



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.11.2003 Bulletin 2003/45

(51) Int Cl.7: **D05B 7/00**

(21) Application number: **03009931.1**

(22) Date of filing: **30.04.2003**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR
 Designated Extension States:
AL LT LV MK

(30) Priority: **01.05.2002 JP 2002129955**

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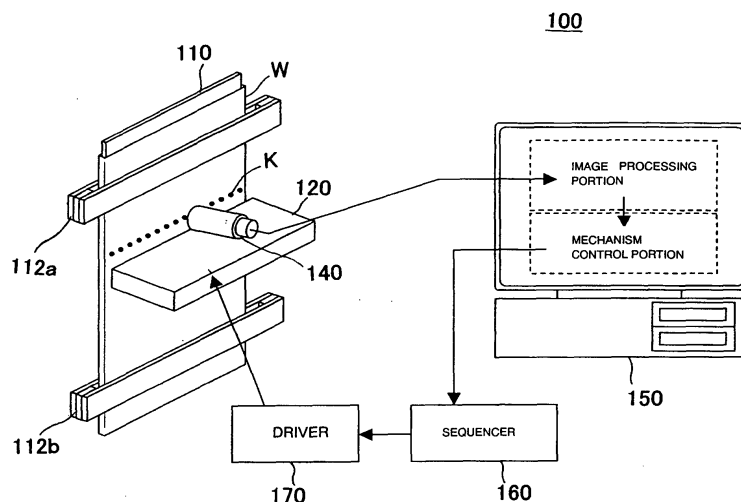
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(54) **Linking method and linking apparatus**

(57) There are provided a linking method and a linking apparatus capable of solidly linking a knitting fabric by automatically carrying out operation of piercing a point needle through an overlocking loop knitted at the knitting fabric swiftly and accurately. A linking method according to the invention is a linking method having a step of expanding a knitting fabric in a state of opposing linking object portions, a step of picking up an image of the expanded knitting fabric, a step of detecting a position of an overlocking loop from the picked-up image, a step of positioning the point needle corresponding to the

detected position of the overlocking loop thereto, a step of piercing the corresponding point needle through the detected overlocking loop and a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric, in which tacking needles are pierced through the overlocking loops at both end portions of the knitting fabric before the step of expanding the knitting fabric and the tacking needles are coupled with the point needles corresponding to the overlocking loops at the both end portions of the knitting fabric after the step of expanding the knitting fabric.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a linking method and a linking apparatus for overlocking a knitting fabric, particularly to a linking method and a linking apparatus for overlocking a knitting fabric by, for example, automatically piercing a point needle through an overlocking loop of the linking fabric.

2. Description of the Prior Art

[0002] Knitting fabric for constituting a material of a knitted product is knitted with a loose course comprising a knitted loop knitted to be larger than other knitted loop (hereinafter, simply referred to as overlocking loop) such that the product is correctly overlocked into prescribed size and shape when the knitted loop is overlocked.

[0003] Therefore, conventionally, overlocking has been carried out by piercing a point needle to each of overlocking loops constituting the loose course by looking through a knitting fabric after an operator pulled to widen the knitting fabric by the hand.

[0004] The operation has been carried out similarly also in the case of circular knitting fabric knitted in a cylindrical shape such as a sock. First, the operator pulls to widen the circular knitting fabric by putting the both hands into an opening portion of the circular knitting fabric, confirms the overlocking loop by looking through the knitting fabric on the depth side in view from the operator, pierces the point needle through the overlocking loop and thereafter, carries out the operation similarly also with regard to the knitting fabric on the operator's side to pierce the same point needle to the overlocking loops to be overlocked to thereby carry out overlocking operation.

[0005] However, it has been very difficult to pierce the point needle through the overlocking loop since the overlocking loop is only formed to be more or less larger than an ordinary knitted loop. Particularly, with regard to the circular knitting fabric, it is difficult to pull to widen the knitting fabric on the operator's side after piercing the point needle through the knitting fabric on the depth side and therefore, the problem is significantly posed. As a result, a long period of time is taken for carrying out the overlocking operation and further, a drawback of overlocking the knitting fabric while being deviated from the overlocking loop is brought about to result in a deterioration in the yield of the product.

[0006] Therefore, as is disclosed in JP-A-11-207061 or JP-A-11-207062, there has been developed a linking apparatus including an inserting member for expanding a knitting fabric by being inserted to an inner portion of a circular knitting fabric having an overlocking loop, image picking up means for picking up an image of the overlocking loop of the knitting fabric expanded by the inserting member, overlocking loop position detecting means for detecting a position of the overlocking loop by subjecting the image picked up by the image picking up means to an image processing, means for corresponding a point needle to the position of the overlocking loop detected by the overlocking loop position detecting means, means for piercing the point needle corresponding to each overlocking loop therethrough, and a sewing machine mechanism for overlocking the knitting fabric based on the pierced point needle, in which the operation of detecting the position of the overlocking loop of the knitting fabric, positioning the point needle corresponding to the detected overlocking loop and piercing the point needle corresponding to the detected overlocking loop therethrough is repeated and after piercing the point needle through each overlocking loop of the knitting fabric, the knitting fabric is overlocked by the sewing machine mechanism.

[0007] However, according to the conventional linking apparatus, the following problems are posed.

[0008] First, although it is necessary to align the point needles at predetermined intervals to be able to overlock by the sewing machine mechanism, when the position of the overlocking loop is detected and the point needle in correspondence with the detected position of the overlocking loop is positioned thereto, the point needle which has already been pierced is simultaneously moved and therefore, the detected overlocking loop is also moved and it may be difficult to pierce the corresponding point needle. Particularly, when an interval of the overlocking loops of the knitting fabric expanded by the inserting member is significantly different from intervals of the point needles, a movement amount in positioning the corresponding point needle to the detected portion of the overlocking loop is increased, also the detected overlocking loop is considerably moved and therefore, it is necessary to repeat operation of detecting the position of the overlocking loop and positioning the point needle again and a long period of time may be taken for linking.

[0009] Second, in order to facilitate to detect the position of the overlocking loop, the inserting member is inserted to the sock to expand in the left and right direction, the sock is expanded in the up and down direction by the hand to fix, or a total thereof is pulled downwardly by a roller to expand in the up and down direction and the sock is brought into a state of being expanded always in the operation of piercing the point needle. Thereby, also a location at which the point needle has already finished inserting or a location thereof other than the overlocking loop to be detected is brought into the state of being expanded always in operating to pierce the point needle and therefore, extra load may

be applied to the knitting fabric.

[0010] Third, although it is necessary to align the point needles at predetermined intervals to be able to overlock by the sewing machine mechanism, since the interval of the overlocking loops of the knitting fabric expanded by the inserting member tends to narrow at both end portions thereof, at vicinities of the both end portions at which the intervals of the overlocking loops are narrow, in order to position the point needles in correspondence with the detected positions of the overlocking loops, it is necessary to considerably move the point needles in directions of the end portions. In this case, as described above, the point needle which has already been pierced is simultaneously moved in the direction of the end portion and therefore, a position of a successive overlocking loop is also moved in the direction of the end portion, when it is repeated to detect the position of the overlocking loop and position the corresponding point needle, the movement amount of the point needle is accumulated, finally, the point needle is deviated from the end portion of the inserting member and positioning thereafter may not be carried out.

[0011] Fourth, the overlocking loop at the vicinity of the V point is not frequently expanded sufficiently, which causes to make detection of the overlocking loop difficult or bring about erroneous detection. Further, as described above, the overlocking loop disposed at the side face of the inserting member cannot be detected automatically, the point needle cannot be pierced automatically and therefore, automated processing of piercing the point needles automatically to all of the overlocking loops including the V point is difficult.

[0012] Fifth, it is not easy to pierce the V point needle to the V point after inserting the inserting member to the sock and expanding the knitting fabric, which causes to impair the knitting fabric or deteriorate the operational efficiency.

[0013] Sixth, at the toe portion of the sock, the knitting fabric is bulged on the side of the toe and a difference between tensions on the front and rear sides may be brought about. Therefore, the overlocking loop line on the toe side may be bent, the overlocking loop line may not be aligned with an overlocking loop line of other knitting fabric and in an extreme case, it may be difficult to detect the position of the overlocking loop or a long period of time may be taken in positioning the point needle.

SUMMARY OF THE INVENTION

[0014] Therefore, an object of the invention is to resolve the problems and provide a linking method and a linking apparatus capable of solidly linking a knitting fabric by piercing a point needle through an overlocking loop knitted at the knitting fabric swiftly and accurately.

[0015] According to a first aspect of the invention, there is provided a linking method comprising a step of expanding a knitting fabric in a state of opposing linking object portions, a step of picking up an image of the expanded knitting fabric, a step of detecting a position of an overlocking loop from the picked-up image, a step of positioning a point needle corresponding to the detected position of the overlocking loop thereto, a step of piercing the corresponding point needle through the detected overlocking loop, and a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric, wherein the step of positioning the corresponding point needle comprises a step of predicting an amount of moving of the detected position of the overlocking loop by movement of the point needle which has already been pierced by the step of piercing the corresponding point needle and positioning the corresponding point needle to the detected overlocking loop.

[0016] The aspect of the invention corresponds to the first problem, when the point needle is positioned to the detected overlocking loop, the point needle is positioned by predicting an amount of moving of the position of the overlocking loop by the point needle which has already been pierced and therefore, the positioning can be carried out accurately in a short period of time without repeating processings of detecting the position of the overlocking loop and positioning the point needle.

[0017] According to a second aspect of the invention, there is provided a linking method comprising a step of expanding a knitting fabric in a state of opposing linking object portions, a step of picking up an image of the expanded knitting fabric, a step of detecting a position of an overlocking loop from the picked-up image, a step of positioning a point needle corresponding to the detected position of the overlocking loop thereto, a step of piercing the corresponding point needle through the detected overlocking loop, and a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric, wherein in the step of expanding the knitting fabric, before the step of detecting the position of the overlocking loop, only a vicinity of the overlocking loop constituting an object is partially expanded.

[0018] The aspect of the invention corresponds to the second problem, when the position of the overlocking loop is detected, only the vicinity of the overlocking loop constituting the object is partially expanded and therefore, a location at which the point needle has already finished inserting or a location other than the overlocking loop to be detected is not expanded and extra load is not applied to the knitting fabric.

[0019] According to a third aspect of the invention, there is provided a linking method comprising a step of expanding a knitting fabric in a state of opposing linking object portions, a step of picking up an image of the expanded knitting fabric, a step of detecting a position of an overlocking loop from the picked-up image, a step of positioning a point

needle corresponding to the detected position of the overlocking loop thereto, a step of piercing the corresponding point needle through the detected overlocking loop, and a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric, further comprising a step of returning a position of the point needle which has already been pierced by the step of piercing the corresponding point needle to an initial position after the step of piercing the corresponding point needle and before the step of picking up the image of the overlocking loop of the knitting fabric for detecting a position of a successive one of the overlocking loop.

[0020] The aspect of the invention corresponds to the third problem, after the point needle has already been pierced, before the position of the successive overlocking loop is detected, the point needle which has already been pierced is returned to the initial position and therefore, even when detection of the position of the overlocking loop and positioning the corresponding point needle are repeated, the movement amount of the point needle is not accumulated and a situation that the point needle is deviated from the inserting member and cannot be positioned can be avoided.

[0021] According to a fourth aspect of the invention, there is provided the linking method according to any one of the first aspect through the third aspect, wherein the step of expanding the knitting fabric comprises a step of inserting a member having converged both end portions to an inner portion of a circular knitted fabric to expand the knitting fabric in a left and right direction.

[0022] The aspect of the invention corresponds to the fourth problem, the member having the converged both end portions is inserted to the inner portion of the knitting fabric to expand the knitting fabric in the left and right direction and therefore, an interval of the overlocking loops at vicinities of both end portions of the knitting fabric is widened and easily detected automatically. Further, also the overlocking loop of the V point is expanded in the left and right direction and therefore, automatic detection or automatic piercing of the point needle can be carried out and automatic processings of automatically detecting all of the overlocking loops and automatically piercing the point needles therethrough become possible.

[0023] According to a fifth aspect of the invention, there is provided the linking method according to any one of the first aspect through the fourth aspect, further comprising a step of piercing tacking needles to the overlocking loops at both end portions of the knitting fabric before the step of expanding the knitting fabric, and a step of coupling the tacking needles to the point needles in correspondence with the overlocking loops at the both end portions of the knitting fabric after the step of expanding the knitting fabric.

[0024] The aspect of the invention corresponds to the fifth problem, the tacking needles are pierced through the overlocking loops at the both end portions of the knitting fabric before expanding the knitting fabric and therefore, can easily be pierced through the knitting fabric at the both end portions of the knitting fabric, the tacking needles are coupled with the corresponding point needles after the step of expanding the knitting fabric and therefore, the corresponding point needles can firmly be pierced through the overlocking loops at the both end portions of the knitting fabric. Thereby, operational efficiency can be improved without impairing the knitting fabric.

[0025] According to a sixth aspect of the invention, there is provided the linking method according to any one of the first aspect through the fifth aspect, wherein the knitting fabric is the circular knitted fabric for constituting a sock, further comprising a step of hanging a toe of the sock of the circular knitted fabric.

[0026] The aspect of the invention corresponds to the sixth problem, when the knitting fabric is expanded, the toe is hung and therefore, bending of the overlocking loop on the toe side is resolved to thereby facilitate to detect the position of the overlocking loop, the overlocking loop is aligned with an overlocking loop at other knitting fabric and a time period of positioning the point needle is shortened.

[0027] According to a seventh aspect of the invention, there is provided a linking apparatus comprising knitting fabric expanding means for expanding a knitting fabric in a state of opposing linking object portions, image picking up means for picking up an image of the knitting fabric expanded by the expanding means, overlocking loop position detecting means for detecting a position of an overlocking loop an image of which is picked up by the picking up means, point needle positioning means for positioning a point needle corresponding to the position of the overlocking loop detected by the overlocking loop position detecting means thereto, point needle piercing means for piercing the corresponding point needle through the detected overlocking loop, and overlocking means for overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric by the point needle piercing means, wherein the point needle positioning means includes a function of predicting an amount of moving the position of the overlocking loop detected by the overlocking loop position detecting means by movement of the point needle which has already been pierced by the point needle piercing means and positioning the corresponding point needle to the detected overlocking loop.

[0028] The aspect of the invention corresponds to the first problem, when the point needle is positioned to the detected overlocking loop, the point needle is positioned by predicting the amount of moving of the position of the overlocking loop by the point needle which has already been pierced and therefore, the point needle can be positioned accurately in a short period of time without repeating processings of detecting the position of the overlocking loop and positioning the point needle.

[0029] According to an eighth aspect of the invention, there is provided a linking apparatus comprising knitting fabric

expanding means for expanding a knitting fabric in a state of opposing linking object portions, image picking up means for picking up an image of the knitting fabric expanded by the knitting fabric expanding means, overlocking loop position detecting means for detecting a position of an overlocking loop an image of which is picked up by the image picking up means, point needle positioning means for positioning a point needle corresponding to the position of the overlocking loop detected by the overlocking loop position detecting means thereto, point needle piercing means for piercing the corresponding point needle to the detected overlocking loop, and overlocking means for overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric by the point needle piercing means, wherein the knitting fabric expanding means includes a function of expanding only a vicinity of the overlocking loop constituting an object of being detected by the overlocking loop position detecting means.

[0030] The aspect of the invention corresponds to the second problem, before detecting the position of the overlocking loop, only the vicinity of the overlocking loop constituting the object is partially expanded and therefore, at a location at which the point needle has already finished inserting or at a location other than the overlocking loop to be detected is not expanded and extra load is not applied to the knitting fabric.

[0031] According to a ninth aspect of the invention, there is provided a linking apparatus comprising knitting fabric expanding means for expanding a knitting fabric in a state of opposing linking object portions, image picking up means for picking up an image of the knitting fabric expanded by the knitting fabric expanding means, overlocking loop position detecting means for detecting a position of an overlocking loop an image of which is picked up by the image picking up means, point needle positioning means for positioning a point needle corresponding to the position of the overlocking loop detected by the overlocking loop position detecting means thereto, point needle piercing means for piercing the corresponding point needle through the detected overlocking loop, and overlocking means for overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric by the point needle piercing means, wherein the point needle positioning means comprising means for returning a position of the point needle which has already been pierced by the point needle piercing means to an initial position when the position of the overlocking loop is detected by the overlocking loop position detecting means.

[0032] The aspect of the invention corresponds to the third problem, after the point needle has been pierced, before the position of the successive overlocking loop is detected, the point needle which has already been pierced is returned to the initial position and therefore, even when detection of the position of the overlocking loop and positioning the corresponding point needle are repeated, the movement amount of the point needle is not accumulated and the situation that the point needle is deviated from the inserting member and cannot be positioned can be avoided.

[0033] According to a tenth aspect of the invention, there is provided the linking apparatus according to any one of the seventh aspect through the ninth aspect, wherein the knitting fabric expanding means comprises means for inserting a member having converged both end portions to an inner portion of a circular knitted fabric to expand the knitting fabric in a left and right direction.

[0034] The aspect of the invention corresponds to the fourth problem, the member having the converged both end portions are inserted to the inner portion of the knitting fabric to expand the knitting fabric in the left and right direction and therefore, the intervals of the overlocking loops at vicinities of the both end portions of the knitting fabric are widened and can easily be detected automatically. Further, also the overlocking loop of the V point is expanded in the left and right direction and therefore, automatic detection and automatic piercing of the point needle can be carried out and automatic processings of automatically detecting all of the overlocking loops and automatically piercing the point needles therethrough become possible.

[0035] According to an eleventh aspect of the invention, there is provided the linking apparatus according to any one of the seventh aspect through the tenth aspect, further comprising tacking needles pierced through the overlocking loops at both end portions of the knitting fabric before expanding the knitting fabric by the knitting fabric expanding means including coupling means for coupling with the point needles corresponding to the overlocking loops at the both end portions of the knitting fabric after expanding the knitting fabric by the knitting fabric expanding means.

[0036] The aspect of the invention corresponds to the fifth problem, the tacking needles are pierced through the overlocking loops at the both end portions of the knitting fabric before expanding the knitting fabric and therefore, the tacking needles can easily be pierced through the overlocking loops at the both end portions of the knitting fabric, the tacking needles are coupled with the corresponding point needles after the step of expanding the knitting fabric and therefore, the corresponding point needles are firmly be pierced through the overlocking loops at the both end portions of the knitting fabric. Thereby, the operational efficiency can be improved without impairing the knitting fabric.

[0037] According to a twelfth aspect of the invention, there is provided the linking apparatus according to any one of the seventh aspect through the eleventh aspect, wherein the knitting fabric expanding means comprises means for hanging a toe of a sock.

[0038] The invention corresponds to the sixth problem, the toe is hung when the knitting fabric is expanded and therefore, bending of the overlocking loop on the toe side is resolved to facilitate to detect the position of the overlocking loop, the overlocking loop is aligned with an overlocking loop of other knitting fabric and a time period of positioning the point needle is shortened.

[0039] The above-described object, other object, characteristics and advantages of the invention will become further apparent from a detailed explanation of the following embodiments described in reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040]

Fig. 1 is an outline constitution view of a main body mechanism according to an embodiment of a linking apparatus of the invention;

Fig. 2 is a view illustrating a point needle;

Fig. 3 is a plane view of a needle piercing mechanism;

Fig. 4 is a side view of the needle piercing mechanism;

Fig. 5 is an operational flowchart according to a first embodiment (V point manually processing type) of a linking apparatus of the invention;

Fig. 6 is an operational flowchart according to a second embodiment (semiautomatic type) of a linking apparatus of the invention;

Fig. 7 is an operational flowchart according to a third embodiment (automatic type) of a linking apparatus of the invention;

Fig. 8 is an operational flowchart according to a fourth embodiment (single needle type) of a linking apparatus of the invention;

Fig. 9 is a processing flowchart according to an embodiment of a processing of detecting a position of an overlocking loop;

Fig. 10 is a processing flowchart according to an embodiment of a processing of detecting a start overlocking loop;

Fig. 11 is a processing flowchart according to an embodiment of a processing of detecting a front side initial overlocking loop;

Fig. 12 is a processing flowchart according to an embodiment of a processing of detecting a rear side initial overlocking loop;

Fig. 13 is a processing flowchart according to an embodiment of a processing of positioning a point needle;

Fig. 14 is a processing flowchart according to an embodiment of a processing of returning a needle;

Fig. 15 is a processing flowchart according to an embodiment of a partially expanding mechanism;

Fig. 16 shows an example of an image of an ordinary overlocking loop;

Fig. 17 is an explanatory view of a method of directly detecting an overlocking loop;

Fig. 18 is an explanatory view of a method of finely detecting an overlocking loop;

Fig. 19 shows an example of an image of a front side initial overlocking loop;

Fig. 20 shows an example of an image of a rear side initial overlocking loop;

Fig. 21 is an explanatory view of a region of detecting a start overlocking loop;

Fig. 22 is an explanatory view of a processing of detecting a start overlocking loop;

Fig. 23 is an explanatory view of a processing of determining an overlocking loop;

Figs. 24A, 24B and 24C show an example of an image processing of a locking loop position detecting processing;

Figs. 25A, 25B, 25C and 25D show an example of an image processing of a processing of detecting an initial overlocking loop;

Figs. 26A and 26B are explanatory views of a jig for hanging a toe of a sock;

Fig. 27 is an explanatory view of a tacking needle for a semiautomatic processing;

Fig. 28 is an explanatory view of a both end converging inserting member; and

Fig. 29 is a conceptual view of a partially expanding mechanism.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0041] Fig. 1 is an outline constitution of a main body mechanism according to an embodiment of a linking apparatus of the invention. In the drawing, a main body mechanism 100 of a linking apparatus comprises an inserting member 110 for inserting a sock W to expand, a needle piercing mechanism 120 for piercing a point needle through an overlocking loop K of the expanded sock W, a CCD camera 140 for picking up an image of the overlocking loop K, a computer 150 including an image processing portion for inputting an image signal from the CCD camera 140 and carrying out an image processing to detect a position of the overlocking loop K and a mechanism control portion for controlling the main body mechanism, a sequencer 160 for controlling the needle piercing mechanism 120 by receiving a control signal from the computer 150, and a driver 170 for driving respective actuators of the needle piercing mechanism 120 by receiving a control signal from the sequencer 160.

[0042] The inserting member 110 is provided with a constant thickness and provided with a width for pertinently

expanding the stock W in a left and right direction when inserting the stock W. Further, the inserting member 110 includes fixing pieces 112a and 112b for expanding the sock W pertinently in an up and down direction to fix when inserting the sock W. Thereby, the overlocking loop K of the sock W is pertinently expanded in the up and down direction and in the left and right direction and therefore, a position of the overlocking loop K can automatically be detected by

subjecting the image picked up by the CCD camera 140 to the image processing by the computer 150.
[0043] The inserting member 110 also serves as an illuminating apparatus when the image of the overlocking loop K is picked up by the CCD camera and EL panels are attached to both faces of the inserting member 110 (not illustrated). Thereby, a hole of a knitted loop of the sock W is caught as a bright image by the CCD camera 140 and a fiber portion thereof is caught as a dark image thereby. In this way, by illuminating from a rear side of the sock W relative to the CCD camera 114 and detecting transmitted light by the CCD camera 140, the hole of the overlocking loop K can be caught with excellent contrast. Further, the illumination is not limited to the EL panel but may use a constitution aligned with LEDs or electric lamps and the illumination may naturally be carried out by using a light guide by fiber or a light guiding plate. Further, even when other illuminating method is used, it is preferable for catching the hole of the overlocking loop K with excellent contrast to illuminate from the rear side of the sock W relative to the CCD camera 140 and detect the transmitted light by the CCD camera 140.

[0044] Fig. 2 shows an outline constitution of a point needle for overlocking. Point needles 132 need to align at predetermined intervals for overlocking by a sewing machine mechanism (not illustrated) and are aligned in a needle box 130 having grooves at predetermined intervals as illustrated. Further, special V point needles 134 for piercing through the overlocking loops K at the both end portions of the sock W are provided at both ends thereof and a manually set previously to the overlocking loops K at the both ends. The V point needles 134 are arranged in a state of being movable in the left and right direction during a processing of piercing the point needles, locked to the needle box 130 at a time point of finishing to pierce all of the point needles 132 through the respective overlocking loops K of the sock W and delivered to the sewing machine mechanism.

[0045] Fig. 3 and Fig. 4 show an outline constitution of the needle piercing mechanism 120. As shown by the drawings, the needle piercing mechanism 120 includes a base 122, the needle box 130 fixed above the base 122 and a needle extruding mechanism 124 fixed above the base 122.

[0046] The needle extruding mechanism 124 includes a feed mechanism 126 for moving in accordance with the interval of the point needle 132 of the needle box 130 and selecting the point needle 132 to be extruded and an actuator 128 for extruding the selected point needle 132 to pierce through the overlocking loop K of the sock W. Although the feed mechanism 126 can be formed by an NC apparatus using a ball screw or the like and the actuator 128 can be formed by using a pneumatic actuator or a solenoid, further simply and conveniently, the actuator 128 may be driven by a spring, the feed mechanism 126 may be provided with a plate for locking extrusion of the needle and the point needles 132 may be extruded successively by drawing away the plates at constant intervals.

[0047] The base 122 of the needle piercing mechanism 120 can be mounted above a table (not illustrated) capable of positioning two-dimensionally in the up and down direction and in the left and right direction and the point needle 132 to be extruded can be positioned to the overlocking loop K of the sock W based on an instruction from the sequencer 160.

[0048] Further, the CCD camera 140 is mounted to the needle extruding mechanism 124 and moved along with the needle extruding mechanism 124. A center of a field of view of the CCD camera 140 is substantially made to coincide with a position of a surface of the sock W to be pierced with the point needle 132 extruded by the actuator 128. By bringing a center of the overlocking loop K of the sock W substantially to the center of the CCD camera 140 thereby, the corresponding point needle 132 can be pierced through the corresponding overlocking loop K and coordinate transformation is facilitated.

[0049] Equivalent ones of the needle piercing mechanisms 120 and the CCD cameras 140 are provided on both sides of the surface and the rear face to carry out operation of detecting the overlocking loops K and piercing the point needles 132 therethrough independently from each other for respective of the front side and the rear side and when the operation of piercing all of the point needles 132 has been finished, the needle piercing mechanism 120 are returned to initial positions, positions of the needles on the front side and the rear side are made to coincide with each other and the inserting member 110 is drawn out. In this case, since the point needles 132 are pressed to the inserting member 110 by air pressure or the like, the sock W is not detached from the needles and the needles on the front side and the needles on the rear side are butted together. Finally, the sock W is moved to one side and overlocked by the sewing machine mechanism.

[0050] Although according to the embodiment, an explanation has been given such that the needle piercing mechanisms 120 use the point needles 132 on both sides of the front side and the rear sides to butt together, a needle on a side opposed to the point needle 132 for finally carrying out the overlocking operation may simply be a guide and may be of a sheath-like shape for coupling with the point needle 132 when butted to the point needle 132.

[0051] Further, it is not necessarily needed to provide the needle piercing mechanisms 120 on the both sides but the needle piercing mechanism 120 may be provided only on, for example, the front side, slits may be provided at

portions for piercing the point needles after piercing all of the point needles 132 through the respective overlocking loops K on the front side by dividing the inserting member 110 in the up and down direction, the positions of the overlocking loops on the rear side may be detected by the CCD camera 140 on the rear side, the positions of the corresponding point needles 132 of the needle piercing mechanism 120 on the front side may be made to coincide with the overlocking loops K on the rear side and the point needles 132 may be pierced therethrough completely to the rear side.

[0052] Next, an explanation will be given of an overlocking loop position detecting processing for detecting a position of an overlocking loop by subjecting an image of a knitted loop picked up by the CCD camera 140 to image processing.

[0053] Fig. 9 shows an example of a processing flow of an overlocking loop position detecting processing. As shown by the drawing, an image is inputted from the CCD camera 140 (S184), a predetermined detecting region is set (S186), and the inputted image is binarized (S188).

[0054] A threshold of the binarization is determined by using a determining analysis method (so-to-speak Ohtsu's method) of calculating a concentration histogram of the image in a predetermined region and selecting a threshold maximizing a dispersion between classes when the calculated concentration histogram is divided into two classes. This is because according to a P tile method of determining a threshold in which a rate of a pixel in the binarized image becomes P, when the cloth is excessively loosened or pulled, in order to make an area ratio constant, knitted loops are made continuous or the knitted loop is crushed and because even a mode method of finding a valley of the concentration histogram to constitute a threshold, poses a problem that when the cloth is loosed and the bimodality of the concentration histogram is lost, the threshold cannot be calculated and in the case of the determining analysis method, even when the bimodality is lost, the threshold can automatically be determined.

[0055] Further, as the threshold of the binarization, when an illuminating condition is stabilized, a fixed threshold may naturally be used. Further, although an explanation is omitted with regard to a pretreatment of the inputted image, it is preferable to remove noise by smoothing or the like before the binarization.

[0056] Next, the binarized image is labeled and a hole having a predetermined area or larger is detected (S190). Further, the position of the overlocking loop is predicted as mentioned later (S192), the overlocking loop is determined by a gravitational center of a label most proximate to the predicted position (S194), it is determined whether the overlocking loop is a correct one from a distance to the predicted position (S196), and the position is transformed into mechanical system position coordinate from the gravitational center of the detected overlocking loop (S198).

[0057] Fig. 16 shows an example of an image of an ordinary overlocking loop picked up by the CCD camera 140. As shown by the drawing, the overlocking loop is knitted to be larger than other knitted loop to facilitate to differentiate therefrom and in view of the structure, a knitted loop paired with the overlocking loop becomes also larger. Both of them do not become smaller than other knitted loop although a large or small relationship of areas of the overlocking loop and the knitted loop paired therewith is changed by the sock. Hence, the overlocking loop is detected by utilizing the structural characteristic that the overlocking loop and the knitted loop paired therewith become larger than other knitted loop.

[0058] Threads are intertwined at a knitted loop and therefore, the knitted loop is provided with a property that even when force is exerted to a certain point, the force effects influence widely at a surrounding thereof, a change of the knitted loop becomes smooth as a whole and a pitch of the overlocking loop becomes substantially constant.

[0059] Hence, when a basic X pitch is constituted by dividing a lateral width of the sock W expanded by the inserting member 110 by a number of the overlocking loops and the overlocking loops of the sock W are set substantially horizontally, a next overlocking loop position can be predicted from a known overlocking loop position by the following equation:

$$|\text{next overlocking loop predicted X position}| = |\text{known overlocking loop X position}| + |\text{basic X pitch}|$$

[0060] Therefore, as shown by Fig. 17, a knitted loop most proximate to the predicted position can be detected as a next overlocking loop. Here, a shape of a knitted loop is proximate to an elliptical shape and therefore, the position of the knitted loop seems to be a gravitational center of the knitted loop and therefore, the gravitational center of the knitted loop most proximate to the predicated position is defined as the overlocking loop position (which is referred to as a direct detecting method).

[0061] However, the loops may be deformed in the up and down direction and a possibility of erroneous detecting is increased only by the above-described detecting method. Hence, as shown by Fig. 18, a method of finely detecting by utilizing the knitted loop paired with the overlocking loop (which is referred to a finely detecting method) may also be used. In this case, the next knitted loop position can be predicted from the known knitted loop position by the following equation:

$$|\text{next knitted loop predicted X position}| = |\text{known knitted}$$

$$\text{loop X position}| + |1/2 \text{ basic X pitch}|$$

$$|\text{next knitted loop predicted Y position}| = |\text{known knitted}$$

$$\text{loop Y position}| \pm |\text{basic Y pitch}|$$

[0062] Ordinary overlocking loops are aligned comparatively regularly except at vicinities of the both end portions and therefore, in this case, first, the overlocking loop is calculated by the direct detecting method, the predicted position and the detected gravitational center are compared, when a distance therebetween is equal to or smaller than a pre-determined distance, the overlocking loop is determined and when the distance is equal to or larger than the pre-determined distance, the overlocking loop is detected again by the finely detecting method. Thereby, the overlocking loop can efficiently be detected and a processing time period thereof can be shortened.

[0063] Figs. 24A, 24B and 24C show an example of detecting a position of an overlocking loop by the above-described processing. Fig. 24A shows a set detecting region, Fig. 24B shows a result of carrying out labeling processing at the detecting region and Fig. 24C shows a result of detecting a position of an overlocking loop from a gravitational center of a label most proximate to a predicted position.

[0064] Although according to the above-described embodiment, the processing of predicting the next overlocking loop position and constituting the overlocking loop by the gravitational center of the label most proximate thereto is used, the next overlocking loop may be detected by not using predicted information but tracking a label contiguous to the known overlocking loop and the position of the next overlocking loop may be constituted by a gravitational center thereof.

[0065] Next, a processing of detecting an initial overlocking loop will be described.

[0066] A knitted loop which is mostly difficult to detect in detecting overlocking loops is an initial overlocking loop. The initial overlocking loop is an overlocking loop most proximate to the V point. Fig. 19 shows an example of an image of an initial overlocking loop and a surrounding thereof on a front side and Fig. 20 shows an example of an image of an initial overlocking loop and a surrounding thereof on a rear side, respectively. As shown by the drawings, a vicinity of the V point is proximate to a position of folding back the cloth and particularly with respect to the front side, a complicated knitted loop structure is constituted by also adding an influence of a gore line of toe and it is difficult to directly detect the initial overlocking loop from the V point.

[0067] However, the initial overlocking loop is brought into a constant positional relationship with other overlocking loop and therefore, a predicted position of the initial overlocking loop can be calculated thereby. Further, although it is difficult to detect an overlocking loop at the V point because of deformation, an overlocking loop disposed at a location remote from the V point to some degree is stabilized and therefore, the overlocking loop can be detected. Hence, the initial overlocking loop is detected by previously detecting an overlocking loop disposed at a position remote from the V point and tracking an overlocking loop line in a reverse direction therefrom.

[0068] Although in detecting the initial overlocking loop, a method of detecting the initial overlocking loop slightly differs between the front side and the rear side, in both cases, detection from the V point is difficult and therefore, detection is carried out from an overlocking loop at a midway (this is referred to as a start overlocking loop). Fig. 21 shows a set detecting region of the start overlocking loop. The largest knitted loop is detected in the region. Depending on the sock, areas of an overlocking loop and a knitted loop paired therewith may be the same and it may not be determined whether a detected knitted loop is an overlocking loop or a knitted loop paired therewith. Therefore, it is determined whether a detected knitted loop is an overlocking loop by utilizing the property that an overlocking loop and a knitted loop paired therewith are larger than other knitted loop. That is, as shown by Fig. 22, knitted loops contiguous to a knitted loop detected in the set region in a skewed upper direction and a skewed lower direction therefrom are detected and areas A1 and A2 of the respective are calculated. A1 and A2 are compared, when A1 is larger, it is determined that the knitted loop disposed in the skewed upper direction therefrom is the overlocking loop and the detected knitted loop is the knitted loop paired therewith and when A2 is larger, it is determined that the knitted loop disposed in the skewed lower direction is the knitted loop paired therewith and the detected knitted loop is the overlocking loop.

[0069] Fig. 10 shows an example of a processing flow of a start overlocking loop detecting processing. As shown by the drawing, similar to detection of an ordinary overlocking loop, an image is inputted (S142), a detecting region is set (S144), the image is binarized (S146), and a hole having a predetermined area or more is detected by labeling (S148). Next, a hole having the largest area is sampled (S150), and areas of a hole on the upper left and a hole on the lower left are compared (S152). When the area on the upper left is larger, the hole on the upper left is determined

as the overlocking loop (S156). Further, when the hole on the lower left is larger, the hole having the largest area is determined as the overlocking loop (S158).

[0070] Next, the final initial overlocking loop is detected by tracking back the overlocking loop line by the fine detecting method from the detected start overlocking loop.

[0071] In determining the final initial overlocking loop, the position of the initial overlocking loop is liable to change by the influence of the gore line on the front side. However, a large knitted loop is knitted at a location connecting the overlocking loop line and the gore line and the initial overlocking loop is necessarily present on the upper right of the large knitted loop. Hence, first, an X coordinate of the right end of the large knitted loop is calculated. Since the knitted loop is the largest knitted loop, the detection can be carried out easily. When the overlocking loop line is tracked back by the fine detecting method, the track becomes proximate to the X coordinate finally. Further, the overlocking loop most proximate to the X coordinate is determined as the initial overlocking loop on the front side.

[0072] Fig. 11 shows an example of a processing flow of a front side initial overlocking loop detecting processing. First, the camera is moved to a vicinity of a left end (S160), an image is inputted (S162), a detecting region is set (S164), and the image is binarized (S166). A hole having a predetermined area or larger is detected by labeling the binarized image (S168), a hole most proximate to the left end is selected from detected holes (S170) and the detecting reference line is set at a location from a right end of the hole by a predetermined distance (S172). Next, the camera is moved to the start overlocking loop detecting position (S174) and the start overlocking loop is detected (S176). Further, the overlocking loop is tracked back from the start overlocking loop to the detection reference line (S178) and when the gravitational center of the detected overlocking loop exceeds the detection reference line (S180), the finally detected overlocking loop is determined as the initial overlocking loop (S182).

[0073] Further, in this case, the detection reference line is set to the right side of the right end of the start overlocking loop by about 1 pitch. Further, the detection reference line may be set to the right end of the start overlocking loop and the overlocking loop at which the gravitational center of the tracked overlocking loop is most proximate to the detection reference line may be determined as the initial overlocking loop.

[0074] Figs. 25A, 25B, 25C and 25D show an example of carrying out the front side initial overlocking loop detecting processing by the above-described processing. In this case, the detection reference line is set at the right end of a large knitted loop at a vicinity of the V point as shown by Fig. 25A, the start overlocking loop is detected as shown by Fig. 25B, the overlocking loop is tracked by the finely detecting method as shown by Fig. 25C and the initial overlocking loop is detected as shown by Fig. 25D.

[0075] With regard to the rear side, the shape of the initial overlocking loop is not varied considerably and therefore, the overlocking loop line is detected back by the finely analyzing method, the detection reference line is set on the inner side of the V point by a constant distance and the overlocking loop exceeding the detection reference line is determined as the initial overlocking loop. In this case, the detection reference line is set to the inner side of the V point by 1.5 times as large as the basic X pitch.

[0076] Fig. 12 shows a processing flow of an initial overlocking loop detecting processing on the rear side. First, the detection reference line is set on the inner side of the left end by a predetermined distance (S130), the camera is moved to the start overlocking loop detecting position (S132), and the start overlocking loop is detected (S134). The overlocking loop is tracked from the start overlocking loop toward the detection reference line (S136), when the gravitational center of the detected overlocking loop exceeds the detection reference line (S138), the finally detected overlocking loop is determined as the initial overlocking loop (S140).

[0077] Next, a processing of determining whether a detected hole is an overlocking loop will be described. In tracking an overlocking loop in the overlocking loop position detecting processing or the initial overlocking loop detecting processing, before determining a detected hole as an overlocking loop, it is determined whether the overlocking loop is not clearly mistaken in view from a detected location thereof. Here, as shown by Fig. 23, a predetermined range is determined by constituting a reference by an overlocking loop predicted position and when a gravitational center of a knitted loop falls in a range, the knitted loop is determined as the overlocking loop. Further, the predetermined range is set to be $\pm 1/4$ X pitch in X direction and $\pm 1/2$ Y pitch in Y direction centering on the overlocking loop predicted position.

[0078] When the detected overlocking loop does not fall in the range, in the case of the directly detecting method, by switching the directly detecting method to the finely analyzing method and the overlocking loop is detected again and in the case of the finely detecting method, a correct overlocking loop is detected newly by using the above-described start overlocking loop detecting processing.

[0079] Further, when assistance of the human being can be carried out, the operation may be switched to manual operation, for example, the human being may be able to designate a correct overlocking loop position by observing a monitor and a next overlocking loop position may be predicted based on the position to continue the automatic processing.

[0080] Several embodiments of linking apparatus of the invention will be explained as follows.

[0081] Fig. 5 shows an operational flow according to a first embodiment of a linking apparatus of the invention, in which the V point needle is processed manually.

[0082] First, the sock W is inserted by the inserting member 110 to expand in the left and right direction (S100), and the V point needle 134 is inserted to the V point (S102). The sock W is expanded in the up and down direction and fixed by the fixing pieces 112a and 112b (S104) and hung by putting the jig to the toe of the sock W (S106).

[0083] The jig is put into the toe because as shown by Figs. 26A and 26B, before inserting the jig, the knitting fabric is bulged on the toe side to bring about a difference between tensions on the front side and the rear side, the overlocking loop line on the front side is bent as shown by the left drawing and the overlocking loop lines on the front side and on the rear side are not aligned. Hence, by inserting a toe hanging jig 114 as shown by the upper view into the toe portion of the sock W, the overlocking loop lines are aligned as shown by the right view, the overlocking loop K becomes easy to detect and a time period of positioning the point needle is shortened.

[0084] Next, the following point needle piercing processing is carried out for both of the front side and the rear side.

[0085] First, an initial overlocking loop detecting processing (S108a, b) is carried out to determine an initial overlocking loop. Next, a camera is moved to a target overlocking loop position (S110a, b), the overlocking loop position is detected (S112a, b), a point needle in correspondence with the detected overlocking loop position is positioned (S114a, b) and the point needle corresponding to the detected overlocking loop is pierced therethrough (S116a, b), which are repeated for all the overlocking loops (S118a, b).

[0086] In this case, movement of the camera to the target overlocking loop position (S110a, b) signifies movement of the camera by advancing the needle extruding mechanism 124 to a successive point needle, however, a successive overlocking loop predicted position may previously be calculated and the needle piercing mechanism 120 may simultaneously be moved such that the position is imaged at the center of the field of view of the camera.

[0087] Further, with regard to an initial time of the operation, the overlocking loop position detected by the initial overlocking loop detecting processing (S108a, b) can be used and therefore, movement of the camera (S108a, b) and the overlocking loop position detecting processing (S112a, b) can be omitted.

[0088] When the processing of piercing the point needle has been finished for all of the overlocking loops, the point needle is returned to an initial position (S120a, b).

[0089] Finally, when both of the front side and the rear side are finished, the inserting member 110 is drawn (S122), the sock W is moved to one of the point needles (S124) and overlocked (S126).

[0090] Fig. 6 shows an operational flow according to a second embodiment of a linking apparatus of the invention, in which a V point processing is carried out semiautomatically by using a tacking needle.

[0091] As shown by Fig. 27, tacking needles 116 are jigs previously pierced through the V points on the both ends of the sock before setting the sock W to the inserting member 110 and by coupling the tacking needles 116 to the V point needles 134 after inserting the inserting member 110 into the sock W, the processing of the V point needles 134 is made to be able to carry out equivalently to other point needle to thereby promote the operational efficiency.

[0092] For such purpose, the tacking needle 116 is previously inserted to the V point of the sock W (S200), the sock W is inserted by the inserting member 110 to expand in the left and right direction (S202), the sock W is expanded in the up and down direction to fix (S204), the toe hanging jig 114 is put into the toe to hang (S206) and the V point needle 134 is pierced through the sock W by constituting a guide by the tacking needle 116 (S208).

[0093] Thereby, the state of setting the V point needle 134 to the V point of the sock W set to the inserting member 110 can easily be brought about, in the following, overlocking is carried out by processings similar to those of the above-described first embodiment (S228).

[0094] Fig. 7 shows an operational flow according to a third embodiment of a linking apparatus of the invention, in which the inserting member 110 both ends of which are converged is used and a processing or piercing all of the point needles including piercing the V point needle into the V point of the sock W is carried out automatically.

[0095] As shown by Fig. 28, by inserting the inserting member 110 both end portions of which are converged into the sock W, also the overlocking loops at vicinities of the both ends of the sock W are expanded to be able to detect and therefore, the operation of piercing the point needles including the processing of the V point is fully automated.

[0096] First, the sock W is inserted by the inserting member 110 both end portions of which are converged to expand in the left and right direction (S300), the sock W is expanded in the up and down direction to fix (S302), and hung by putting the toe hanging jig 114 into the toe (S304). Although the processing of piercing the point needles thereafter is similar to that of the first embodiment, the initial overlocking loop detecting processing detects the V point. Further, the processing of detecting the V point can be carried out by detecting the start overlocking loop, tracking the overlocking loop toward the end portion therefrom and determining the V point by the overlocking loop most proximate to the end portion similar to the above-described processing of detecting the initial overlocking loop.

[0097] Fig. 8 shows an operational flow according to a fourth embodiment of a linking apparatus of the invention, in which a slit is provided at the portion of piercing the point needle by dividing the inserting member 110 in the up and down direction and the point needle can pierce the both faces by a single one of the needle piercing mechanism 120.

[0098] The sock W is inserted by the inserting member 110 of an up and down dividing type to expand in the left and right direction (S700) and the V point needle 134 is inserted (S702). Further, the sock W is expanded in the up and down direction to fix (S706), the toe hanging jig 114 is put into the toe to hang (S706) and the inserting member 110

is divided in the up and down direction to thereby form the slit (S708).

[0099] Next, the initial overlocking loop detecting processing (S710a, b) is carried out to determine the initial locking loop.

[0100] The camera is moved to the target locking loop position (S712a, b) and the overlocking loop position is detected (S714a, b). The point needle is positioned to the front side overlocking loop position (S716), and the point needle is pierced only through the front side (S718). Further, the point needle is positioned to the rear side locking loop position (S720) and the point needle is pierced to the rear side (S722). The above-described processings are repeated from S712a, b until finishing with regard to all of the overlocking loops (S724).

[0101] When the point needles have pierced through all of the overlocking loops, the inserting member 110 is drawn (S726) and overlocking is carried out by the point needles (S728).

[0102] Thereby, the processing of piercing the point needle through the overlocking loops on the both sides can be carried out by the single needle piercing mechanism 120 and further, the processing of butting the needles is dispensed with and the processing time period is shortened.

[0103] Although according to all of the above-described embodiments, the CCD camera 140 is mounted to the needle extruding mechanism 124 of the needle piercing mechanism 120 and the center of the field of view is disposed at the position of piercing the point needle 132 extruded by the needle extruding mechanism 124 through the sock W, the invention is not limited thereto but the CCD camera 140 may be mounted to a mechanism of positioning independently from the needle piercing mechanism 120. Further, the CCD camera may fixedly be installed by using a CCD camera having, for example, high resolution, an image of a total of the overlocking loop line of the sock W may simultaneously be picked up and a range of carrying out image processing may successively be moved.

[0104] Although according to the above-described embodiments, an explanation has been given such that the toe hanging jig 114 is put into the toe in order to prevent the overlocking loop line on the toe side from being bent, a grubbing mechanism for grubbing the toe may be installed and the toe may be pulled downwardly by grubbing the toe by the grubbing mechanism to achieve a similar effect.

[0105] Although according to the above-described embodiments, an explanation has been given such that the inserting member 110 is provided with a width providing a predetermined expanded state when inserting the sock W, a mechanism of expanding the sock W in the left and right direction may be provided and when inserting the sock W, a width easy to insert the sock W may be constituted and after inserting the sock W, the width may be expanded to a width capable of providing the predetermined expanded state.

[0106] Although according to the above-described embodiments, an explanation has been given such that in expanding the sock W in the up and down direction, the sock W is expanded manually and fixed by the fixing pierces 112a and 112b, for example, one of the pieces may be constituted by a roller mechanism and after inserting the sock by the inserting member 110, the sock W may be expanded in the up and down direction by driving the roller mechanism.

[0107] Next, a processing of positioning a point needle by predicting a moving amount of an overlocking loop position by a point needle which has already been pierced will be shown. As shown by Fig. 13, a detected overlocking loop position is put into a target position and a position of a corresponding point needle is put into a current position (S400), a movement amount is determined by an amount of the target position subtracted by the current position (S402), and an overlocking loop predicted movement amount is predicted from the movement amount (S404).

[0108] Here, the overlocking loop predicted movement amount may be calculated by multiplying a constant coefficient by assuming that the overlocking loop predicted movement amount is proportional to the movement amount of the point needle, an approximate equation calculated by experiment may be used, or the overlocking loop predicted movement amount may be calculated by looking up a function table.

[0109] Further, the target position is added with the overlocking loop predicted movement amount and the current position is added with the movement amount (S406), the operation is repeated from S402 until a difference between the target position and the current position falls in a range of an allowable error (S408).

[0110] Finally, when the difference between the target position and the current position falls in the range of the allowable error, the point needle is positioned to the target position (S410).

[0111] Thereby, the positioning can be carried out by one time without actually moving the point needle and therefore, the operational time period is shortened.

[0112] Although according to the above-described embodiment, an explanation has been given such that the operation is carried out repeatedly until the difference between the target position and the current position is converged to be equal to or smaller than the allowable error, the invention is not limited thereto but the movement amount of the point needle may be calculated by one time operation by calculating a calculation equation from a recurrent equation, or the movement amount of the point needle may be calculated by one time reference by looking up a function table.

[0113] Next, an explanation will be given of a method of preventing a problem that in processing to position a point needle, since a point needle which has already been pierced is moved, a successive overlocking loop is moved and a point needle is positioned by detecting a position of the overlocking loop, repeatedly and therefore, a movement amount of the point needle is accumulated and the point needle is deviated from the inserting member.

[0114] As shown by Fig. 14, similar to the processing flow of the processing of piercing an ordinary point needle, the camera is moved to a target overlocking loop position (S500), a processing of detecting a position of an overlocking loop is carried out (S502). a processing of positioning a point needle is carried out (S504), the point needle is pierced (S506) and finally, after returning the point needle to an initial position at every time (S508), a processing of detecting a position of a successive overlocking loop is carried out.

[0115] Thereby, when the position of the successive overlocking loop is detected, the point needle is always returned to the original point and therefore, the problem of accumulating the movement amount by moving of the successive overlocking loop by the point needle which has already been pierced is improved.

[0116] Next, an explanation will be given of a method of improving a problem that in operation of piercing a point needle, other than a portion of detecting a position of an overlocking loop is always expanded to apply load on the total of knitting fabric.

[0117] Fig. 29 shows a conceptual view of a partially expanding mechanism for partially expanding a knitted fabric. As shown by the drawing, rollers 118a and 118b for partially expanding a portion of the knitting fabric an image of which is picked up by the CCD camera 140 are provided and pressed to the sock W inserted by the inserting member 110, the upper roller 118a pulls the sock W upwardly and the lower roller 118b pulls the sock W downwardly. Thereby, only a vicinity of an overlocking loop to be detected can be expanded. The rollers 118a and 118b are mounted to the needle extruding mechanism 124 along with the CCD camera 140 and can selectively expand the knitted fabric at a vicinity of an overlocking loop constituting an object for piercing the selected point needle 132.

[0118] Fig. 15 shows a method of carrying out a processing of piercing a point needle by using the partially expanding mechanism. As shown by the drawing, the camera is moved to a target overlocking loop position (S600), the partially expanding mechanism is operated (S602), an overlocking loop position is detected (S604), the point needle is positioned (S606), the point needle is pierced (S608), and the partially expanding mechanism is released (S610). The above-described processings are repeated until all of the overlocking loops have been processed (S612).

[0119] Further, it is necessary to position the point needle in operating the partially expanding mechanism and therefore, the point needle is constituted to be locked to a side of the inserting member 110 in operating the partially expanding mechanism and locked to a side of the needle extruding mechanism 124 after releasing the partially expanding mechanism.

[0120] Although according to the above-described embodiment, only expansion in the up and down direction is partially carried out, a function of partially carrying out expansion in the left and right direction may be added. For example, rollers may be arranged in skewed four directions to pull the sock W respectively in directions of being remote from the center.

[0121] Although according to the above-described embodiment, an explanation has been given by taking the example of a sock as an object of linking, the invention is not limited thereto but is applicable to any knitting fabric so far as overlocking is carried out by butting knitting fabrics having overlocking loops to achieve the effect of the invention.

[0122] As described above, according to the invention, the operation of piercing a point needle to an overlocking loop knitted at knitting fabric can automatically be carried out swiftly and accurately to solidly link the knitting fabric.

Claims

1. A linking method comprising:

- a step of expanding a knitting fabric in a state of opposing linking object portions;
- a step of picking up an image of the expanded knitting fabric;
- a step of detecting a position of an overlocking loop from the picked-up image;
- a step of positioning a point needle corresponding to the detected position of the overlocking loop thereto;
- a step of piercing the corresponding point needle through the detected overlocking loop; and
- a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric;

wherein the step of positioning the corresponding point needle comprises:

- a step of predicting an amount of moving of the detected position of the overlocking loop by movement of the point needle which has already been pierced by the step of piercing the corresponding point needle and positioning the corresponding point needle to the detected overlocking loop.

2. A linking method comprising:

a step of expanding a knitting fabric in a state of opposing linking object portions;
a step of picking up an image of the expanded knitting fabric;
a step of detecting a position of an overlocking loop from the picked-up image;
a step of positioning a point needle corresponding to the detected position of the overlocking loop thereto;
a step of piercing the corresponding point needle through the detected overlocking loop; and
a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric;

wherein in the step of expanding the knitting fabric, before the step of detecting the position of the overlocking loop, only a vicinity of the overlocking loop constituting an object is partially expanded.

3. A linking method comprising:

a step of expanding a knitting fabric in a state of opposing linking object portions;
a step of picking up an image of the expanded knitting fabric;
a step of detecting a position of an overlocking loop from the picked-up image;
a step of positioning a point needle corresponding to the detected position of the overlocking loop thereto;
a step of piercing the corresponding point needle through the detected overlocking loop; and
a step of overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric, further comprising:

a step of returning a position of the point needle which has already been pierced by the step of piercing the corresponding point needle to an initial position after the step of piercing the corresponding point needle and before the step of picking up the image of the overlocking loop of the knitting fabric for detecting a position of a successive one of the overlocking loop.

4. The linking method according to any one of Claim 1 through Claim 3, wherein the step of expanding the knitting fabric comprises:

a step of inserting a member having converged both end portions to an inner portion of a circular knitted fabric to expand the knitting fabric in a left and right direction.

5. The linking method according to any one of Claim 1 through Claim 4, further comprising:

a step of piercing tacking needles to the overlocking loops at both end portions of the knitting fabric before the step of expanding the knitting fabric; and
a step of coupling the tacking needles to the point needles in correspondence with the overlocking loops at the both end portions of the knitting fabric after the step of expanding the knitting fabric.

6. The linking method according to any one of Claim 1 through Claim 5, wherein the knitting fabric is the circular knitted fabric for constituting a sock, further comprising:

a step of hanging a toe of the sock of the circular knitted fabric.

7. A linking apparatus comprising:

knitting fabric expanding means for expanding a knitting fabric in a state of opposing linking object portions;
image picking up means for picking up an image of the knitting fabric expanded by the knitting fabric expanding means;
overlocking loop position detecting means for detecting a position of an overlocking loop an image of which is picked up by the image picking up means;
point needle positioning means for positioning a point needle corresponding to the position of the overlocking loop detected by the overlocking loop position detecting means thereto;
point needle piercing means for piercing the corresponding point needle through the detected overlocking loop; and
overlocking means for overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric by the point needle piercing means;

wherein the point needle positioning means includes a function of predicting an amount of moving of the position of the overlocking loop detected by the overlocking loop position detecting means by movement of the point needle which has already been pierced by the point needle piercing means and positioning the corresponding point needle to the detected overlocking loop.

8. A linking apparatus comprising:

knitting fabric expanding means for expanding a knitting fabric in a state of opposing linking object portions;
 image picking up means for picking up an image of the knitting fabric expanded by the knitting fabric expanding means;
 overlocking loop position detecting means for detecting a position of an overlocking loop an image of which is picked up by the image picking up means;
 point needle positioning means for positioning a point needle corresponding to the position of the overlocking loop detected by the overlocking loop position detecting means thereto;
 point needle piercing means for piercing the corresponding point needle through the detected overlocking loop; and
 overlocking means for overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric by the point needle piercing means;

wherein the knitting fabric expanding means includes a function of expanding only a vicinity of the overlocking loop constituting an object of being detected by the overlocking loop position detecting means.

9. A linking apparatus comprising:

knitting fabric expanding means for expanding a knitting fabric in a state of opposing linking object portions;
 image picking up means for picking up an image of the knitting fabric expanded by the knitting fabric expanding means;
 overlocking loop position detecting means for detecting a position of an overlocking loop an image of which is picked up by the image picking up means;
 point needle positioning means for positioning a point needle corresponding to the position of the overlocking loop detected by the overlocking loop position detecting means thereto;
 point needle piercing means for piercing the corresponding point needle through the detected overlocking loop; and
 overlocking means for overlocking the knitting fabric based on the point needle pierced through each of the overlocking loops of the knitting fabric by the point needle piercing means;

wherein the point needle positioning means comprising:

means for returning a position of the point needle which has already been pierced by the point needle piercing means to an initial position when the position of the overlocking loop is detected by the overlocking loop position detecting means.

10. The linking apparatus according to any one of Claim 7 through Claim 9, wherein the knitting fabric expanding means comprises:

means for inserting a member having converged both end portions to an inner portion of a circular knitted fabric to expand the knitting fabric in a left and right direction.

11. The linking apparatus according to any one of Claim 7 through Claim 10, further comprising:

tacking needles pierced through the overlocking loops at both end portions of the knitting fabric before expanding the knitting fabric by the knitting fabric expanding means including coupling means for coupling with the point needles corresponding to the overlocking loops at the both end portions of the knitting fabric after expanding the knitting fabric by the knitting fabric expanding means.

12. The linking apparatus according to any one of Claim 7 through Claim 11, wherein the knitting fabric expanding means comprises:

means for hanging a toe of a sock.

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FIG. 1

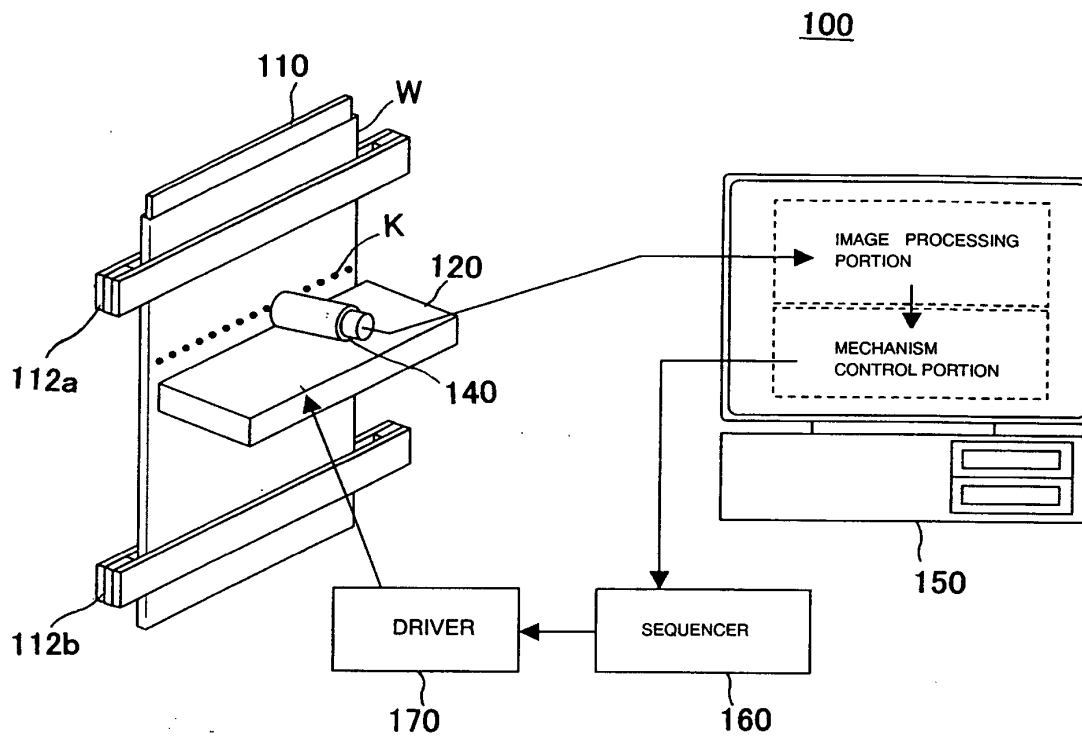


FIG. 2

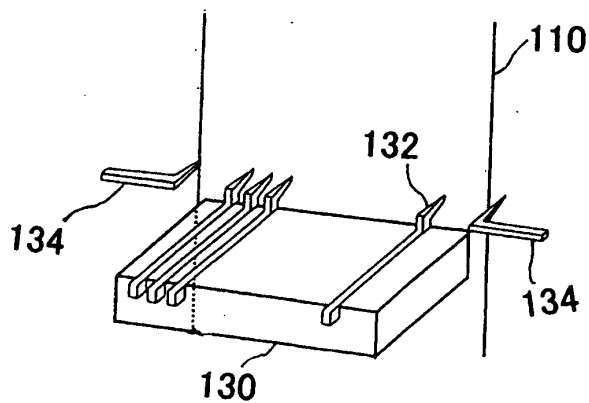


FIG. 3

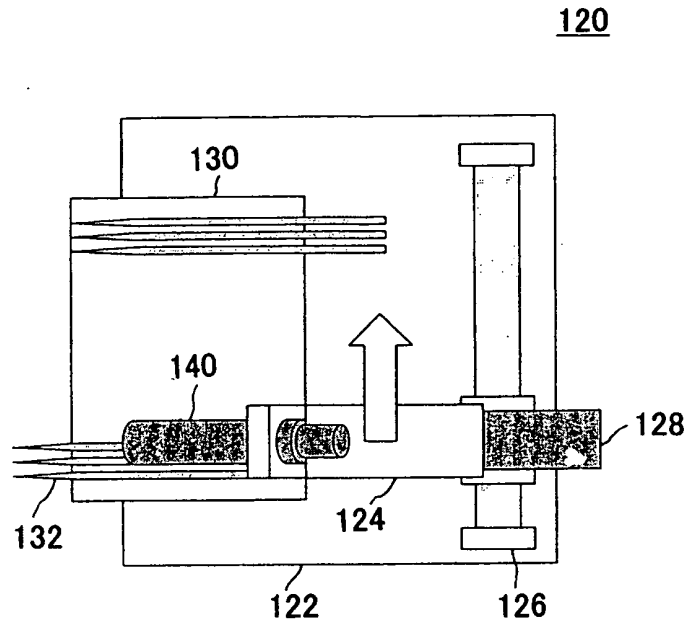


FIG. 4

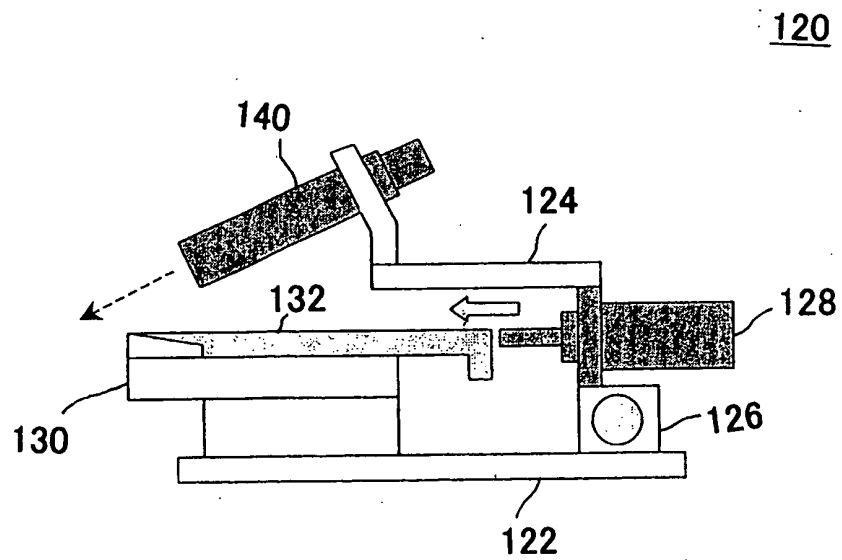


FIG. 5

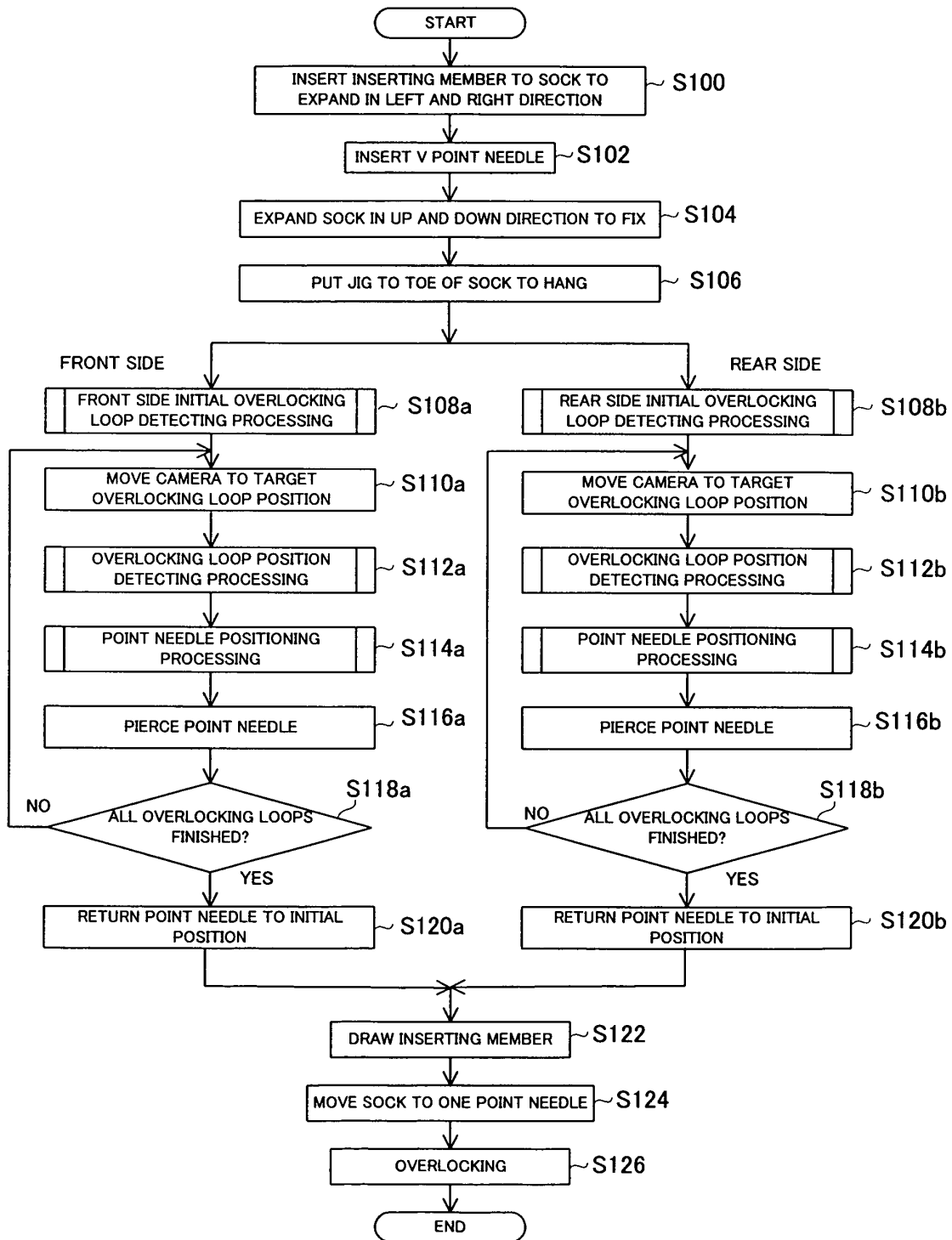


FIG. 6

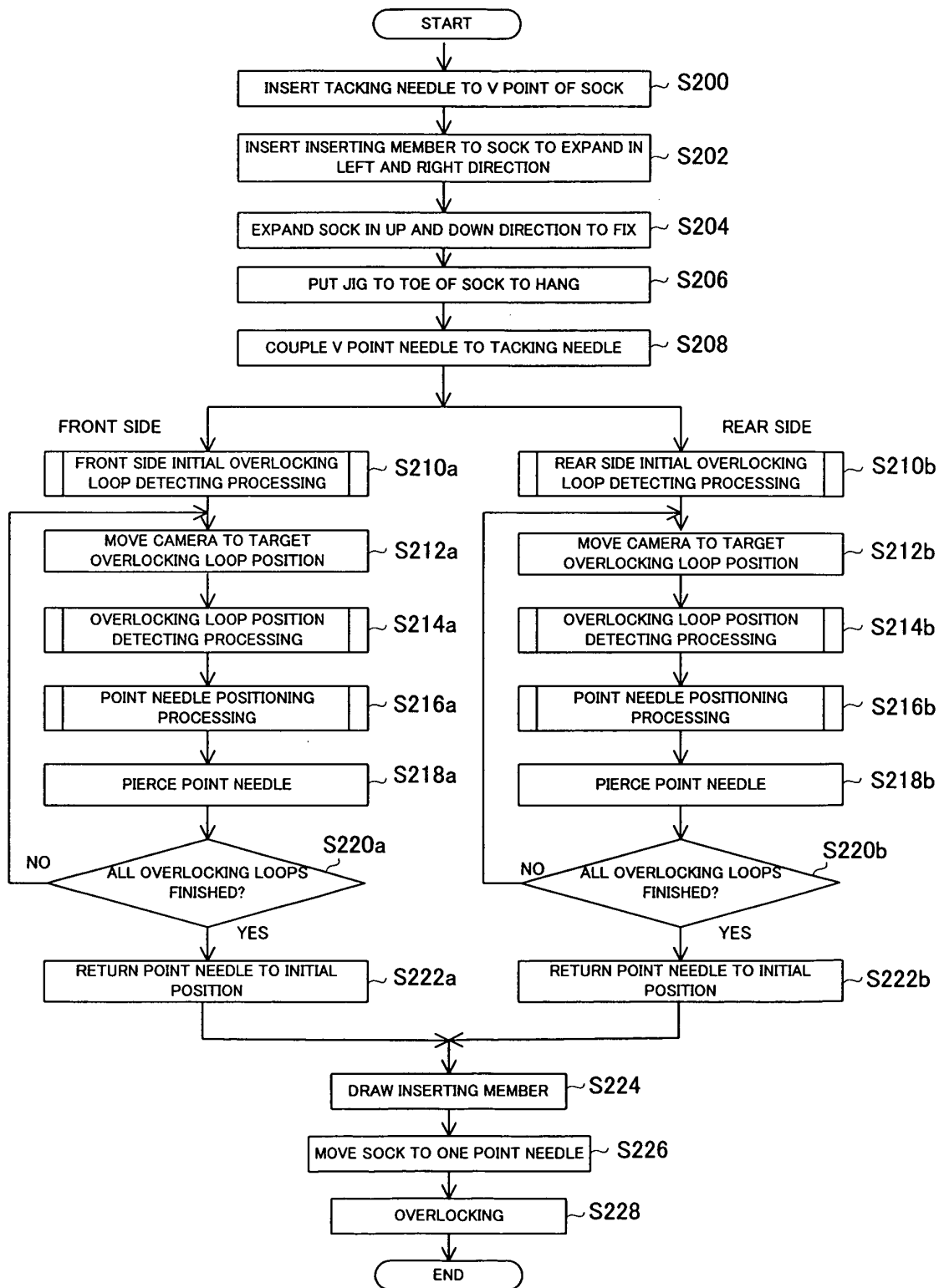


FIG. 7

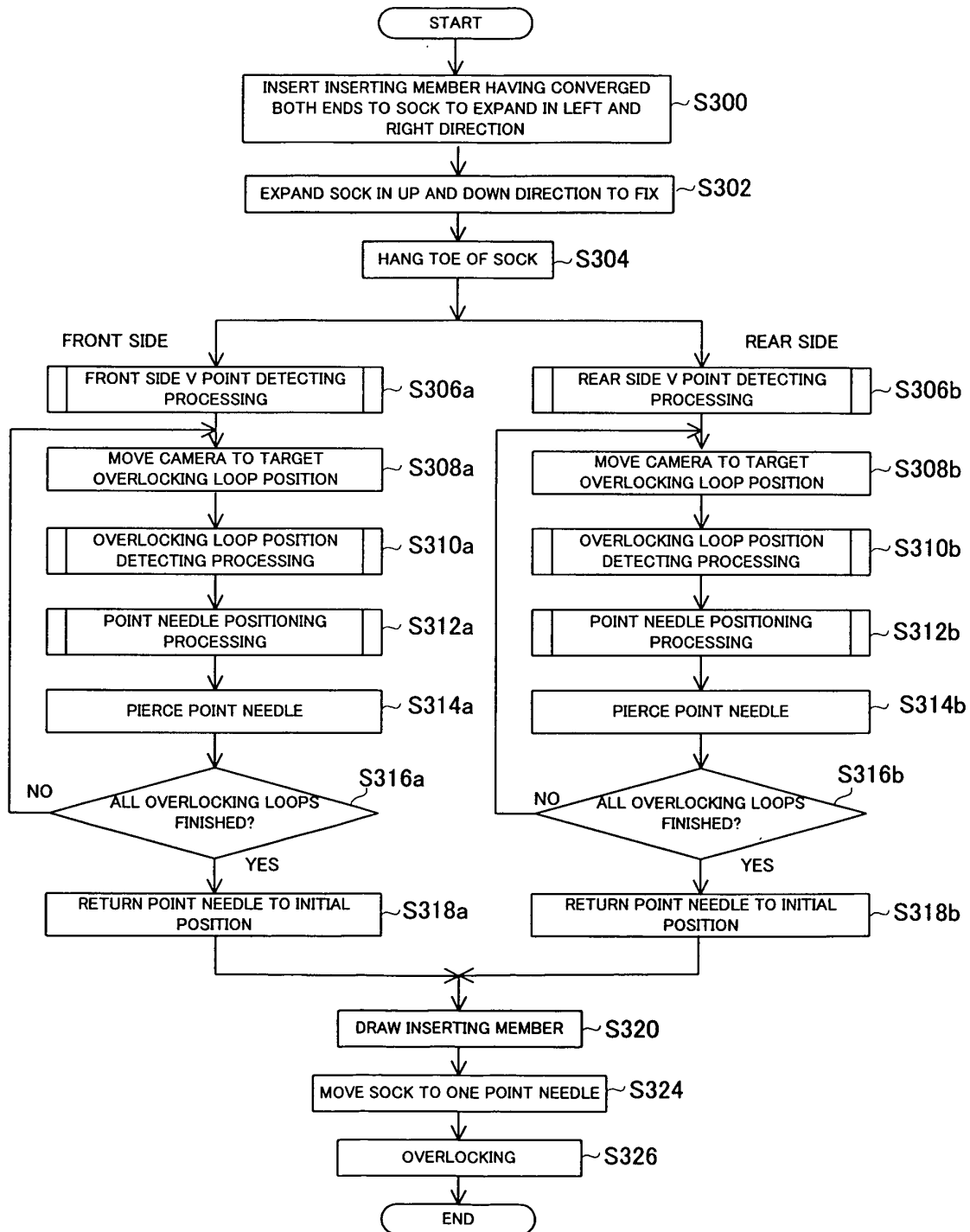


FIG. 8

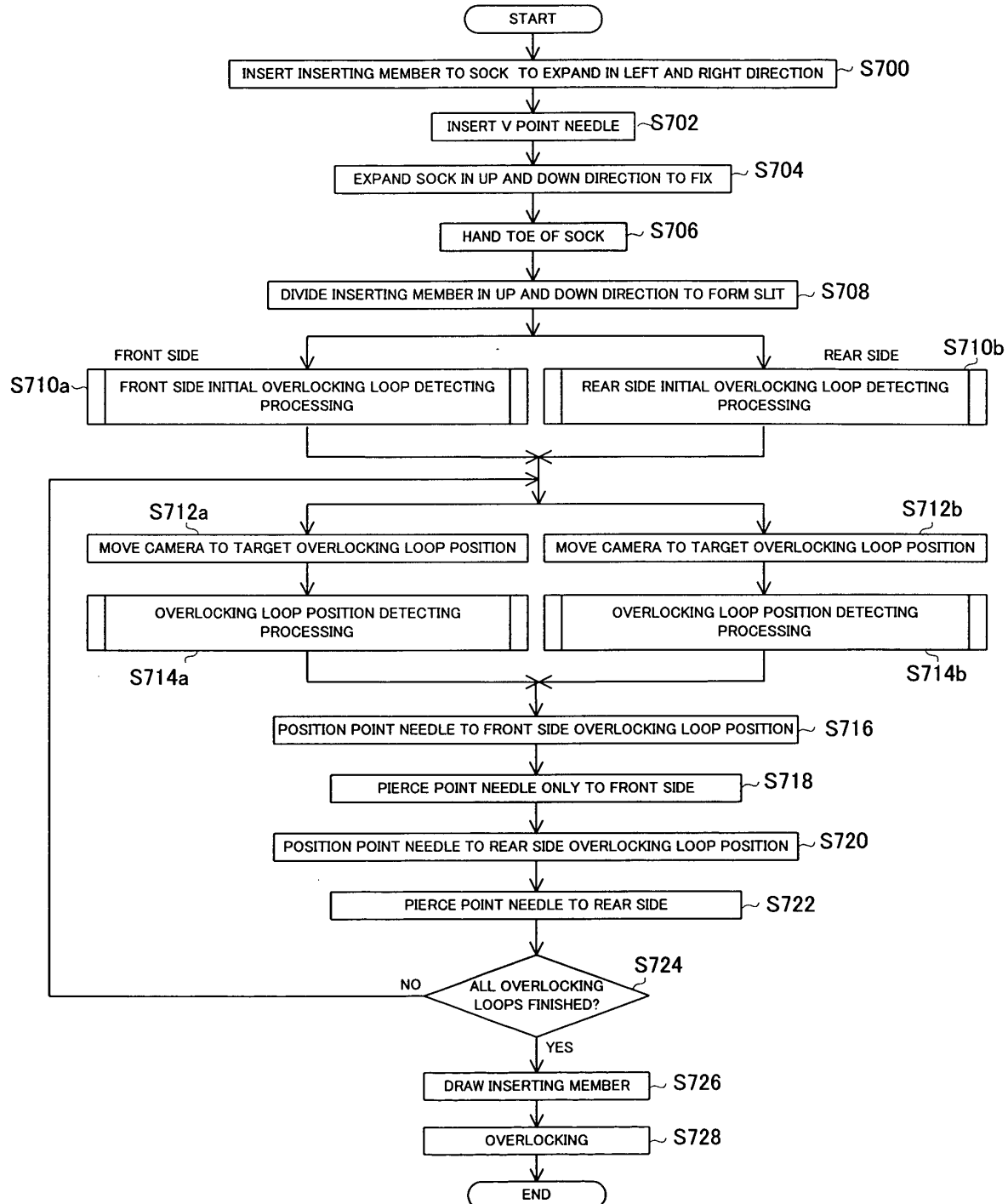


FIG. 9

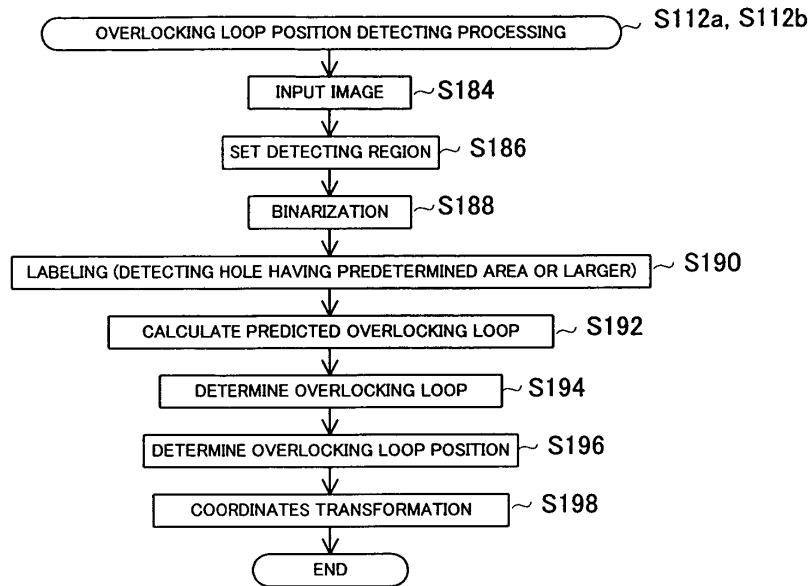


FIG. 10

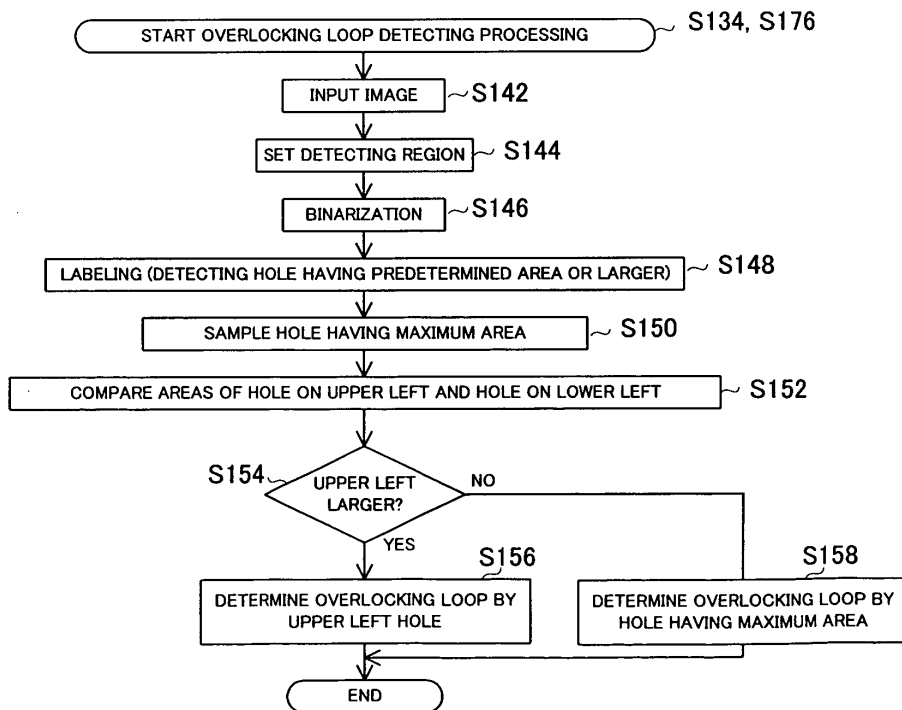


FIG. 11

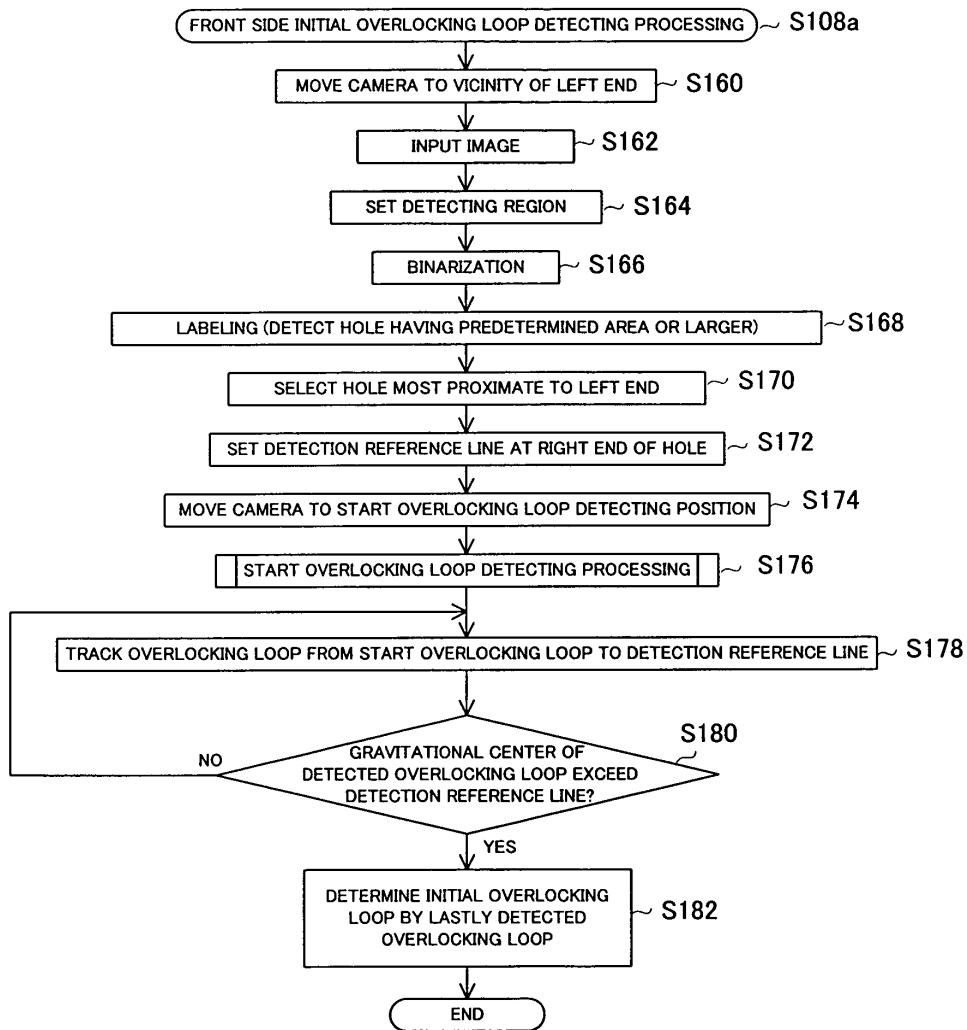


FIG. 12

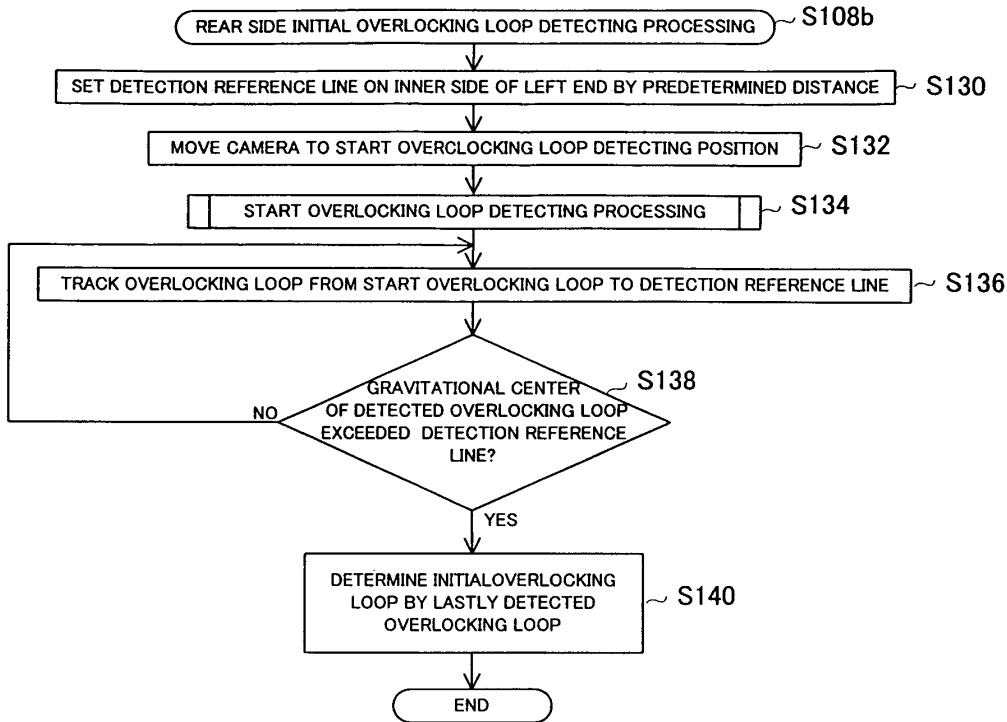


FIG. 13

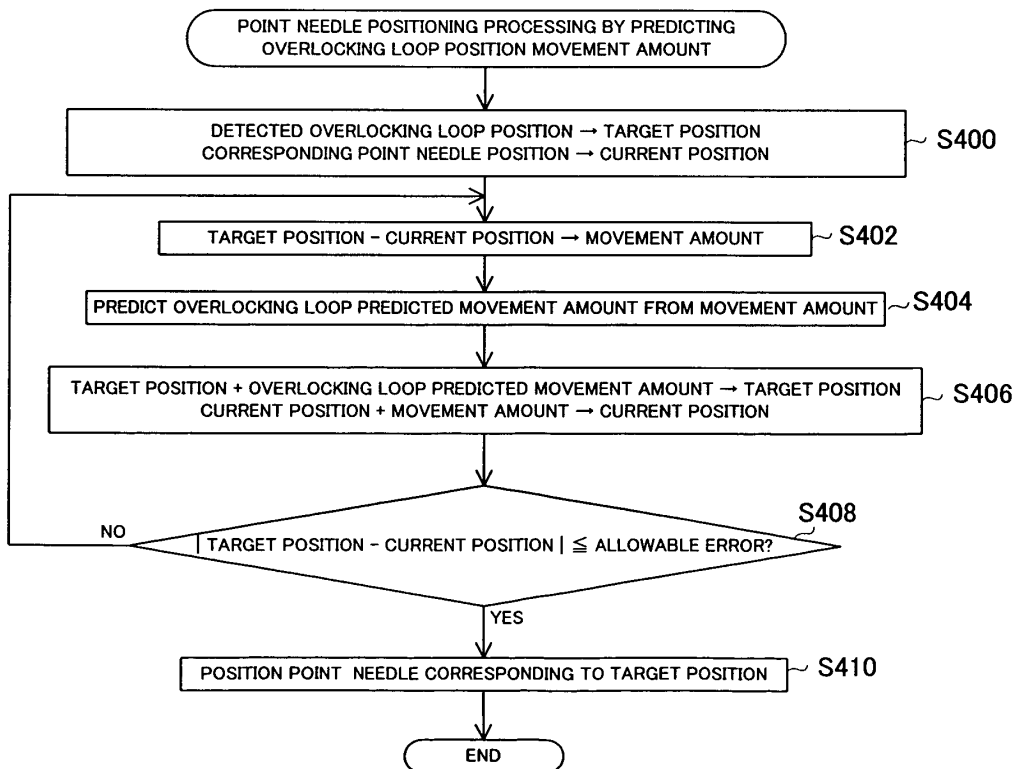


FIG. 14

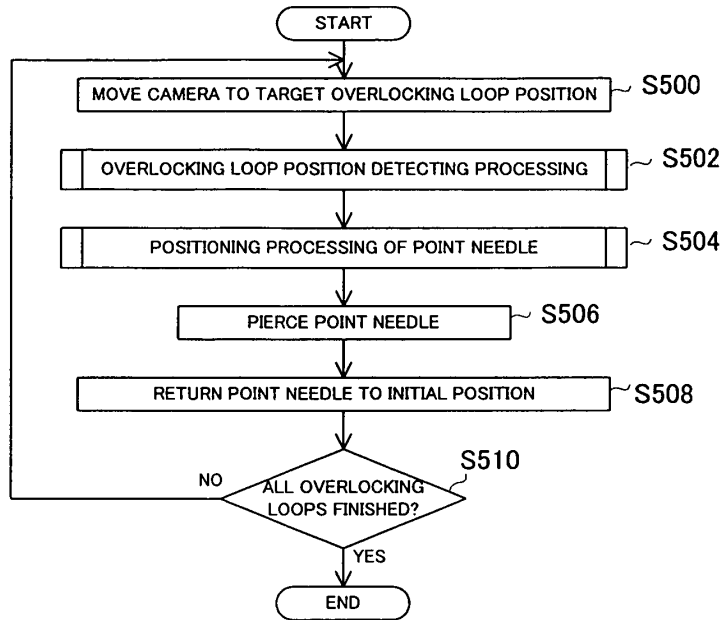


FIG. 15

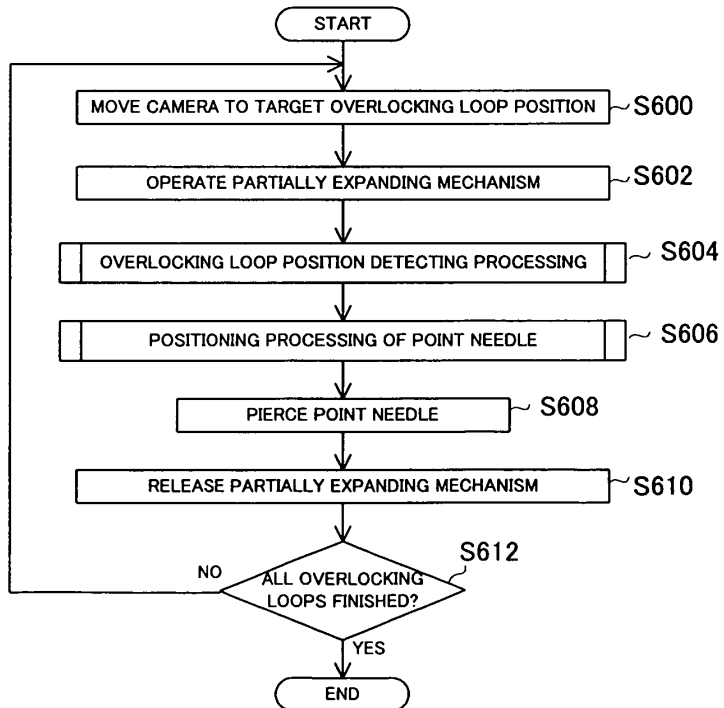


FIG. 16

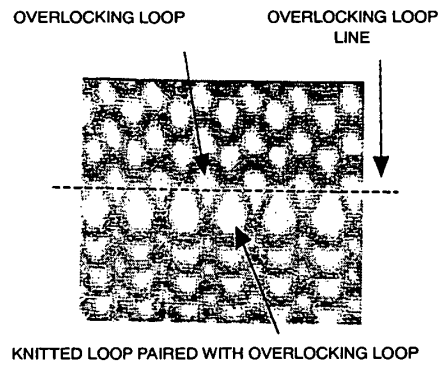


FIG. 17

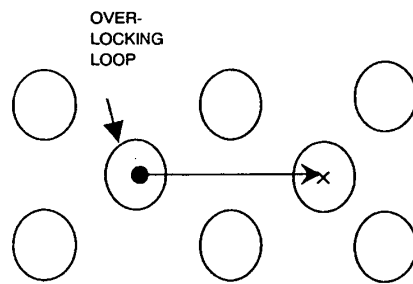


FIG. 18

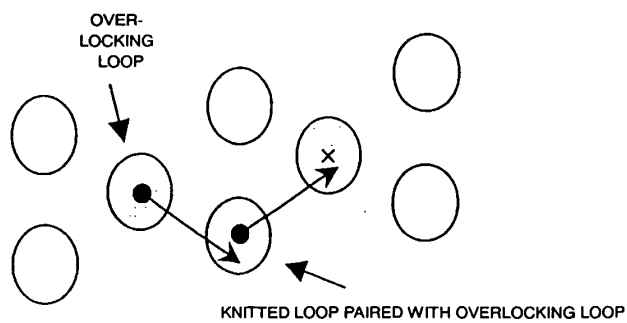


FIG. 19

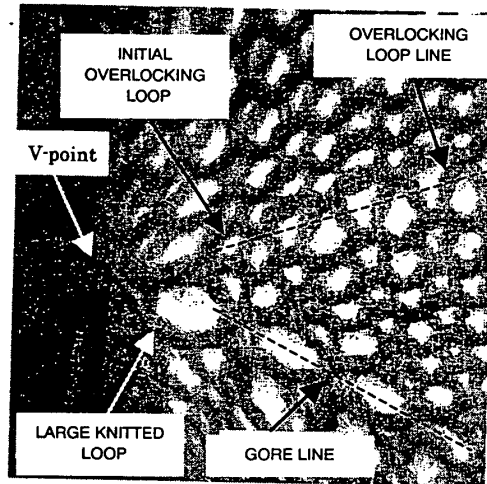


FIG. 20

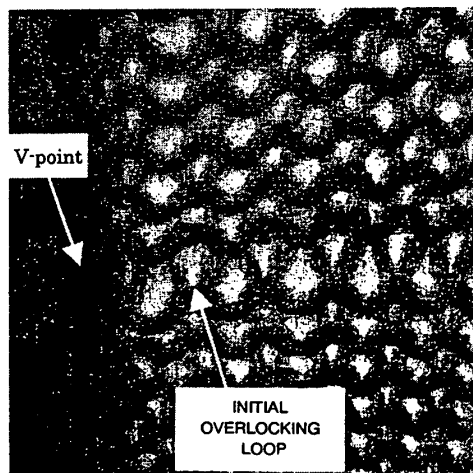


FIG. 21

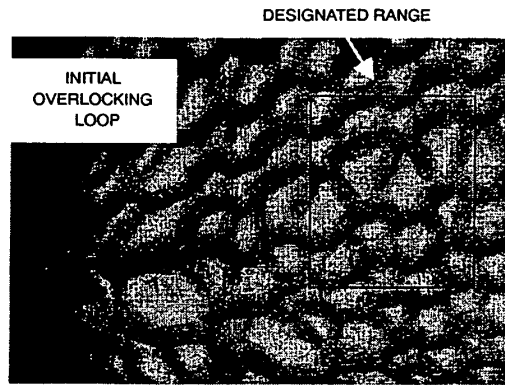


FIG. 22

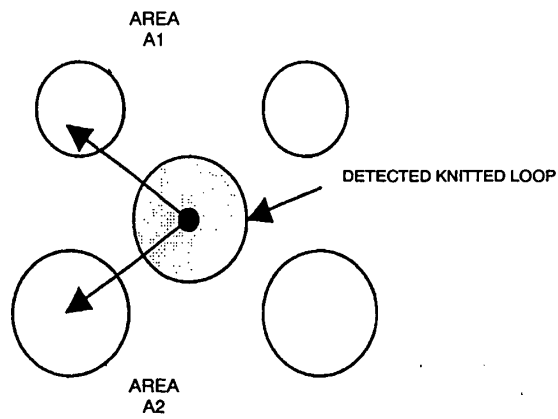


FIG. 23

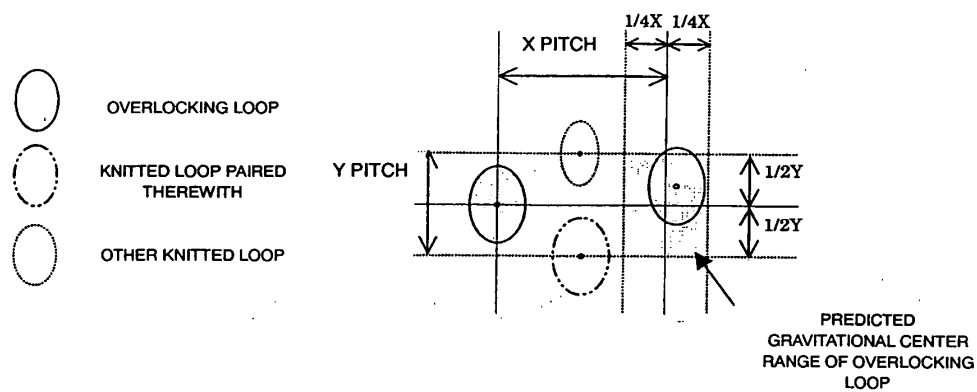
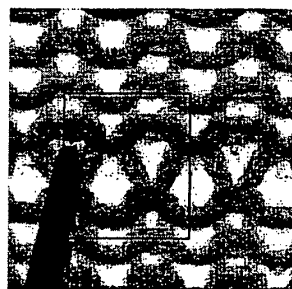


FIG. 24A



DESIGNATE RAGE

FIG. 24B



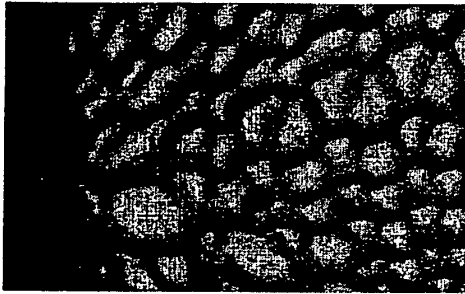
LABELING PROCESSING

FIG. 24C



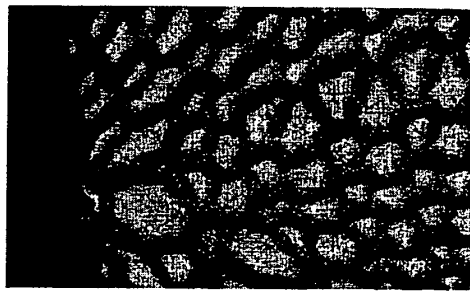
GRAVITATIONAL CENTER DETECTION

FIG. 25A

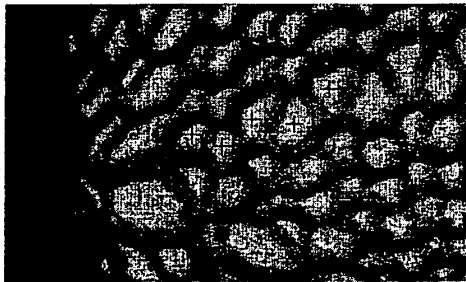


SET DETECTION REFERENCE LINE

FIG. 25B

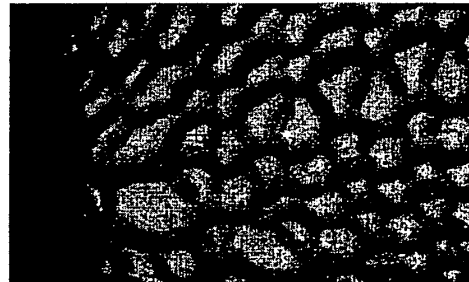


DETECT START OVERLOCKING LOOP



TRACK OVERLOCKING LOOP

FIG. 25 C



DETECT INITIAL OVERLOCKING LOOP

FIG. 25D

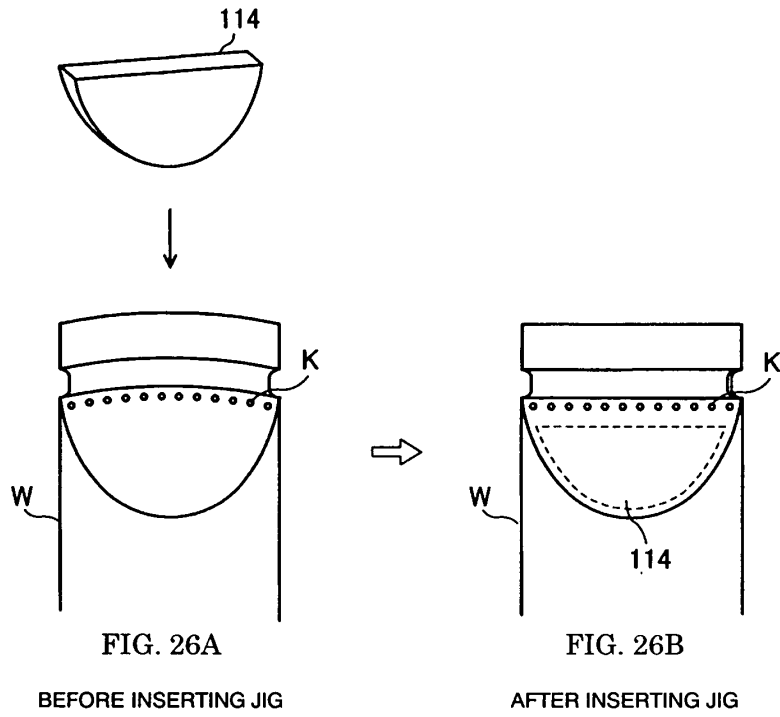


FIG. 27

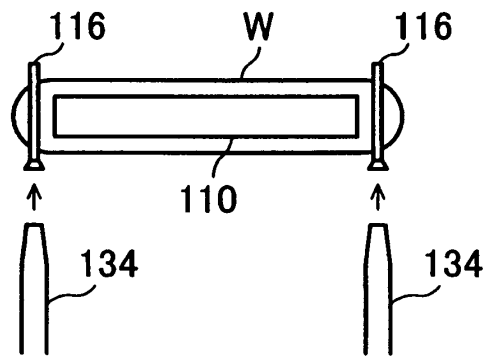


FIG. 28

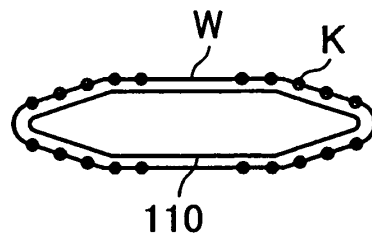
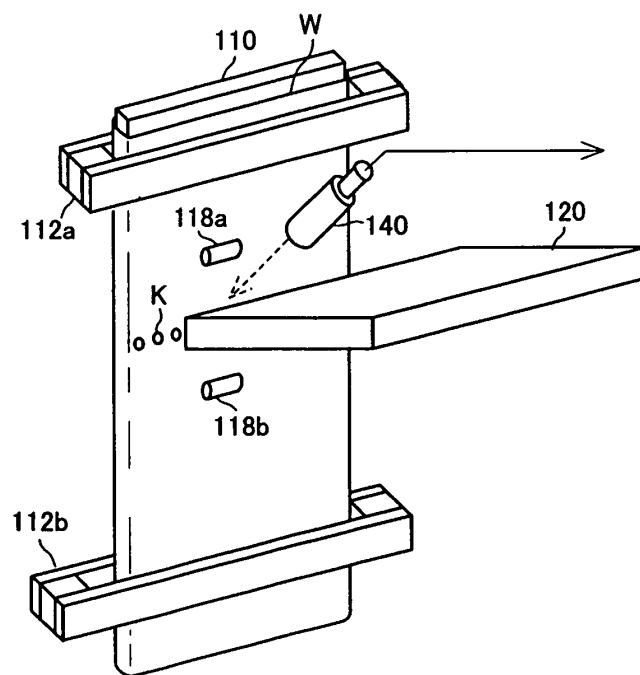


FIG. 29





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 00 9931

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A	* page 2, line 19 - line 29 * * page 4, line 36 - line 52 * * page 6, line 15 - line 22 * * page 6, line 40 - line 50 * * page 7, line 31 - page 8, line 13 * * page 9, line 16 - line 39; figures 6,9,10,17-22,27 *	4-6, 10-12	
A,D	--- PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) & JP 11 207062 A (DAN:KK), 3 August 1999 (1999-08-03) * abstract; figures 2-5,8-12 *	1-12	
A	--- PATENT ABSTRACTS OF JAPAN vol. 1997, no. 08, 29 August 1997 (1997-08-29) & JP 09 099187 A (TSUDAKOMA CORP), 15 April 1997 (1997-04-15) * abstract; figures 1,4-7,10-12 *	1,3,7,9	TECHNICAL FIELDS SEARCHED (Int.Cl.7) D05B D04B
A	--- EP 0 930 389 A (DAN CO LTD) 21 July 1999 (1999-07-21) * figures 2-5,8-12 * -----	1-3,7-9	
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 1 August 2003	Examiner Herry-Martin, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

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ON EUROPEAN PATENT APPLICATION NO.**

EP 03 00 9931

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The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82