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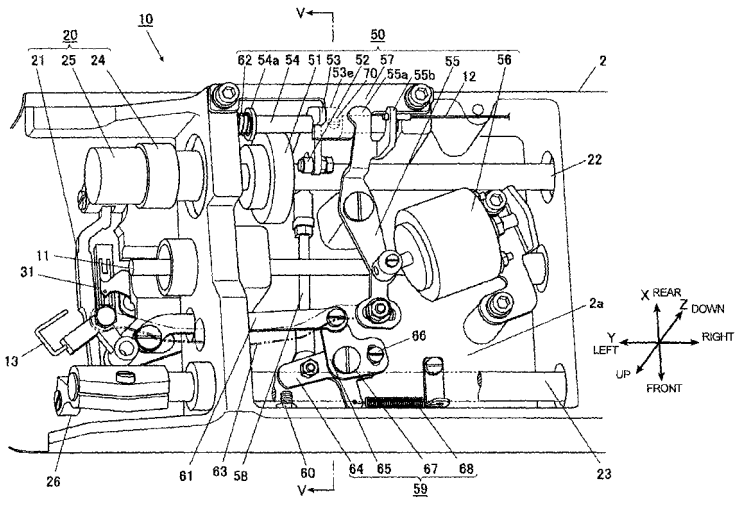
(54) **Sewing machine**

(57) The invention relates to a sewing machine (10). The sewing machine (10) includes a main shaft which is rotated by a motor (1) to move a sewing needle, a position detecting means (14, 15) for detecting a rotation angle of the main shaft as a main shaft angle, a thread cutting mechanism (30) having a movable knife (31), a thread cutting cam (51) having a cam groove (51a) formed along a circumferential direction and rotating in synchronization with the rotation of the main shaft, a cam follower (52) configured to engage with the cam groove (51a) to move the movable knife (31) in accordance with the cam groove (51a), a thread cutting actuator (56) which switches the cam follower (52) between an engaging position and a disengaging position with respect to the thread cutting cam (51), and a control means (100) for controlling the thread cutting actuator (56) and the motor (1). The control means (100) includes an operation timing determining means for determining an operation start timing of the thread cutting actuator (56) or the motor (1), based on at least one of a rotation speed (v1, v2) of the motor (1) for a thread cutting operation and a main shaft stopped angle (θ1) at which the main shaft has stopped immediately before the thread cutting operation.

FIG. 2



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Description

[0001] The present invention relates to a sewing machine including a thread cutting device configured to cut a thread in accordance with a thread cutting cam.

[0002] Sewing machines, like the one described in JP 2007-181609 A, include a thread cutting device having a thread cutting cam (a driver of a cam mechanism) formed with a cam groove along a circumferential direction and rotated by a motor, a roller (a follower of the cam mechanism) configured to engage with and disengage from the cam groove of the thread cutting cam, a thread cutting solenoid for engaging the roller with the grooved cam, and a movable knife configured to cut a thread in conjunction with the roller guided by the grooved cam. The cam groove has an engaging section in which the roller can be inserted into the cam groove to engage with the cam groove and an operation section for giving a cutting movement to the movable knife. The roller in a disengaged condition cannot be fitted into the cam groove from the operation section of the cam groove.

[0003] More specifically, while a main shaft of the sewing machine rotates from a lower stop position, i.e. an rotation angle of the main shaft at which a hook of the shuttle starts capturing a sewing thread from a sewing needle moving up from the lowest point, and stops at an upper stop position, the thread cutting solenoid is operated at a given phase of the main shaft to engage the roller with the cam groove, and the thread cutting cam gives the cutting movement to the movable knife to cut the thread.

[0004] The sewing machine is configured to perform two different controls for thread cutting. That is, when a pedal is backwardly operated (heel-pedaled) while the main shaft is being stopped at the lower stop position, the motor is driven to rotate the main shaft at a certain speed and the thread cutting solenoid is turned on. When the pedal is backwardly operated directly from a forwardly pedaled condition while a sewing machine is being driven, the thread cutting solenoid is turned on after decelerating the main shaft to a certain level.

[0005] In the thread cutting mechanism described above, the roller can be reliably maintained engaged with the cam groove of the thread cutting cam by completely inserting the roller into the cam groove. Therefore, the timing at which the thread cutting solenoid is to be activated is set in consideration of the time required for the roller to be completely inserted into the cam groove after turning on the thread cutting solenoid.

[0006] However, when stopping the main shaft at a predetermined lower stop position, a rotation phase of the actually stopped position may deviate from the predetermined lower stop position. For example, when the main shaft is stopped after passing through the predetermined lower stop position and the pedal is backwardly pedaled to activate the thread cutting solenoid, the cam groove opposed to the roller may already be in the operation section by the time the roller reaches the cam groove. In such a case, the roller cannot be successfully inserted into the cam groove, resulting in a failure of thread cutting operation by the movable knife.

[0007] Some sewing machines are configured such that the rotation speed of the motor during the thread cutting operation is adjustable as needed, speeded down for a stable cutting operation and speeded up for a quicker operation.

[0008] When the rotation speed of the motor during the cutting operation is set to be high, the thread cutting cam rotates at a high speed in conjunction with the motor. In this case, the cam groove may be shifted from the engaging section to the operation section before the roller engaging operation is completed, causing a roller engagement failure.

[0009] In the case of direct backward pedaling from the forwardly pedaled position during sewing, the problems described above are more likely to occur.

[0010] Moreover, in some cases, a shuttle presser called a "picker" is used during the thread cutting operation. The shuttle presser is operated interlockingly with the roller by the thread cutting solenoid, and is butted against a bobbin inside the shuttle from the outside of the shuttle to prevent bobbin idling so that an appropriate residual length of the thread is ensured. In such a case, when the rotation speed of the motor during the thread cutting is set to be low, the shuttle presser may be moved toward the bobbin before the sewing needle is sufficiently withdrawn upward from the shuttle, and may hit the sewing needle. As a result, the shuttle presser may not function properly, or the shuttle presser or the sewing needle may be damaged.

[0011] It is an object of the present invention to provide a sewing machine capable of performing an appropriate thread cutting operation.

[0012] According to a first aspect of the present invention, a sewing machine includes a main shaft which is rotated by a motor to move a sewing needle up and down; a position detecting means for detecting a rotation angle of the main shaft as a main shaft angle; a thread cutting mechanism including a movable knife configured to capture a sewing thread and to cut the sewing thread; a thread cutting cam having a cam groove formed along a circumferential direction of the thread cutting cam and rotating in synchronization with the rotation of the main shaft; a cam follower configured to engage with and disengage from the cam groove of the thread cutting cam and to move the movable knife in accordance with the cam groove while engaging with the cam groove; a thread cutting actuator which switches the cam follower between an engaging position and a disengaging position with respect to the thread cutting cam; and a control means for controlling the thread cutting actuator and the motor.

[0013] The sewing machine is characterized in that the control means includes an operation timing determining means for determining an operation start timing of the thread cutting actuator or the motor, based on at least one of a rotation speed of the motor for a thread cutting

operation and a main shaft stopped angle at which the main shaft has stopped immediately before the thread cutting operation.

[0014] According to a second aspect of the present invention, the sewing machine further includes a speed setting means for setting the rotation speed of the motor for the thread cutting operation. The operation timing determining means determines an operation angle as the operation start timing of the thread cutting actuator, based on the rotation speed set by the speed setting means, such that the operation of the thread cutting actuator to switch the cam follower to the engaging position is completed at a target main shaft angle, and starts the operation the thread cutting actuator when the main shaft angle reaches the operation angle.

[0015] According to a third aspect of the present invention, the sewing machine further includes a shuttle presser configured to be butted against a bobbin inside a shuttle in conjunction with the cam follower by the operation of the thread cutting actuator to stop a rotation of the bobbin. The target main shaft angle, at which the operation of the thread cutting actuator to switch the cam follower to the engaging position is completed, is set within an range from a main shaft angle, at which the shuttle presser and the sewing needle become free from interfering with each other, to a main shaft angle, at which the switching of the cam follower to the engaging position becomes inoperable.

[0016] According to a fourth aspect of the present invention, the operation timing determining means includes an operation angle determining means for determining the operation angle based on the rotation speed set by the speed setting means, an operation angle judging means for judging whether the main shaft angle has reached the operation angle, and an actuator driving means for driving the thread cutting actuator when the operation angle judging means judges that the main shaft angle has reached the operation angle.

[0017] According to a fifth aspect of the present invention, the operation timing determining means is activated in association with a backward pedaling operation of a pedal from a forward pedaling position.

[0018] According to a sixth aspect of the present invention, the control means adjusts a waiting time from the operation start of the thread cutting actuator to the operation start of the motor, based on one of the rotation speed of the motor for the thread cutting operation and the main shaft stopped angle.

[0019] According to a seventh aspect of the present invention, the control means adjusts a waiting time from the operation start of the thread cutting actuator to the operation start of the motor, based on the rotation speed of the motor for the thread cutting operation and the main shaft stopped angle.

[0020] According to an eighth aspect of the present invention, the control means performs the thread cutting operation in association with a backward pedaling operation of a pedal from a neutral position.

[0021] According to the first aspect of the present invention, the operation start timing of the thread cutting actuator or the motor is determined in accordance with at least one of the rotation speed of the motor for the thread cutting operation and the main shaft stopped angle. Therefore, regardless of the rotation speed of the motor during the thread cutting operation and the main shaft stopped angle, the cam follower can be engaged with the cam groove. Accordingly, a cutting failure can be avoided and sewing work efficiency can be prevented from being deteriorated.

[0022] According to the second aspect of the present invention, the operation angle which as the operation start timing of the thread cutting actuator is determined in accordance with the rotation speed set by the speed setting means such that the operation of the thread cutting actuator to switch the cam follower to the engaging position is completed at the target main shaft angle, and when the main shaft angle reaches the operation angle, the operation of the thread cutting actuator is started. Therefore, even when the rotation speed of the motor during the cutting control is optionally set, the main shaft angle at which the operation of the thread cutting solenoid to engage the cam follower is completed can be fixed, so that similar effect as described above can be effectively obtained.

[0023] According to the third aspect of the present invention, the fixed main shaft angle, at which the operation of the thread cutting actuator to switch the cam follower to the engaging position is completed, is set within the range from the main shaft angle at which the shuttle presser and the sewing needle become free from interfering with each other, to the main shaft angle, at which switching of the cam follower to the engaging position becomes inoperable. Therefore, the shuttle presser can be prevented from interfering with the sewing needle and causing breakage.

[0024] According to the fourth aspect of the present invention, the operation angle determining means for determining the operation angle in accordance with the rotation speed set by the speed setting means, the operation angle judging means for judging whether the main shaft angle has reached the operation angle, and the actuator driving means for driving the thread cutting actuator when the operation angle judging means judges that the main shaft angle has reached the operation angle, are provided. Therefore, the cam follower can be more reliably engaged with the cam groove. Accordingly, a cutting failure can be avoided and the sewing work efficiency can be prevented from being deteriorated.

[0025] According to another aspect of the present invention, upon the cutting control, the motor is stopped at a predetermined needle lower stop position as a target. Then, the main shaft stopped angle as an actually stopped position is detected by the position detector, and/or the preset rotation speed of the motor for the thread cutting operation is read out.

[0026] By detecting the main shaft stopped angle, an

angle to the start of a displacement section in which the thread cutting cam applies a thread cutting operation to the cam follower is given, so that when the angle to this displacement section is small, adjustment is performed to lengthen the waiting time from the operation start of the thread cutting solenoid to the operation start of the motor, and when the angle to the displacement section is large, adjustment is performed to shorten the waiting time from the operation start of the thread cutting solenoid to the operation start of the motor.

[0027] From the preset rotation speed set of the motor, it can be determined whether the time required to reach the displacement section of the thread cutting cam is long or short from the operation start of the thread cutting solenoid, so that when the rotation speed is low, adjustment is performed to shorten the waiting time from the operation start of the thread cutting solenoid to the operation start of the motor, and when the set rotation speed is high, adjustment is performed to lengthen the waiting time from the operation start of the thread cutting solenoid to the operation start of the motor.

[0028] By performing either or both of the adjustments described above, the risk of reaching the displacement section of the thread cutting cam before the completion of engagement of the cam follower with the cam groove can be further be reduced, and the operation start timing of the motor start timing is adjusted depending on the situation, so that excessive delay can also be avoided, whereby the cam follower engaging operation can appropriately be made.

[0029] Other aspects and advantages of the present invention will be apparent from the following description, the drawings and the claims.

[0030] The following description of a preferred embodiment of the invention serves to explain the invention in greater detail in conjoint with the drawings. These show:

Fig. 1: a block diagram of an overall configuration of a sewing machine according to an embodiment of the present invention;
Fig. 2: a bottom perspective view of the sewing machine with a bottom plate being removed;
Fig. 3: a bottom view of a thread cutting mechanism;
Fig. 4: a sectional view along the line V-V of Fig. 2;
Fig. 5: an enlarged bottom view showing a configuration around a knife drive arm;
Fig. 6: a bottom view of a knife position adjuster;
Fig. 7: a flowchart of a sewing control;
Fig. 8: a diagram illustrating a change in a needle bar height (vertical axis) with respect to the main shaft angle (horizontal axis);
Fig. 9: an explanatory diagram of a table for specifying a proper delay time, using a lower stop angle θ1 and a thread cutting rotation speed v1 as parameters;
Fig. 10: a flowchart of a first cutting control;
Fig. 11: an explanatory diagram of a table for specifying a proper timing (the main shaft angle) to start driving of the thread cutting solenoid, using a thread cutting rotation speed v2 as a parameter;
Fig. 12: a flowchart of second cutting control;
Fig. 13: an explanatory diagram of a table for determining proper thread cutting rotation speeds V1 to V12 with respect to the lower stop angle θ1; and
Fig. 14: a flowchart of another example of the first cutting control.

[0031] Overall Configuration of Sewing Machine

[0032] A sewing machine 10 according to an embodiment of the present invention includes a sewing machine frame including an arm portion and a bed portion 2 (Fig. 2), a main shaft (an upper shaft) coupled to a motor 1 (Fig. 1) and provided inside the arm portion along the extending direction of the arm portion, a needle up-down moving mechanism provided inside the arm portion and having a known structure for moving a sewing needle up and down in conjunction with the main shaft, and a horizontal shuttle mechanism provided inside the bed portion 2 and having a known structure for forming stitches by entangling upper and lower threads in cooperation with the sewing needle.

[0033] The sewing machine 10 further includes, as shown in Fig. 2, a cloth feeding mechanism 20 including a feed dog which protrudes from an opening formed in a throat plate to feed a workpiece in a cloth feeding direction, a thread cutting mechanism 30 which includes a movable knife 31 and a fixed knife 33 and cuts the upper thread and the lower thread, and a thread cutting drive mechanism 50 which applies a cutting operation to the movable knife 31 of the thread cutting mechanism 30.

[0034] The sewing machine 10 further includes a control device 100 (control means) configured to control operations of the respective components described above as shown in Fig. 1.

[0035] In the following description, in a state where the sewing machine 10 is placed on a horizontal surface, a horizontal direction along the cloth feeding direction of the feed dog is referred to as an X-axis direction, a horizontal direction orthogonal to the X-axis direction is referred to as a Y-axis direction, and the vertical direction is referred to as a Z-axis direction. As the front and rear sides in the X-axis direction, the side on which an operator operates the sewing machine is referred to as "rear," and the opposite side is referred to as "front," and as the left and right sides in the Y-axis direction, the left side as viewed from the rear side in the X-axis direction is referred to as "left," and the right side is referred to as "right."

[0036] In this embodiment, "a thread cutting device" includes the thread cutting mechanism 30 and the thread cutting drive mechanism 50.

[0037] Horizontal Shuttle Mechanism

[0038] The horizontal shuttle mechanism includes a shuttle shaft 11 supported rotatably along the Y-axis direction inside the bed portion 2, and a full rotary shuttle

(not shown) coupled to the tip end of the shuttle shaft 11 and including an outer shuttle which rotates around the axis of the shuttle shaft 11. The shuttle shaft 11 is coupled to the motor 1 (Fig. 1) so as to rotate at a speed twice the speed of the main shaft.

[0039] Cloth Feeding Mechanism

[0040] The cloth feeding mechanism 20 includes a feed base 21 having a feed dog (not shown) provided on the upper surface which protrudes from an opening of the throat plate, an up-down feed shaft 22 which is driven to rotate by the motor 1, a horizontal feed shaft 23 which is rotated in a reciprocating manner by the motor 1, an eccentric cam 24 fixed to the up-down feed shaft 22, an up-down feed rod 25 having one end portion coupled to an eccentric shaft of the eccentric cam 24 and the other end portion coupled to the rear end portion of the feed base 21, and a horizontal feed arm 26 which swings its swinging end portion fixed to and supported on the horizontal feed shaft 23 and coupled to the feed base 21 in the front-rear direction. The up-down feed shaft 22 is coupled to the main shaft via a belt not shown so that when the main shaft rotates one revolution, the up-down feed shaft 22 also rotates one revolution at the same period as that of the main shaft.

[0041] The up-down feed shaft 22 is disposed closer to the rear side (the operator side) than the shuttle shaft 11 inside the bed portion 2 and supported rotatably along the Y-axis direction. A driven pulley with teeth not shown is fixed to the up-down feed shaft 22, and is given a torque via a timing belt with teeth from a driver pulley provided on the main shaft of the needle up-down moving mechanism. Specifically, the up-down feed shaft 22 is driven to rotate by the motor 1 via the main shaft, and the transmission ratio is set so that the up-down feed shaft 22 rotates at a speed equal to that of the main shaft.

[0042] According to full rotation of the up-down feed shaft 22, only the up-down movement component of the revolving motion of the eccentric shaft of the eccentric cam 24 is transmitted to the feed base 21 by the up-down feed rod 25, and the feed base 21 moves up and down at the same period as that of the up-down movement of the sewing needle.

[0043] To the shuttle shaft 11 described above, a rotating operation is applied from the up-down feed shaft 22 via a speed increasing gear train, and the rotating operation at a speed twice the speed of the up-down feed shaft 22 is applied.

[0044] The horizontal feed shaft 23 is disposed closer to the front side than the shuttle shaft 11 inside the bed portion 2, and supported rotatably along the Y-axis direction. On the up-down feed shaft 22 described above, the eccentric rod holding an eccentric cam not shown fixed to the up-down feed shaft 22 is provided, and a driven arm not shown is fixed to the horizontal feed shaft 23. By coupling an end portion not on the eccentric cam side of the eccentric rod and the swinging end portion of the driven arm, a reciprocating rotation is applied to the horizontal feed shaft 23 from the up-down feed shaft 22. Specifically, to the horizontal feed shaft 23, a reciprocating rotation is applied by the motor 1 via the up-down feed shaft 22 and the main shaft, and the transmission ratio is set so that the reciprocating rotation period of the horizontal feed shaft 23 becomes equal to the rotation period of the up-down feed shaft 22.

[0045] Accordingly, to the feed base 21, a reciprocating up-down movement and a reciprocating forward-backward movement are applied at the same period, and by properly adjusting the phases of these, the feed base 21 moves in an oval course along the cloth feeding direction. Then, the feed dog of the feed base 21 protrudes upward from the opening of the throat plate in an upper section of the oval movement, and the oval rotation direction of the feed base 21 is adjusted so that the movement direction at this time matches the cloth feeding direction, and enables feeding of the workpiece on the throat plate in the predetermined feeding direction.

[0046] Thread Cutting Device

[0047] The thread cutting device includes the thread cutting mechanism 30 and the thread cutting drive mechanism 50.

[0048] In Fig. 3, the thread cutting mechanism 30 includes a main body frame 32 fixed to the bed portion 2, a fixed knife 33 having an edge portion 33a on its tip end portion and fixed to and supported on the main body frame 32, a movable knife 31 including an edge portion 31a provided on its tip end portion and an engaging projection 31b provided so as to project from the upper surface, and an actuation arm 34 which turns the movable knife 31.

[0049] The movable knife 31 is axially supported on the main body frame 32 by a shoulder screw 35 so as to turn between a standby position shown by the alternate long and two short dashed line and a most retreated position shown by the solid line. The movable knife 31 is normally spaced from the shown stitch point S at the standby position, and reciprocates when cutting (thread cutting operation), and when moving forward, retreats to the solid-line position and handles (divides) sewing threads (upper thread and lower thread) to be cut, and when returning, captures a sewing thread to be cut during forward movement to the standby position, and cuts the captured sewing thread at the standby position in cooperation with the fixed knife 33.

[0050] The edge portion 33a of the fixed knife 33 sandwiches and cuts a sewing thread with the edge portion 31a of the movable knife 31 when the movable knife 31 advances.

[0051] The actuation arm 34 is axially supported rotatably with respect to the main body frame 32 at a longitudinal intermediate position by a shoulder screw 36, and one end portion thereof is coupled to a second link body 61 of the thread cutting drive mechanism 50 described later. On the other end portion of the actuation arm 34, a groove-like notch 34a in which the engaging projection 31b of the movable knife 31 is fitted is formed, and the movable knife 31 can be turned along with the rotation

of the actuation arm 34.

[0052] By thus forming the groove-like notch 34a, the engaging projection 31b can move inside the notch 34a, and a turning radius difference between the actuation arm 34 and the movable knife 31 can be allowed.

[0053] In the thread cutting device, by rightward and leftward advancing/retreating movements of the second link body 61 of the thread cutting drive mechanism 50 in Fig. 3, the end portion on the notch 34a side of the actuation arm 34 turns leftward and then turns rightward, and by turning the movable knife 31 in the same direction, a thread cutting operation can be performed.

[0054] Thread Cutting Drive Mechanism

[0055] As shown in Fig. 2 and Fig. 4, the thread cutting drive mechanism 50 includes a thread cutting cam 51 fixed to the up-down feed shaft 22, a roller 52 (a cam follower) engageable in the cam groove 51a of the thread cutting cam 51, a knife drive arm 53 which retains the roller 52 by an input portion 53a and turns in a reciprocating manner to transmit a cutting operation to the movable knife 31, a pivot shaft 54 which supports the knife drive arm 53, a clutch member 55 which applies a switching operation for switching from a withdrawn position at which the roller 52 is not fitted in the cam groove 51a to a fitting position at which the roller 52 is fitted in the cam grove 51a via the knife drive arm 53, a thread cutting solenoid 56 as a thread cutting actuator which becomes a drive source of the switching operation of the clutch member 55, a first stopper 57 which engages with the knife drive arm 53 to prohibit forward turning of the drive knife 31 when the roller 52 is at the withdrawn position, a first link body 58 (link body) having one end portion coupled to an output portion 53b of the knife drive arm 53, a knife position adjuster 59 as a knife position adjusting means coupled to the other end portion of the first link body 58, a second stopper 60 (stopper) the position of which is adjustable and which stops the knife drive arm 53 on one end side of the movement start side of the movable knife 31 in the turning range, and a second link body 61 (movable knife drive link) joining the knife position adjuster 59 and the actuation arm 34 of the thread cutting mechanism 30.

[0056] The thread cutting cam 51 is formed into a substantially disk shape as viewed in the Y-axis direction and fixed to and supported on the up-down feed shaft 22 positioned at the center of the disk shape, and has a cam groove 51 a the depth direction of which is in the Y-axis direction and which is formed on a right end face perpendicular to the up-down feed shaft 22.

[0057] In the cam groove 51a, a non-displaced section at a fixed distance from the up-down feed shaft 22 as a rotation center and a displacement section which gradually approaches the up-down feed shaft 22 as a rotation center and then returns to the point at the same distance as that of the non-displaced section (only the non-displaced section is shown in Fig. 4) continue to each other in an endless annular shape. When the up-down feed shaft 22 is at a shaft angle at which the roller 52 faces the non-displaced section, the roller 53 enters or comes out from the cam groove 51a. The roller 52 that has entered the cam groove 51 a receives an input of displacement substantially in the Z-axis direction from the cam groove 51a when it is in the displacement section, and transmits this displacement to the knife drive arm 53. The displacement section is formed in a main shaft angle range from 285 degrees to 45 degrees described later, and the section from 45 degrees to 285 degrees is the non-displaced section.

[0058] As shown in Fig. 2 to Fig. 5, the knife drive arm 53 includes a cylindrical base portion 53c fixed to the pivot shaft 54, the input portion 53a extended toward the outer side in a turning radial direction from the base portion 53c, the output portion 53b extended toward the outer side in a turning radial direction different from the extending direction of the input portion 53a from the base portion 53c, and a position restricting projection 53d extended toward the outer side in the turning radial direction in a direction different from the directions of the input portion 53a and the output portion 53b from the base portion 53c. Specifically, in the state where the knife drive arm 53 is supported on the pivot shaft 54, the position restricting projection 53d is extended substantially downward, the input portion 53a is extended substantially toward the front side in the X-axis direction, and the output portion 53b is extended substantially upward.

[0059] Further, the input portion 53a, the base portion 53c, and the position restricting projection 53d of the knife drive arm 53 are positioned lower than the up-down feed shaft 22, horizontal feed shaft 23, and the shuttle shaft 11, and the output portion 53b is positioned higher than the up-down feed shaft 22, horizontal feed shaft 23, and the shuttle shaft 11.

[0060] Inside the bed portion 2, the up-down feed shaft 22, the horizontal fed shaft 23, and the shuttle shaft 11 are disposed parallel to each other, so that the inside of the bed portion 2 is divided into a lower area and an upper area by these shafts 22, 23, and 11, however, the knife drive arm 53 is across these shafts 22, 23, and 11 from the lower side to the upper side as described above, so that it becomes possible that with respect to the knife drive arm 53, the components (the clutch member 55, the thread cutting solenoid 56, and the first stopper 57, etc.) to be used for engaging or disengaging the roller 52 and the thread cutting cam 51 are disposed in the lower area, and components (the first link body 58, the knife position adjuster 59, and the second link body 61, etc.) which perform power transmission from the knife drive arm 53 to the movable knife 31 are all disposed in the upper area.

[0061] The knife drive arm 53 includes the input portion 53a and the output portion 53b which become turning end portions extending in two directions with respect to the pivot shaft 54, so that the knife drive arm 53 has a bell crank structure. With this structure, when a turning movement is input according to the cam groove 51a from the roller 52 provided on the input portion 53a, the output

portion 53b also turns, and advancing and retreating movements can be applied along the longitudinal direction (substantially X-axis direction) of the first link body 58 to the first link body 58 coupled to the output portion 53b along the tangential direction of the arc movement locus of the turning.

[0062] The knife drive arm 53 has a projection 53e formed along the Y-axis direction (referred to as an up-down feed shaft direction). In the projection 53e, a through hole is opened, and the pivot shaft 54 described later is inserted through the through hole. Then, the knife drive arm 53 is fixed to the pivot shaft 54 by a screw 70.

[0063] Instead of this, it is also easily conceivable that the pivot shaft 54 is provided with two E-rings or two thrust collars to support both ends in the Y-axis direction of the knife drive arm 53. It is also easily conceivable that a stepped portion is provided on one end side of the pivot shaft 54, and after the knife drive arm 53 is fitted, the other end side is locked by an E-ring or the like. Thus, the knife drive arm 53 is supported rotatably, and the knife drive arm 53 moves in the Y-axis direction according to movement in the Y-axis direction of the pivot shaft 54.

[0064] The pivot shaft 54 is supported at its both end portions on the sewing machine frame by the bed portion 2 so as to become capable of advancing and retreating along the Y-axis direction (up-down feed shaft direction) and turning around the Y-axis. The pivot shaft 54 is enabled to advance and retreat along the Y-axis direction by collars and bearings, etc., provided on the sewing machine frame.

[0065] Therefore, the knife drive arm 53 is capable of advancing and retreating and turning similar to the pivot shaft 54. The pivot shaft 54 is provided with a flange portion 54a, and the pivot shaft 54 and the knife drive arm 53 are always pressed rightward by a pressing spring 62 via the flange portion 54a.

[0066] On the other hand, the first stopper 57 has a recess 57a on the right of the position restricting projection 53d, and an engagement maintaining projection 57b projecting leftward for maintaining engagement of the roller 52 in the cam groove 51a is formed adjacent to the front side of the recess 57a.

[0067] As described above, the knife drive arm 53 is always pressed rightward by the pressing spring 62, so that the fitting of the position restricting projection 53d in the recess 57a recessed rightward is maintained. Then, when the position restricting projection 53d is pressed leftward against the pressure of the pressing spring 62 by the thread cutting solenoid 56 and the clutch member 55, it can come out from the recess 57a, and further, when the roller 52 retained by the input arm 53a of the knife drive arm 53 is fitted in the cam groove 51a and a turning movement is applied to the knife drive arm 53 so as to move the position restricting projection 53d to the front side by the displacement section of the cam groove 51a, the contact state (shown by the alternate long and two short dashed line in Fig. 5) of the engagement maintaining projection 57b is caused just to the right next to the position restricting projection 53d, and the knife drive arm 53 does not move rightward even if it is subjected to a pressing force of the pressing spring 62, and the roller 52 is also maintained so as not to come out from the cam groove 51a.

[0068] As described above, the thread cutting solenoid 56 and the clutch member 55 are disposed in the lower area. The clutch member 55 is axially supported rotatably around the Z-axis by the bed portion 2 at the intermediate portion in the longitudinal direction, and one turning end portion thereof is a contact portion 55a which comes into contact with the position restricting projection 53d of the knife drive arm 53 to release the retaining state of the first stopper 57 when it turns counterclockwise. Further, the clutch member 55 has a thread tension releasing portion 55b adjacent to the contact portion 55a and coupled to a release wire 12 for releasing the thread tensioning state of an upper thread tensioning device not shown. When the contact portion 55a turns in the direction of releasing the retaining state of the position restricting projection 53d, the thread tension releasing portion 55b is actuated to release the thread tension concurrently.

[0069] To the vicinity of the other turning end portion of the clutch member 55, a plunger of the thread cutting solenoid 56 is coupled, and turning of the clutch member 55 is energized. When the thread cutting solenoid 56 is not driven, the plunger projects, and when the thread cutting solenoid 56 is driven, the plunger retracts and energizes counterclockwise turning of the clutch member 55 in Fig. 2.

[0070] Further, to the other turning end portion of the clutch member 55, a joint link member 63 for pulling the shuttle presser 13 that blocks rotation of the bobbin housed inside the inner shuttle of the shuttle mechanism to a rotation blocking state is coupled. Accordingly, when the thread cutting solenoid 56 turns the clutch member 55 counterclockwise in Fig. 2, the shuttle presser 13 is concurrently turned to block rotation of the bobbin so as to prevent the lower thread from being extended from the bobbin and causing a cutting failure during thread cutting.

[0071] In Fig. 6, the knife position adjuster 59 includes first and second turning pieces 64 and 65 (a plurality of L-shaped turning links) superimposed on each other, and these are coupled integrally by a joint screw 66, and the two turning pieces 64 and 65 are axially supported around the Z-axis direction concurrently by one shoulder screw 67. The first turning piece 64 has a turning end portion extended substantially leftward in the Y-axis direction, and this turning end portion is coupled to an end portion of the first link body 58. The second turning piece 65 has a turning end portion extended substantially forward in the X-axis direction, and this turning end portion is coupled to an end portion of the second link body 61. According to this structure, the knife position adjuster 59 has a bell crank structure. Specifically, when advancing and retreating movements of the first link body 58 substantially along the X-axis direction give a turning movement to the first turning piece 64, the second turning piece

65 also turns in the same direction around the shoulder screw 67 (pivot shaft), and advancing and retreating movements can be applied to the second link body 61 substantially along the Y-axis direction.

[0072] A first turning piece 64 (first L-shaped turning link) is energized to turn counterclockwise by a tension spring 68 in Fig. 2, and on the other hand, on the counterclockwise turning tip of the first turning piece 64, a second stopper 60 is provided, and a state where the first turning piece 64 is pressed against the second stopper 60 is maintained. A turning angle at which the first turning piece 64 is retained by the second stopper 60 is for maintaining a turning angle of the knife drive arm 53 so that the roller 52 comes to a position at which the roller 52 can enter the non-displaced section of the cam groove 51a via the first link body 58.

[0073] The second stopper 60 consists of a columnar screw (set screw) 60a without a head, and a nut 60b for fixing the screw position, and by screwing-in and tightening the screw 60a with the nut 60b, the stop angle of the first turning piece 64 can be adjusted. Specifically, the second stopper 60 and the tension spring 68 function as an initial position adjusting mechanism of the roller 52 (cam follower) capable of adjusting the initial position of the roller 52.

[0074] Further, a second turning piece (second L-shaped turning link) is coupled to the first turning piece 64 by a joint screw 66 via a slot 65a, and when the joint screw 66 is loosened, the first turning piece 64 and the second turning piece 65 are allowed to turn relative to each other around a shoulder screw 67. In the tightened state of the joint screw 66, when the initial position of the roller 52 is adjusted by the second stopper 60 described above, the entire knife position adjuster 59 turns and causes the standby position of the movable knife 31 to fluctuate, however, in this case, by adjusting turning of only the second turning piece 65 by loosening the joint screw 66, while the initial position of the roller 52 is properly adjusted, the standby position of the movable knife 31 can also be adjusted to a proper position.

[0075] As described above, in the present embodiment, the first turning piece 64 and the second turning piece 65 are used. Instead of this, it is easily conceivable that one turning piece is used and given the same function by joining a link body 58 to one end side and joining a movable knife drive link 61 described later to the other end side.

[0076] The stopper 60 is configured to come into contact with the first turning piece 64, however, it is also easily conceivable that the stopper 60 is configured to come into contact with the link body 58 described later.

[0077] The link body 58 joins the knife drive arm 53 and the first turning piece 64 (first L-shaped turning link) of the knife position adjuster 59, and has a function to transmit advancing and retreating movements substantially along the X-axis direction of the output portion 53b of the knife drive arm 53 to the turning end portion of the first turning piece 64. The output portion 53b of the knife drive arm 53 is displaced in the X-axis direction and the Z-axis direction due to the turning movement, and the first turning piece 64 is displaced in the X-axis direction and the Y-axis direction due to the turning movement. Further, the position of the knife drive arm 53 is also switched along the pivot shaft 54 (Y-axis direction).

[0078] Thus, on both end portions of the first link body 58, displacement is caused in various directions, so that both end portions are connected to the knife drive arm 53 and the first turning piece 64 via spherical bearings 58a and 58b. Accordingly, even when displacement is caused in various directions at both end portions, smooth movement transmission can be realized.

[0079] The link body 58 is substantially orthogonal to the shuttle shaft 11, and disposed between the shuttle shaft 11 and the sewing machine bed upper surface 2a.

[0080] On the other hand, the second link body (movable knife drive link) 61 joins the second turning piece 65 of the knife position adjuster 59 and the actuation arm 34 of the thread cutting mechanism 30, and has a function to transmit advancing and retreating movements substantially along the Y-axis direction of the second turning piece 65 to the turning end portion of the actuation arm 34. The second turning piece 65 and the actuation arm 34 are displaced in the X-axis direction and the Y-axis direction due to turning, and these displacements coincide with each other, so that unlike the first link body 58, they do not need spherical bearings.

[0081] Control Device

[0082] Next, a control device 100 as a control means of the sewing machine 10 and a control system of the sewing machine 10 relating to the control device 100 will be described with reference to Fig. 1.

[0083] The control device 100 includes a ROM 102 storing programs for executing various controls described later of the sewing machine 10 and various set data, a CPU 101 which executes various programs stored in the ROM 102, a RAM 103 which becomes a work area for temporarily storing data when executing programs of the CPU 101, an EEPROM 104 for storing various data the settings of which are changeable and predetermined programs, a drive circuit 105 of the motor 1 described above, an operation panel 109 for inputting various commands and settings into the sewing machine, an interface circuit 106 of the operation panel 109, a thread cutting drive circuit 107 of the above-described thread cutting solenoid 56, and a pedal sensor 108 provided in a pedal to input sewing start, interruption, and thread cutting execution, etc., and detect a pedal operating position.

[0084] For the pedal described above, a neutral position at which the pedal is positioned when it is not operated is set, and with reference to the neutral position, a toe-side (front-side) pedaling operation (forward pedaling) and a heel-side (rear-side) pedaling operation (backward pedaling) are possible.

[0085] On the output shaft of the motor 1, an encoder 14 which outputs a pulse in increments of a micro angle

is provided, and on the main shaft which is driven to rotate by the motor 1, a needle position detector 15 which outputs a signal at a predetermined angle is provided. These are connected to the CPU 101, and from outputs from these, the CPU 101 can always detect the rotation angle of the main shaft (main shaft angle). That is, these function as "position detecting means."

[0086] Sewing Control

[0087] The control device 100 detects an input operation into the pedal from the pedal sensor 108, and executes sewing control corresponding to the input operation.

[0088] Specifically, when a forward pedaling operation is performed, according to detection by the pedal sensor 108, the motor 1 is started, and a sewing operation by rotational driving of the main shaft at a speed corresponding to the forward pedaling amount is performed, and when the pedal is returned to the neutral position from the sewing operation state, an operation to stop the motor 1 at the lower stop position that is a main shaft angle at which the needle bar bottom dead center is passed through and the hook of the shuttle starts capturing a sewing thread is performed.

[0089] When a backward pedaling operation is performed after the pedal is returned to the neutral position, first cutting control is performed, and when backward pedaling is performed directly from the forward pedaling state without stopping at the neutral position, second cutting control is performed. The first and second cutting controls constitute an operation timing determining means.

[0090] Next, sewing control in which the CPU 101 executes a sewing control program stored in the ROM 102 will be described with reference to the flowchart shown in Fig. 7.

[0091] In the sewing possible state of the sewing machine 10, detection of a forward pedaling operation is performed by the pedal sensor 108 (Step S11), and when forward pedaling is performed, at a rotation speed corresponding to the pedaling amount, the motor 1 is driven to rotate, and sewing is started (Step S12).

[0092] During sewing, it is detected whether the pedal has been operated to the neutral position (Step S 13), and when an operation to the neutral position is detected, the motor 1 is stopped so that the main shaft stops at the lower stop position (Step S 14).

[0093] Specifically, when an operation to the neutral position is detected, the CPU 101 decelerates the motor 1, and after waiting for detection of the main shaft angle showing the lower stop position from outputs of the needle position detector 15 and the encoder 14, the CPU 101 stops the motor 1.

[0094] Then, detection of forward pedaling is performed in the stopped state of the motor 1 (Step S15), and when forward pedaling is detected, the process is returned to Step S12 and the motor 1 is driven to continue sewing again.

[0095] When forward pedaling is not detected, detection of backward pedaling is performed (Step S16), and when backward pedaling is not detected, the process is returned to Step S 15 and turns to a forward pedaling detecting state. On the other hand, when backward pedaling is detected at Step S16, the CPU 101 executes the first cutting control (Step S 17), and then ends sewing.

[0096] On the other hand, in Step S 13, when an operation to the neutral position is not detected, it is detected whether a backward pedaling operation has been performed directly after a forward pedaling state (Step S 18).

[0097] When the backward pedaling operation is not performed, the process returns to Step S 13 and performs detection of the neutral position again, and when a backward pedaling operation is performed, the CPU 101 performs second cutting control (Step S19), and then ends sewing.

[0098] First Cutting Control

[0099] Next, the first cutting control to be performed by the CPU 101 according to a first cutting control program stored in the ROM 102 will be described. As shown in Fig. 8, the first cutting control will be described by assuming that when the main shaft angle is 0 degrees, the needle bar is positioned at the top dead center, and when the main shaft angle is 180 degrees, the needle bar is positioned at the bottom dead center.

[0100] In the first cutting control, in the state where the motor 1 is stopped at the lower stop position, by a backward pedaling operation, actuation of the thread cutting solenoid 56 is started and the roller 52 is made to enter and engage with the cam groove 51a of the thread cutting cam 51, and after waiting for elapse of a predetermined delay time (waiting time) from the start of driving of the thread cutting solenoid 56, the motor 1 is started to perform thread cutting.

[0101] The thread cutting solenoid 56 has a time lag from reception of a driving start command to the actual start of driving due to influences of a load, etc., and further, the roller 52 vibrates due to reaction when it is inserted in the cam groove 51a, so that the engagement (joining) is completed only after the vibration stops. Specifically, from the start of driving of the thread cutting solenoid 56 to completion, the above-described time lag and the time until the vibration stops are taken.

[0102] When the motor 1 stops the main shaft at the lower stop position, the actual stop position of the main shaft fluctuates depending on various conditions, and varies in the range of the rotation phase from 215 to 250 degrees of the main shaft (lower stop section).

[0103] On the other hand, the roller 52 of the thread cutting drive mechanism 50 can be inserted in the cam groove 51a only in the non-displaced section of the cam groove 51a of the thread cutting cam 51, and in the displacement section (cam operation section) of the cam groove 51a, the position of the cam groove 51a deviates with respect to the advancing and retreating direction of the roller 52, and accordingly, the roller 52 cannot be inserted in the cam groove 51a. Therefore, before reaching the displacement section of the cam groove 51a by

restart of driving of the motor 1, the engagement of the roller 52 in the cam groove 51a by the thread cutting solenoid 56 must be completed.

[0104] Therefore, when the motor 1 is stopped at the lower stop position, if the actual stop position deviates to the displacement section side, that is, for example, when it is stopped at 250 degrees, there is a possibility that the roller 52 cannot be engaged with the cam groove.

[0105] The rotation speed of the motor 1 when cutting a thread (thread cutting rotation speed v1) can be optionally set in the range from 160 to 680 rpm from the operation panel 109 (speed setting means). The set value is stored in the EEPROM 104, and read out when performing the first cutting control.

[0106] When the thread cutting rotation speed is set to be high (for example, 680 rpm), the thread cutting cam 51 starts at a high speed, so that the operation speed of the thread cutting solenoid 56 cannot catch up with the speed of the thread cutting cam 51, and the engagement of the roller 52 with the cam groove 51a may not be completed in time.

[0107] Therefore, in this first cutting control, the delay time (waiting time) from the start of driving of the thread cutting solenoid 56 to the thread cutting drive of the motor 1 is adjusted.

[0108] Further, the table data shown in Fig. 9 using the lower stop angle θ1 which is a stop position of the main shaft and the value of the thread cutting rotation speed v1 as parameters are stored in advance in the ROM 102 or the EEPROM 104.

[0109] Specifically, in the first cutting control, the CPU 101 specifies a proper delay time from the stored table according to the lower stop angle θ1 which is the actual stop position of the main shaft detected from outputs of the encoder 14 and the needle position detector 15 and the value of the thread cutting rotation speed v1. Then, by setting a difference corresponding to this delay time, the thread cutting solenoid 52 and the sewing machine 1 are driven, the engaging operation of the roller 52 is executed without excess and deficiency, and thread cutting is performed.

[0110] In the table described above, the values are set so that the closer the lower stop angle θ1 to the cam operation section, the longer the delay time (ms), and the higher the thread cutting rotation speed v1, the longer the delay time. In the table, the blank column indicates a delay time of 0 ms.

[0111] The table may be prepared by repeating an actual measurement test and acquiring proper delay times according to two parameters, or a time from each main shaft angle in the lower stop section when the motor 1 is driven at each thread cutting rotation speed to reach to the cam operation section is calculated, and a proper delay time is acquired by calculation.

[0112] Without limiting to this case where a delay time is specified by referring to the table, a delay time may be calculated by the above-described calculation each time of the first cutting control.

[0113] The first cutting control program in which the CPU 101 executes the first cutting control program will be described with reference to the flowchart shown in Fig. 10.

[0114] First, in a state where the motor 1 has already stopped in the lower stop section, an actual lower stop angle θ1 is detected from outputs of the encoder 14 and the needle position detector 15 (Step S31), and a set value of the thread cutting rotation speed v1 stored in the EEPROM 104 is read (Step S32).

[0115] Further, by referring to the table of Fig. 9, a delay time T is determined from the lower stop angle θ1 and the thread cutting rotation speed v1 (Step S33).

[0116] Next, the thread cutting solenoid 56 is turned on (Step S34), and an elapsed time t from driving is clocked (step S35). Then, it is judged whether the elapsed time t has exceeded the delay time T (Step S36), and when the delay time T elapses, the motor 1 is driven at the thread cutting rotation speed v1 (Step S37).

[0117] According to turning-on of the thread cutting solenoid 56, the shuttle presser 13 is actuated via the joint link member 63, and rotation of the bobbin housed inside the inner shuttle of the shuttle mechanism is blocked.

[0118] Further, the thread tension releasing portion 55b of the clutch member 55 draws the release wire 12 to release the upper thread tensioning device.

[0119] The contact portion 55a of the clutch member 55 presses the position restricting projection 53d of the knife drive arm 53 leftward and moves it to the outside of the recess 57a, and makes the roller 52 enter the inside of the cam groove 51a of the thread cutting cam 51. At this time, the non-displaced section of the cam groove 51a has come to the entering position of the roller 52, so that the roller 52 smoothly enters and is engaged with the inside of the cam groove 51a. The second stopper 60 is adjusted in advance.

[0120] Then, by driving the motor 1, the thread cutting cam 51 rotates according to rotation of the up-down feed shaft 22 interlocking with the main shaft, and when the roller 52 comes to the cam operation section, the knife drive arm 53 is turned counterclockwise in Fig. 4. Accordingly, via the first link body 58, the knife position adjuster 59 is rotated clockwise in Fig. 2.

[0121] As a result, the joining end portion of the actuation arm 34 of the thread cutting mechanism 30 turns rightward in Fig. 3 via the second link body 61 and turns the movable knife 31 so that the movable knife 31 retreats from the standby position. Specifically, the movable knife 31 moves from the position shown by the alternate long and two short dashed line to the position shown by the solid line in Fig. 3, and accordingly, it passes through the stitch point and selects a thread to be cut.

[0122] Further, when the thread cutting cam 51 rotates, the roller moves to return to the second half section after the displacement section, that is, to the non-displaced section, and as a result, the knife drive arm 53 turns clockwise in Fig. 4, and the knife position adjuster 59 is turned counterclockwise in Fig. 2 via the first link body 58.

[0123] As a result, the joining end portion of the actuation arm 34 of the thread cutting mechanism 30 turns leftward in Fig. 3 via the second link body 61 and turns the movable knife 31 so that the movable knife 31 advances from the retreated position to the standby position, and the movable knife 31 is moved from the movable knife position shown by the solid line to the position shown by the alternate long and two short dashed line in Fig. 3. Accordingly, the movable knife 31 passes through the stitch point again, and further, carries a thread to be cut to the edge portion 33a of the fixed knife 33 and cuts it.

[0124] During this operation, it is judged whether the rotation angle θ2 of the main shaft has reached a set main shaft angle (for example, 53 degrees) which is the upper stop position from outputs of the encoder 14 and the needle position detector 15 (Step S38). When the angle reaches the set main shaft angle, the motor 1 is stopped (Step S39), and driving of the thread cutting solenoid 56 is stopped (Step S40). Accordingly, the first cutting control is ended.

[0125] Second Cutting Control

[0126] Next, second cutting control in which the CPU 101 executes a second cutting control program stored in the ROM 102 will be described with reference to Fig. 8, Fig. 11, and Fig. 12.

[0127] In the second cutting control, according to a backward pedaling operation during a sewing operation with a forward pedaling operation, a solenoid operation angle θ3 which is a main shaft angle at which driving of the thread cutting solenoid 56 is started is determined according to a thread cutting rotation speed v2 which is a rotation speed when performing thread cutting of the motor 1 set in advance, and at this solenoid operation angle θ3, driving of the thread cutting solenoid 56 is started to perform thread cutting. Accordingly, when the thread cutting rotation speed v2 is set to any value, the main shaft phase in which the engagement of the roller 52 with the cam groove 51a is completed can be set to a fixed target angle A (refer to Fig. 8, for example, 230 degrees).

[0128] In the second cutting control, the rotation speed (thread cutting rotation speed v2) of the motor 1 in the thread cutting operation can be optionally set in the range from 180 to 500 rpm from the operation panel 109 (speed setting means), and the set value is stored in the EEPROM 104, and read out when performing thread cutting.

[0129] A time necessary from the start to completion of the operation of the thread cutting solenoid 56 is fixed, however, the rotation speed (thread cutting rotation speed v2) of the motor 1 can be set to an arbitrary value, so that when the timing (main shaft angle) to start driving of the thread cutting solenoid 56 is fixed, the timing of completion of the engagement of the roller 52 by the thread cutting solenoid 56 varies according to the thread cutting rotation speed v2 of the motor 1.

[0130] Specifically, when the thread cutting rotation speed v2 of the motor 1 is set to be high, the thread cutting solenoid 56 is actuated and the timing of completion of the engagement of the roller 52 with the cam groove 51a delays, and the engagement may not be completed before the above-described cam operation section.

[0131] On the other hand, when the thread cutting solenoid 56 is actuated for thread cutting as described above, in conjunction with this, the shuttle presser 13 performs a shuttle pressing operation. When the thread cutting rotation speed v2 of the motor 1 is set to be low, the shuttle pressing operation of the shuttle presser 13 by the thread cutting solenoid 56 which regularly starts to operate is performed in an earlier rotation phase of the main shaft, and the shuttle presser 13 may interfere (come into contact) with the sewing needle which has not sufficiently moved up. The main shaft angle at which the shuttle presser 13 is likely to interfere (come into contact) with the sewing needle is from 155 degrees to 205 degrees.

[0132] Therefore, in this second cutting control, according to the set value of the thread cutting rotation speed v2, the timing (main shaft angle) to start driving of the thread cutting solenoid 56 is changed and adjusted, and when the thread cutting rotation speed v2 is high, driving of the thread cutting solenoid 56 is started at an earlier main shaft angle, and when the thread cutting rotation speed v2 is low, driving of the thread cutting solenoid 56 is started at a later main shaft angle.

[0133] Accordingly, when the set rotation speed v2 is set to any value, the timing of completion of the engagement of the roller 52 by the thread cutting solenoid 56 or the operation timing of the shuttle presser 13 becomes a fixed target timing.

[0134] The target timing is preferably set in a first predetermined section (220 degrees to 260 degrees) from a main shaft angle (non-contact section at 205 degrees) at which the shuttle presser 13 does not come into contact with the sewing needle to a main shaft angle (285 degrees) at which the cam operation section starts.

[0135] The shuttle presser 13 is energized by a spring not shown, so that when the bobbin is pressed by the shuttle presser 13, dumping (vibration) occurs. Due to this dumping, a gap occurs between the shuttle presser 13 and the bobbin, and when the thread is pulled up, the thread may not be latched on the shuttle presser 13 and the thread remaining length on the needle side may become short.

[0136] In order to prevent this, the target timing is more preferably set in a second predetermined section (220 to 240 degrees) by considering the time until dumping stops.

[0137] It is still more preferable that the engagement of the roller 52 by the thread cutting solenoid 56 is completed at a predetermined main shaft angle (for example, 230 degrees) intermediate in the second predetermined section.

[0138] The timing (main shaft angle) to start driving of the thread cutting solenoid 56 with respect to the thread cutting rotation speed v2 of the motor 1 is determined in

the table of Fig. 11, and the table is prepared in advance in the EEPROM 104 or ROM 102.

[0139] In the table, the timing to start driving of the thread cutting solenoid 56 becomes later as the thread cutting rotation speed v2 becomes lower.

[0140] The above-described table may be prepared by repeating an actual measurement test and acquiring a proper driving start timing of the thread cutting solenoid 56 with respect to the thread cutting rotation speed v2, or a time to reach to the target position A when the motor 1 is driven at each thread cutting rotation speed v2 is calculated, and a proper driving start timing of the thread cutting solenoid 56 is acquired by calculation.

[0141] Without limiting to this case where the delay time is specified by referring to the table, the delay time may be obtained by the above-described calculation each time of the second cutting control.

[0142] In the flowchart shown in Fig. 12, the second cutting control in which the CPU 101 executes the second cutting control program will be described.

[0143] During driving of the sewing machine by forward pedaling, when backward pedaling is performed at Step S 18 (Fig. 7), the set value of the thread cutting rotation speed v2 stored in the EEPROM 104 is read out (Step S61), and an operation to decelerate the motor 1 to the readout thread cutting rotation speed v2 is performed (Step S62).

[0144] Further, by referring to the table shown in Fig. 11, a solenoid operation rotation angle θ3 corresponding to the thread cutting rotation speed v2 is determined (Step S63). Specifically, the CPU 101 functions as "operation angle determining means" in Step S63.

[0145] Then, it is judged whether the current main shaft angle θ has reached the solenoid operation angle θ3 from outputs of the encoder 14 and the needle position detector 15 (Step S64), and when it reaches θ3, the thread cutting solenoid 56 is driven (Step S65). Specifically, the CPU 101 functions as "operation angle judging means" in Step S64, and functions as "solenoid driving means" in Step S65.

[0146] According to driving of the thread cutting solenoid 56, the thread cutting mechanism 30 and the thread cutting drive mechanism 50 operate in the same manner as in the first cutting control to execute sewing thread cutting.

[0147] Thereafter, it is judged whether the current upper stop angle has reached the set main shaft angle (for example, 53 degrees) of the upper stop position θ2 from outputs of the encoder 14 and the needle position detector 15 (Step S66), and when it reaches the set main shaft angle, the motor 1 is stopped (Step S67), and the thread cutting solenoid 56 is turned off (Step S68). Accordingly, the second cutting control is ended.

[0148] Advantageous Effects

[0149] In the sewing machine 10, in the first cutting control, according to a delay time T determined according to the lower stop angle θ1 and the thread cutting rotation speed v1, control to delay the start of driving of the motor 1 from the start (start of driving) of the thread cutting solenoid 56 is performed, so that failures in which the cam operation section (displacement section) of the thread cutting cam 51 is reached before the engagement of the roller 52 in the cam groove 51a is completed can be further avoided or reduced, and additionally, the restarting timing of the motor 1 is adjusted according to the situation, so that excessive delay can also be avoided, and the joining operation of the cam follower can be made proper.

[0150] In the sewing machine 10, in the second cutting control, driving of the thread cutting solenoid 56 is started according to the solenoid operation angle θ3 determined according to the thread cutting rotation speed v2, so that when the thread cutting rotation speed v2 is set to any value, the engagement of the roller 52 by the thread cutting solenoid 56 can be completed at the fixed target position A, and both of interference between the sewing needle and the shuttle presser 13 due to excessively early driving of the thread cutting solenoid 56 and delay of the engagement of the roller 52 due to excessively late driving of the thread cutting solenoid 56 can be effectively avoided, and a stable thread cutting operation can be performed.

[0151] Modifications

[0152] In the sewing machine 10, a cam mechanism structured so that the roller 52 moves along the direction of the rotation shaft of the thread cutting cam 51 and engages with the cam groove 51a is adopted, however, for example, a cam mechanism structured so that, for example, a section as a part of the cam groove opens toward the outer side in the rotation radial direction and the roller moves toward the inner side in the rotation radial direction from the opening and engages with the cam groove can also be adopted. In this case, the cam mechanism is not structured like the cam mechanism described above in which the roller 52 is allowed to engage with the cam groove only when the cam groove is in the non-displaced section, however, the roller is allowed to engage with the cam groove only in the section with the opening, so that the rotational driving start timing of the motor 1 with respect to the start of driving of the thread cutting solenoid 56 is still an important point, and as in the example described above, by properly adjusting the waiting time based on the detected main shaft angle when the motor 1 is stopped at the lower stop position and the restart driving speed of the motor 1, the roller joining operation to the thread cutting cam can be made proper.

[0153] In the first cutting control, the delay time T is determined according to both of the lower stop angle θ1 and the thread cutting rotation speed v1, however, the delay time may be determined according to either one of the lower stop angle θ1and the thread cutting rotation speed v1. To determine the delay time according to the lower stop angle θ1, it is also possible that instead of making the thread cutting rotation speed v1 changeable and adjustable to an arbitrary value, cutting may be per-

formed always at a fixed rotation speed.

[0154] In the first cutting control, control to determine a delay time T based on a lower stop angle θ1 and a thread cutting rotation speed v1 is performed, however, it is also possible that instead of making the thread cutting rotation speed v1 optionally changeable and adjustable, the control device 100 determines a proper thread cutting rotation speed v1 according to a detected lower stop angle θ1, restarts driving of the motor 1 at this thread cutting rotation speed v1, and performs sewing thread cutting control.

[0155] In this case, preferably, in the EEPROM 104 of the control device 100, a table determining proper thread cutting set rotation speeds V1to V12 with respect to the respective values of the lower stop angle θ1 to be detected is prepared in advance (refer to Fig. 13), and by referring to this table, the thread cutting rotation speed v1 is determined. Without limiting to the use of the table, a thread cutting rotation speed v1 which does not cause delay of completion of the engagement of the roller 52 may be calculated according to a rotation angle from a lower stop angle θ1 to reach to the cam operation section based on a time necessary to complete the engagement of the roller 52 from the start of driving of the thread cutting solenoid 56 and the lower stop angle θ1.

[0156] Another example of the first cutting control obtained by excluding the delay from the above-described example will be described based on the flowchart of Fig. 14.

[0157] First, in the state where the motor 1 has already stopped in the lower stop section, an actual lower stop angle θ1 is detected from outputs of the encoder 14 and the needle position detector 15 (Step S81). Then, by referring to the table shown in Fig. 13, a thread cutting rotation speed v3 corresponding to the lower stop angle θ1 is determined (Step S82).

[0158] Then, the thread cutting solenoid 56 is turned on (Step S83), and without providing the above-described delay time T, the motor 1 is driven at the thread cutting rotation speed v3 (Step S84).

[0159] Accordingly, sewing thread cutting is executed.

[0160] Thereafter, it is judged whether the current upper stop angle θ2 has reached a set main shaft angle (for example, 53 degrees) of the upper stop position θ2 from outputs of the encoder 14 and the needle position detector 15 (Step S85). When the angle reaches the set main shaft angle, the motor 1 is stopped (Step S86), and the thread cutting solenoid 56 is turned off (Step S87). Accordingly, the first cutting control is ended.

[0161] A solenoid is shown as an example of the thread cutting actuator, however, other driving devices such as an air-driven system or motor can also be used.

Claims

1. A sewing machine (10) comprising:

a main shaft which is rotated by a motor (1) to move a sewing needle up and down;

a position detecting means (14, 15) for detecting a rotation angle of the main shaft as a main shaft angle;

a thread cutting mechanism (30) having a movable knife (31) configured to capture a sewing thread and to cut the sewing thread;

a thread cutting cam (51) having a cam groove (51a) formed along a circumferential direction of the thread cutting cam (51) and rotating in synchronization with the rotation of the main shaft;

a cam follower (52) configured to engage with and disengage from the cam groove (51a) of the thread cutting cam (51) and to move the movable knife (31) in accordance with the cam groove (51a) while engaging with the cam groove (51a);

a thread cutting actuator (56) which switches the cam follower (52) between an engaging position and a disengaging position with respect to the thread cutting cam (51); and

a control means (100) for controlling the thread cutting actuator (56) and the motor (1),

characterized in that the control means (100) comprises an operation timing determining means for determining an operation start timing of the thread cutting actuator (56) or the motor (1), based on at least one of a rotation speed (v1, v2) of the motor (1) for a thread cutting operation and a main shaft stopped angle (θ1) at which the main shaft has stopped immediately before the thread cutting operation.

2. The sewing machine (10) according to claim 1, further comprising a speed setting means (109) for setting the rotation speed (v1, v2) of the motor (1) for the thread cutting operation,

wherein the operation timing determining means determines an operation angle (θ3) as the operation start timing of the thread cutting actuator (56), based on the rotation speed (v2) set by the speed setting means (109), such that the operation of the thread cutting actuator (56) to switch the cam follower (52) to the engaging position is completed at a target main shaft angle (A), and starts the operation the thread cutting actuator (56) when the main shaft angle reaches the operation angle (θ3).

3. The sewing machine (10) according to claim 2, further comprising a shuttle presser (13) configured to be butted against a bobbin inside a shuttle in conjunction with the cam follower (52) by the operation of the thread cutting actuator (56) to stop a rotation of the bobbin,

wherein the target main shaft angle (A), at which the operation of the thread cutting actuator (56) to switch the cam follower (52) to the engaging position is com-

pleted, is set within an range from a main shaft angle, at which the shuttle presser (13) and the sewing needle become free from interfering with each other, to a main shaft angle, at which the switching of the cam follower (52) to the engaging position becomes inoperable.

4. The sewing machine (10) according to claim 2, wherein the operation timing determining means comprises:

an operation angle determining means for determining the operation angle (θ3) based on the rotation speed (v2) set by the speed setting means (109);
an operation angle judging means for judging whether the main shaft angle has reached the operation angle (θ3); and
an actuator driving means for driving the thread cutting actuator (56) when the operation angle judging means judges that the main shaft angle has reached the operation angle (θ3).

5. The sewing machine (10) according to any one of the preceding claims, wherein the operation timing determining means is activated in association with a backward pedaling operation of a pedal from a forward pedaling position.

6. The sewing machine (10) according to claim 1, wherein the control means (100) adjusts a waiting time (T) from the operation start of the thread cutting actuator (56) to the operation start of the motor (1), based on one of the rotation speed (v1) of the motor (1) for the thread cutting operation and the main shaft stopped angle (θ1).

7. The sewing machine (10) according to claim 1, wherein the control means (100) adjusts a waiting time (T) from the operation start of the thread cutting actuator (56) to the operation start of the motor (1), based on the rotation speed (v1) of the motor (1) for the thread cutting operation and the main shaft stopped angle (θ1).

8. The sewing machine (10) according to claim 6 or 7, wherein the control means (100) performs the thread cutting operation in association with a backward pedaling operation of a pedal from a neutral position.

FIG. 1

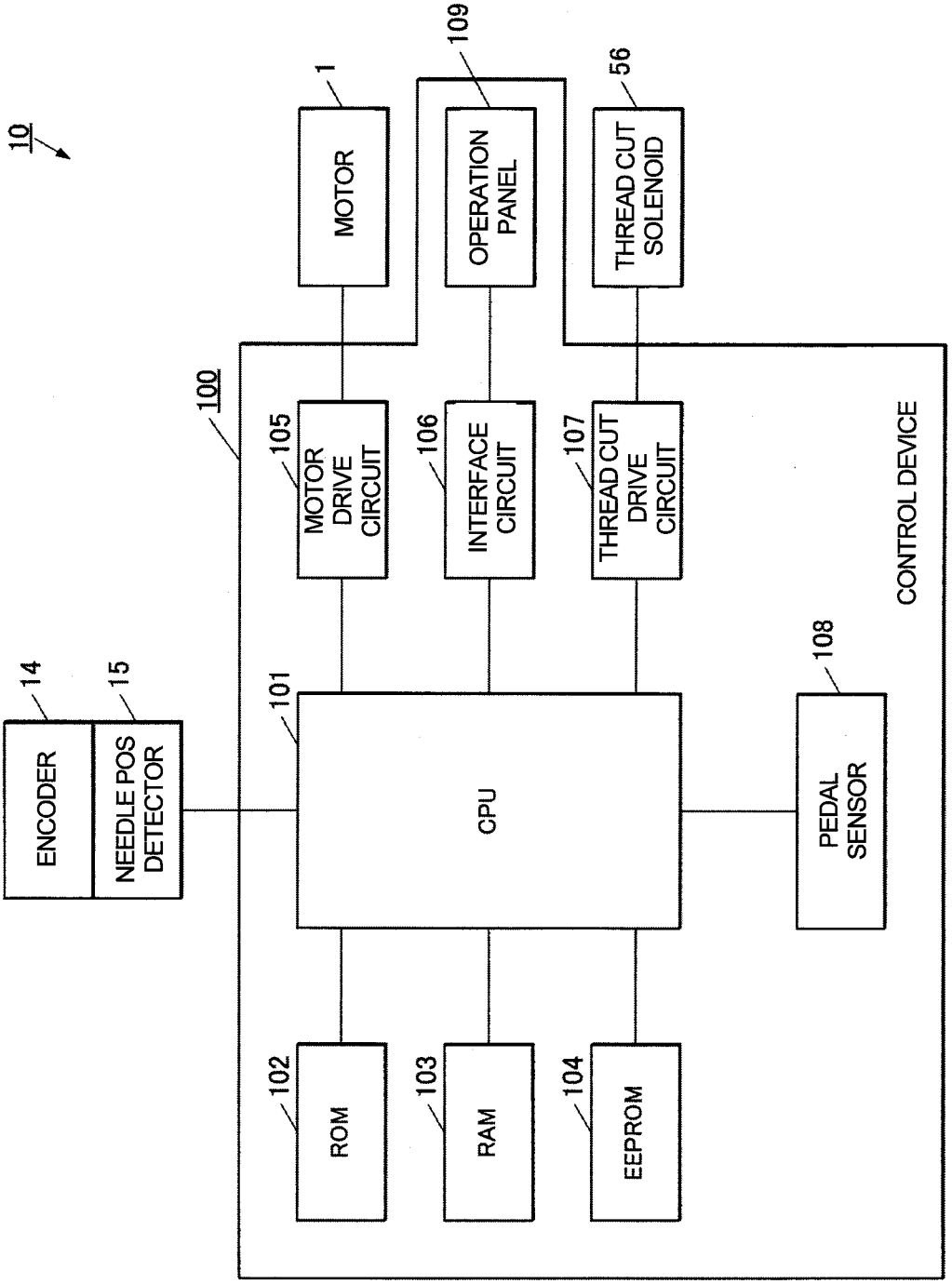

10
100
CONTROL DEVICE
MOTOR
1
OPERATION PANEL
109
THREAD CUT SOLENOID
56
MOTOR DRIVE CIRCUIT
105
INTERFACE CIRCUIT
106
THREAD CUT DRIVE CIRCUIT
107
ENCODER
14
NEEDLE POS DETECTOR
15
CPU
101
PEDAL SENSOR
108
ROM
102
RAM
103
EEPROM
104

FIG. 2

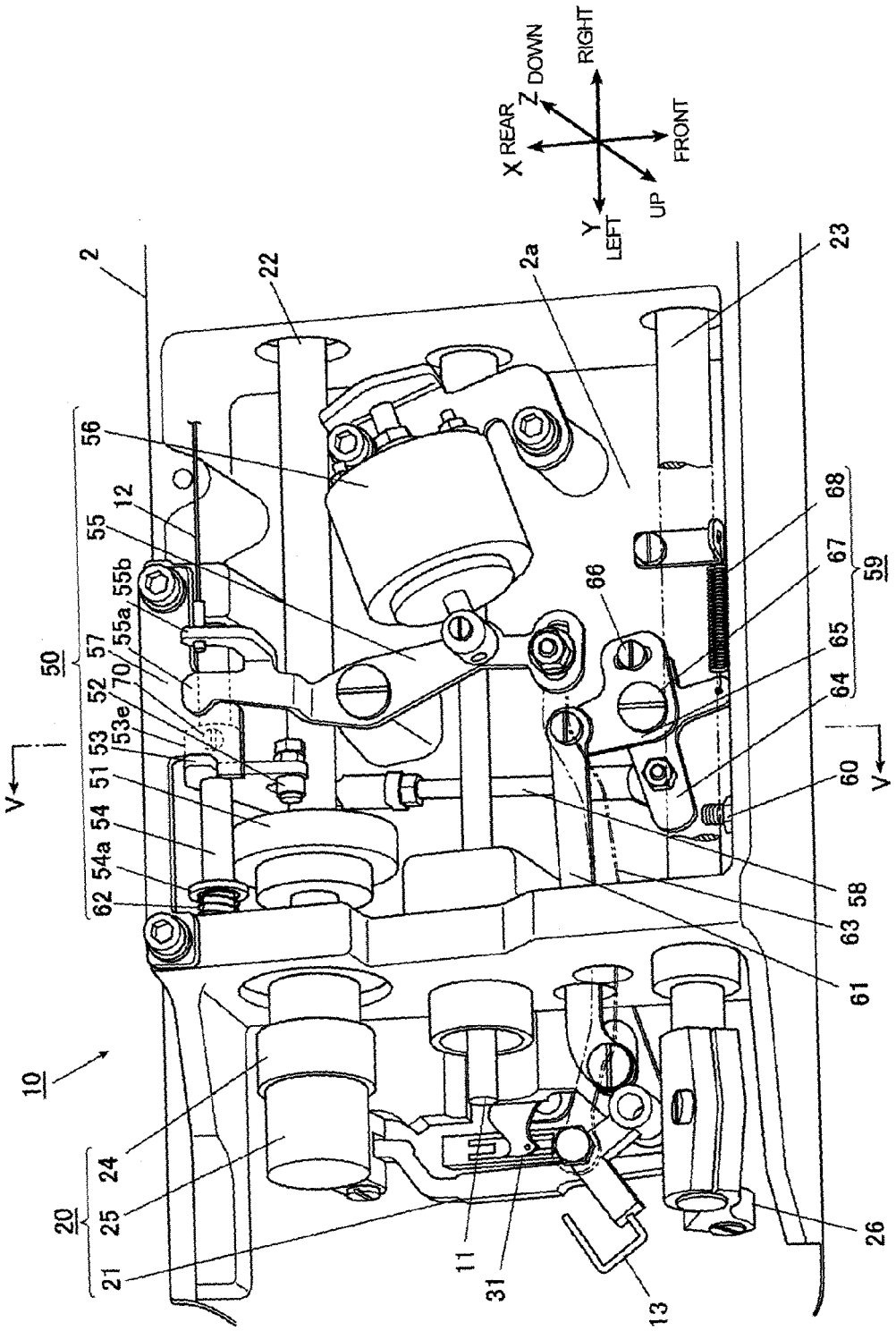

X REAR
Z DOWN
RIGHT
FRONT
Y LEFT
UP
2
22
2a
23
56
12
55
55b
55a
57
70
52
53e
53
51
54
54a
62
50
V
V
10
20
24
25
21
11
31
13
26
66
68
67
59
65
64
60
58
63
61

FIG. 3

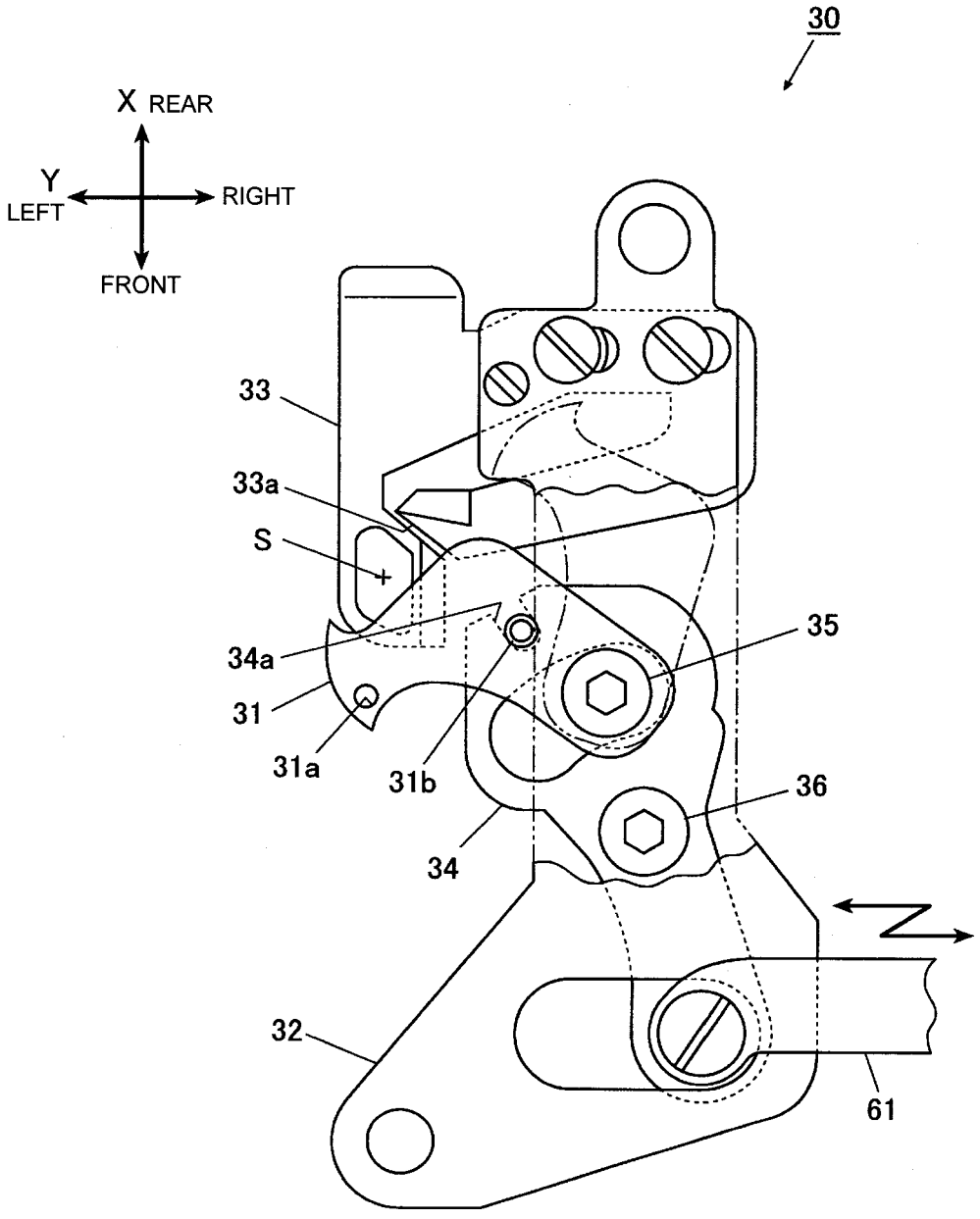

30
X REAR
Y
LEFT
RIGHT
FRONT
33
33a
S
34a
31
31a
31b
35
36
34
Z
32
61

FIG. 4

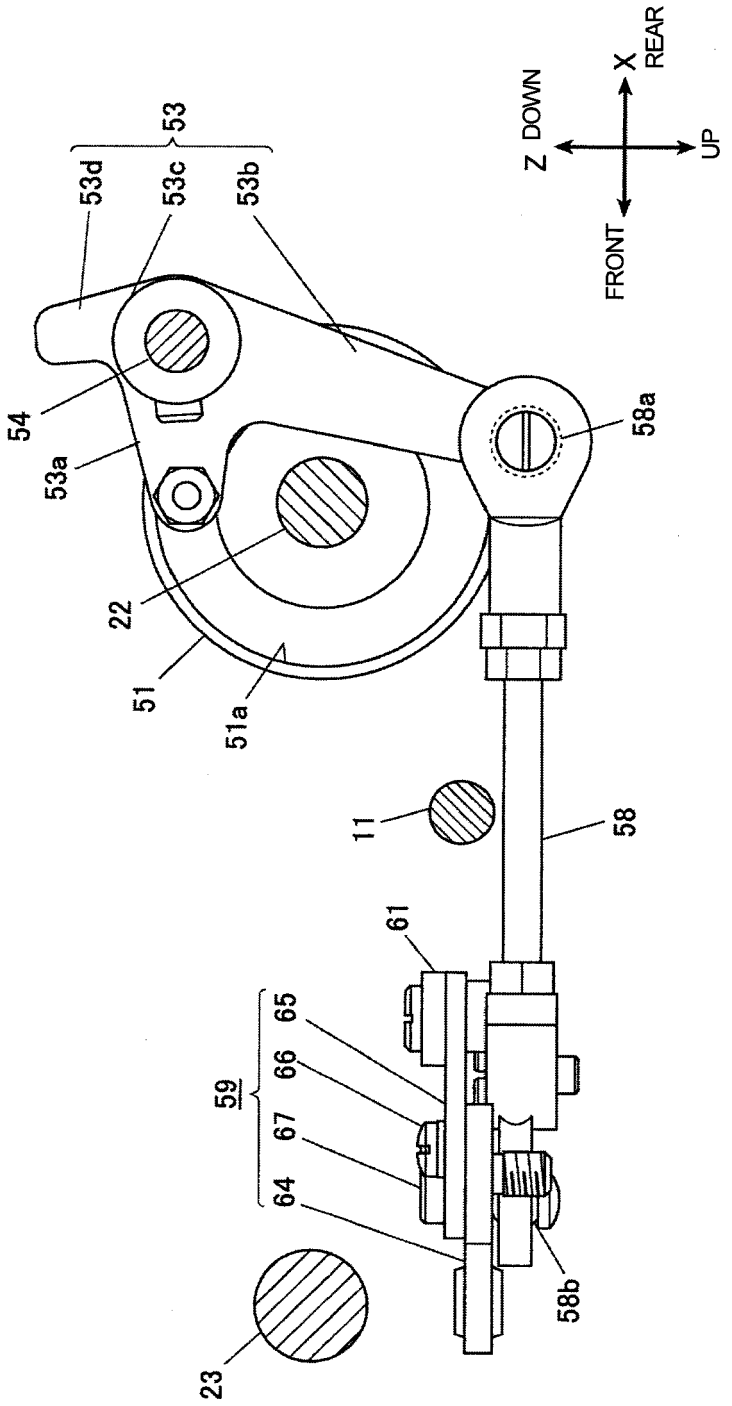

Z DOWN
X REAR
UP
FRONT
53
53d
53c
53b
54
53a
58a
22
51
51a
11
58
61
59
65
66
67
64
58b
23

FIG. 5

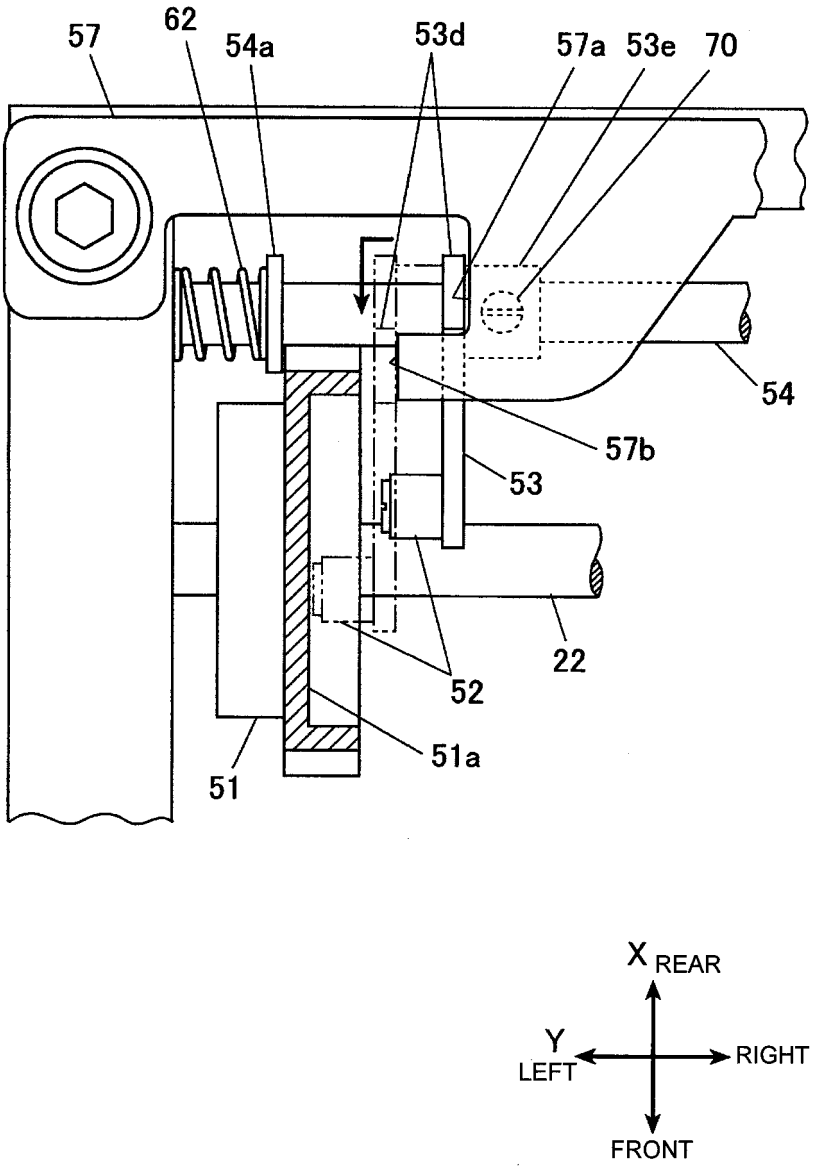

57
62
54a
53d
57a
53e
70
54
57b
53
22
52
51a
51
X REAR
Y
LEFT
RIGHT
FRONT

FIG. 6

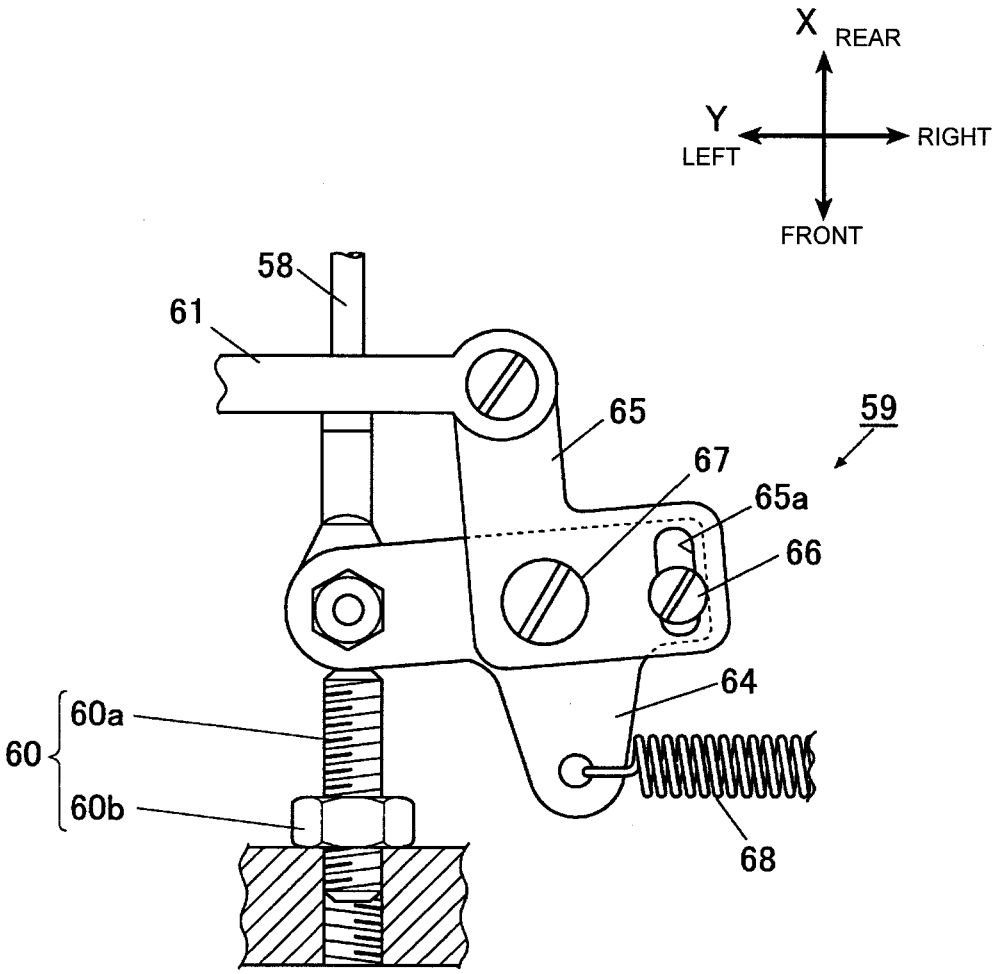


FIG. 7

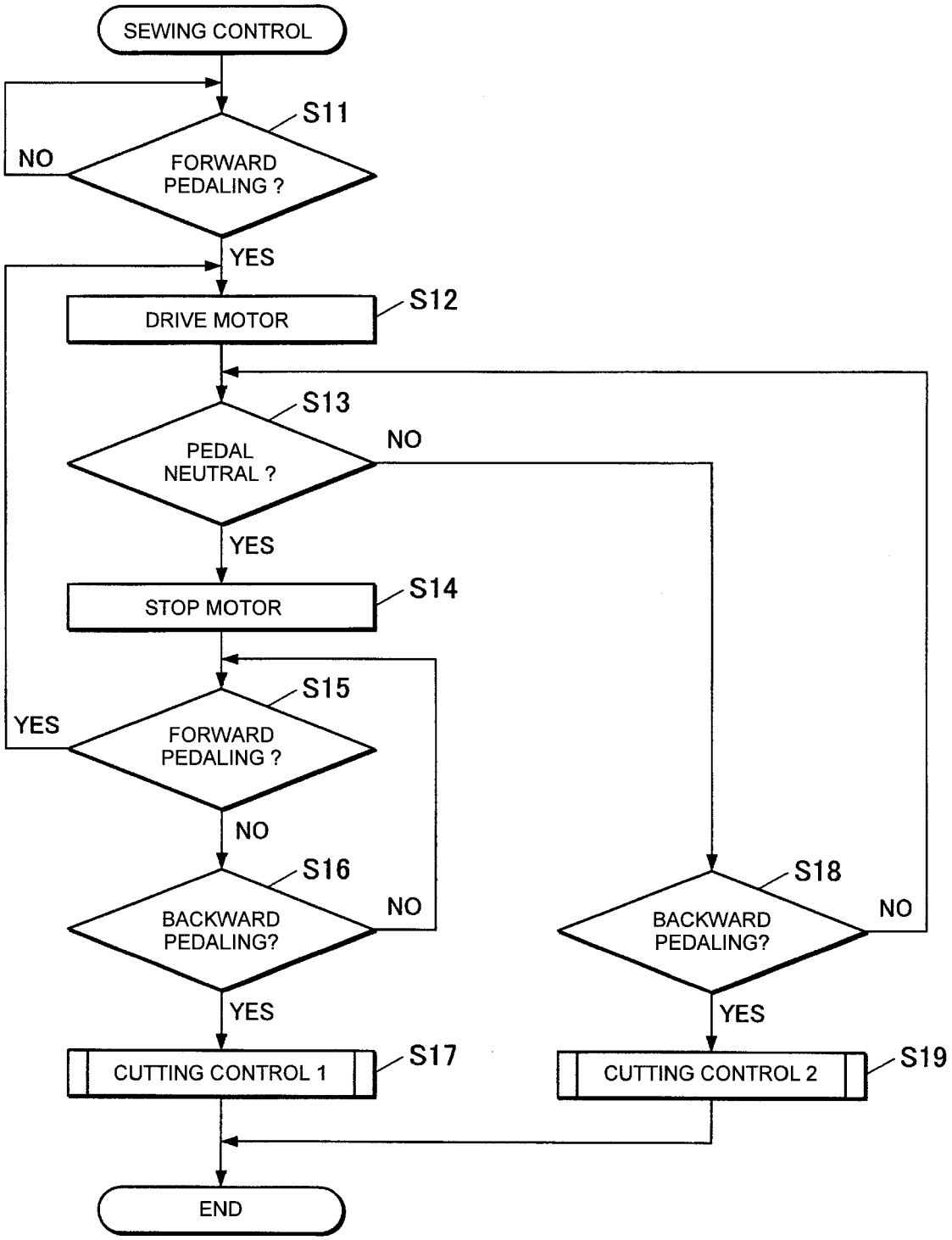

SEWING CONTROL
S11
FORWARD PEDALING ?
NO
YES
DRIVE MOTOR
S12
S13
PEDAL NEUTRAL ?
NO
YES
STOP MOTOR
S14
S15
FORWARD PEDALING ?
YES
NO
S16
BACKWARD PEDALING?
NO
YES
CUTTING CONTROL 1
S17
S18
BACKWARD PEDALING?
NO
YES
CUTTING CONTROL 2
S19
END

FIG. 8

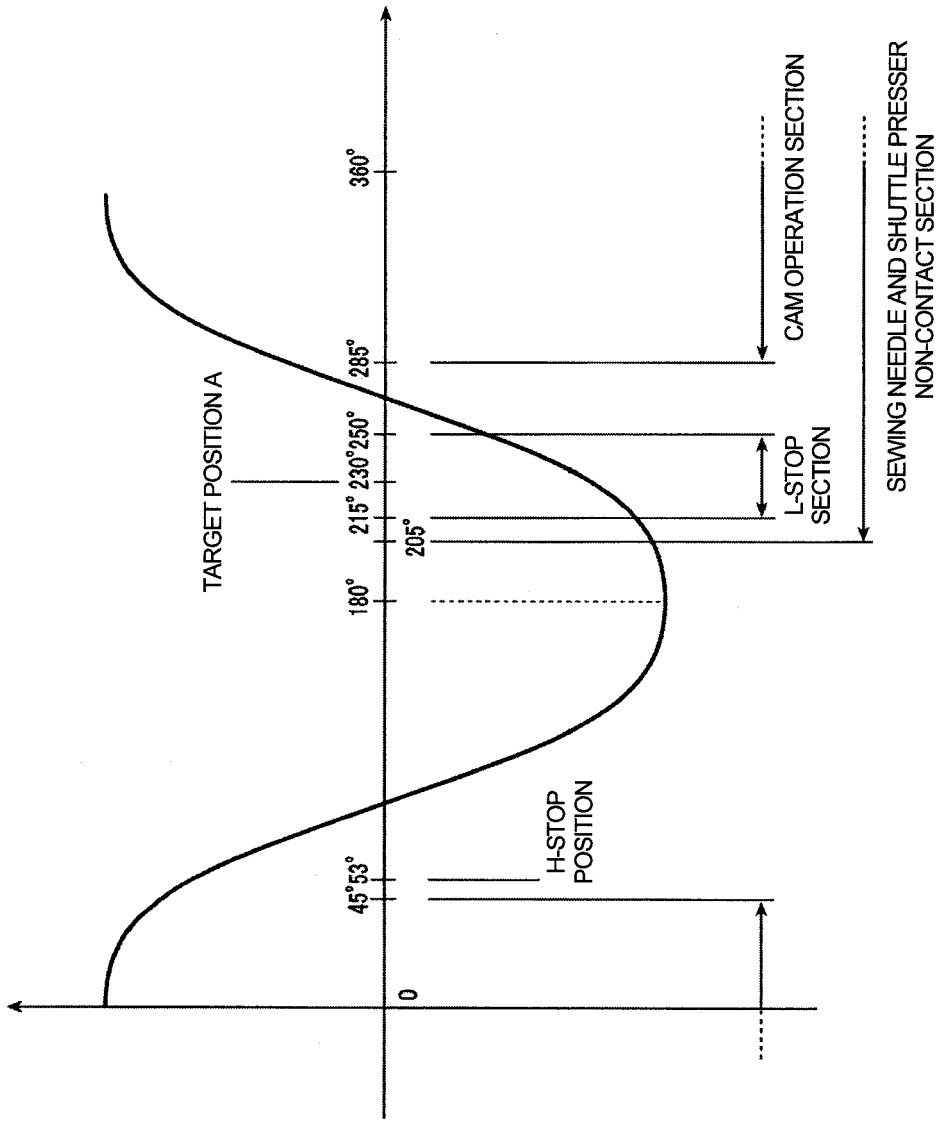
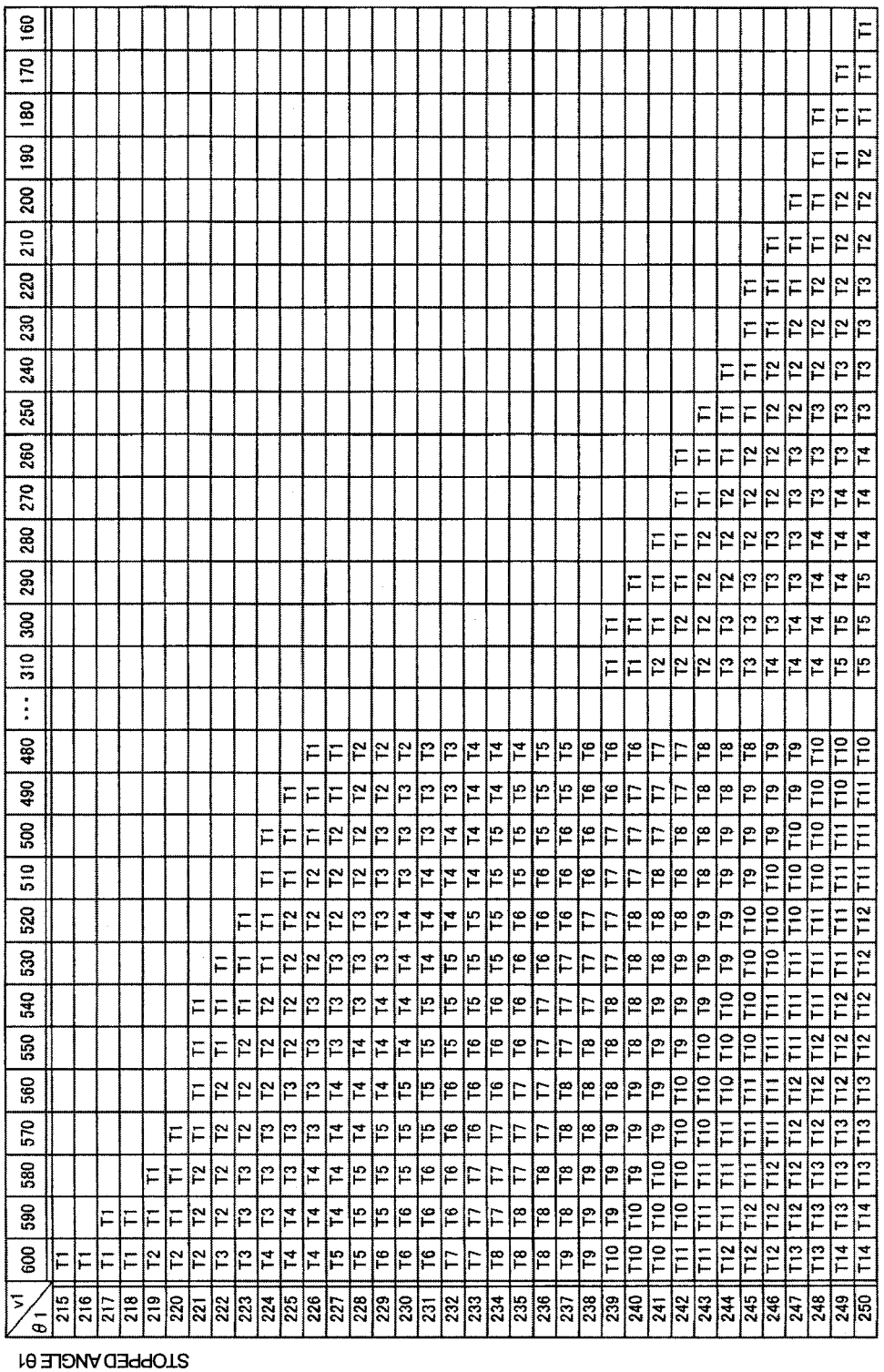

360°
285°
250°
230°
215°
205°
180°
TARGET POSITION A
CAM OPERATION SECTION
L-STOP SECTION
SEWING NEEDLE AND SHUTTLE PRESSER NON-CONTACT SECTION
45°
53°
H-STOP POSITION
0

FIG. 9



θ1 \ v1	600	590	580	570	560	550	540	530	520	510	500	490	480	...	310	300	290	280	270	260	250	240	230	220	210	200	190	180	170	160
215	T1																													
216	T1																													
217	T1	T1																												
218	T1	T1																												
219	T2	T1	T1																											
220	T2	T1	T1	T1																										
221	T2	T2	T2	T1	T1	T1	T1																							
222	T3	T2	T2	T2	T2	T1	T1	T1																						
223	T3	T3	T3	T2	T2	T2	T1	T1	T1	T1																				
224	T4	T3	T3	T3	T2	T2	T2	T1	T1	T1	T1																			
225	T4	T4	T3	T3	T3	T2	T2	T2	T2	T1	T1	T1																		
226	T4	T4	T4	T3	T3	T3	T3	T2	T2	T2	T2	T1	T1																	
227	T5	T4	T4	T4	T4	T3	T3	T3	T2	T2	T2	T1	T1																	
228	T5	T5	T5	T4	T4	T4	T3	T3	T3	T2	T2	T2	T2																	
229	T6	T5	T5	T5	T4	T4	T4	T4	T4	T3	T3	T2	T2																	
230	T6	T6	T5	T5	T5	T4	T4	T4	T4	T3	T3	T3	T2																	
231	T6	T6	T6	T5	T5	T5	T5	T4	T4	T4	T3	T3	T3																	
232	T7	T6	T6	T6	T6	T5	T5	T5	T4	T4	T4	T3	T3																	
233	T7	T7	T7	T6	T6	T6	T5	T5	T5	T4	T4	T4	T4																	
234	T8	T7	T7	T7	T6	T6	T6	T5	T5	T5	T5	T4	T4																	
235	T8	T8	T7	T7	T7	T6	T6	T6	T6	T5	T5	T5	T4																	
236	T8	T8	T8	T7	T7	T7	T7	T6	T6	T6	T5	T5	T5																	
237	T9	T8	T8	T8	T8	T7	T7	T7	T6	T6	T6	T5	T5																	
238	T9	T9	T9	T8	T8	T8	T7	T7	T7	T6	T6	T6	T6																	
239	T10	T9	T9	T9	T8	T8	T8	T7	T7	T7	T7	T6	T6		T1	T1														
240	T10	T10	T9	T9	T9	T8	T8	T8	T8	T7	T7	T7	T6		T1	T1	T1													
241	T10	T10	T10	T9	T9	T9	T9	T8	T8	T8	T7	T7	T7		T2	T1	T1	T1												
242	T11	T10	T10	T10	T9	T9	T9	T9	T8	T8	T8	T7	T7		T2	T2	T1	T1	T1											
243	T11	T11	T11	T10	T10	T9	T9	T9	T9	T8	T8	T8	T8		T2	T2	T2	T2	T1	T1	T1									
244	T12	T11	T11	T11	T10	T10	T10	T9	T9	T9	T9	T8	T8		T3	T3	T2	T2	T2	T1	T1	T1								
245	T12	T12	T11	T11	T11	T10	T10	T10	T10	T9	T9	T9	T8		T3	T3	T3	T2	T2	T2	T1	T1	T1	T1						
246	T12	T12	T12	T11	T11	T11	T11	T10	T10	T10	T9	T9	T9		T4	T3	T3	T3	T2	T2	T2	T2	T1	T1	T1					
247	T13	T12	T12	T12	T12	T11	T11	T11	T10	T10	T10	T9	T9		T4	T4	T3	T3	T3	T2	T2	T2	T2	T1	T1	T1				
248	T13	T13	T13	T12	T12	T12	T11	T11	T11	T10	T10	T10	T10		T4	T4	T4	T4	T3	T3	T3	T3	T2	T2	T2	T1	T1			
249	T14	T13	T13	T13	T12	T12	T12	T11	T11	T11	T11	T10	T10		T5	T5	T4	T4	T4	T3	T3	T3	T2	T2	T2	T2	T1	T1	T1	
250	T14	T14	T13	T13	T13	T12	T12	T12	T12	T11	T11	T11	T10		T5	T5	T5	T4	T4	T4	T3	T3	T3	T3	T3	T2	T2	T2	T1	T1

STOPPED ANGLE θ1

(msec)

FIG. 10

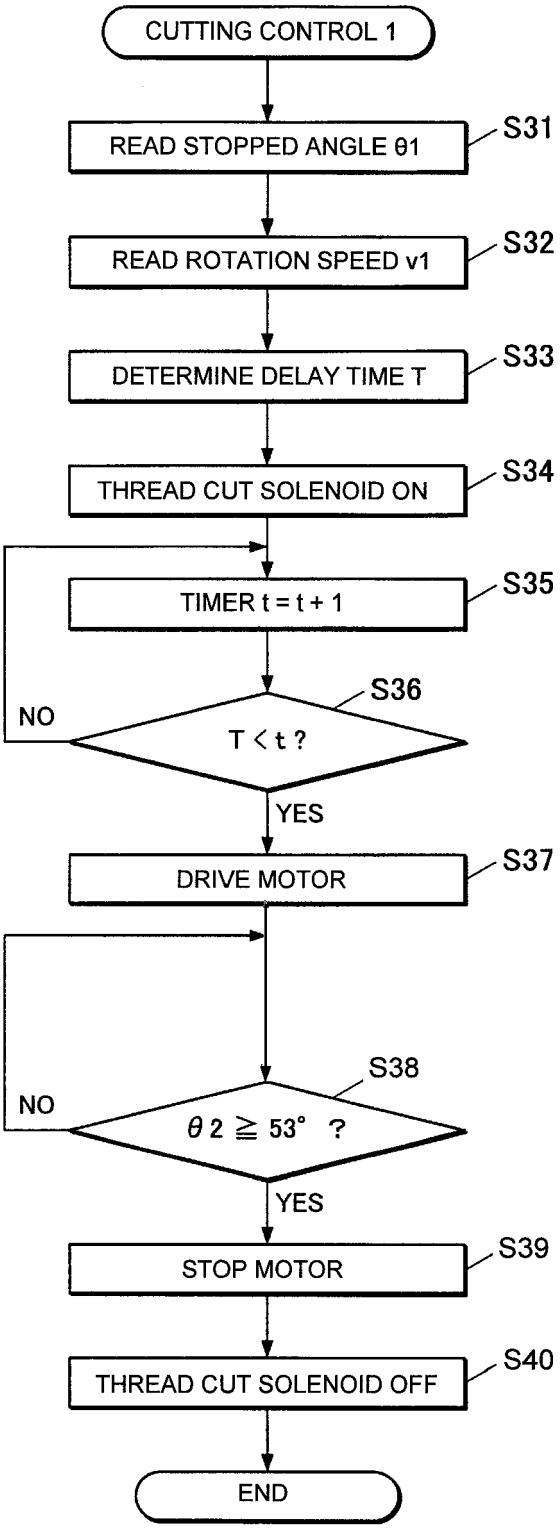

CUTTING CONTROL 1
READ STOPPED ANGLE θ1
S31
READ ROTATION SPEED v1
S32
DETERMINE DELAY TIME T
S33
THREAD CUT SOLENOID ON
S34
TIMER t = t + 1
S35
S36
NO
T < t ?
YES
DRIVE MOTOR
S37
S38
NO
θ2 ≧ 53° ?
YES
STOP MOTOR
S39
THREAD CUT SOLENOID OFF
S40
END

FIG. 11

v2	500	480	460	440	420	400	380	360	340	320	300	280	260	240	220	200	180
$\theta 3$	r1	r2	r3	r4	r5	r6	r7	r8	r9	r10	r11	r12	r13	r14	r15	r16	r17

FIG. 12

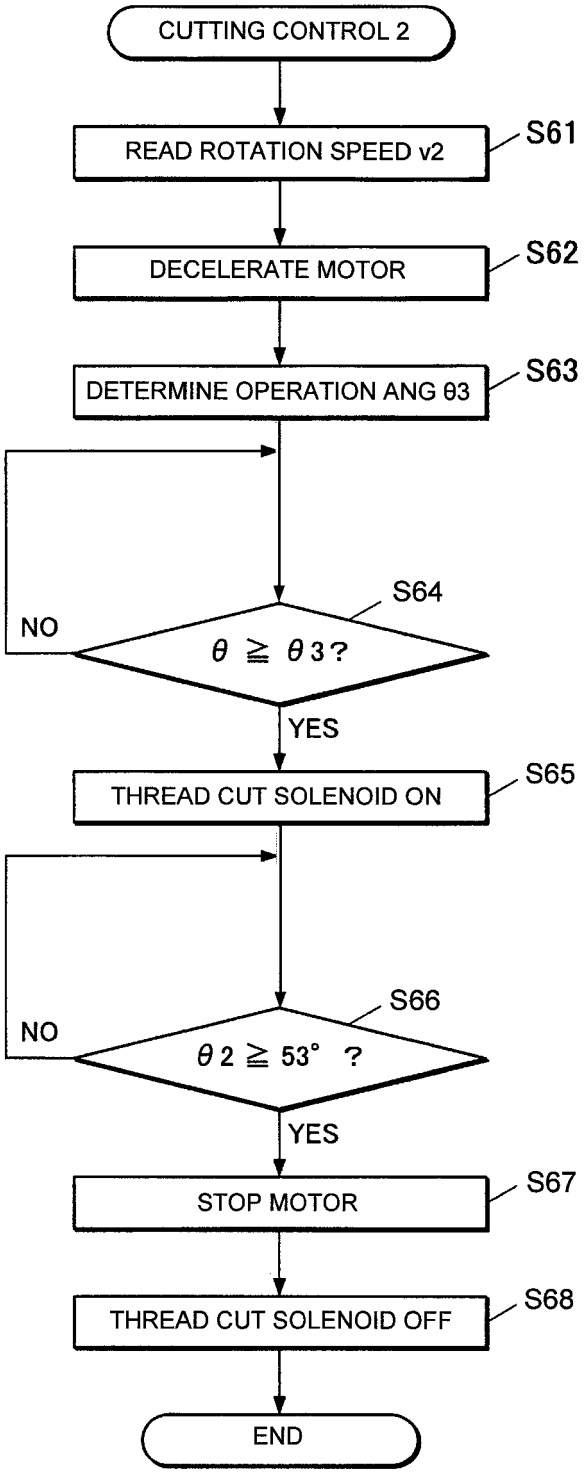
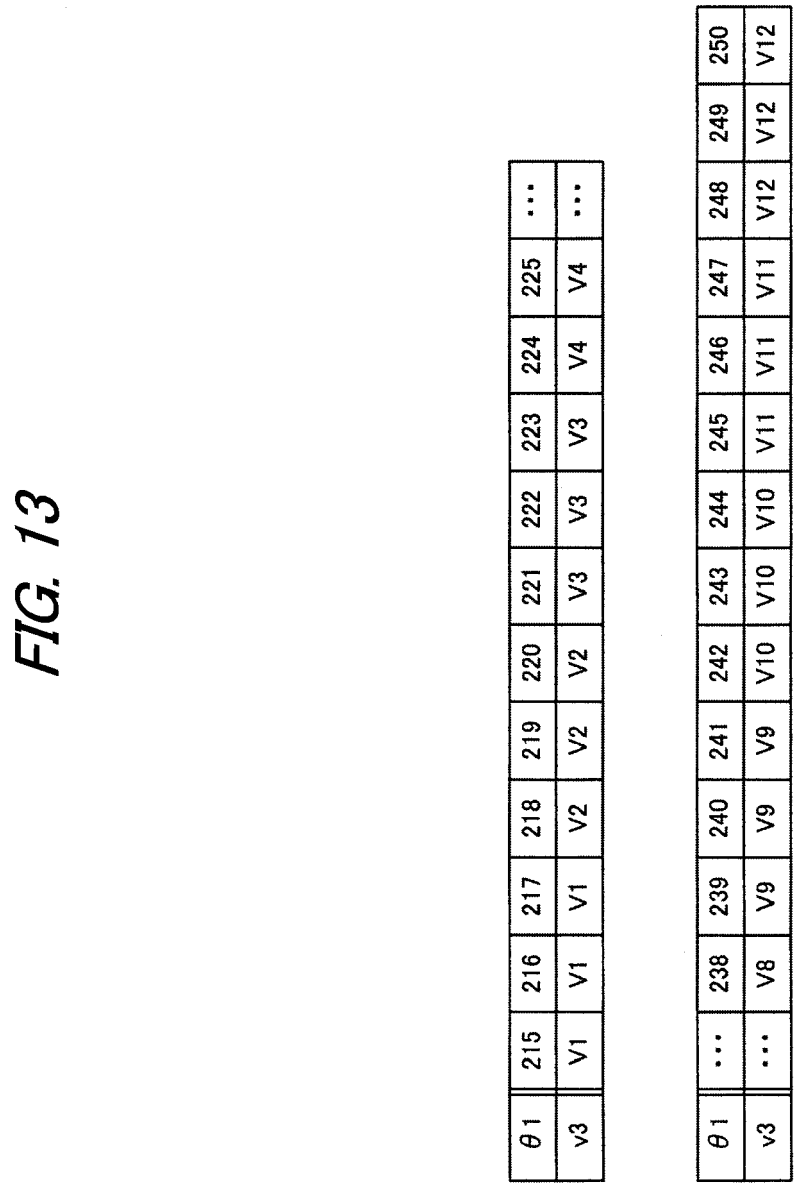

CUTTING CONTROL 2
READ ROTATION SPEED v2
S61
DECELERATE MOTOR
S62
DETERMINE OPERATION ANG θ3
S63
S64
NO
θ ≧ θ3?
YES
THREAD CUT SOLENOID ON
S65
S66
NO
θ2 ≧ 53° ?
YES
STOP MOTOR
S67
THREAD CUT SOLENOID OFF
S68
END

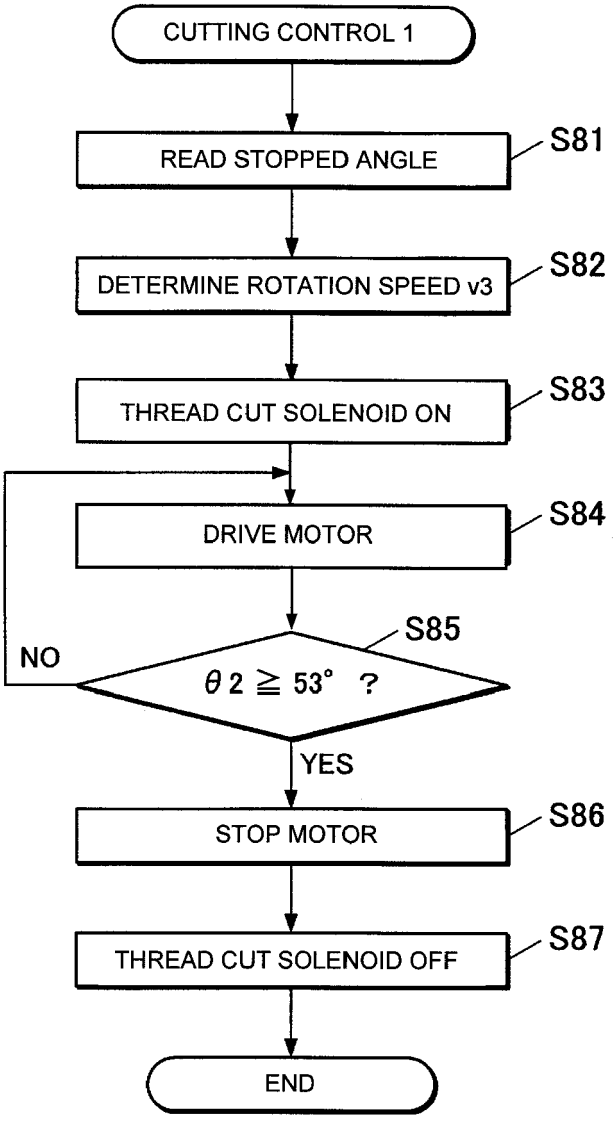
FIG. 13



θ1	215	216	217	218	219	220	221	222	223	224	225	...
v3	V1	V1	V1	V2	V2	V2	V3	V3	V3	V4	V4	...

θ1	...	238	239	240	241	242	243	244	245	246	247	248	249	250
v3	...	V8	V9	V9	V9	V10	V10	V10	V11	V11	V11	V12	V12	V12

FIG. 14


CUTTING CONTROL 1
READ STOPPED ANGLE
S81
DETERMINE ROTATION SPEED v3
S82
THREAD CUT SOLENOID ON
S83
DRIVE MOTOR
S84
S85
NO
θ2 ≧ 53° ?
YES
STOP MOTOR
S86
THREAD CUT SOLENOID OFF
S87
END

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007181609 A **[0002]**