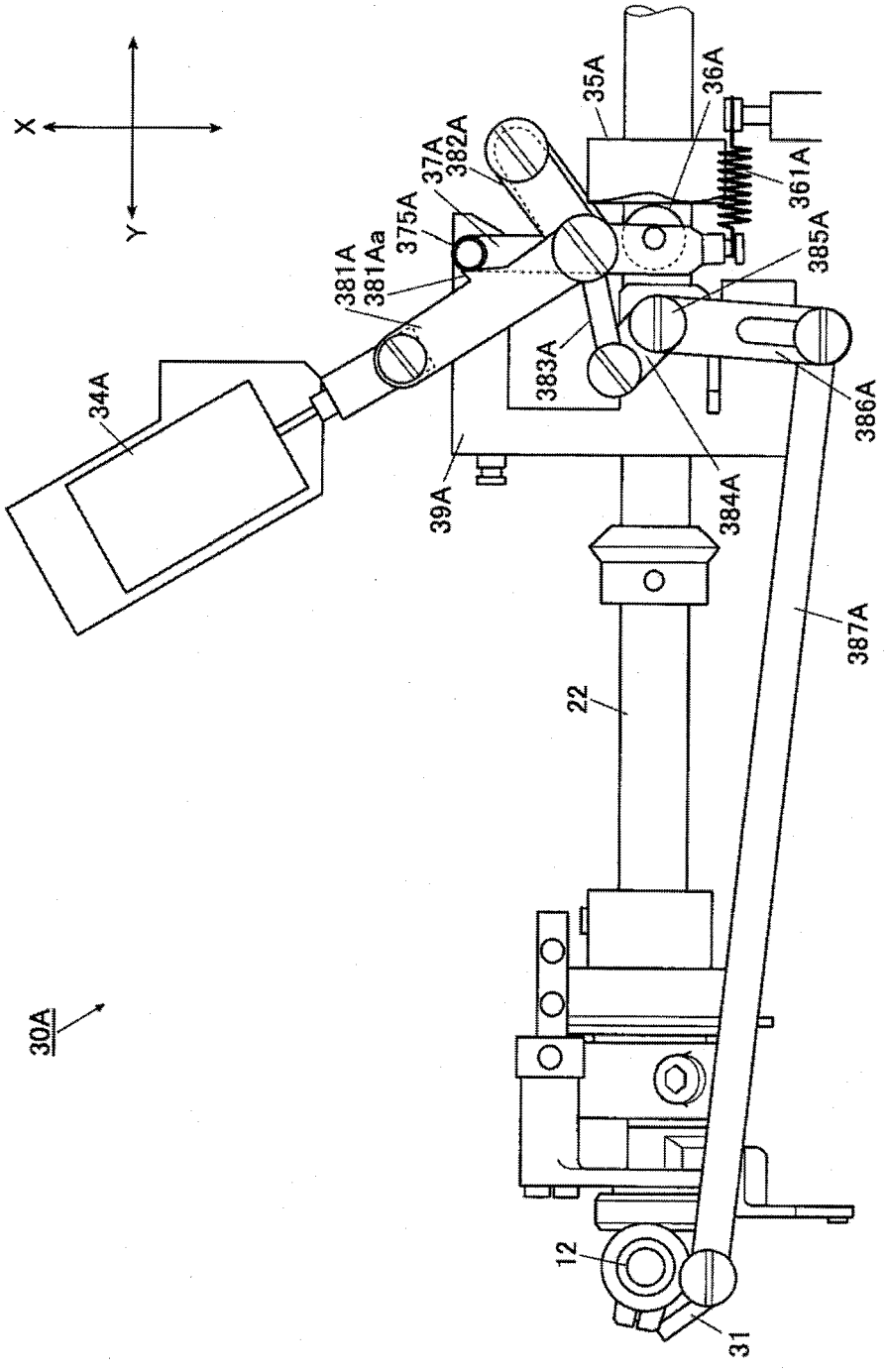

X
Y
35A
36A
37A
382A
375A
361A
381A
381Aa
385A
383A
34A
386A
39A
384A
387A
22
30A
12
31

FIG. 32

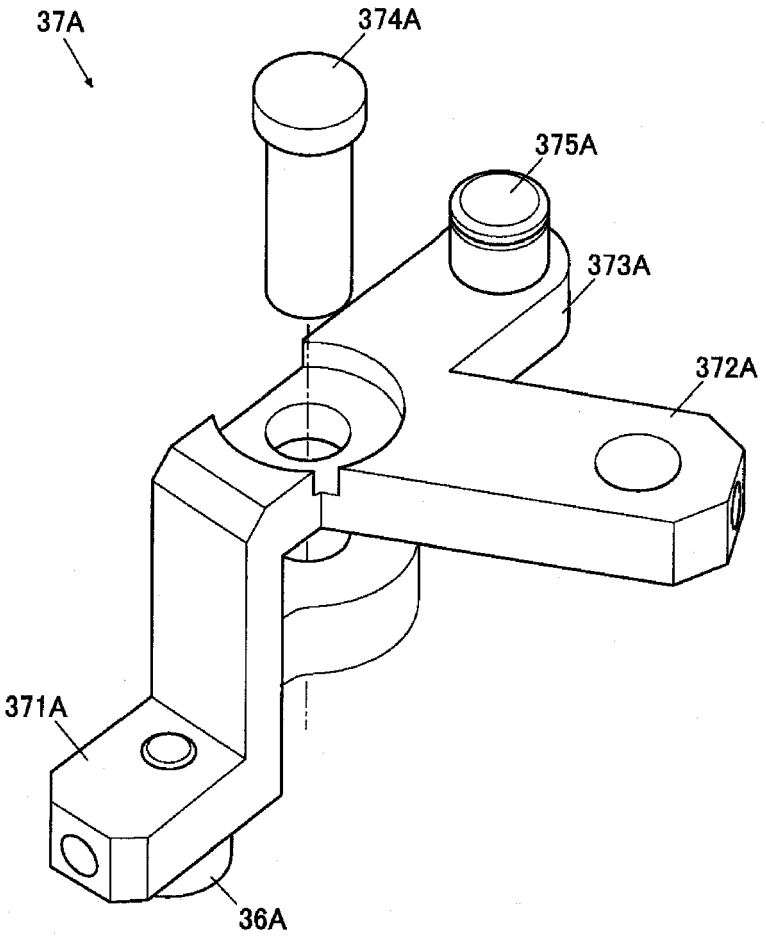


FIG. 33

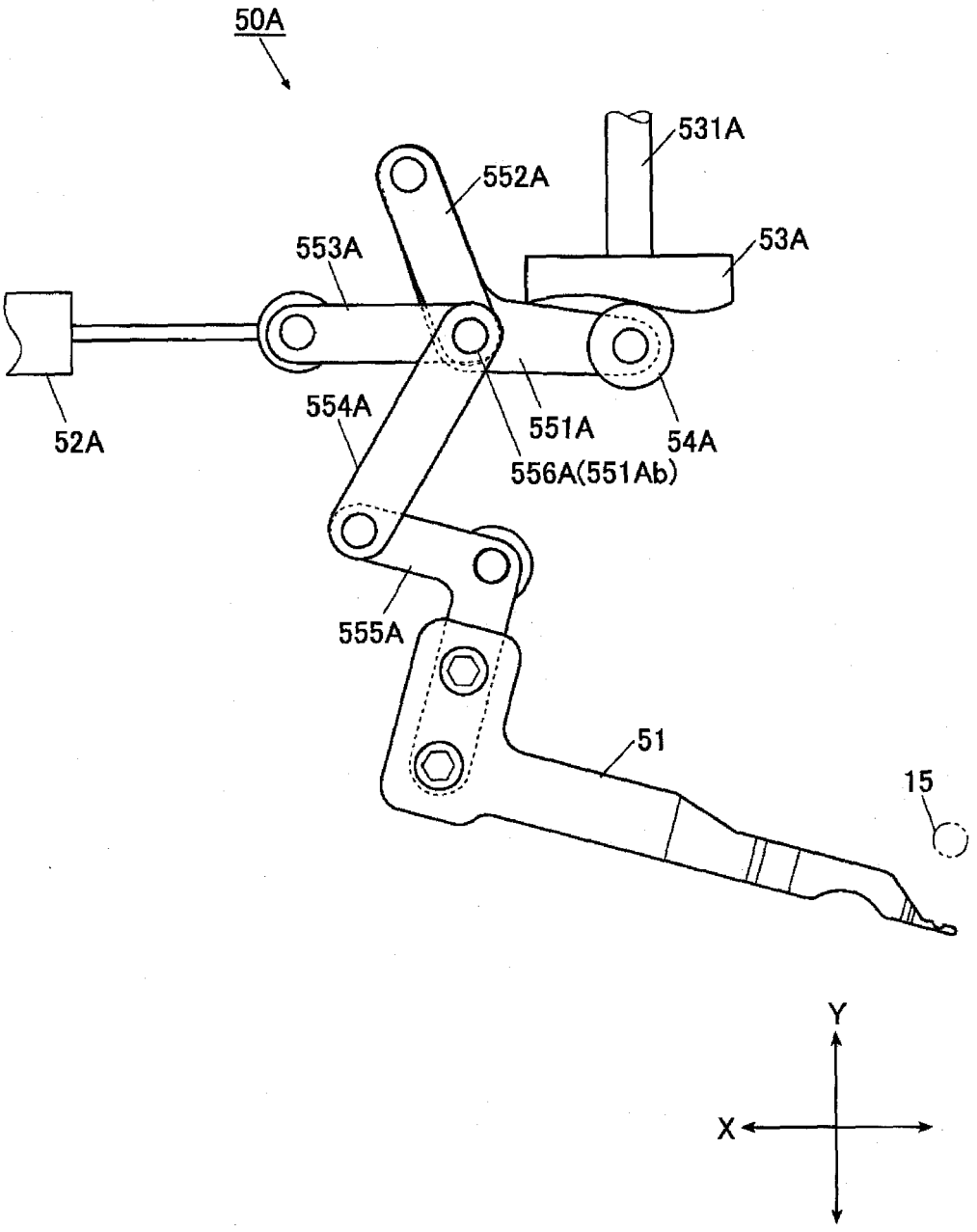

50A
531A
552A
553A
53A
52A
554A
551A
54A
556A(551Ab)
555A
51
15
Y
X

FIG. 34

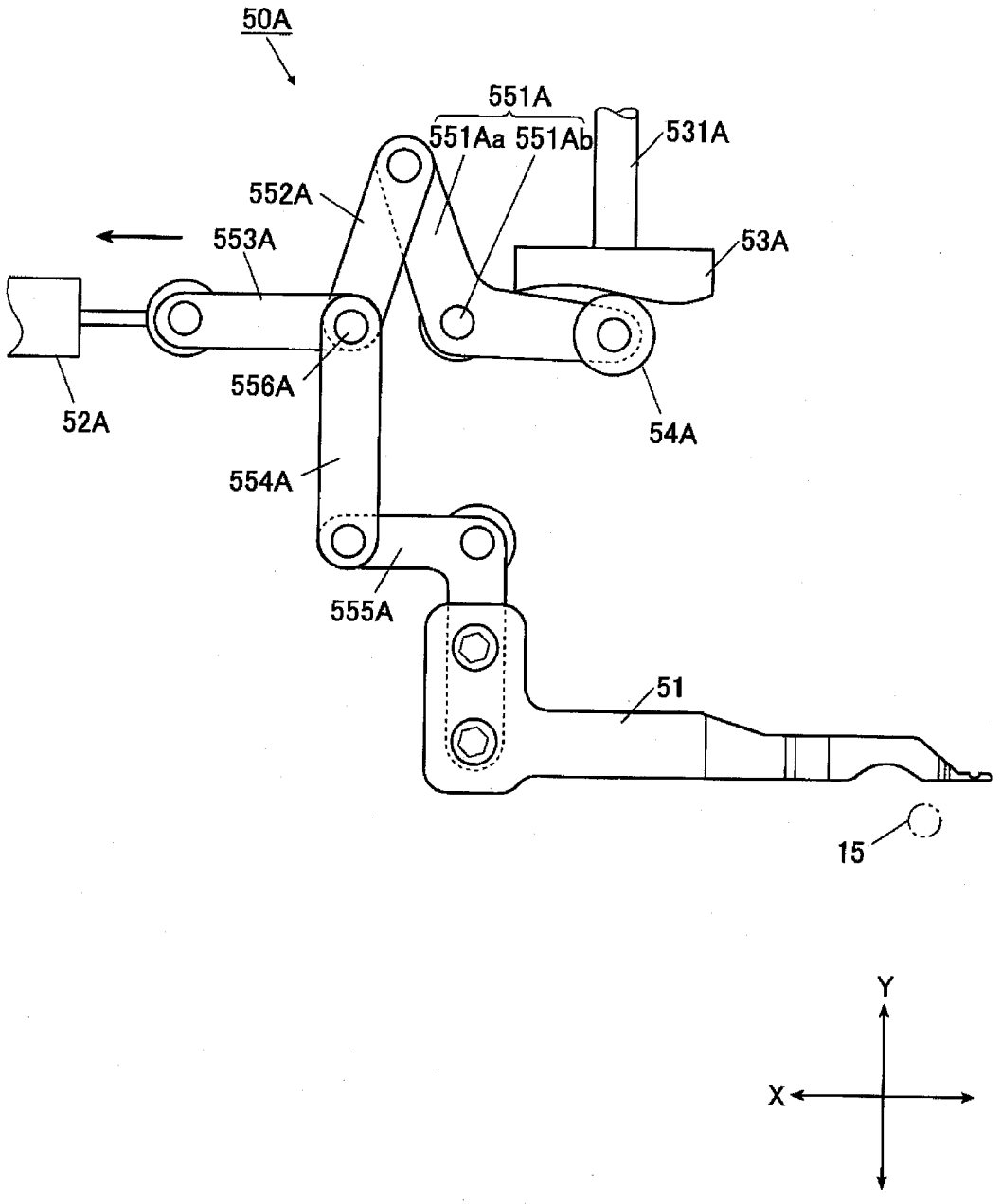

50A
551A
551Aa
551Ab
531A
552A
553A
53A
556A
52A
54A
554A
555A
51
15
Y
X

FIG. 35

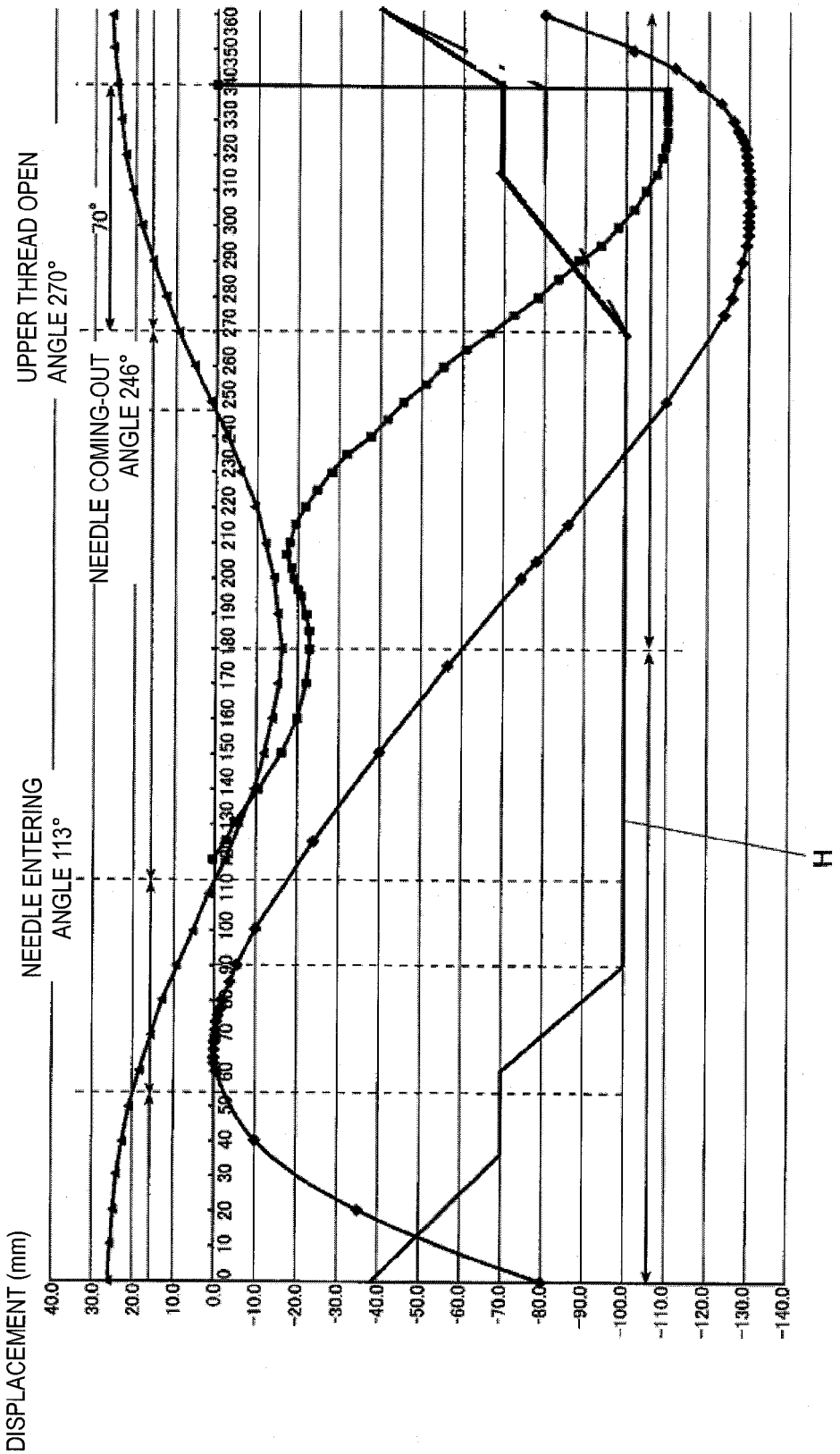

DISPLACEMENT (mm)
NEEDLE ENTERING ANGLE 113°
NEEDLE COMING-OUT ANGLE 246°
UPPER THREAD OPEN ANGLE 270°
70°
H

FIG. 36

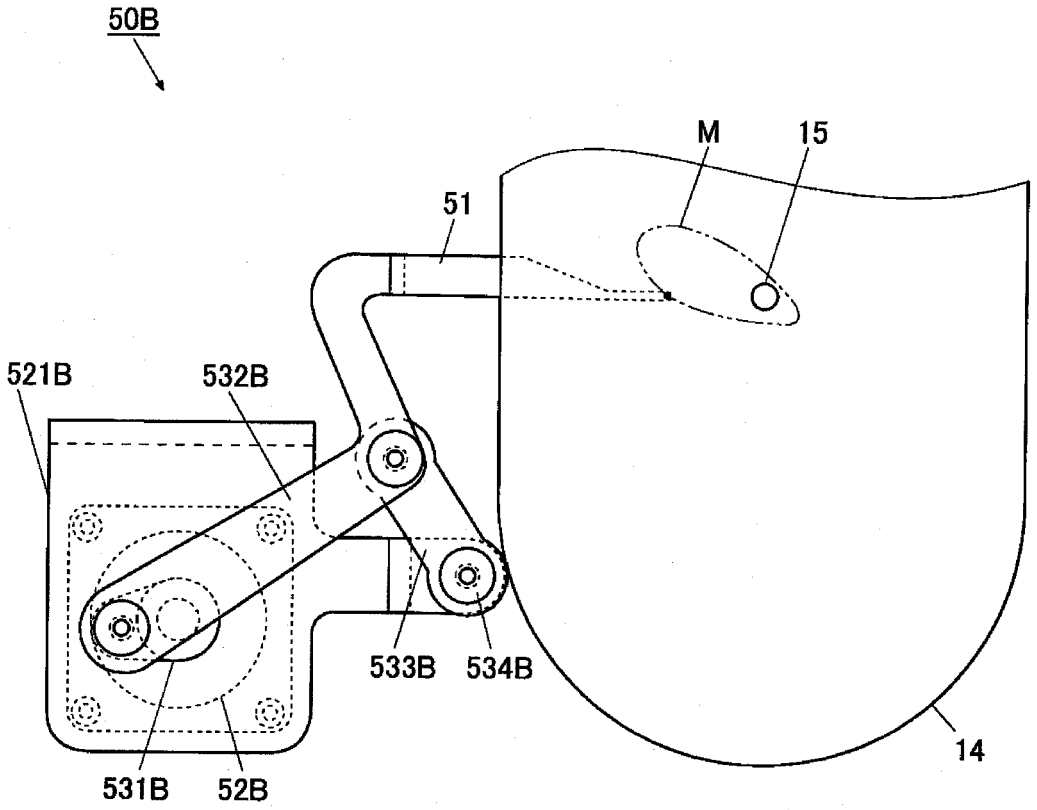


FIG. 37A

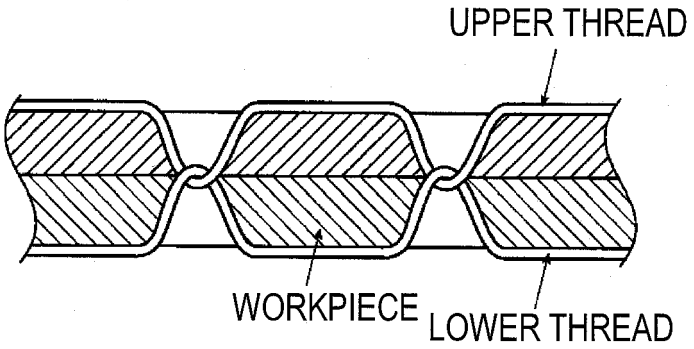


FIG. 37B

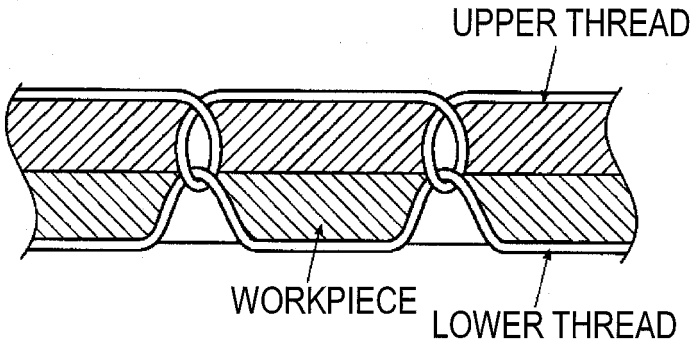


FIG. 38

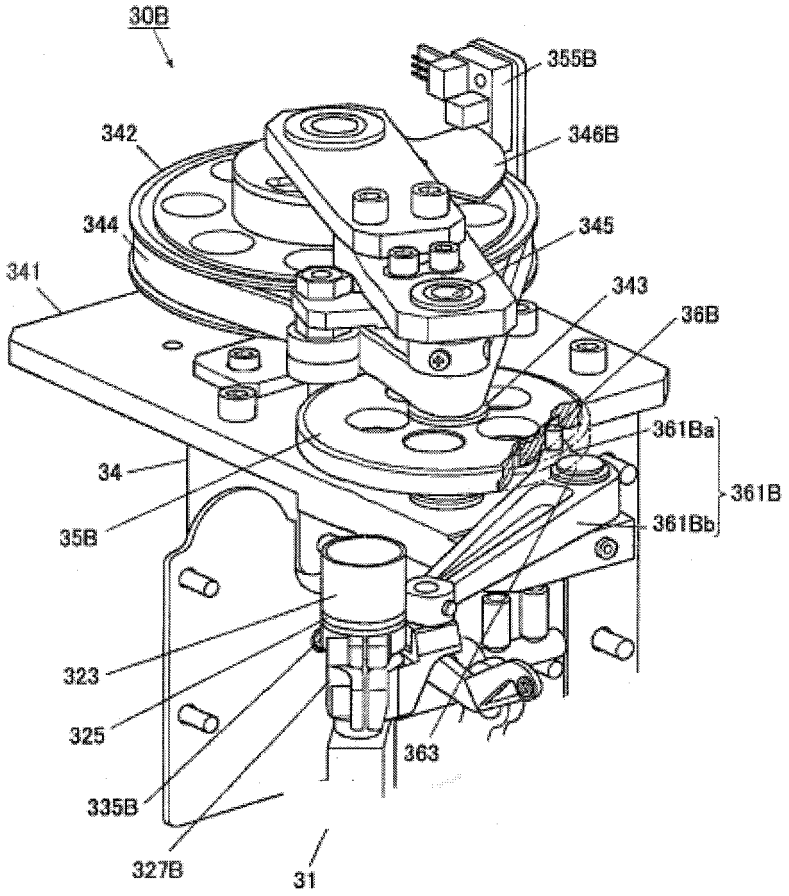

30B
355B
342
346B
344
345
341
343
36B
361Ba
34
361B
35B
361Bb
323
325
363
335B
327B
31

FIG. 39

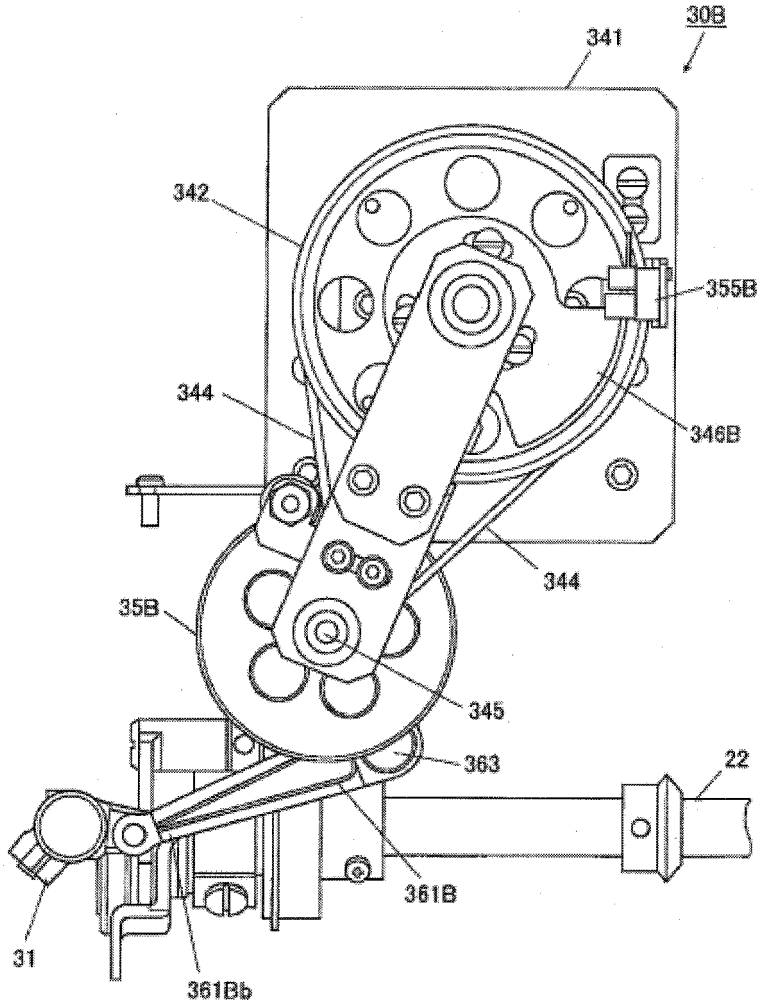


FIG. 40

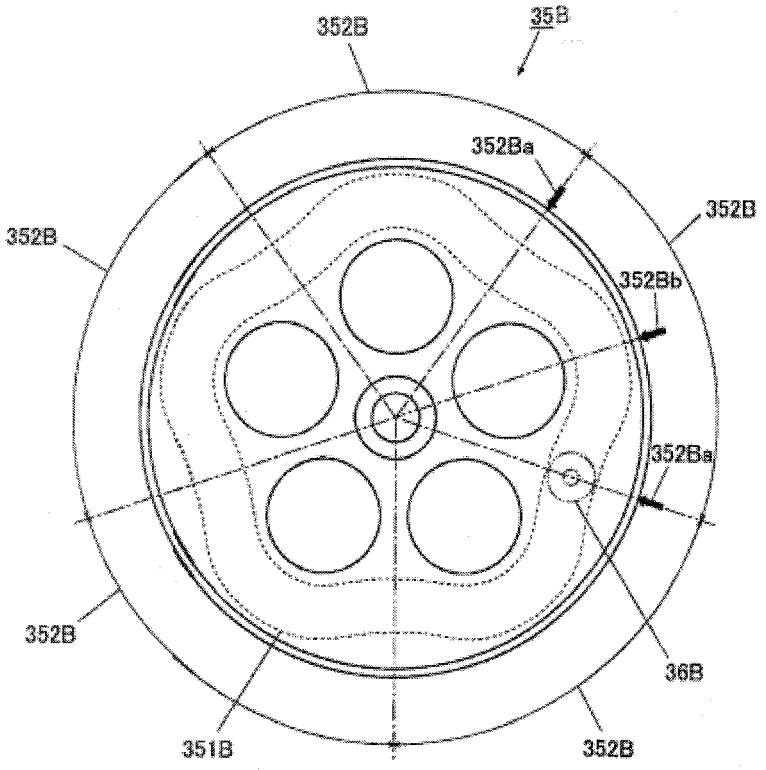


FIG. 41

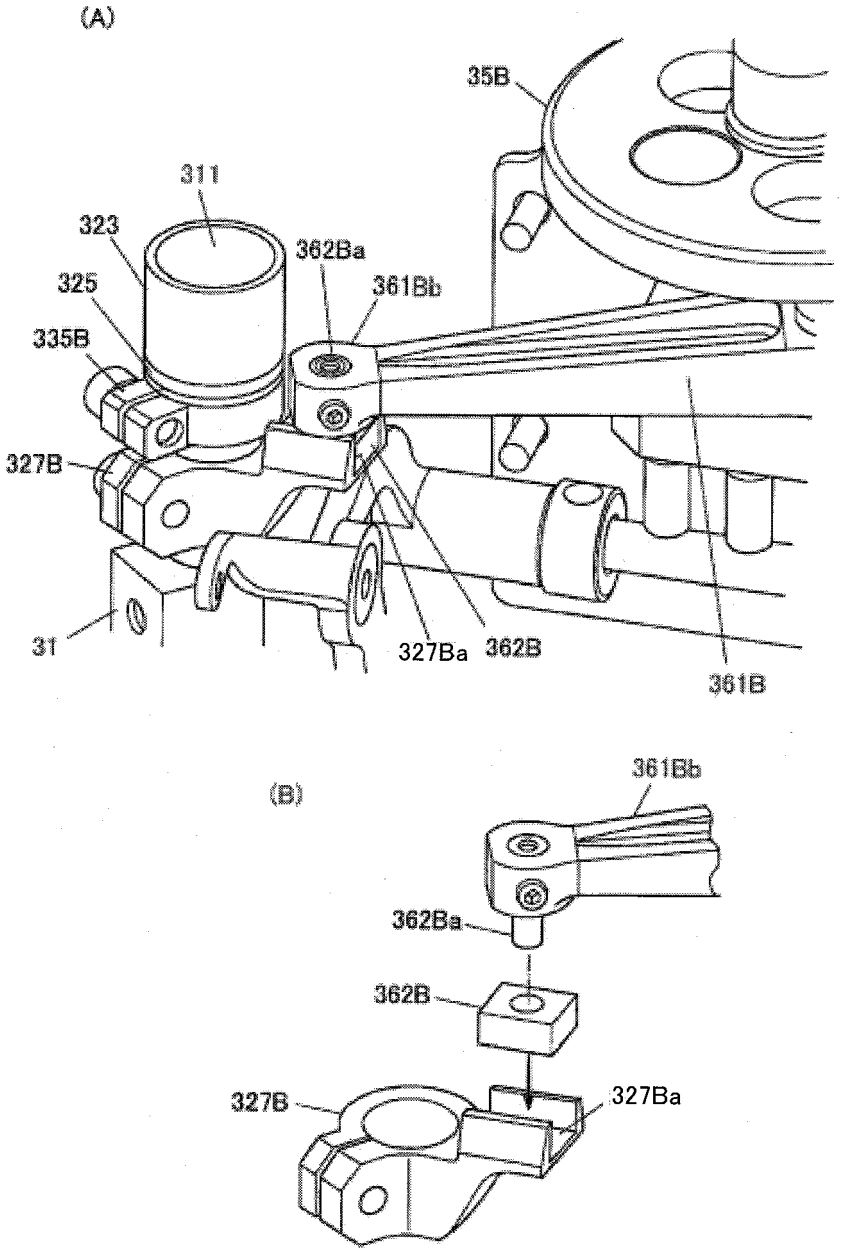

(A)
35B
311
323
362Ba
325
361Bb
335B
327B
31
327Ba
362B
361B
(B)
361Bb
362Ba
362B
327B
327Ba

FIG. 42

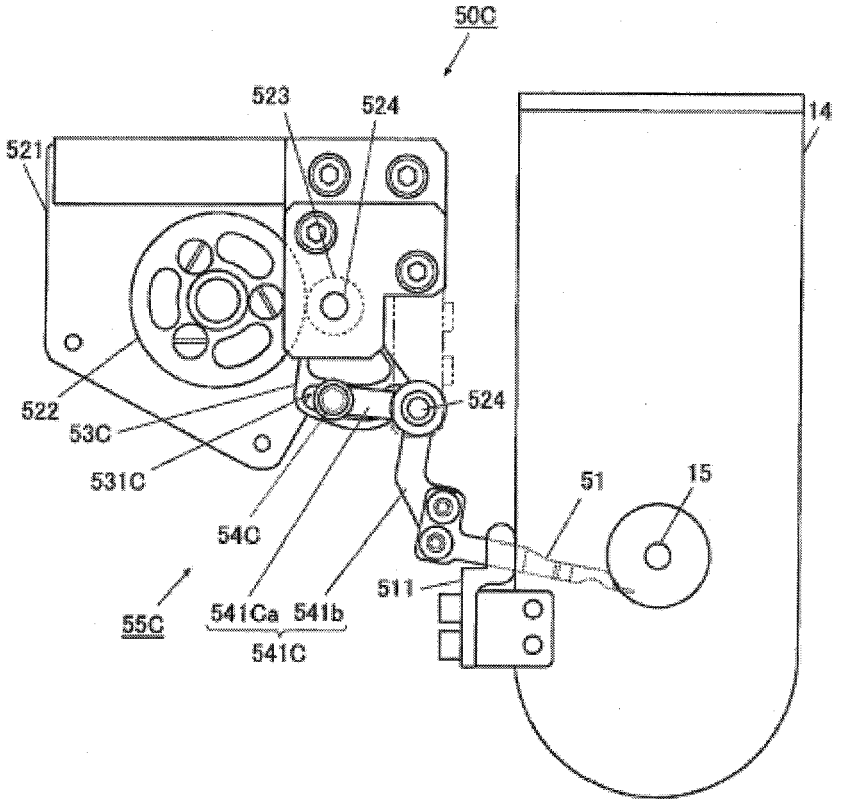

50C
523
524
14
521
522
53C
524
531C
51
15
54C
511
55C
541Ca
541b
541C

FIG. 43

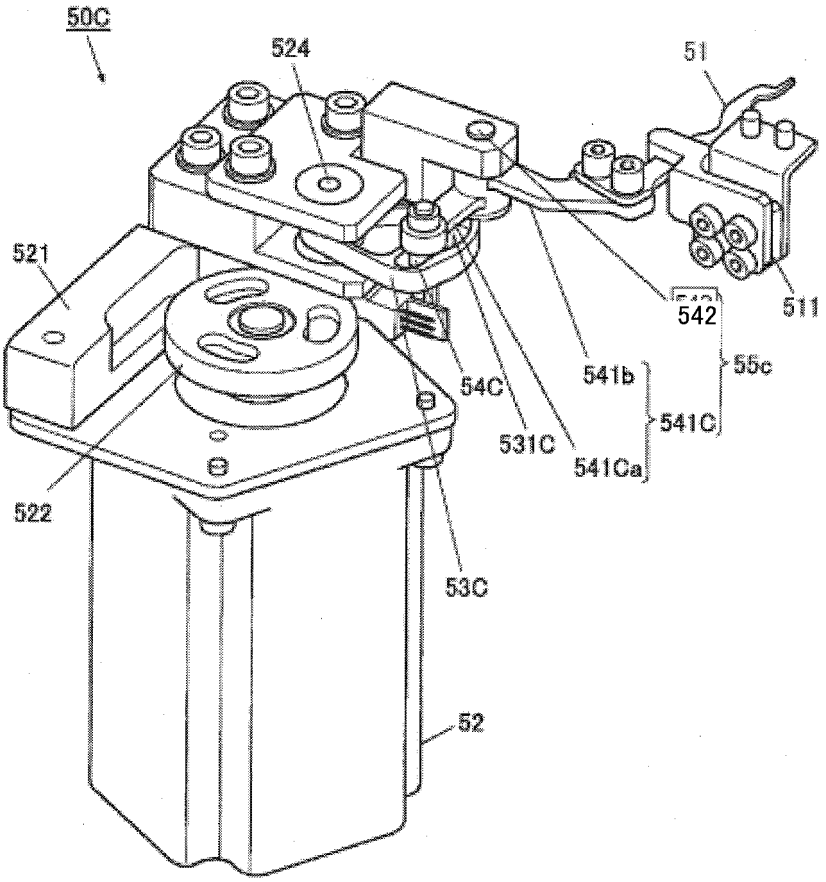
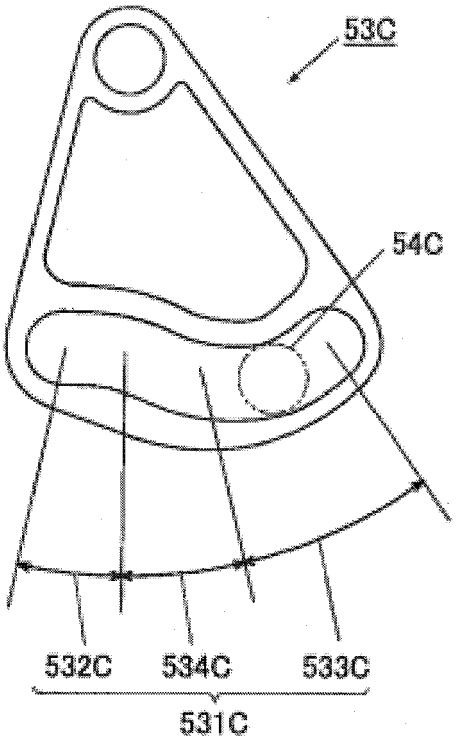


FIG. 44



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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 2557

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	JP 2008 023261 A (BROTHER IND LTD) 7 February 2008 (2008-02-07) * abstract; figures 1-16 *	1-17	INV. D05B1/12 D05B19/12 D05B19/14
A	JP 3 063091 A (JUKI KK) 19 March 1991 (1991-03-19) * abstract; figures 1-10 *	1-17	D05B47/04
A	JP 2000 153085 A (BROTHER IND LTD) 6 June 2000 (2000-06-06) * abstract; figures 1-9 *	1-17	
A	US 6 962 120 B1 (FUJIKURA TAKASHI [JP] ET AL) 8 November 2005 (2005-11-08) * column 4, line 9 - column 10, line 12; figures 1-10 *	1-17	
A	DE 103 48 494 A1 (MIKASA CORP [JP]) 9 June 2004 (2004-06-09) * paragraph [0022] - paragraph [0056]; figures 1-6 *	1-17	TECHNICAL FIELDS SEARCHED (IPC) D05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 July 2012	Herry-Martin, D

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1

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Patent documents cited in the description

- JP 9220391 A **[0004] [0006]**
- JP 2008023261 A **[0005] [0007] [0008]**