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(54) **Sewing machine and controller therefor**

(57) The present disclosure relates to a sewing machine that sews patterns by moving a cloth holding frame holding a workpiece cloth in an X direction and a Y direction respectively based on sewing data of a pattern selected by a user and a controller therefore.

The controller determines a cloth feed start timing

so that an X feed start timing to execute an X directional feed for every feed operation in each sewing operation precedes a Y feed start timing to execute Y directional feed based on the sewing data. The controller allows cloth feed execution without an upper thread being wound on the sewing needle.

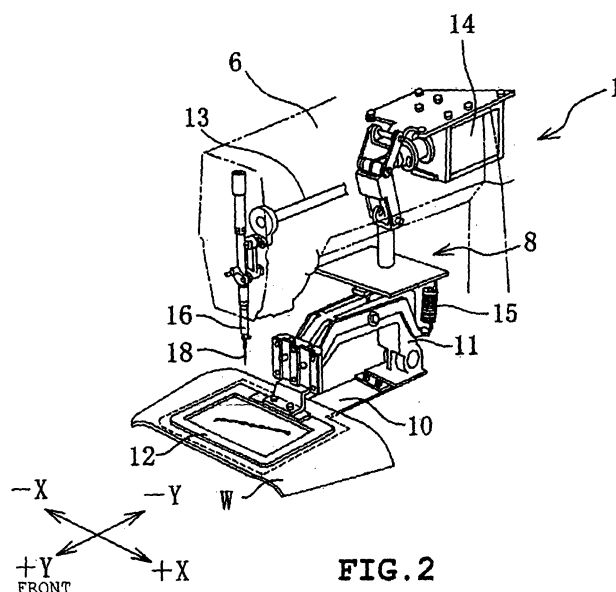


FIG. 2

Description

FIELD

[0001] The present disclosure is directed to a sewing machine and a controller therefor that form sewing patterns by moving a cloth holding frame holding a workpiece cloth in an X direction and a Y direction respectively based on sewing data of the sewing pattern selected by the user.

BACKGROUND

[0002] Conventional electronic sewing machines form sewing patterns by moving a cloth holding frame holding a workpiece cloth independently in an X direction perpendicular to a main shaft and a Y direction parallel to the main shaft. Various cloth feed controllers have been suggested that control execution of cloth feed so that all of the stitches are formed as perfect stitches when forming sewing patterns.

[0003] For example, JP H06-31065 A (pages 3 to 5, FIGS.2 and 4) discloses a controller for an automatic sewing machine that drives a servo motor based on sewing data (corresponding to the sewing data of the present disclosure) of the stitch pattern (corresponding to a sewing pattern of the present disclosure) to be sewn. The servo motor transfers the cloth holding frame in the X direction and the Y direction. Normally, the controller sews stitch patterns in accordance with the sequence of the sewing data. In case hitch stitches occur in the sewing data, the controller forms sewing patterns in reverse sequence of the sewing data (executes sewing operation from the opposite direction).

[0004] The controller of the automatic sewing machine disclosed in the aforementioned patent document may encounter cases where the upper thread becomes entangled (wound) with the sewing needle depending upon the sequence of the X directional and Y directional feed of the cloth holding frame. This results in formation of hitch stitches. In such case, increased resistance in drawing up the upper thread causes erroneous effects, consequently resulting in loose threads and preventing formation of neat stitches.

[0005] In FIG.13 of the present disclosure, for instance, an upper thread UT passes through an eye 18a of the sewing needle 18 from the rear side (-Y direction) to the front side (+Y direction). FIG.13 shows the sewing needle 18 forming a stitch at needle drop position Na in the -X direction and the -Y direction from the previous needle drop position N0 (which precedes the needle drop point Na by one stitch). The -X direction and -Y direction indicates that the cloth is being fed in the -X direction and the -Y direction. The following occurs in case cloth is fed in the -X direction after being fed in the -Y direction. The upper thread UT passing through the eye 18a in the forward direction is engaged with the right side of the distal end to be wound on the sewing needle 18 and oriented

leftward. This results in formation of hitch stitches. The sewing needle 18 penetrating the workpiece cloth W in such wound state also leads to loose stitches preventing formation of neat stitches.

[0006] FIG.14 illustrates the sewing needle 18 forming a stitch at the next needle drop position Nb which is oriented in the +X direction and the -Y direction from the previous needle drop position. In case the cloth is fed in the +X direction after being fed in the -Y direction, the upper thread UT passing through the eye 18a in the forward direction is wound around the left side of the distal end of the sewing needle 18 to be oriented rightward. The sewing needle 18 penetrating the workpiece cloth W in such wound state also leads to loose stitches preventing formation of neat stitches.

SUMMARY

[0007] An object of the present disclosure is to provide a sewing machine and a controller therefor capable of feeding the workpiece cloth with the upper thread passed through the eye of the sewing needle being free from being wound around the sewing needle to provide tight and neat stitches.

[0008] The sewing machine of claim 1 and the controller therefor (hereinafter simply referred as controller) of claim 7 sew patterns based on sewing data and are provided with a sewing mechanism including a needle bar provided with a sewing needle and a rotary hook and driven by a sewing machine motor, a frame transfer mechanism capable of transferring a cloth holding frame that holds a workpiece cloth on an upper surface of a needle plate independently in an X direction and a Y direction perpendicular to each other in a horizontal plane, the X direction being perpendicular to a direction of an eye of the sewing needle, and the Y direction being parallel to the eye of the sewing needle. The controller determines a timing to start cloth feed based on the sewing data of the sewing patterns so that an X feed start timing to execute X directional feed for every feed operation accompanying each sewing operation is arranged to precede a Y feed start timing to execute Y directional feed.

[0009] According to the above configuration, the upper thread drawn from a thread supply reaches the eye of the sewing needle via a thread take-up and is inserted through the eye in a direction parallel to the direction of the eye of the sewing needle from a Y directional rear side (-Y directional side) to a Y directional front side (+Y directional side). Since the controller executes the X directional cloth feed prior to the Y directional feed when executing cloth feed for each sewing operation, the upper thread forwardly passing through the eye of the sewing needle is positioned either in the right side or the left side relative to the sewing needle without being wound on the sewing needle.

[0010] The upper thread is directed toward the left side of the eye when executing -X directional feed, and the right side when executing +X directional feed. The con-

troller executes the Y directional feed after the direction of the upper thread extending from the eye with respect to the sewing needle has been determined. Thus, even if the Y directional feed is directed in the -Y direction which is the opposite of the direction in which the upper thread passes through the eye, the upper thread is free from being wound on the sewing needle. Thus, a neat and tight stitch is formed at the next needle drop position after completion of cloth feed.

[0011] The sewing machine of claim 2 and the controller of claim 8 execute a predetermined amount of X directional feed after the X feed start timing and thereafter executes the Y directional feed.

[0012] The above configuration reliably prevents the upper thread from being wound on the sewing needle.

[0013] The sewing machine of claim 3 and the controller of claim 9 include a cloth feed determiner that determines whether or not a Y directional feed amounting to a sum of the amount of the Y directional feed and the predetermined amount of the X directional feed is possible at the time of cloth feed execution. A deceleration instructing portion instructs deceleration of rotational speed of the sewing machine motor when the cloth feed determiner determines that cloth feed is not possible.

[0014] According to the above configuration, the deceleration instruction portion decelerates the rotational speed of the sewing machine motor and provides marginal time for cloth feed, thereby reliably allowing the X directional feed to be executed prior to the Y directional feed.

[0015] The sewing machine of claim 4 and the controller of claim 10 include a storage that stores speed-feed amount information that maps the rotational speed of the sewing machine motor with a Y directional feedable amount, and the cloth feed determiner makes determinations based on the sewing data and the speed-feed amount information stored in the storage.

[0016] According to the above configuration, whether cloth feed is possible or not can be determined reliably by the cloth feed determiner even if rotational speed of the sewing machine motor is changed.

[0017] The sewing machine of claim 5 and the controller of claim 11 detect whether an exit position of a lower thread exiting from the rotary hook toward a needle hole of the needle plate is in a right side or a left side of an extension of a vertical movement locus of the sewing needle by a lower thread exit detector. The controller determines whether to execute the predetermined amount of X directional feed in the + X direction or the -X direction based on the exit position detected by the lower thread exit detector when the amount of X directional feed by the sewing data is less than the predetermined amount.

[0018] When the lower thread is in the right side of the extension of the vertical movement locus of the sewing needle, the upper thread is free from being wound on the sewing needle when the upper thread is engaged to the right side relative to the sewing needle. When the lower

thread is in the left side of the extension of the vertical movement locus of the sewing needle, the upper thread is free from being wound on the sewing needle when the upper thread is engaged to the left side relative to the sewing needle.

[0019] The sewing machine of claim 6 and the controller of claim 12 execute +X directional feed or the -X directional feed whichever determined by the cloth feed determiner in an amount equivalent to a sum of the amount of X directional feed executed by the sewing data and the dummy feed amount. Thereafter, the sewing machine and the controller execute a reverse cloth feed in an opposite direction in an amount equivalent to the dummy feed amount.

[0020] In case the X directional feed amount is "nearly equal to zero", it is not possible to determine whether the direction of the upper thread relative to the sewing needle will be in the left or the right side. Cloth feed is executed initially in the predetermined dummy feed amount (extra cloth feed) in the direction determined based on the exit position detected by the lower thread detector. Thereafter, the controller of the sewing machine executes Y directional cloth feed. Thus, the upper thread is prevented from being wound on the sewing needle. Thereafter, the controller of the sewing machine executes a reverse feed in an amount equivalent to the dummy feed amount before completion of cloth feed to offset the dummy feed amount in the X direction (extra cloth feed).

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Other objects, features and advantages of the present disclosure will become clear upon reviewing the following description of the illustrative aspects with reference to the accompanying drawings, in which,

FIG.1 is a perspective view of a sewing machine in accordance with an illustrative aspect of the present disclosure;

FIG.2 is a partial perspective view of an enlarged view of a main portion of the sewing machine;

FIG.3 is a front view of a vertical full rotary hook when a lower thread exit hole is in the left side position;

FIG.4 is a plan view of the vertical full rotary hook;

FIG.5 is a plan view of a bobbin;

FIG. 6 is a front view of the vertical full rotary hook when the lower thread exit hole is in the right side position;

FIG.7 is a block diagram of a control system of the sewing machine;

FIG.8 indicates data specified in a speed-feed amount table;

FIG.9 is a flowchart of the cloth feed control;

FIG.10 is a time chart of the vertical movement of the sewing needle and an X directional and a Y directional feed;

FIG.11 is a descriptive view describing a movement locus of the X directional and the Y directional feed;

FIG.12 is a descriptive view describing a relation of positioning of an upper thread, the sewing needle and a needle drop position;
 FIG.13 corresponds to FIG.12 and describes a conventional technique; and
 FIG.14 corresponds to FIG.12 and describes a conventional technique varying from the state shown in FIG.13.

DETAILED DESCRIPTION

[0022] The present disclosure will be described in detail with reference to the drawings. FIGS. 1 to 12 indicate one exemplary embodiment of the present disclosure.

[0023] Referring to FIG.1, a sewing machine 1 is provided with a bed 5 disposed on the upper surface side of a table 3, and an arm 6. A needle plate 7 is secured in the upper front surface (the lower left portion of FIG.1 indicates the front side) of the bed 5 and a cloth presser 8 is provided on the upper side of the needle plate 7.

[0024] Referring to FIG.2, the cloth presser 8 includes a feed plate 10 capable of longitudinally and laterally (the lower left portion of FIG.2 indicates the front side) moving over the needle plate 7; a presser arm 11 provided on the feed plate 10; and a cloth presser plate 12 in a rectangular frame-form mounted vertically movably on the front end of the presser arm 11. The cloth presser 8 holds the workpiece cloth W to be sewn by the cloth presser plate 12 and the feed plate 10. A later described controller 35 transfers the feed plate 10 in the lateral direction (X direction) perpendicular to a later described main shaft 13 via an X directional drive mechanism 49 (refer to FIG. 7) driven by an X shaft drive motor 45 (refer to FIG.7). The controller 35 also transfers the feed plate 10 in the longitudinal direction (Y direction) parallel to the main shaft 13 via a Y directional drive mechanism 50 (refer to FIG. 7) driven by the Y shaft drive motor 47 (refer to FIG. 7).

[0025] The cloth presser plate (cloth holding frame) 12 is normally in a raised position distanced from the feed plate 10 by the bias of a spring 15. A solenoid 14 mounted on the arm 6 lowers the cloth presser plate 12 to a position to be placed in contact with the presser plate 10. The cloth presser plate 12 being lowered by the solenoid 14 holds the workpiece cloth W in cooperation with the feed plate 10. The cloth presser 12 and the feed plate 10 holding the workpiece cloth W therebetween are transferred in synchronism in the X direction and the Y direction.

[0026] The X directional drive mechanism 49 and the Y directional drive mechanism 50 moving the cloth presser plate 12 and the feed plate 10 in the X direction and the Y direction correspond to the frame transfer mechanism.

[0027] The aforementioned main shaft 13 is provided longitudinally in the arm 6. A vertically reciprocating needle bar 16 and a thread take-up (not shown) are provided at the front end of the arm 6. The sewing needle 18 is disposed at the lower end of the needle bar 16. The main

shaft 13 drives the needle bar 16 and the thread take-up. Provided in the bed 5 is a vertical full rotary hook 25 (refer to FIG.3) that forms stitches in cooperation with the sewing needle 18. The needle bar 16 having the sewing needle 18 mounted thereto and the vertical full rotary hook 25, and the like, constitute the sewing mechanism.

[0028] As illustrated in FIG.1, an operation panel 20 to be operated by the user is disposed on the upper right surface of the table 3. The user operates the operation panel 20 primarily for inputting various instructions for the sewing machine 1.

[0029] As illustrated in FIG.1, a control box 22 is disposed under the table 3. The control box 22 contains the controller 35 described afterwards. A start/stop switch 24 in the form of a pedal is disposed under the table 3.

[0030] The start/stop switch 24 starts and stops the sewing operation and also triggers the switching of the cloth presser plate 12 operation between a lifting operation and a lowering operation.

[0031] A brief description will be given on a switch mechanism. The switch mechanism switches an exit position of a lower thread DT which is drawn from the vertical full rotary hook 25 and oriented toward the needle eye 7a of the needle plate 7 between the left side or the right side of an extension N of the vertical movement locus of the sewing needle 18.

[0032] Referring to FIGS.3 and 4, the vertical full rotary hook 25 includes an outer hook 26 rotated by a lower shaft 32 synchronized with the main shaft 13; a middle hook 27 fitted into the outer hook 26 and mounted rotatably relative to the outer hook 26; a bobbin case 28 mounted on the middle hook 27; and a hook stopper 29 that prevents rotation of the middle hook 27. The hook stopper 29 is mounted on the needle plate 7. The lower thread DT is wound on a lower thread bobbin (not shown) contained in a bobbin case 28. Of note is that the eye 18a of the sewing needle 18 is defined in the longitudinal direction. An upper thread UT drawn from a thread take-up (not shown) is passed from the rear to the front side of the eye 18a. The eye 18a of the sewing needle 18 is directed in a direction parallel to the Y direction and perpendicular to the X direction.

[0033] The middle hook 27 has a lower thread guide 27a formed integrally therewith, and the lower thread guide 27a projects from the upper side of the middle hook 27. The lower thread guide 27a has formed thereto an engagement hole 27b. The engagement hole 27b allows a later described left-side engagement 29a of the hook stopper 29 to be inserted therein. An engagement wall 27c is formed in the right-side end relative to the engagement hole 27b of the lower thread guide 27a.

[0034] As illustrated in FIG.3, a thread tension spring 30 is provided on the upper right portion of the outer peripheral wall of the bobbin case 28. The thread tension spring 30 adjusts the thread tension to be applied on the lower thread DT drawn out of the lower thread bobbin. Referring to FIG.5, two lower thread exit holes 28a and 28b are defined on the outer peripheral wall of the bobbin

case 28. The lower thread exit holes 28a and 28b are disposed at positions confronting each other over a center line Q as viewed in planar view. The lower thread DT passes between the thread tension spring 30 and the outer peripheral wall and exits from the lower thread exit hole 28a or the lower thread exit hole 28b via the distal end of the thread tension spring 30. When the lower thread DT moves out of the lower thread exit hole 28a, the lower thread exit of the lower thread DT extending from the vertical full rotary hook 25 is placed in the left side relative to the extension N of the vertical movement locus of the sewing needle 18. When the lower thread DT moves out of the lower thread exit hole 28b, the lower thread exit of the lower thread DT extending from the vertical full rotary hook 25 is placed in the right side relative to the extension N of the vertical movement locus of the sewing needle 18.

[0035] The hook stopper 29 takes a plate form and has bifurcated left and right engagements 29a and 29b formed on the rear end of thereof. The left engagement 29a is inserted into the engagement hole 27b of the middle hook 27. The right engagement 29b is placed in abutment with the right-side edge of the engagement wall 27c of the middle hook 27. The left and right engagements 29a and 29b perform positioning of the middle hook 27 by holding the engagement wall 27c therebetween. In other words, the left and right engagements 29a and 29b perform positioning of the middle hook 27.

[0036] A description will be given on a control system of the sewing machine 1.

[0037] Referring to FIG.7, the controller 35 is configured by a computer including a CPU 36, a ROM 37, and a RAM 38. Connected to the controller 35 are the start/stop switch 24, a presser switch 39, a main shaft rotational angle detection sensor 40, the operation panel 20, drive circuits 43, 44, 46 and 48, and the lower thread exit setting switch 34.

[0038] The presser switch 39 switches the presser arm 11 between the pressed position and the retracted position.

[0039] The main shaft rotational angle detection sensor 40 detects the rotational angle of the main shaft 13. The main shaft rotational angle detection sensor 40 is configured by a rotary encoder, for example.

[0040] The drive circuit 43 drives the sewing machine motor 42. The main shaft 13 is rotated by the drive of the sewing machine motor 42. The drive circuit 44 drives the solenoid 14. The drive circuit 46 drives the X shaft drive motor 45 configured by a step motor. The drive circuit 48 drives the Y shaft drive motor 47 configured by a step motor. The lower thread exit setting switch 34 specifies whether the exit position of the lower thread exit is at the lower thread exit hole 28a or the lower thread exit hole 28b.

[0041] The operation panel 20 is configured by a compact liquid crystal display 20a, ten keys 20b for numerical input, and various switches 20c for specifying sewing parameters.

[0042] The ROM 37 stores various control programs for controlling the sewing machine 1, a later described cloth feed control program constituting the feature of the present disclosure and a plurality of sewing data, and the like, for sewing a plurality of patterns. The ROM 37 also stores a speed-feed amount table indicated in FIG.8. The speed-feed amount table maps the rotational speed of the sewing machine motor 42 with the Y directional feedable amount at that rotational speed. The ROM 37 corresponds to a storage of the present disclosure.

[0043] The RAM 38 allocates regions for temporary storage of calculation results produced by the CPU 36, counter regions, and the like, on a required basis.

[0044] The cloth feed control executed by the controller 35 is described based on the flowchart indicated in FIG. 9. Of note is that reference symbol Si (i=11, 12, 13...) indicate each step of the control flow.

[0045] When the control indicated in FIG.9 is started (START), first, the controller 35 stands by until the start/stop switch 24 outputs a sewing start instruction (S11: No). When the user selects the desired pattern to be sewn and starts the sewing operation by operating the start/stop switch 24 (S11:Yes), the controller 35 initializes the count N of the stitch counter to "1" (S12). Then, the controller 35 reads data (sewing data) corresponding to the stitch number specified by the stitch count N and calculates an X directional feed amount XD and a Y directional feed amount YD (S13).

[0046] The controller 35 obtains the current rotational speed of the sewing machine motor 42 by the sensor signal (encoder signal) inputted from the main shaft rotational angle detection sensor 40 at predetermined small time intervals.

[0047] The controller 35 determines the Y directional feedable amount based on the current rotational speed of the sewing machine motor 42 and the data in the speed-feed amount table indicated in FIG.8. Then the controller 35 compares the feed amount equivalent to the sum of the Y directional feed amount YD and the predetermined small feed amount in the X direction (this corresponds to the predetermined amount of 0.5 mm, for example) with the Y directional feedable amount determined earlier to determine whether or not Y directional feed is possible (S14). If Y directional feed is possible (S14:Yes), the controller 35 then determines whether or not the X directional feed amount XD is greater than the predetermined feed amount (approximately 0.5 mm) (S15). If the X directional feed amount XD is determined to be greater than the predetermined feed amount by the controller 35 (S15:Yes), the controller 35 stands by until a feed start timing (S16:No).

[0048] When the sewing needle 18 is moved above the needle plate 7, to assume a feed start timing allowing execution of cloth feed (S16:Yes), the controller 35 starts the X directional feed prior to the Y directional feed (S17). Though not shown, the controller 35 drives the X shaft drive motor 45 pulse by pulse by a motor drive control. The controller 35 determines whether or not the X direc-

tional feed has reached the predetermined small feed amount upon each pulse-by-pulse drive of the X shaft drive motor 45 (S18). The controller 35 repeats S18 when X directional cloth feed has not reached the predetermined small feed amount (S18:No).

[0049] In case the X directional feed reaches the predetermined small feed amount (S18:Yes), the controller 35 starts the Y directional feed (S19). From here after, the controller 35 executes Y directional feed of Y directional feed amount YD and X directional feed of X directional feed amount XD in parallel. Upon completion of X directional feed of X directional feed amount XD and Y directional feed of Y directional feed amount YD (S20: Yes), the controller 35 determines whether or not the stitch count N is the last stitch (S21). If the stitch count N is not the last stitch (sewing operation is ongoing) (S21: No), the controller 35 increments the stitch count N by one (S22), and repeats S13 and onwards. If the stitch count N is the last stitch (S21:Yes), the controller 35 stops the sewing machine 1 and returns the control to S11.

[0050] In S14, if the controller 35 determines that Y directional feed which amounts to the equivalent of the sum of Y directional feed amount YD and predetermined small feed amount in the X direction is not possible (S14: No), the controller 35 decelerates the rotational speed of the sewing machine motor 42 (S23) so as to increase the feedable period. The portion of the controller 35 that executes S23 corresponds to the deceleration instructing portion of the present disclosure.

[0051] In case the X directional feed amount XD is equal to or less than the predetermined feed amount (approximately 0.5 mm) (S15: No), the controller 35 detects the lower thread exit position based on the signal of the lower thread exit setting switch 34 (S24). Then the controller 35 sets a positive/negative direction (+X direction or -X direction) for a dummy X directional feed, based on the detection result of the lower thread exit setting switch 34 (S25). Then, the X directional direction (+X direction or -X direction) of the upper thread UT relative to the sewing needle 18 is set, the upper thread UT forwardly extending from the eye 18a of the sewing needle 18. The dummy X directional feed prevents occurrence of hitch stitches even in case the X directional feed amount XD is "zero" or "nearly equal to zero".

[0052] When the lower thread DT is specified to exit from the lower thread exit hole 28a by the lower thread exit switch 34 (refer to FIGS. 3 and 5), the upper thread UT needs to be engaged to the left side of the sewing needle 18. In such case, since the lower thread exit of the lower thread DT extending from the vertical full rotary hook 25 is in the left side of the extension N of the vertical movement locus of the sewing needle 18, the controller 35 forcibly specifies "left side: -X direction" as the dummy X directional feed.

[0053] When the lower thread DT is specified to exit from the lower thread exit hole 28b by the lower thread exit switch 34 (refer to FIG. 6), the upper thread UT needs to be engaged to the right side of the sewing needle 18.

In such case, since the lower thread exit of the lower thread DT extending from the vertical full rotary hook 25 is in the right side of the extension N of the vertical movement locus of the sewing needle 18, the control unit 35 forcibly specifies "right side: +X direction" as the dummy X directional feed.

[0054] The controller 35 executes cloth feed in the positive/negative direction (+X direction or -X direction) specified in S25 based on the X directional feed amount XD equal to or less than the predetermined feed amount and the dummy feed amount DD (approximately 0.5 mm, for example) (S26). Thereafter, the controller 35 executes Y directional feed by the Y directional feed amount YD (S27). Then, the controller 35 executes reverse feed in an amount equivalent to the dummy feed amount DD to offset the dummy feed amount DD (S28) and repeats S20 and onwards.

[0055] The portion of the controller 35 that executes S14 of the cloth feed control (refer to FIG. 9) corresponds to a cloth feed determiner. The data contained in the speed-feed amount table stored in the ROM 37 (refer to FIG.8) corresponds to the speed-feed amount information. The portion of the controller 35 that executes S24 of the cloth feed control corresponds to a lower thread exit detector.

[0056] A description will be given on the operation and effect of the cloth feed control.

[0057] Referring to FIG.10, the main shaft 13 assumes a phase angle of 0 degrees when the distal end of the sewing needle 18 is in the uppermost position. The controller 35 determines whether Y directional feed in a feed amount equivalent to the sum of the predetermined small feed amount in the X direction and the Y directional feed amount YD is possible or not within the feedable period based on the rotational speed of the sewing machine motor 42 and the information specified in the speed-feed amount table indicated in FIG.8. For example, a description will be given on a case where X directional feed amount XD for forming the next stitch Na from the current stitch N0 (refer to FIG.11) is "-2 mm" and the Y directional feed amount YD is "-2 mm". The description is based upon the assumption that the predetermined small feed amount in the X direction is "0.5 mm".

[0058] As indicated in FIG. 8, the maximum Y directional feedable amount is 2.9 mm when rotational speed of the sewing machine motor 42 is 3000 rpm. The maximum Y directional feedable amount is 3.9 mm when rotational speed of the sewing machine motor 42 is 2900 rpm. As illustrated in FIG.8, when the Y directional cloth feed amount is equal to or greater than 4 mm, the rotational speed needs to be at 2800 rpm or less. The above described Y directional feed amount amounting to "2 mm+0.5 mm=2.5 mm" can be executed at the rotational speed of 3000 rpm.

[0059] The controller 35 initially feeds a predetermined small amount (0.5 mm) in the -X direction in advance at the start of the feedable period in which the distal end of the sewing needle 18 is moved above the needle plate

7. The -Y directional feed is started upon completion of the -X directional feed in the predetermined small feed amount (0.5 mm). Thereafter, the controller 35 executes -X directional feed of the remaining feed amount of "1.5 mm", which is the remainder after subtracting the predetermined small feed amount "0.5 mm" from the X directional feed amount XD and -Y directional feed is executed in the Y-directional feed amount YD "-2 mm".

[0060] Referring to FIG.11, since the controller 35 initially executes -X directional feed in the predetermined small feed amount (0.5 mm), the sewing needle 18, at this point in time, is in a position corresponding to point "N0x" on the X axis which is displaced by 0.5 mm in the +X direction from the needle drop position N0. At this time, referring to FIG.12, the upper thread UT passing through the eye 18a of the sewing needle 18 from the rear side to the front side extends in the direction of the previous stitch N0, in other words, the leftward direction without being wound on the sewing needle 18. From this point on, the controller 35 executes the remaining -X directional feed and the -Y directional feed. Consequently, as illustrated in FIGS.11 and 12, the sewing needle 18 is moved to be positioned above the next stitch Na, at which point the upper thread UT is directed toward the previous needle drop position N0 without being wound on the sewing needle 18.

[0061] A description will be given on a case where the X directional feed amount XD is "-0.2 mm" which is close to being "nearly equal to zero" and the predetermined small feed amount (0.5 mm) cannot be reached in the initial X directional feed. The controller 35 executes -X directional feed in a small feed amount (approximately -0.7 mm) which is the sum of the X directional feed amount XD and the dummy feed amount (0.5 mm, for example) based on the signal of the lower thread exit setting switch 34. Thus, even if the X directional feed amount XD is "nearly equal to zero", the direction of the upper thread UT relative to the sewing needle 18 can be set to the desired direction that does not form a hitch stitch. In order to offset the extra X directional dummy feed amount, the controller 35 executes a reverse feed in the amount equivalent to the dummy feed amount DD before terminating the execution of cloth feed.

[0062] Next, a description will be given on partial modifications of the present embodiment.

[0063] The X directional feed initially executed in the predetermined small feed amount when executing cloth feed for each stitch by stitch sewing operation has been set at approximately 0.5 mm that amounts to 10 pulses of the X shaft drive motor 45. However, any given feed amount may be set depending upon the thickness and the type of the upper thread UT or the thickness of the sewing needle 18.

[0064] The timing for starting the X directional feed when executing cloth feed for each stitch by stitch sewing operation has been specified at the start point of the feedable period.

[0065] If the amount of X directional or Y directional

feed is small and the X directional feed amount XD is greater than the Y directional feed amount YD, the start timing of cloth feed may be specified as follows.

[0066] The start timing of cloth feed may be specified so that feeding of half the X directional feed amount XD and the Y directional feed amount YD respectively ($XD/2$, $YD/2$) may be completed when the sewing needle 18 is in the uppermost position (main shaft 13 at 0 degrees). In such case, since the X directional feed amount XD is greater than the Y directional feed amount YD, the X directional feed is started prior to the Y directional feed.

[0067] The Y directional feed may be started after fully completing the feeding of the X directional feed amount XD. In such case, the X directional feed and the Y directional feed need to be completed during the feedable period.

[0068] In the present embodiment, the lower thread exit position is switched by the two lower thread exit holes 28a and 28b provided in the bobbin case 28. The controller 35 perceives the lower thread exit position by the lower thread exit position setting switch 34. This mechanism may be replaced by the following.

[0069] The bobbin case 28 may be provided with a single lower thread exit hole and a transfer mechanism may be provided to laterally move the bobbin case 28 by external force. A detector for detecting the position of the transfer mechanism may be provided in the proximity of the transfer mechanism. Under such configuration, the controller 35 perceives the position (in other words, the lower thread exit position) of the transfer mechanism by the detector.

[0070] The present embodiment is described based on a vertical full rotary hook, however a shuttle hook may be used instead.

[0071] In the present embodiment, the eye (18a) of the sewing needle 18 is directed in a direction parallel to the direction of the main shaft. Alternatively, the eye 18a may be oriented in a direction perpendicular to the main shaft. In such case also, the cloth is initially fed in the direction perpendicular to the direction of the eye 18a of the sewing needle 18, in other words, the cloth is initially fed in the direction parallel to the direction of the main shaft.

[0072] The foregoing description and drawings are merely illustrative of the principles of the present disclosure and are not to be construed in a limited sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the disclosure as defined by the appended claims.

Claims

1. A sewing machine capable of sewing patterns based on sewing data provided with a sewing mechanism including a needle bar (16) provided with a sewing needle (18) and a rotary hook (25) and driven by a sewing machine motor (42), a frame transfer mech-

- anism (49, 50) capable of transferring a cloth holding frame (12) that holds a workpiece cloth on an upper surface of a needle plate (7) independently in an X direction and a Y direction perpendicular to each other in a horizontal plane, the X direction being perpendicular to a direction of an eye (18a) of the sewing needle (18), and the Y direction being parallel to the eye (18a) of the sewing needle (18), the sewing machine **characterized by** a controller (35) that determines a feed start timing based on the sewing data of the sewing patterns so that an X feed start timing to execute X directional feed for every feed operation accompanying each sewing operation is arranged to precede a Y feed start timing to execute Y directional feed.
2. The sewing machine of claim 1, **characterized in that** the controller (35) executes a predetermined amount of X directional feed after the X feed start timing and thereafter executes the Y directional feed.
 3. The sewing machine of claim 2, **characterized in that** the controller (35) includes a cloth feed determiner that determines whether or not a Y directional feed amounting to a sum of the amount of the Y directional feed and the predetermined amount of the X directional feed is possible at the time of cloth feed execution and a deceleration instructing portion that instructs deceleration of rotational speed of the sewing machine motor (42) when the cloth feed determiner determines that cloth feed is not possible.
 4. The sewing machine of claim 3, further **characterized by** a storage (37) that stores speed-feed amount information that maps the rotational speed of the sewing machine motor (42) with a Y directional feedable amount, and the cloth feed determiner makes determinations based on the sewing data and speed-feed amount information stored in the storage (37).
 5. The sewing machine of claims 2 to 4, further **characterized by** a lower thread exit detector that detects whether an exit position of a lower thread exiting toward a needle hole (7a) of the needle plate (7) from the rotary hook (25) is in a right side or a left side of an extension of a vertical movement locus of the sewing needle (18) and the controller (35) determines whether to execute the predetermined amount of X directional feed in the + X direction or the -X direction based on the exit position detected by the lower thread exit detector when the amount of X directional feed amount by the sewing data is less than the predetermined amount.
 6. The sewing machine of claim 5, **characterized in that** the controller (35) executes +X directional feed or -X directional feed whichever determined by the cloth feed determiner in an amount equivalent to a sum of the amount of X directional feed executed by the sewing data and the dummy feed amount and thereafter executes a reverse cloth feed in an opposite direction in an amount equivalent to the dummy feed amount.
 7. A controller of a sewing machine capable of sewing patterns based on sewing data provided with a sewing mechanism including a needle bar (16) provided with a sewing needle (18) and a rotary hook (25) and driven by a sewing machine motor (42), a frame transfer mechanism (49, 50) capable of transferring a cloth holding frame (12) that holds a workpiece cloth on an upper surface of a needle plate (7) independently in an X direction and a Y direction perpendicular to each other in a horizontal plane, the X direction being perpendicular to a direction of an eye (18a) of the sewing needle 18, and the Y direction being parallel to the eye (18a) of the sewing needle (18), the controller of the sewing machine **characterized by** a controller (35) that determines a timing to start cloth feed based on sewing data of the sewing patterns so that an X feed start timing to execute X directional feed for every cloth feed accompanying each sewing operation is arranged to precede a Y feed start timing to execute Y directional feed.
 8. The controller of claim 7, **characterized in** executing a predetermined amount of X directional feed after the X feed start timing and thereafter executes the Y directional feed.
 9. The controller of claim 8, further **characterized by** a cloth feed determiner that determines whether or not a Y directional cloth feed amounting to a sum of the amount of the Y directional feed and the predetermined amount of the X directional feed is possible at the time of cloth feed execution and a deceleration instructing portion that instructs deceleration of rotational speed of the sewing machine motor (42) when the cloth feed determiner determines that cloth feed is not possible.
 10. The controller of claim 9, further **characterized by** a storage (37) that stores speed-feed amount information that maps the rotational speed of the sewing machine motor (42) with a Y directional feedable amount, and the cloth feed determiner makes determinations based on the sewing data and speed-feed amount information stored in the storage (37).
 11. The controller of claims 7 to 10, further **characterized by** a lower thread exit detector that detects whether an exit position of a lower thread exiting toward a needle hole (7a) of the needle plate (7) from the rotary hook (25) is in a right side or a left side of an extension of a vertical movement locus of the sewing

ing needle (18) and the controller (35) determines whether to execute the predetermined amount of X directional feed in the +X direction or the -X direction based on the exit position detected by the lower thread exit detector when the amount of X directional feed by the sewing data is less than the predetermined amount. 5

12. The controller of claim 11, **characterized in that** the controller (35) executes +X directional feed or -X directional feed whichever determined by the cloth feed determiner in an amount equivalent to a sum of the amount of X directional feed executed by the sewing data and the dummy feed amount and thereafter executes a reverse cloth feed in an opposite direction in an amount equivalent to the dummy feed amount. 10 15

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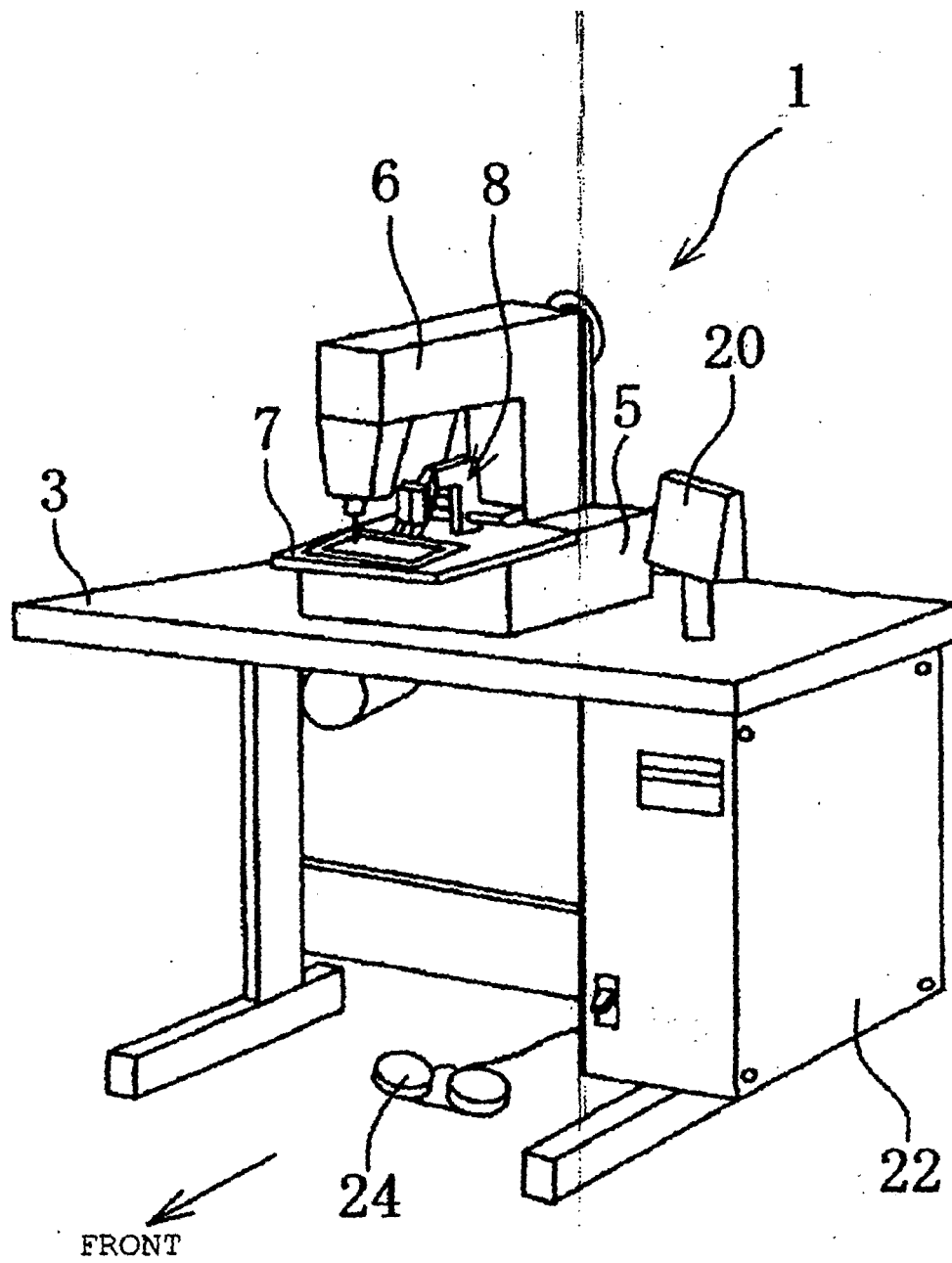
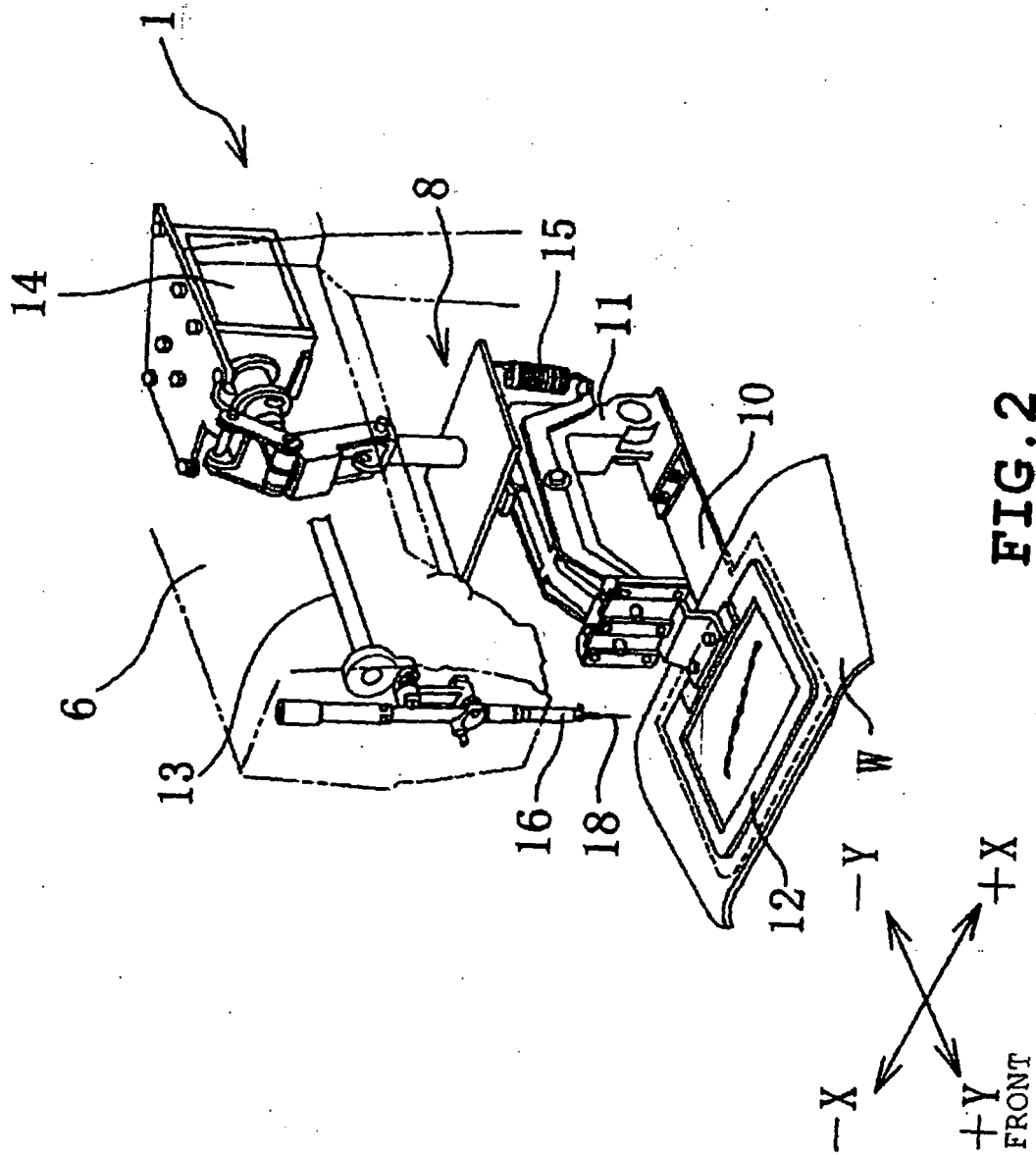


FIG. 1



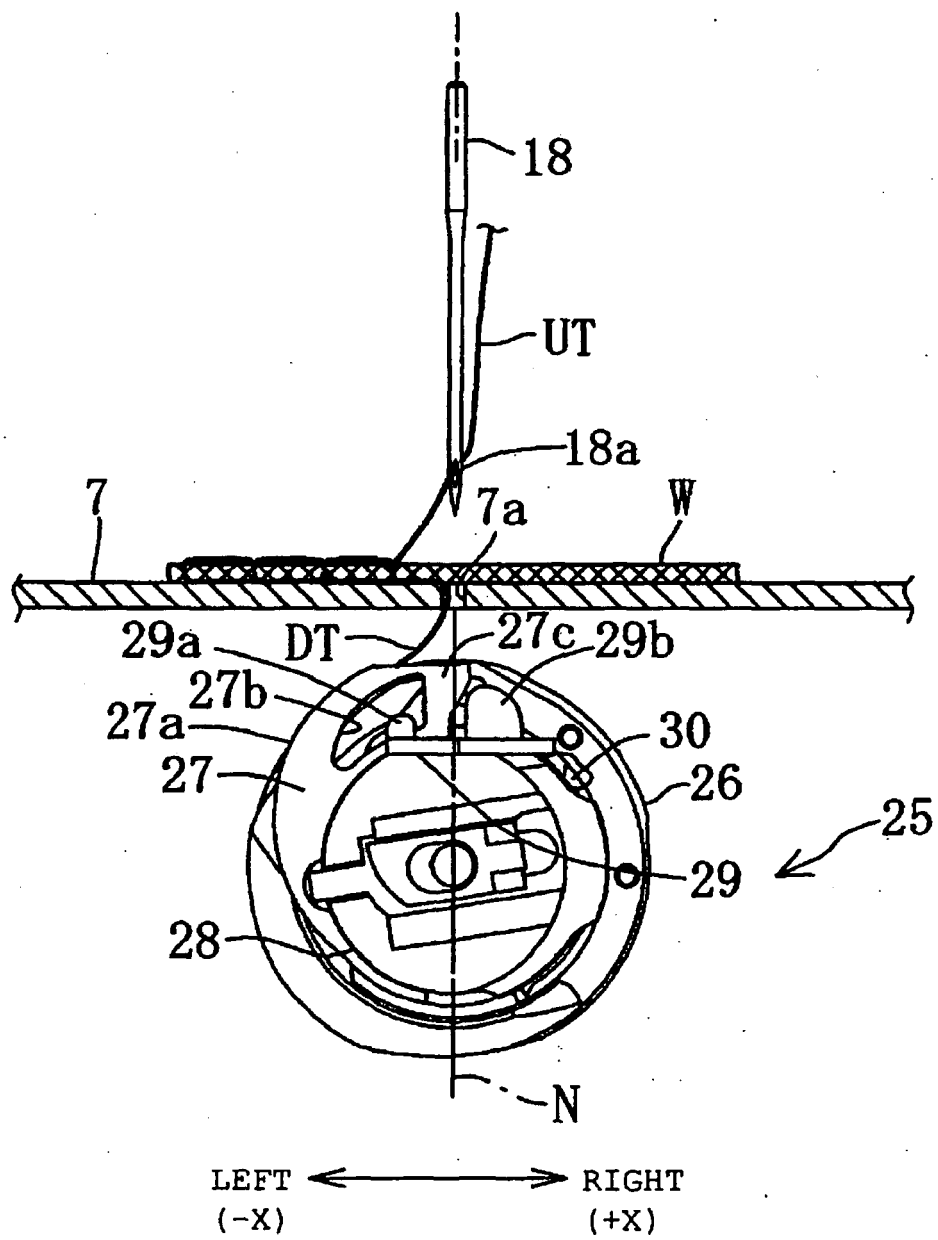
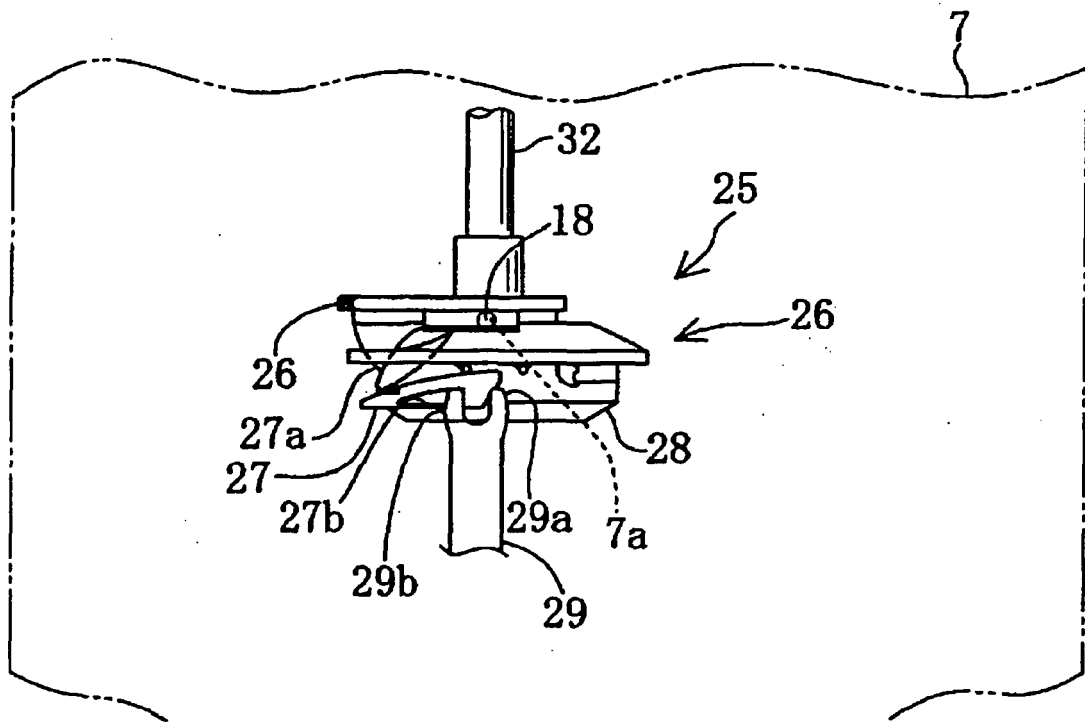


FIG. 3



FRONT

FIG. 4

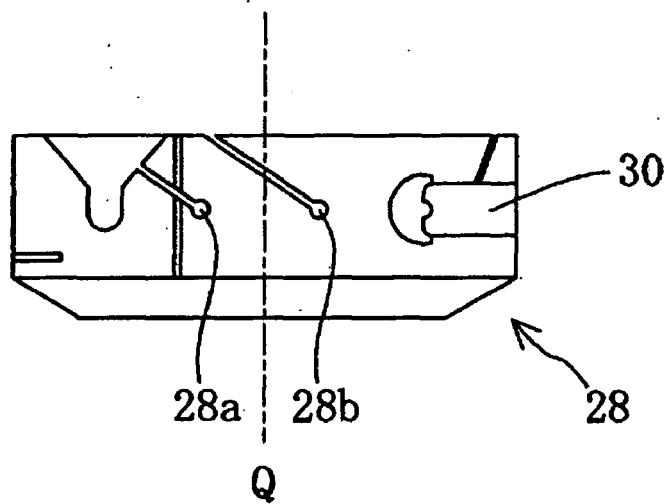


FIG. 5

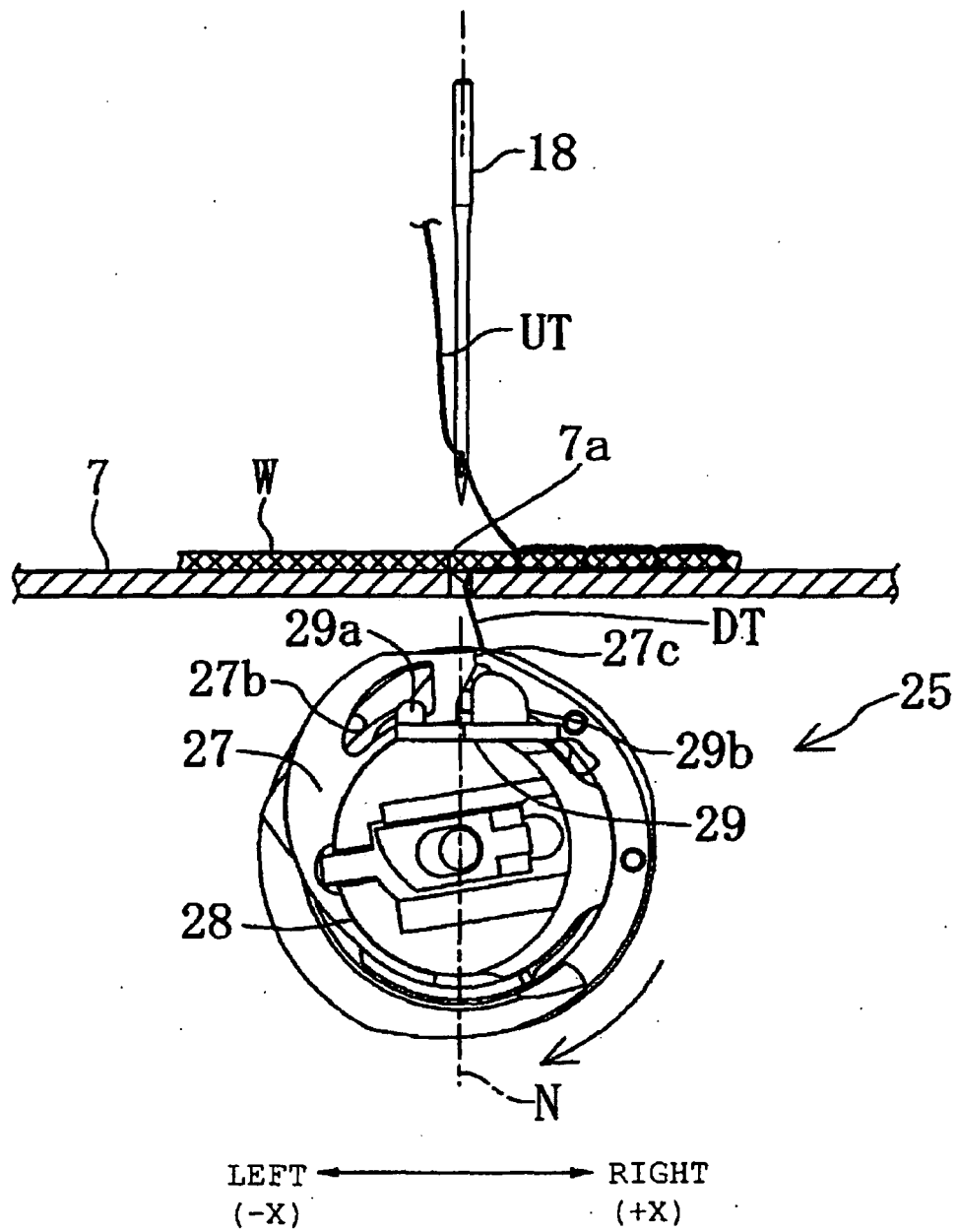


FIG. 6

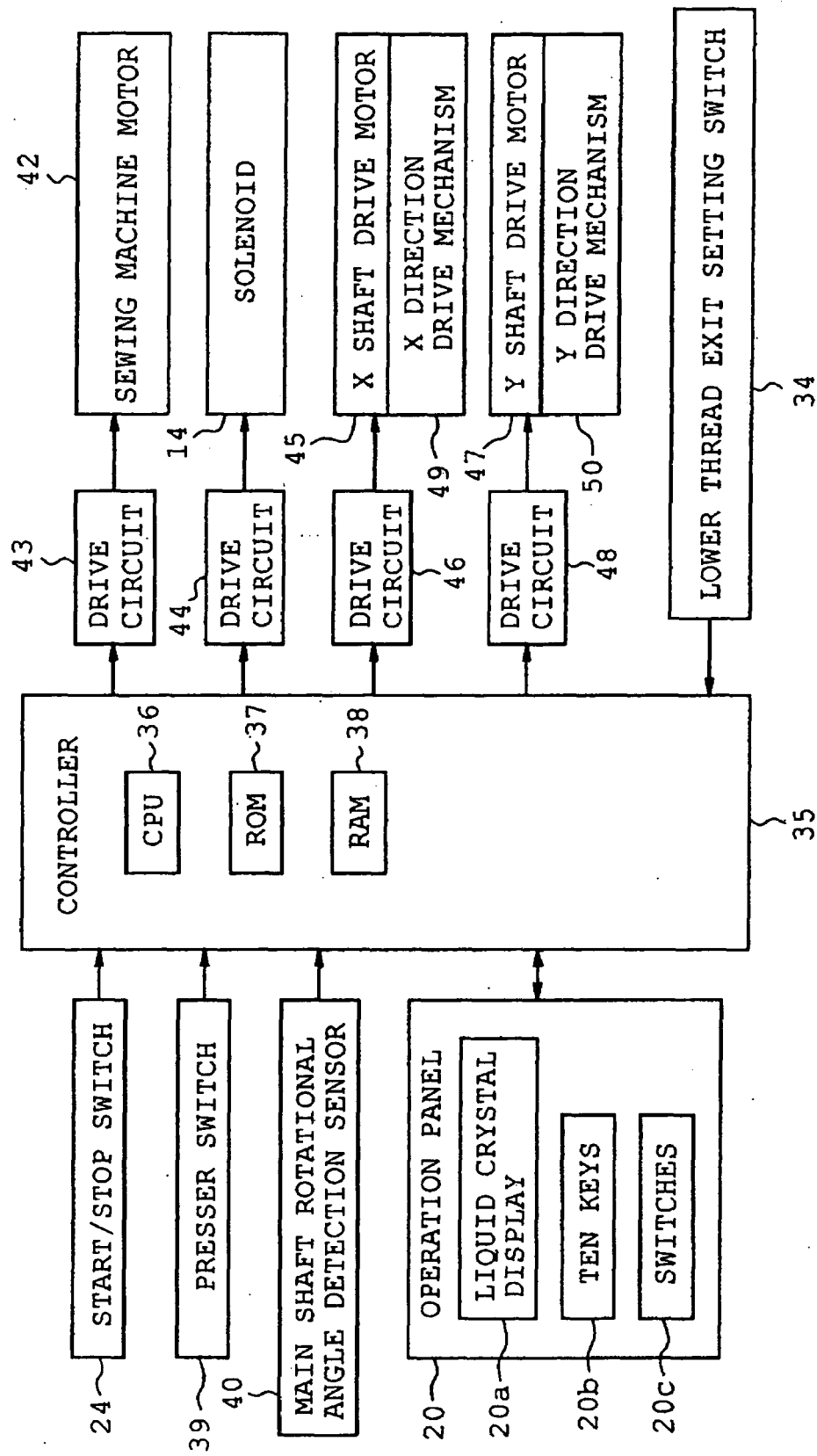


FIG. 7

ROTATIONAL SPEED (rpm) OF SEWING MACHINE MOTOR	Y DIRECTIONAL FEEDABLE AMOUNT (mm)
3000	0.1
3000	0.2
.	.
.	.
.	.
3000	2.9
2900	3.0
2900	3.1
.	.
.	.
.	.
2900	3.9
2800	4.0
2800	4.1
.	.
.	.
.	.

FIG. 8

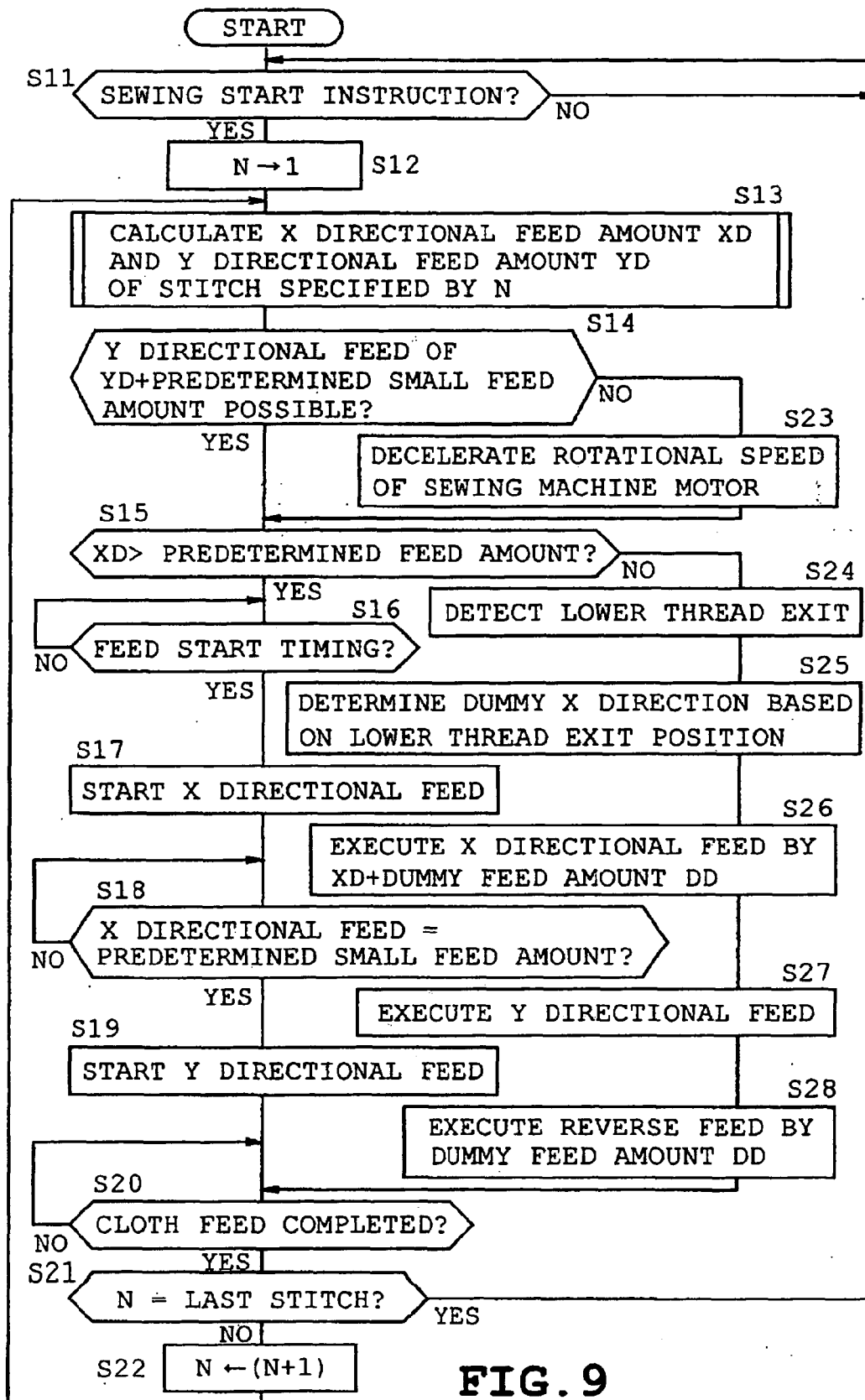


FIG. 9

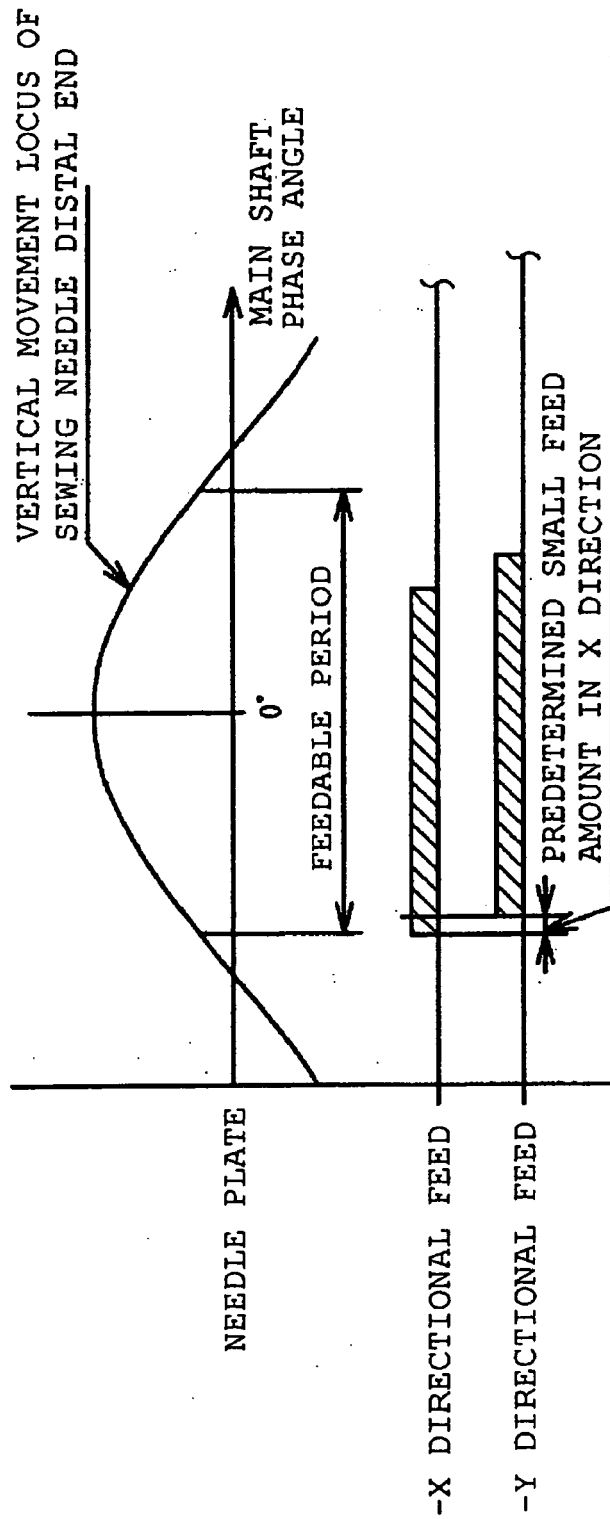


FIG. 10

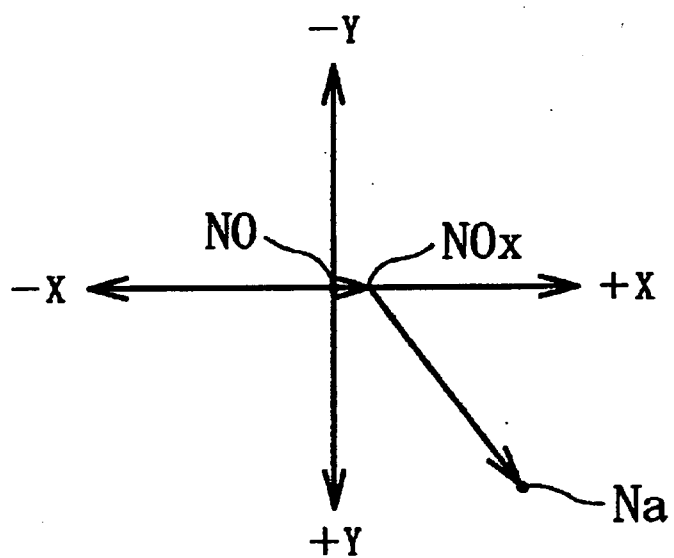


FIG. 11

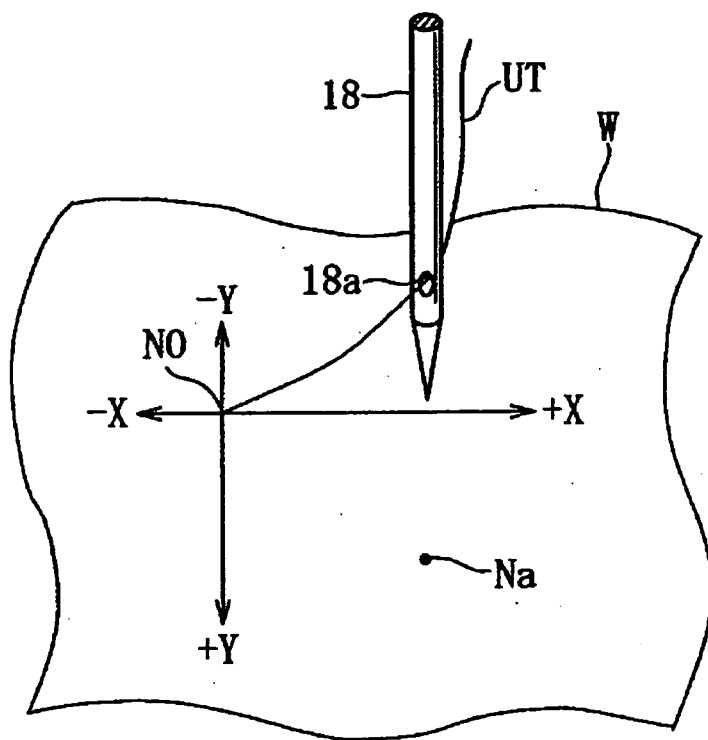


FIG. 12

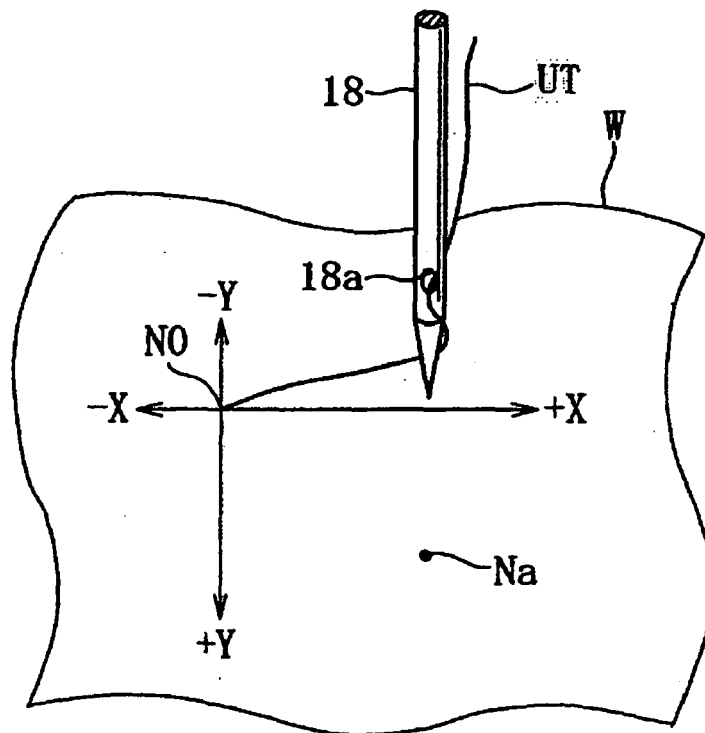


FIG. 13

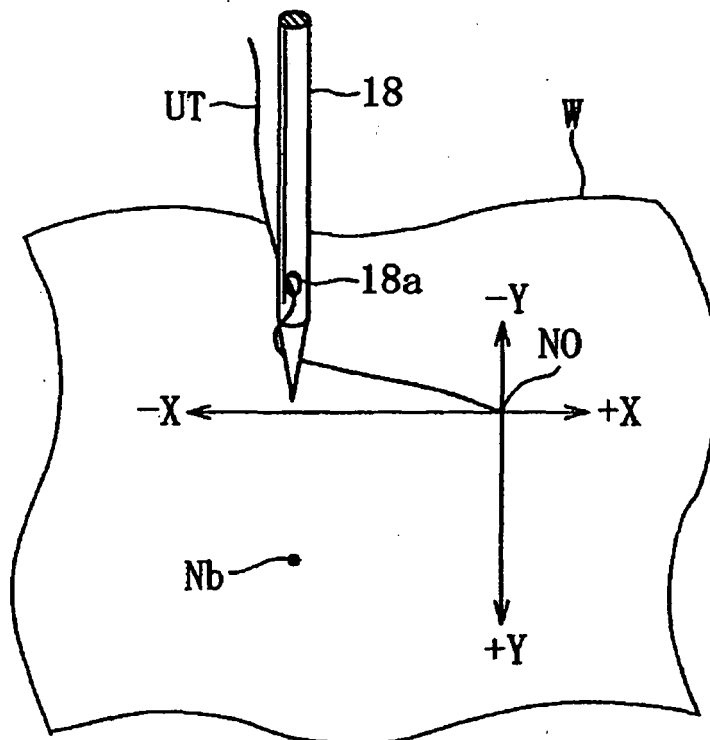


FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H0631065 A [0003]