(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 316 991 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.05.2011 Bulletin 2011/18

(21) Application number: **09800290.0**

(22) Date of filing: **22.06.2009**

(51) Int Cl.:
D04B 15/00 *(2006.01)* ***D04B 35/00*** *(2006.01)*

(86) International application number:
PCT/JP2009/061323

(87) International publication number:
WO 2010/010775 (28.01.2010 Gazette 2010/04)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

(30) Priority: **25.07.2008 JP 2008192362**

(71) Applicant: **Shima Seiki Manufacturing., Ltd.**
Wakayama-shi, Wakayama 641-0003 (JP)

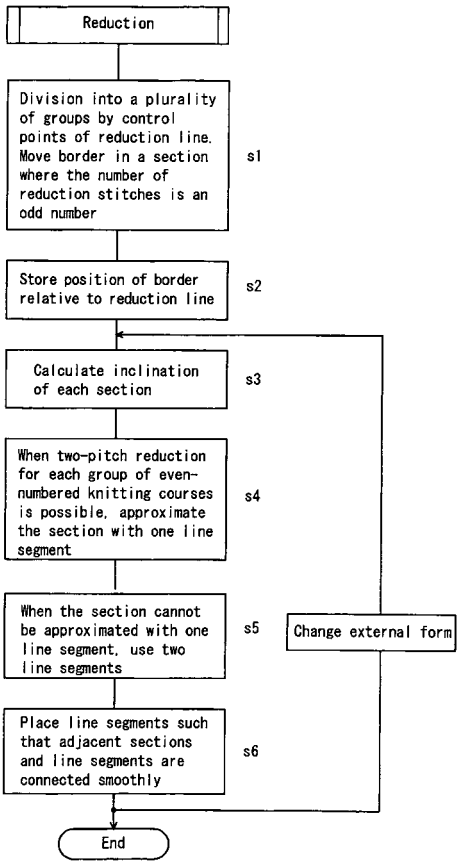
(72) Inventors:
- **ENYO Takahiro**
  Wakayama-shi
  Wakayama 641-0003 (JP)
- **MAEOKA Shigeki**
  Wakayama-shi
  Wakayama 641-0003 (JP)

(74) Representative: **Emde, Eric**
Wagner & Geyer
Gewürzmühlstrasse 5
80538 München (DE)

(54) KNIT DESIGN METHOD, KNIT DESIGN DEVICE, AND DESIGN PROGRAM

(57) The inclination of the external form of a knitted fabric, which is specified by design data, is calculated for each section, and a plurality of line segments are generated for each section to regularly decrease the stitches by a predetermined number with respect to a predetermined number of knitting courses. The length of each line segment is determined such that the total number of knitting courses of the line segment is equal to the number of knitting courses defined by the external form, and that the total number of stitches to be decreased is equal to the number of stitches to be decreased as defined by the external form. The line segments are placed for the corresponding sections and the adjacent line segments are connected to each other, thereby to generate a decrease line. The decrease line is generated that comparatively fits the contour of the external form and can be knitted efficiently and also can offer an orderly fashion line.

FIG. 2



EP 2 316 991 A1

Description

[0001] The present invention relates to the design of a knitted article, and particularly to the designs of decrease lines and increase lines.

[0002] Designing a knitted article requires decrease lines, or lines for gradually decreasing the knitting width, as well as increase lines, or lines for gradually increasing the knitting width. For example, because the knitting width of a knitted article decreases gradually at an armhole, a neck hole and the like, decrease lines are required for decreasing stitches as faithfully as possible according to design data. Also, when gradually increasing the knitting width in a body or sleeves, increase lines according to design data are required.

[0003] An example of the decrease lines is described using a conventional example. In a conventional way of designing a knit, a J-curve and S-curve shown in Fig. 12 are used, wherein, first, the contour of an external form on a design into a plurality of line segments is divided into a plurality of line segments to obtain an inclination of each line segment. In the J-curve the line segments are arranged in ascending order of the inclination, while in the S-curve the line segments are arranged in descending order of the inclination. In the J-curve and S-curve, decrease of the lines is not necessarily executed regularly, as it is executed along the inclinations of the line segments. In terms of knitting, decreasing the lines by two stitches is efficient, but the lines could also be decreased by one stitch, depending on the inclinations of the line segments. This, however, lowers the knitting efficiency, causing the fashion lines of rows of decrease stitches to become unsteady. Moreover, the J-curve tends to form a knitted fabric smaller than the design, while the S-curve tends to form a knitted fabric larger than the design, which makes it difficult to obtain decrease lines faithful to the design. The same is true of the increase lines.

[0004] An object of the present invention is to generate decrease lines and increase lines that are comparatively faithful to a design, improve the knitting efficiency, and easily obtain regular fashion lines.

An additional object of the present invention is to generate the smoothest possible decrease lines and increase lines.

Yet additional object of the present invention is to eliminate the need of manually inputting a border between sections when the external form of a design is changed.

[0005] The present invention is a method for converting an external form of a knitted fabric specified according to design data, into a form with decrease lines or increase lines by decreasing or increasing the number of stitches, in order to create knitting data executable by means of a flat knitting machine, the method having: an inclination calculation step of obtaining an inclination of the external form with respect to each of a plurality of sections; a line segment generation step of regularly decreasing or increasing the number of stitches by a predetermined number with respect to a predetermined number of knitting courses, and generating, in relation to each section of the external form, a plurality of line segments having inclinations close to the inclination of each of the sections; a line segment length determination step of determining a length of each of the line segments so that a total number of knitting courses for the plurality of line segments matches the number of knitting courses defined by the external form, and that a total number of decrease or increase stitches matches the number of decrease or increase stitches defined by the external form; and a line segment placing step of placing the line segments corresponding to each of the sections and connecting the adjacent line segments to each other, thereby to generate the decrease lines or increase lines.

[0006] Furthermore, the present invention is an apparatus for converting an external form of a knitted fabric specified according to design data, into a form with decrease lines or increase lines by decreasing or increasing the number of stitches, in order to create knitting data executable by means of a flat knitting machine, the apparatus having: inclination calculation means for obtaining an inclination of the external form with respect to each of a plurality of sections; line segment generation means for regularly decreasing or increasing the number of stitches by a predetermined number with respect to a predetermined number of knitting courses, and generating, in relation to each section of the external form, a plurality of line segments having inclinations close to the inclination of each of the sections; line segment length determination means for determining a length of each of the line segments so that a total number of knitting courses for the plurality of line segments matches the number of knitting courses defined by the external form, and that a total number of decrease or increase stitches matches the number of decrease or increase stitches defined by the external form; and line segment placing means for placing the line segments corresponding to each of the sections and connecting the adjacent line segments to each other, thereby to generate the decrease lines or increase lines.

[0007] The present invention is also a knit design program for converting an external form of a knitted fabric specified according to design data, into a form with decrease lines or increase lines by decreasing or increasing the number of stitches, in order to create knitting data executable by means of a flat knitting machine, the program causing the knit design apparatus to function as: inclination calculation means for obtaining an inclination of the external form with respect to each of a plurality of sections; line segment generation means for regularly decreasing or increasing the number of stitches by a predetermined number with respect to a predetermined number of knitting courses, and generating, in relation each section of the external form, a plurality of line segments having inclinations close to the inclination of to each of the sections; line segment length determination means for determining a length of each of the line seg-

ments so that a total number of knitting courses for the plurality of line segments matches the number of knitting courses defined by the external form, and that a total number of decrease or increase stitches matches the number of decrease or increase stitches defined by the external form; and line segment placing means for placing the line segments corresponding to each of the sections and connecting the adjacent line segments to each other, thereby to generate the decrease lines or increase lines.

[0008] In the present invention, one or more line segments, in particular one or two line segments, are placed in each section so as to be close to each other. Because the line segments are not moved across each section, decrease lines or increase lines to be generated can be made comparatively faithful to the external form according to the design data.

Decreasing or increasing the number of stitches is regularly and efficiently executed because only a predetermined number of stitches is decreased or increased with respect to each group of a predetermined number of knitting courses in each line segment. Therefore, the decrease lines or increase lines become regular fashion lines.

[0009] In this specification, the descriptions of the knit design method apply directly to the knit design apparatus and the knit design program, and the descriptions of the knit design apparatus apply directly to the knit design method and the knit design program.

Each of the steps described in this specification can be executed in an order different from that described in embodiments, unless otherwise specified, or unless there is a natural order.

[0010] It is preferred that, when the plurality of line segments having different inclinations are associated with one section, the line segments be connected in the line segment placing step such that the line segments having a relatively small difference in inclination relative to the adjacent sections are connected to each other preferentially to the line segments having a relatively large difference in inclination. Accordingly, the line segments are connected comparatively smoothly at a border between the sections.

[0011] It is also preferred that the inclination calculation step divide the external form into the plurality of sections by using a control point of a free curve expressing the external form. As a result, the sections can be generated automatically, and the external form can be divided into the sections according to the characteristics of the external form by obtaining the control point expressing the characteristics of the external form as the border between the sections.

[0012] Instead of obtaining the sections first, the inclination calculation step may extract straight line sections from the external form to obtain the sections, and the line segment length determination step may extend the line segments of the adjacent sections with respect to a gap between the sections, or may generate a new section in the gap.

In this manner, the sections can be generated automatically by taking the straight line part of the external form as one of the sections and extending the straight line part to the gap or taking the gap as a new section. The sections are generated based on the straight line part and therefore follow the external form.

[0013] Preferably, the inclination calculation step stores a position of the control point relative to the external form, and, when the external form is changed, generates a section with respect to the changed external form on the basis of the stored relative position. Changing the external form in this manner allows a new section to be generated automatically. The relative position corresponds to, for example, the number of a knitting course where the border is located, with respect to the total number of knitting courses of the decrease lines along a knitting course direction.

[0014] More preferably, when generating the decrease lines, the line segment generation step decreases the number of stitches by two with respect to each group of even-numbered knitting courses. In this manner, the decrease can be executed more efficiently. In the case of increasing the stitches, the number of stitches is preferably increased by one with respect to each of the even-numbered knitting courses.

[0015]

Fig. 1 is a block diagram of a knit design apparatus according to an embodiment;
Fig. 2 is a flowchart showing a decrease line generation algorithm according to the embodiment;
Fig. 3 is a flowchart showing an increase line generation algorithm according to the embodiment;
Fig. 4 is a diagram showing how decrease lines are generated in the embodiment;
Fig. 5 is a diagram showing the decrease lines generated in Fig. 4;
Fig. 6 is a diagram showing the contour of an external form obtained after changing a design;
Fig. 7 is a diagram showing the decrease lines corresponding to Fig. 6;
Fig. 8 is a flowchart showing a decrease line generation algorithm according to a modification;
Fig. 9 is a flowchart showing an increase line generation algorithm according to the modification;
Fig. 10 is a diagram showing how decrease lines are generated in the modification;
Fig. 11 is a diagram showing how the decrease lines are generated in the modification in the contour of the external form that has a section with a complicated straight-line approximation;
Fig. 12 is a diagram showing a conventional method for generating decrease lines;
Fig. 13 is a diagram showing a design image;
Fig. 14 is a diagram showing the decrease lines with respect to the design image shown in Fig. 13 according to the conventional example (decrease by one

stitch/knitting course);

Fig. 15 is a diagram showing the decrease lines with respect to the design image shown in Fig. 13 according to the conventional example (decrease by two stitches/knitting course);

Fig. 16 is a diagram showing the decrease lines with respect to the design image shown in Fig. 13 according to the embodiment (decrease by two stitches/knitting course with respect to each of even-numbered knitting courses); and

Fig. 17 is a diagram showing the decrease lines, wherein (a) shows the design image, (b) the conventional example of decrease by one stitch/knitting course, (c) the conventional example of decrease by two stitches/knitting course, and (d) the embodiment of the decrease by two stitches/knitting course with respect to each of the even-numbered knitting courses.

[0016] The best mode for implementing the present invention is described hereinafter.

[0017] Figs. 1 to 17 show embodiments and modifications thereof. In each of the diagrams, reference numeral 2 represents a knit design apparatus, and reference numeral 4 represents a bus. Reference numeral 6 represents a keyboard, and 8 a mouse, which may also be a joystick, trackball, stylus or other manual inputting means. Reference numeral 10 represents a color monitor, and 12 a disc drive which is capable of exchanging data with a disk such as a CD-ROM and connectable with a USB. Reference numeral 16 is a color printer and 18 a memory. The knit design apparatus 2 is a computer that additionally has a CPU and ROM, which are not shown.

[0018] Reference numeral 20 is a knit design part, which designs a knitted article in response to inputs from the mouse 8, keyboard 6, disc drive 12, and a LAN interface 14. A Bezier curve generator 22 processes the external form of each part of the knitted article as a free curve such as a Bezier curve. Instead of the Bezier curve, a β-spline curve or any types of free curves may be used. The Bezier curve generator 22 converts the outline of each part of the knitted article designed by the knit design apparatus 20, into the Bezier curve. A free curve such as this Bezier curve generally has a plurality of control points.

[0019] A decrease/increase line generator 24 generates a decrease line or increase line on the outline of each part. The decrease line is an outline used for performing knitting while decreasing the knitting width of the part, whereas the increase line is an outline used for performing knitting while increasing the knitting width of a knit part. The decrease line or increase line generated by the line generator 24 is a line in which the knitting width is decreased or increased regularly by a predetermined number of stitches with respect to each of a predetermined number of knitting courses. In the decrease line, the knitting width is decreased by, for example, two stitches. In the increase line, the knitting width is decreased by, for example, one stitch.

[0020] In the decrease line or increase line, decrease or increase is performed based on the number of stitches defined from the design of the knitted article with respect to a total number of knitting courses of the line defined from the design. It is preferred that the decrease line or increase line match the external form of each part that is defined from the design of the knitted article. It is also important that decrease stitches or increase stitches be shown regularly and that these decrease stitches or increase stitches form a fashion line. The decrease or increase is preferably performed for, for example, each even-numbered knitting course to facilitate the knitting. When performing the decrease, it is preferred that two stitches be decreased in each decrease so that the knitting is carried out efficiently.

[0021] A section divider 26 divides the external form of each part into a plurality of sections in order to generate the decrease line or increase line. Boundaries are used as, for example, the control points of the Bezier curve in order to divide these sections. A straight-line approximation part 28 approximates the interior of each of the divided sections using one or two line segments. These line segments abide by a rule of, for instance, decreasing two stitches in each of the even-numbered knitting courses or increasing one stitch in each of the even-numbered knitting courses. Inclinations in the sections do not necessarily match, since, for instance, two stitches can be decreased in each group of five knitting courses, or, under a preferred condition, two stitches can be decreased in each group of four knitting courses or in each group of six knitting courses. For this reason, for example, a section in which two stitches are decreased with respect to each group of five knitting courses is approximated with a line segment in which two stitches are decreased with respect to each group of four knitting courses and a line segment in which two stitches are decreased with respect to each group of six knitting courses. Two types of line segments or one type of line segment can be used for approximating a single section.

[0022] If the inclination is constant at a border between the sections, these sections are connected smoothly. When a single section has two types of line segments, placement of these two types of line segments is determined so that the inclinations of the line segments become smooth between the right and left sections. For instance, suppose that a line segment in which two stitches are decreased with respect to each group of four knitting courses and a line segment in which two stitches are decreased with respect to each group of six knitting courses are allocated to a certain section. When the left-hand side section is made up of the line segment in which two stitches are decreased with respect to each group of four knitting courses, and the right-hand side section is made up of the line segment in which two stitches are decreased with respect to each group of six knitting courses, the line segments are placed from the left to the

right in order of two stitches with respect to each group of four knitting courses, two stitches with respect to each group of four knitting courses, two stitches with respect to each group of six knitting courses, and two stitches with respect to each group of six knitting courses, whereby the border between the sections becomes smoothly connected. In other words, the two line segments are placed to keep the difference between the inclinations of the line segments between the right and left sections small.

[0023] The decrease line or increase line is first divided into the sections in the present embodiment. In a modification, however, the sections are generated in the course of straight-line approximation performed on the decrease line or increase line. In this case, the section divider 26 is not required.

[0024] A data converter 30 converts the design of the knitted article into knitting data 34 that can be knitted using a flat knitting machine, not shown. The memory 18 stores a design program 32 for causing the knit design apparatus 2 to generate the decrease line or increase line. The program 32 is input from the LAN interface 14 or disc drive 12, but it may be stored in a CD-ROM or other storage medium and then input from the LAN interface 14 through the Internet or carrier wave.

[0025] Figs. 2 to 7 show the processes performed in the present embodiment. A front body 40 to be processed is shown in Fig. 4, wherein reference numeral 41 represents the decrease line of an armhole, and 42 the decrease line of a neck hole. The decrease line 41 of the armhole is explained as an example here, but the same processing is carried out using the decrease line 42 of the neck hole. In this specification, the horizontal direction of a knitted fabric is represented as an x-direction, which is a wale direction, and the vertical direction is represented as a y-direction, which is a knitting course direction. The stitches are formed while a carriage, which is not shown, is moved along the wale direction. The stitches are arranged vertically along the knitting course direction and knitted from an area where the value of the y is small, to an area where the value of the y is large.

[0026] Fig. 2 shows a decrease line generation algorithm. In step 1, the control points of the Bezier curve generated by the Bezier curve generator 22 are used for dividing the decrease line into the plurality of sections with respect to the external form of each part obtained based on the design of the knitted article. In the case of Fig. 4, the control points a to e on the Bezier curve are used to divide the decrease line into sections I to IV, and the border between the sections is configured by the control points a to e. The number of decrease stitched included in the sections I to IV is made to be an even number, but when the number of decrease stitches is an odd-number, the border plotted by the control points b, c and d are moved. Furthermore, the position of the border relative to the decrease line is stored in order to change the external form (step 2). In the present embodiment, a coordinate system scaled in units of one stitch along the wale direction and knitting course direction is used for storing, for example, the coordinates of the border plotted by the control points b, c and d along the knitting course direction.

[0027] A ratio between the inclination, which is the number of knitting courses of each section, and the number of decrease stitches is calculated with respect to each section (step 3). For example, when the number of decrease stitches is 10 in relation to thirty courses, two stitches may be decreased with respect to each group of six knitting courses, and the section can be approximated with one line segment. In this case, the processing of step 4 is carried out. However, the inclination of each section is generally not simple, each section is approximated with a line segment with two types of inclinations having an average inclination of the section therebetween (step 5). Moreover, two types of line segments are placed such that adjacent sections match the inclination of the line segment (step 6).

[0028] This processing is shown in Fig. 4. In the section I, for example, the number of decrease stitches is 36 in relation to 46 knitting courses. When the stitches are decreased by two stitches per knitting course, the decrease needs to be performed eighteen times. Since the decrease is performed eighteen times in the 46 knitting courses in the section I, the decrease may be performed once on the average of approximately 2.5 knitting courses. The number of times the decrease is performed is represented by an alphabet "a," and an equation $2a + 4 (18 - a) = 46$ is established. By decreasing the stitches by two stitches with respect to each of the even-numbered knitting courses on either side where a single decrease is carried out on 2.5 knitting courses, two stitches are decreased with respect to each group of two knitting courses, and two stitches are decreased with respect to each group of four knitting courses. If "a" is used for representing the number of times two stitches are decreased with respect to each group of two knitting courses, "a" becomes 13 by solving the abovementioned equations. Therefore, the decrease of two stitches with respect to each group of two knitting courses is executed 13 times, and the decrease of two stitches with respect to each group of four knitting courses is executed five times. As a result, the section I can be approximated with two line segments.

[0029] The sections II and III have the same average inclination, thus the decrease of two stitches may be performed 10 times throughout the 46 knitting courses. Since the decrease of two stitches is performed 4.6 times for each of the knitting courses, the decrease of two stitches per group of four knitting courses is executed "a" times, and the decrease of two stitches per group of six knitting courses is performed "10 - a" times. Because $4a + 6 (10 - a) = 46$ is established, "a" becomes 7. In the section IV, 26 stitches are decreased throughout the 46 knitting courses, thus the decrease of two stitches may be executed with respect to each group of 3.54 knitting courses. When the number of times the decrease of two

stitches is performed with respect to each group of two knitting courses is "a" and the number of times the decrease of two stitches is performed with respect to each group of four knitting courses is "13 - a," 2a + 4 (13 - a) = 46 is established. Therefore, "a" becomes 3.

[0030] In Fig. 4, each of the sections I to IV is approximated with two types of line segments are used and therefore connected smoothly. In order to accomplish this, in the first part of the section I, the line segment for decreasing two stitches with respect to each group of two knitting courses is placed, and then the line segment for decreasing two stitches with respect to each group of four knitting courses is placed. In the first part of the section II as well, two stitches are decreased with respect to each group of four knitting courses, and two stitches are decreased with respect to each group of six knitting courses in the last half of the section II. Subsequently two stitches are decreased with respect to each group of six knitting courses in the first half of the section III. Two stitches are decreased with respect to each group of four knitting courses in the last half of the section III. Two stitches are decreased with respect to each group of four knitting courses in the first half of the section IV, and two stitches are decreased with respect to each group of two knitting courses at the end of the section IV. The circles "O" shown in Fig. 5 represent points where the line segments are changed in the interior of each section.

[0031] In the sections I and IV, the decrease of two stitches with respect to each group of two knitting courses is combined with the decrease of two stitches with respect to each group of four knitting courses. However, for example, the decrease of two stitches with respect to each group of two knitting courses may be combined with the decrease of two stitches with respect to each group of six knitting courses. The reason that the decrease is executed with respect to each group of even-numbered knitting courses is because, when the placement of the carriage and the like is substantially the same as the original placement as the carriage reciprocates, the subsequent decrease is executed. This aims at accomplishing efficient knitting and does not necessarily eliminate the processing of decreasing two stitches with respect to each group of three knitting courses. Decreasing two stitches at once also aims at accomplishing efficient knitting, but, in an extreme case, does not aim at eliminating the processing of decreasing one stitch with respect to each group of three knitting courses.

[0032] Figs. 6 and 7 show the processing carried out when changing the external form. In step 2 shown in Fig. 2, the position of the border of each section relative to the decrease line is stored. In Fig. 4, the border is shown for each group of 46 knitting courses. Suppose that the decrease line of the armhole is changed as shown in Fig. 6. In this case, a total number of decrease stitches is 76, and a total number of knitting courses has 220 stitches. Because the external form is changed, the number of knitting courses is no longer the same between the sections. Therefore, the result shown in Fig. 7 can be obtained by generating two types of line segments used for approximating the sections I to IV, as with Figs. 4 and 5. Note that the alphabets a' to e' shown in Fig. 6 represent points that are moved as a result of deforming the original control points a to e of the border. In Figs. 6 and 7 the external form is changed by moving the control points.

[0033] In the case of performing grading, the external form is changed by decreasing or enlarging the external from non-significantly. By storing the position of the border line relative to the decrease line in step 2 of Fig. 2, it is not necessary to input a new border once the external form is changed. For example, because the decrease line is divided into four parts by the control points b, c and d on the border in Fig. 4, control points b', c' and d' are generated on the border in order to divide the graded decrease line into four parts.

[0034] The present embodiment has explained the decrease, but the same is true of the increasing. Fig. 3 shows an increase algorithm. In the same step as that shown in Fig. 2, increasing is performed instead of the decrease, and therefore the detail of the processing is substantially the same. In step 11, an increase line is divided into a plurality of sections by the control points of a Bezier curve represented as the increase line. The position of the border between the sections relative to the increase line is stored (step 2). Next, the inclination of each section is calculated (step 3). If there is a section where the increase line can be approximated with a single line segment scaled by one-pitch increase per even-numbered knitting course, the increase line is approximated (step 4). For the section where the increase line cannot be approximated with a single line segment, the increase line is approximated with two line segments by using a method similar to, for example, that of Figs. 4 and 5 (step 5). The generated two line segments are placed so that the adjacent sections are connected smoothly (step 6). When the external form is changed, the same processing as that shown in Figs. 6 and 7 is executed.

Modification

[0035] In the embodiment, the sections are set first and then the inclinations thereof are obtained. On the other hand, a straight line with substantially a constant inclination is extracted in the contour of the external form and obtained as a section. The extracted section is approximated with one type or two types of line segments. Next, the right and left line segments are extended with respect to a gap between the sections, or the gap is taken as a new section. When processing the gap, a restraint condition is added where the total number of decrease stitches or increase stitches conforms with the data on the design or the total number of knitting courses on the decrease line or increase line conforms with the design data. In this manner as well, the decrease line or increase line can be generated. Such a modification is shown in Figs. 8 to 11.

[0036] In step 21 shown in Fig. 8, the straight line section within the contour of the external form is approximated with one or two line segments scaled by two-pitch decrease per even-numbered knitting course. In step 22, the right and left line segments are allocated to the gap between the sections, or the gap is obtained as a new section and approximated with a single line segment. In step 23, the total number of decrease stitches and a target total number are checked. When these numbers do not match, allocation of the line segments to the gap between the sections is changed. Fig. 9 shows an example of how the increase line is generated, wherein steps 22 and 23 are the same as those shown in Fig. 8, and wherein in step 31 the straight line section within the contour of the external form is approximated with one or two line segments in which the stitches are increased by one stitch with respect to each group of even-numbered knitting courses. Moreover, when the number of increase stitches does not match the target number in Fig. 9, steps 22 and 23 are re-executed.

[0037] The design shown in Fig. 10 is same as the one shown in Fig. 4. The left-hand side of Fig. 10 shows an inclination for decreasing two stitches with respect to each group of two knitting courses, an inclination for decreasing two stitches with respect to each group of four knitting courses, and an inclination for decreasing two stitches with respect to each six knitting courses, wherein a section g-h in the decrease line 41 can be approximated with a line segment for decreasing two stitches with respect to each group of four knitting courses. A section h-i can be approximated with two types of line segments, the line segment for decreasing two stitches with respect to each group of four knitting courses and the line segment for decreasing two stitches with respect to each group of six knitting courses. A section i-j is approximated with two types of line segments, the line segment for decreasing two stitches with respect to each group of two knitting courses and the line segment for decreasing two stitches with respect to each group of four knitting courses. Similarly, a section f-g is approximate with two types of line segments, the line segment for decreasing two stitches with respect to each group of two knitting courses and the line segment for decreasing two stitches with respect to each group of four knitting courses.

[0038] These line segments are placed such that the inclinations thereof in the border between the sections. In the section f-g, the line segment for decreasing two stitches with respect to each group of two knitting courses is placed on the border f side, and the line segment for decreasing two stitches with respect to each group of four knitting courses is placed on the border g side. The line segment for decreasing two stitches with respect to each group of six knitting courses is placed in an appropriate position in the section h-i. The line segment for decreasing two stitches with respect to each group of four knitting courses is placed on the i-side of the section i-j, and the line segment for decreasing two stitches with respect to each group of two knitting courses is placed on the j-side.

[0039] In Fig. 10, the outline 41 can be approximated with four types of line segments. Fig. 11 shows an example in which such approximation is not performed easily. In this case, a section k-m and section n-p are the straight line sections. The section k-m can be approximated with the line segment for decreasing two stitches with respect to each group of two knitting courses, whereas the section n-p can be approximated with the line segment for decreasing two stitches with respect to each group of two knitting courses and the line segment for decreasing two stitches with respect to each group of four knitting courses. A section m-n is not a straight line section but can be subjected to straight-line approximation using, for example, the line segment for decreasing two stitches with respect to each group of six knitting courses. Consequently, the line segment for decreasing two stitches with respect to each group of four knitting courses is placed on the n-side of the section n-p, and the border of the section can be connected relatively smoothly.

Results

[0040] Fig. 12 shows a conventional example. Unlike the decrease line 41 shown in Fig. 4, a decrease line 51 is called "J-curve." In other words, the decrease line 41 is approximated with short line segments, which are rearranged in ascending order of inclination. Next, courses in which the decrease is executed are placed on the line segments respectively, in accordance with a rule where one stitch is decreased in a single decrease or two stitches are decreased in a single decrease. In the decrease line 51 illustrated with the J-curve, the outline of the knitted fabric retreats easily unlike in the decrease line 41.

[0041] In a decrease line 61 illustrated with the S-curve, the line segments of the decrease line 41 are rearranged in descending order of inclination. Each of the line segments is expressed such that one stitch is decreased for each course or two stitches are decreased for each course. A knitted fabric that is larger than the actual one is obtained using the S-curve.

[0042] Fig. 13 shows an example of a design of an actual garment. Fig. 14 shows a decrease line that is obtained when the decrease line of the armhole of the front body is approximated with the J-curve by decreasing one stitch per knitting course. Fig. 15 shows a decrease line that is obtained when the same decrease line is approximated by decreasing two stitches per knitting course using the same J-curve. In Figs. 14 and 15, the black part represents an area with no stitches, the dark gray part represents an area with normal stitches, and white parts represent decrease stitches. In Fig. 14, the decrease stitches are placed regularly, but knitting efficiency is low because the decrease of only one stitch per knitting course is performed. In Fig. 15, the decrease stitches are placed in an irregular manner, and therefore a regular fashion line is not generated. In addition, the

decrease of two stitches per group of three knitting courses is performed, the knitting efficiency does not necessarily improve.

[0043] Fig. 16 shows the decrease line according to the embodiment. First, there is a line segment for decreasing two stitches with respect to each group of two knitting courses, and then there is a line segment for decreasing two stitches with respect to each group of four knitting courses. The fashion line is bend at the middle and therefore in a regular manner. Because the stitches are decreased by two stitches with respect to each group of even-numbered knitting courses, high knitting efficiency is achieved.

[0044] Fig. 17 shows outlines for a design (a) in a conventional examples (b) and (c) and the embodiment (d). Each of parts 100 to 104 shows the difference between the decrease line and the design, wherein the solid lines represent the outlines on the design and the dashed lines represent the decrease lines. In the example of (b) where the decrease of one stitch per knitting course is performed, the knitted fabric is swollen in the section 100, compared to the design. In the conventional example (c) where the decrease of two stitches per knitting course is executed, the knitted fabric is narrower at the section 102 than the actual knitted fabric. In the embodiment (d) the decrease line is removed from the design at the small section 104 but forms a decrease line that is faithful to the design.

Additional note

[0045] The decrease performed is an internal decrease that is carried out within an end part of the knitted fabric in the embodiment, but an external decrease may be carried out. The increasing may be performed at an end part of each part or the interior of the same. When the knitted fabric is configured by a plurality of parts extending in the y-direction, such as a gore or parachute pattern, and the borders between the parts form the decrease lines, the embodiment is applied to each decrease line.

[0046]

2	Knit design apparatus
4	Bus
6	Keyboard
8	Mouse
10	Color monitor
12	Disc drive
14	LAN interface
16	Color printer
18	Memory
20	Knit design part
22	Bezier curve generator
24	Decrease/increase line generator
26	Section divider
28	Straight-line approximation part
30	Data converter
32	Design program
34	Knitting data
40	Front body
41	Decrease line of armhole
42	Decrease line of neck hole
51	Decrease line illustrated by J-curve
61	Decrease line illustrated by S-curve
a to e	Border
I to IV	section
y	Knitting course direction
x	Wale direction

Claims

1. A knit design method for converting an external form of a knitted fabric specified according to design data, into a form with decrease lines or increase lines by decreasing or increasing the number of stitches, in order to create knitting data executable by means of a flat knitting machine,
the knit design method comprising:

an inclination calculation step of obtaining an inclination of the external form with respect to each of a plurality of sections;
a line segment generation step of regularly decreasing or increasing the number of stitches by a predetermined number with respect to a predetermined number of knitting courses, and generating, in relation to each section of the external form,
a plurality of line segments having inclinations close to the inclination of each of the sections;
a line segment length determination step of determining a length of each of the line segments so that a total number of knitting courses for the plurality of line segments matches the number of knitting courses defined by the external form, and that a total number of decrease or increase stitches matches the number of decrease or increase stitches defined by the external form; and
a line segment placing step of placing the line segments corresponding to each of the sections and connecting the adjacent line segments to each other, thereby to generate the decrease lines or increase lines.

2. The knit design method according to claim 1, **characterized in that**, when the plurality of line segments having different inclinations are associated with one section, the line segments are connected in the line segment placing step such that line segments having a relatively small difference in inclination relative to the adjacent sections are connected to each other preferentially to the line segments having a relatively large difference in inclination.

3. The knit design method according to claim 3, **characterized in that** the inclination calculation step divides the external form into the plurality of sections by using a control point of a free curve expressing the external form.

4. The knit design method according to claim 1, **characterized in that** the inclination calculation step extracts straight line sections from the external form to obtain the sections, and the line segment length determination step extends the line segments of the adjacent sections with respect to a gap between the sections, or generates a new section in the gap.

5. The knit design method according to claim 1, **characterized in that** the inclination calculation step stores a position of the control point relative to the external form, and, when the external form is changed, generates a section with respect to the changed external form on the basis of the stored relative position.

6. The knit design method according to claim 1, **characterized in that** when generating the decrease lines, the line segment generation step decreases the number of stitches by two stitches with respect to even-numbered knitting courses.

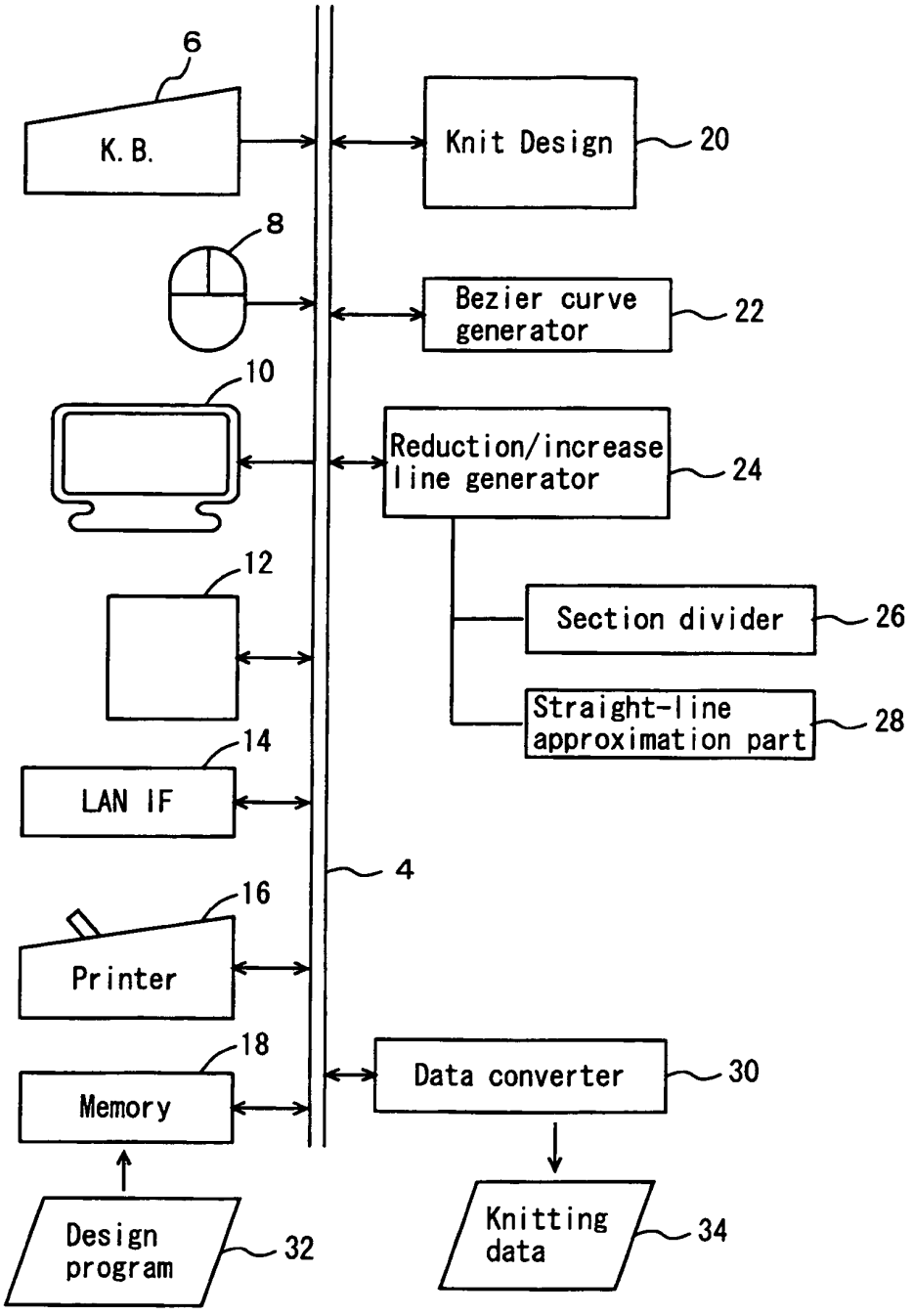
7. A knit design apparatus (2) for converting an external form of a knitted fabric specified according to design data, into a form with decrease lines or increase lines by decreasing or increasing the number of stitches, in order to create knitting data executable by means of a flat knitting machine,
the apparatus (2) comprising:

inclination calculation means for obtaining an inclination of the external form with respect to each of a plurality of sections;
line segment generation means for regularly decreasing or increasing the number of stitches by a predetermined number with respect to a predetermined number of knitting courses, and generating, in relation to each section of the external form, a plurality of line segments having inclinations close to the inclination of each of the sections;
line segment length determination means for determining a length of each of the line segments so that a total number of knitting courses for the plurality of line segments matches the number of knitting courses defined by the external form, and that a total number of decrease or increase stitches matches the number of decrease or increase stitches defined by the external form; and
line segment placing means for placing the line segments corresponding to each of the sections and connecting the adjacent line segments to each other, thereby to generate the decrease lines or increase lines.

8. A knit design program (32) for converting an external form of a knitted fabric specified according to design data, into a form with decrease lines or increase lines by decreasing or increasing the number of stitches, in order to create knitting data executable by means of a flat knitting machine,
the program (32) being **characterized in** causing the knit design apparatus to function as:

inclination calculation means for obtaining an inclination of the external form with respect to each of a plurality of sections;
line segment generation means for regularly decreasing or increasing the number of stitches by a predetermined number with respect to a predetermined number of knitting courses, and generating, in relation to each section of the external form, a plurality of line segments having inclinations close to the inclination of each of the sections;
line segment length determination means for determining a length of each of the line segments so that a total number of knitting courses for the plurality of line segments matches the number of knitting courses defined by the external form, and that a total number of decrease or increase stitches matches the number of decrease or increase stitches defined by the external form; and
line segment placing means for placing the line segments corresponding to each of the sections and connecting the adjacent line segments to each other, thereby to generate the decrease lines or increase lines.

FIG. 1


6
K.B.
Knit Design
20
8
Bezier curve generator
22
10
Reduction/increase line generator
24
12
Section divider
26
Straight-line approximation part
28
14
LAN IF
4
16
Printer
18
Memory
Data converter
30
Design program
32
Knitting data
34

2

FIG. 2

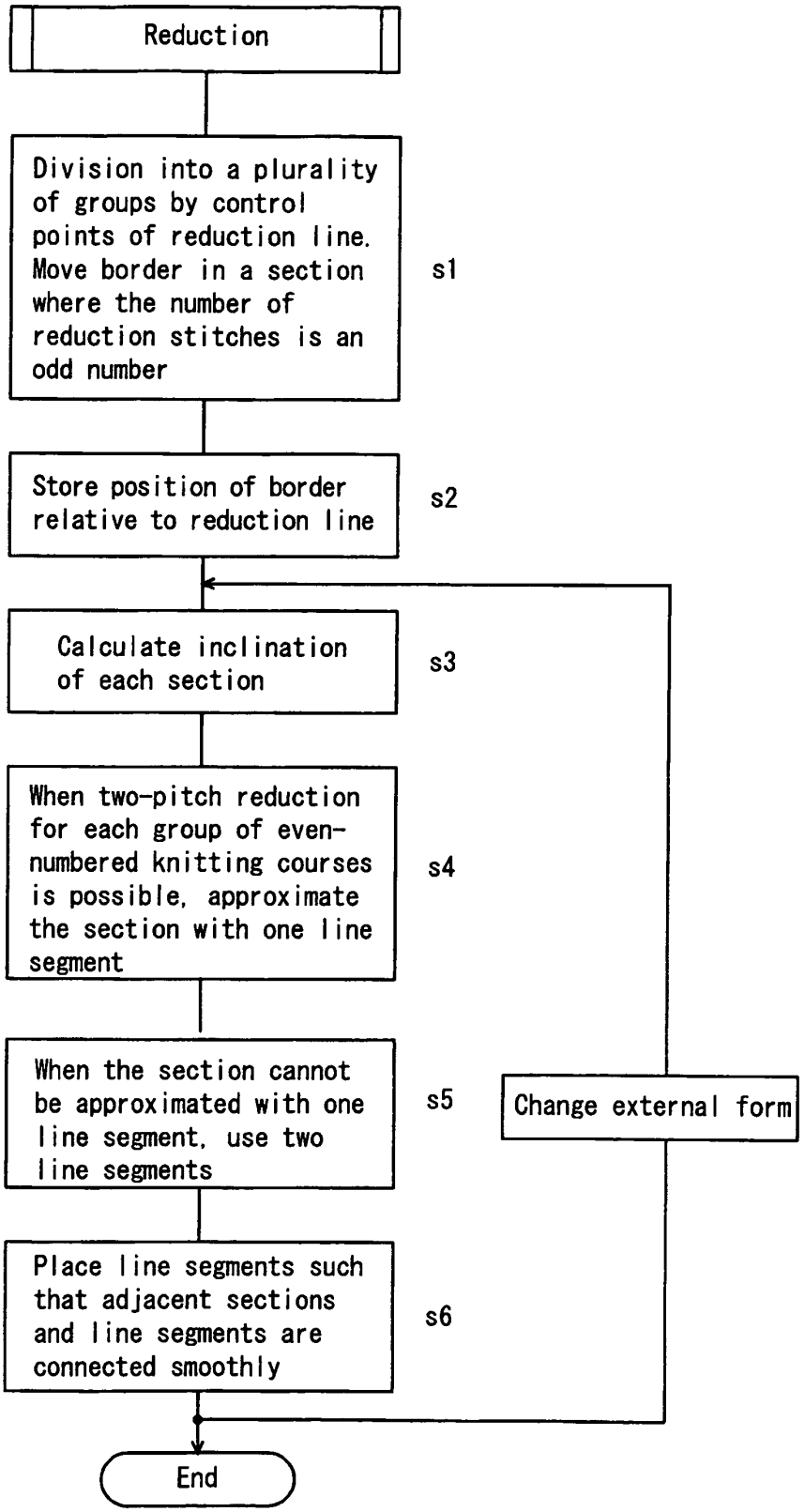

Reduction
Division into a plurality of groups by control points of reduction line. Move border in a section where the number of reduction stitches is an odd number
s1
Store position of border relative to reduction line
s2
Calculate inclination of each section
s3
When two-pitch reduction for each group of even-numbered knitting courses is possible, approximate the section with one line segment
s4
When the section cannot be approximated with one line segment, use two line segments
s5
Change external form
Place line segments such that adjacent sections and line segments are connected smoothly
s6
End

FIG. 3

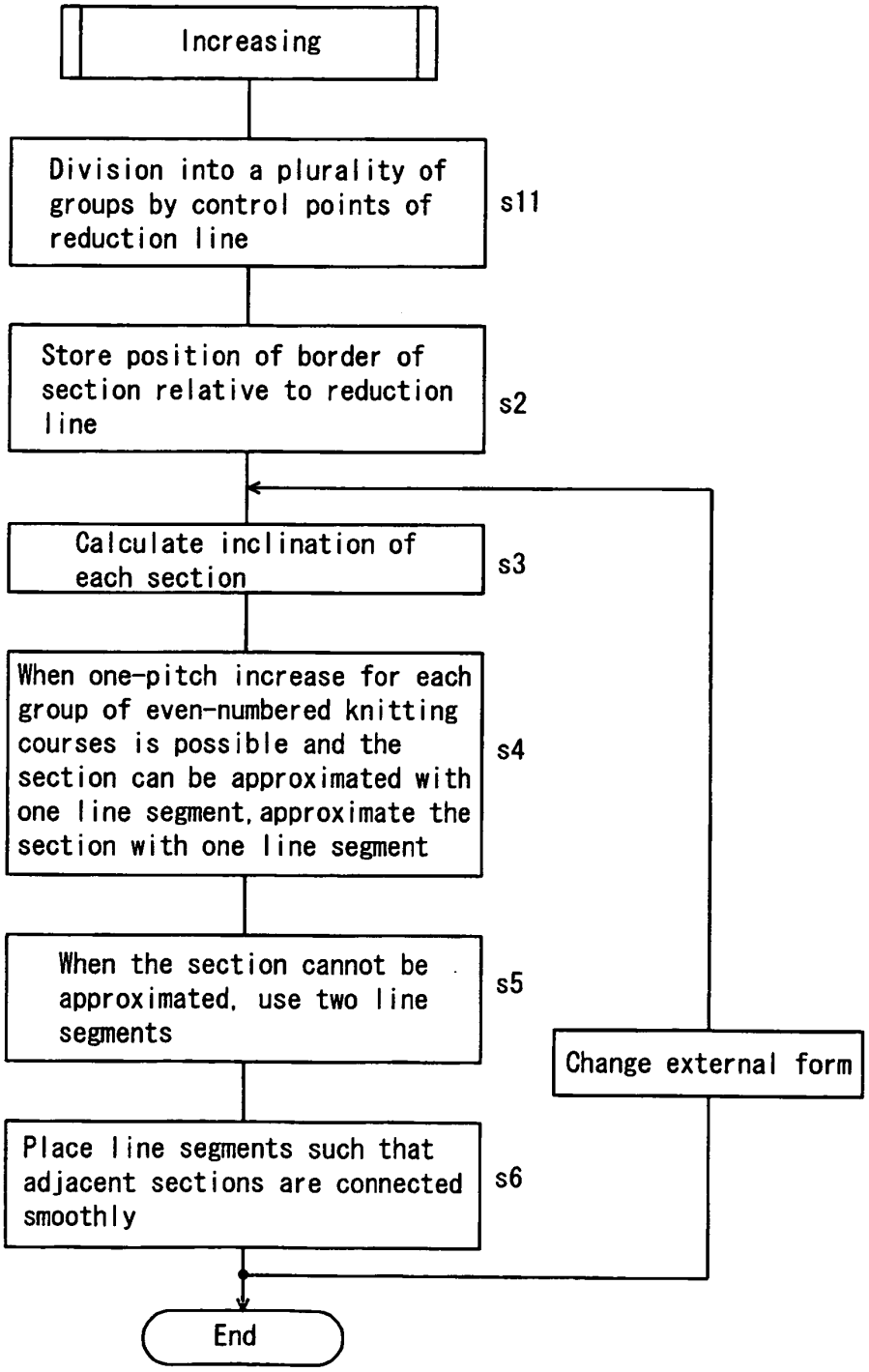
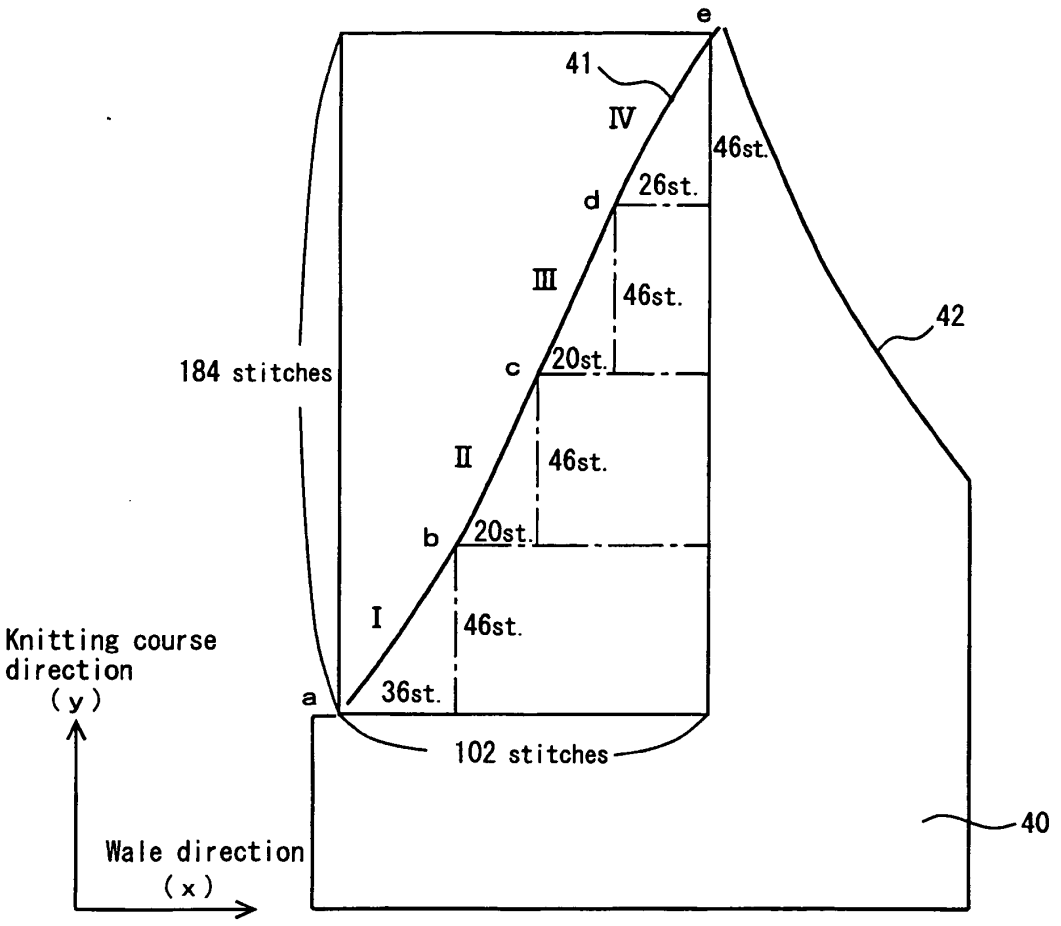

Increasing
Division into a plurality of groups by control points of reduction line
s11
Store position of border of section relative to reduction line
s2
Calculate inclination of each section
s3
When one-pitch increase for each group of even-numbered knitting courses is possible and the section can be approximated with one line segment, approximate the section with one line segment
s4
When the section cannot be approximated, use two line segments
s5
Change external form
Place line segments such that adjacent sections are connected smoothly
s6
End

FIG. 4



I : $46 \div (36/2) = 2.5$

$2a + 4(18 - a) = 46$

$a = 13$

Reduction by two stitches with respect to each group of two knitting courses × 13 times
Reduction by two stitches with respect to each group of four knitting courses × 5 times

II : $46 \div (20/2) = 4.6$

$4a + 6(10 - a) = 46$

$a = 7$

Reduction by two stitches with respect to each group of four knitting courses × 7 times
Reduction by two stitches with respect to each group of six knitting courses × 3 times

IV : $46 \div (26/2) = 3.54$

$2a + 4(13 - a) = 46$

$a = 3$

Reduction by two stitches with respect to each group of two knitting courses ×3 times
Reduction by two stitches with respect to each group of four knitting courses × 10 times

FIG. 5

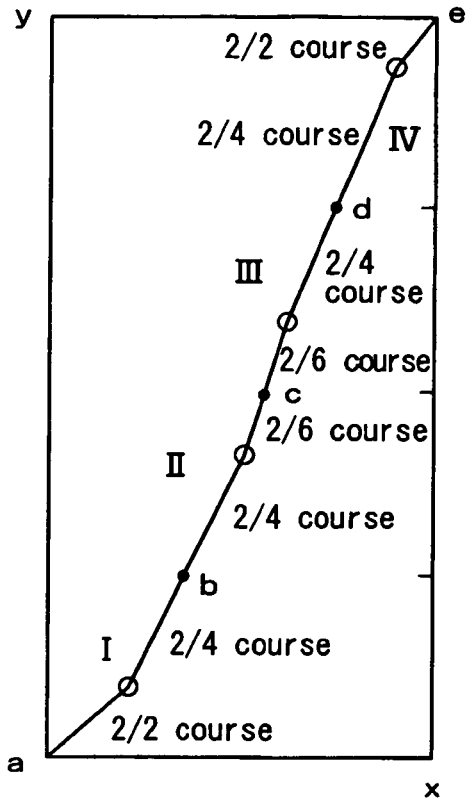
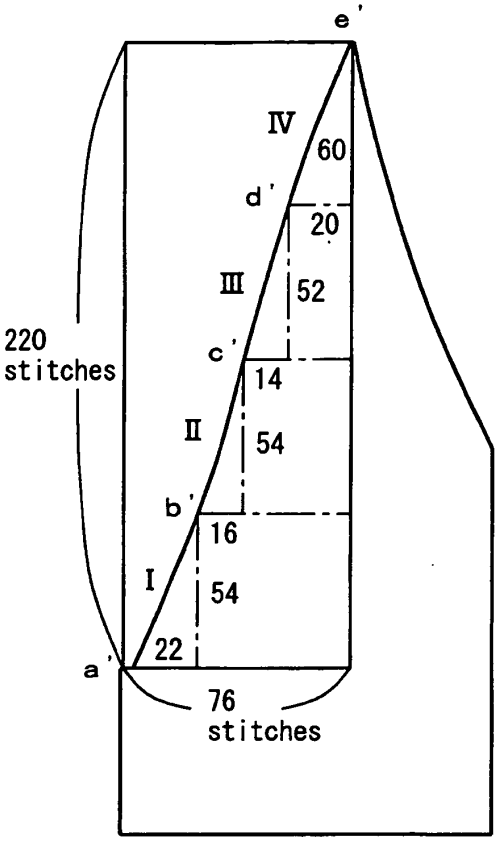

y
e
2/2 course
2/4 course
IV
d
III
2/4
course
2/6 course
c
2/6 course
II
2/4 course
b
I
2/4 course
2/2 course
a
x

FIG. 6



I : Reduction with respect to each group of four knitting courses × 6 times
Reduction with respect to each group of six knitting courses × 5 times
Based on 4a+6(11−a)=54

II : Reduction with respect to each group of six knitting courses × 5 times
Reduction with respect to each group of eight knitting courses × 3 times

III : Reduction with respect to each group of six knitting courses × 2 times
Reduction with respect to each group of eight knitting courses × 5 times

IV : Reduction with respect to each group of six knitting courses × 10 times

FIG. 7

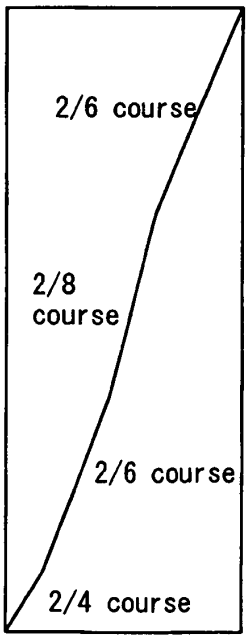


FIG. 8

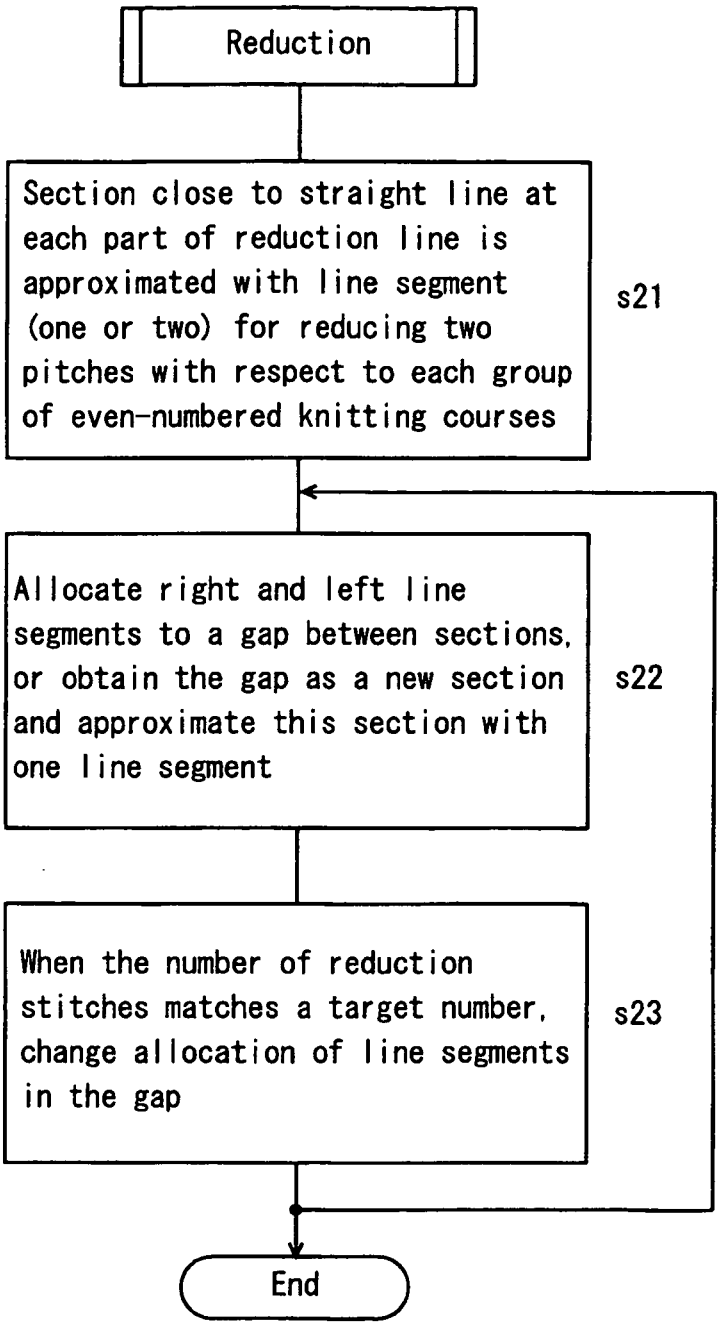

Reduction
Section close to straight line at each part of reduction line is approximated with line segment (one or two) for reducing two pitches with respect to each group of even-numbered knitting courses
s21
Allocate right and left line segments to a gap between sections, or obtain the gap as a new section and approximate this section with one line segment
s22
When the number of reduction stitches matches a target number, change allocation of line segments in the gap
s23
End

FIG. 9

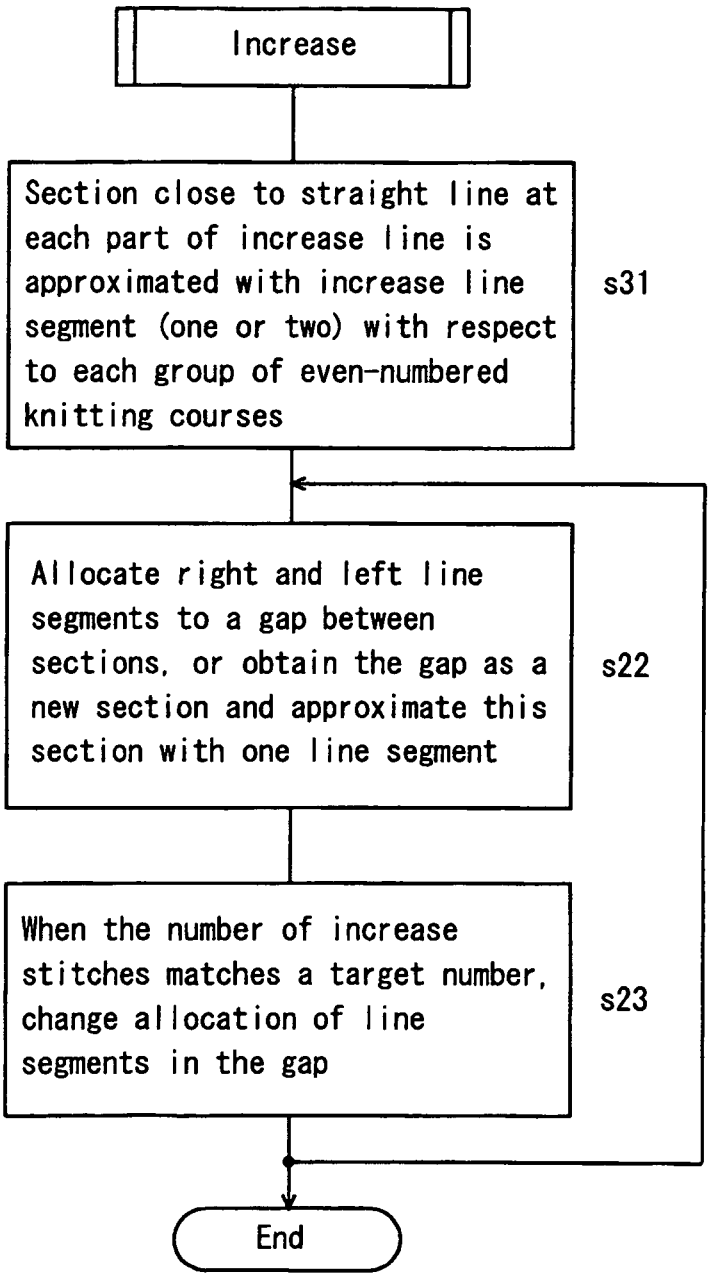

Increase
Section close to straight line at each part of increase line is approximated with increase line segment (one or two) with respect to each group of even-numbered knitting courses
s31
Allocate right and left line segments to a gap between sections, or obtain the gap as a new section and approximate this section with one line segment
s22
When the number of increase stitches matches a target number, change allocation of line segments in the gap
s23
End

FIG. 10

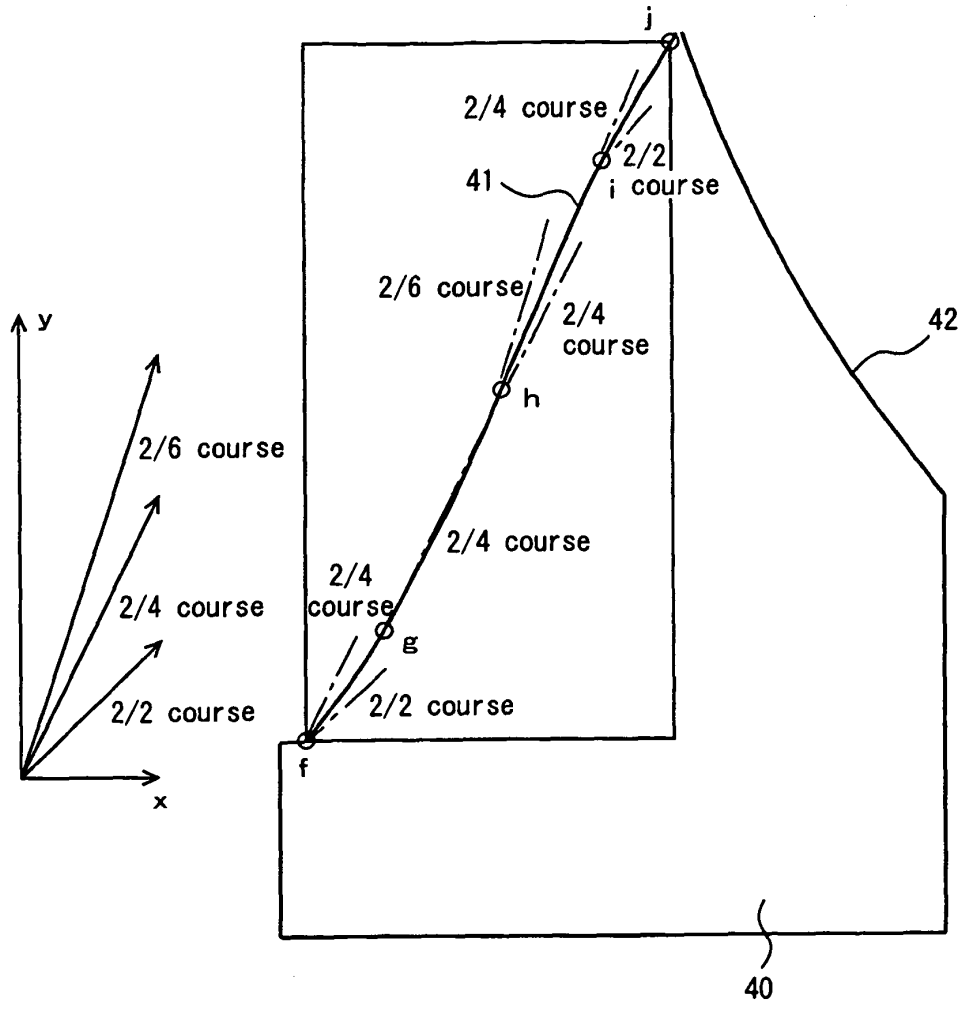

j
2/4 course
2/2
i course
41
2/6 course
2/4
course
42
h
y
2/6 course
2/4 course
2/4 course
2/4
course
g
2/2 course
2/2 course
f
x
40

FIG. 11

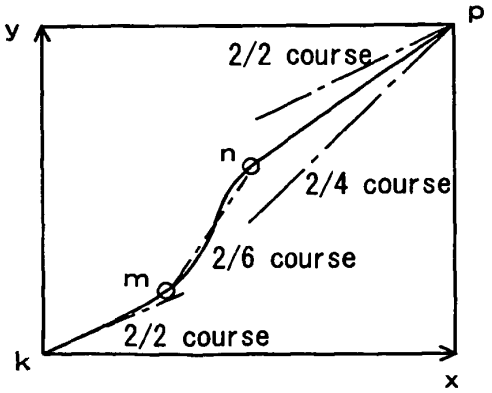
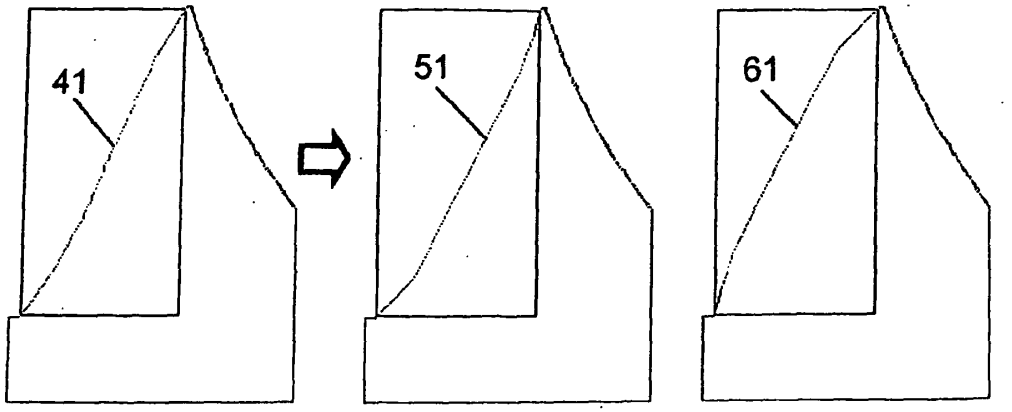

y
p
2/2 course
n
2/4 course
2/6 course
m
2/2 course
k
x

FIG. 12



Prior Art

FIG. 13

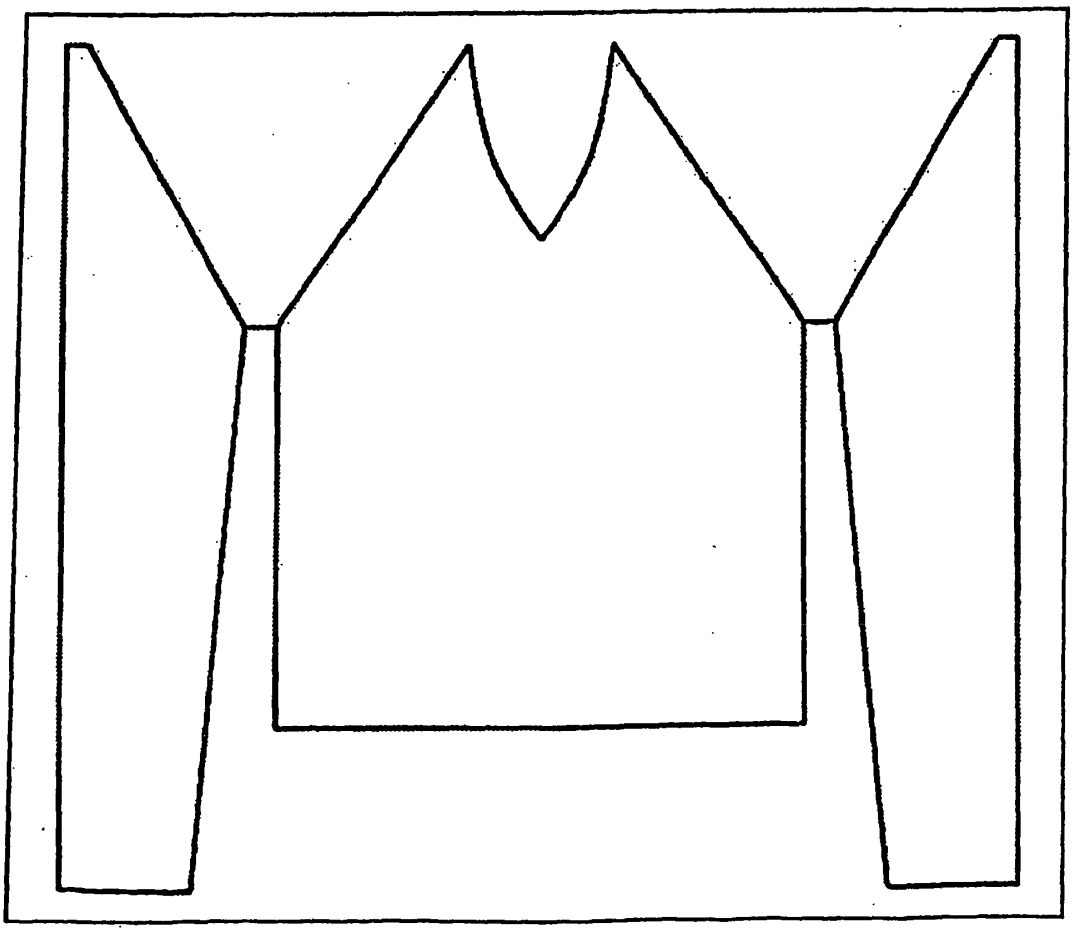
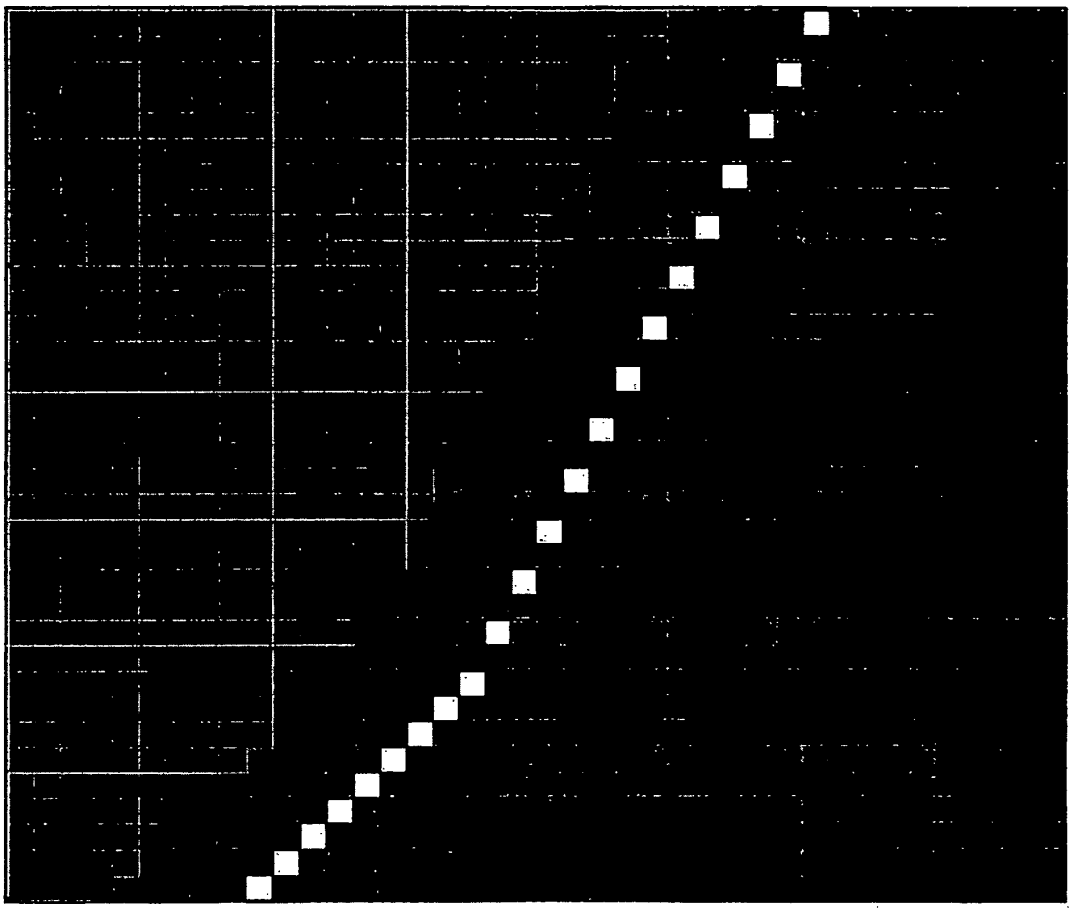
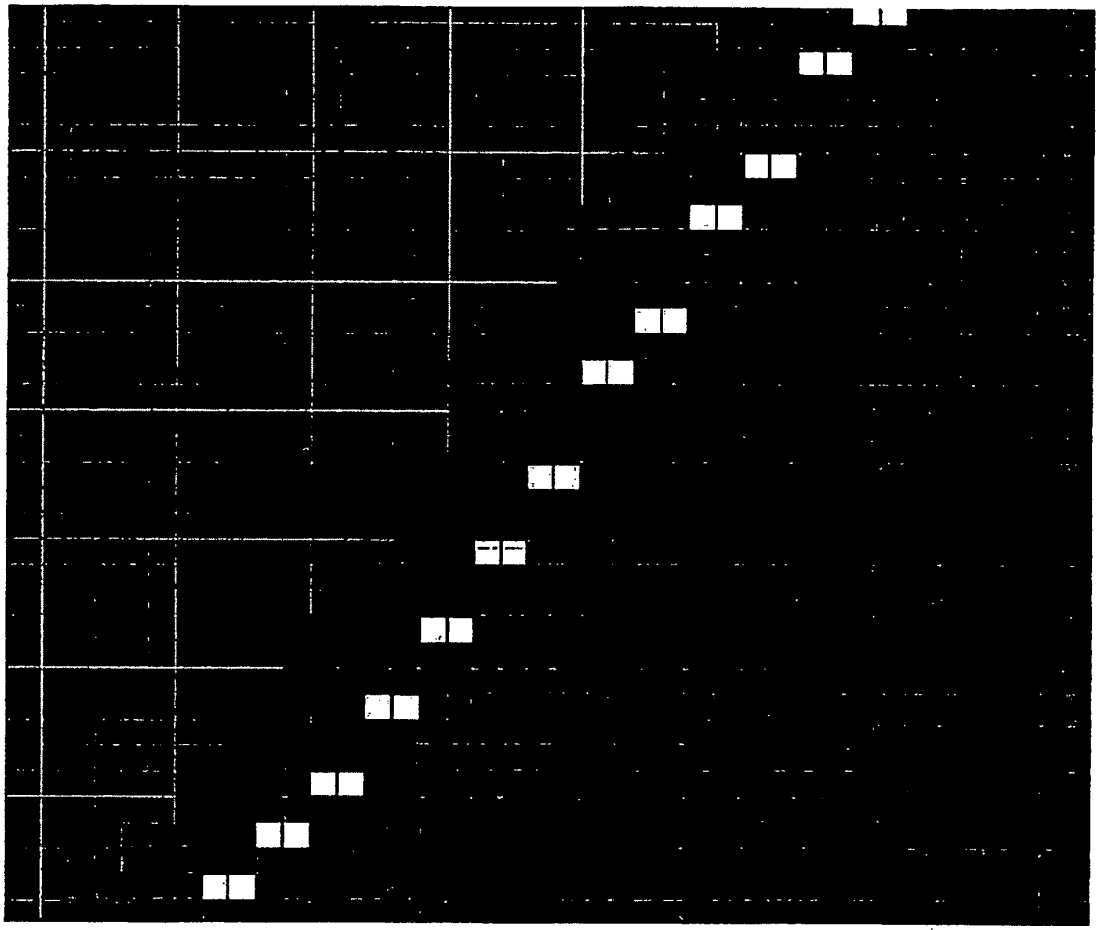


FIG. 14



Prior Art

FIG. 15



Prior Art

FIG. 16

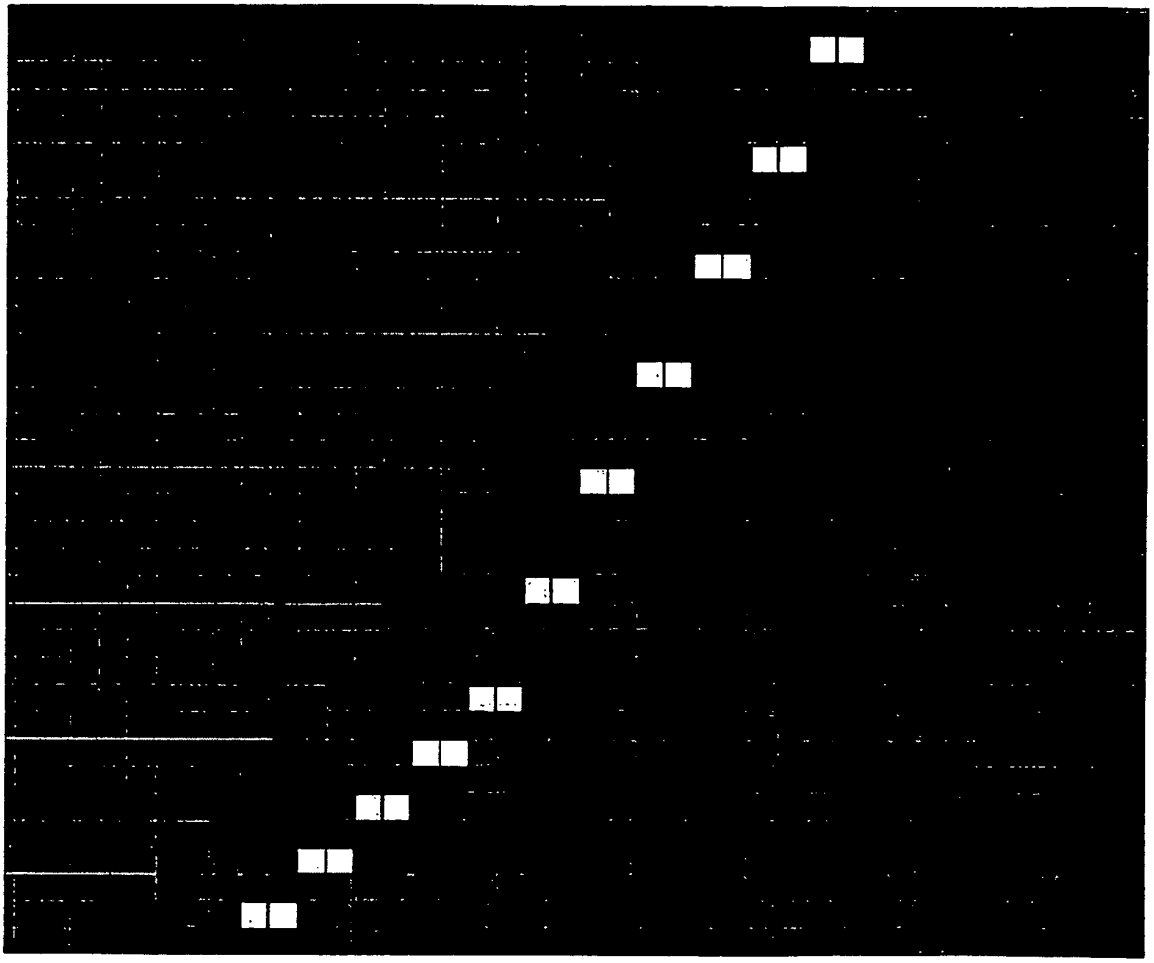
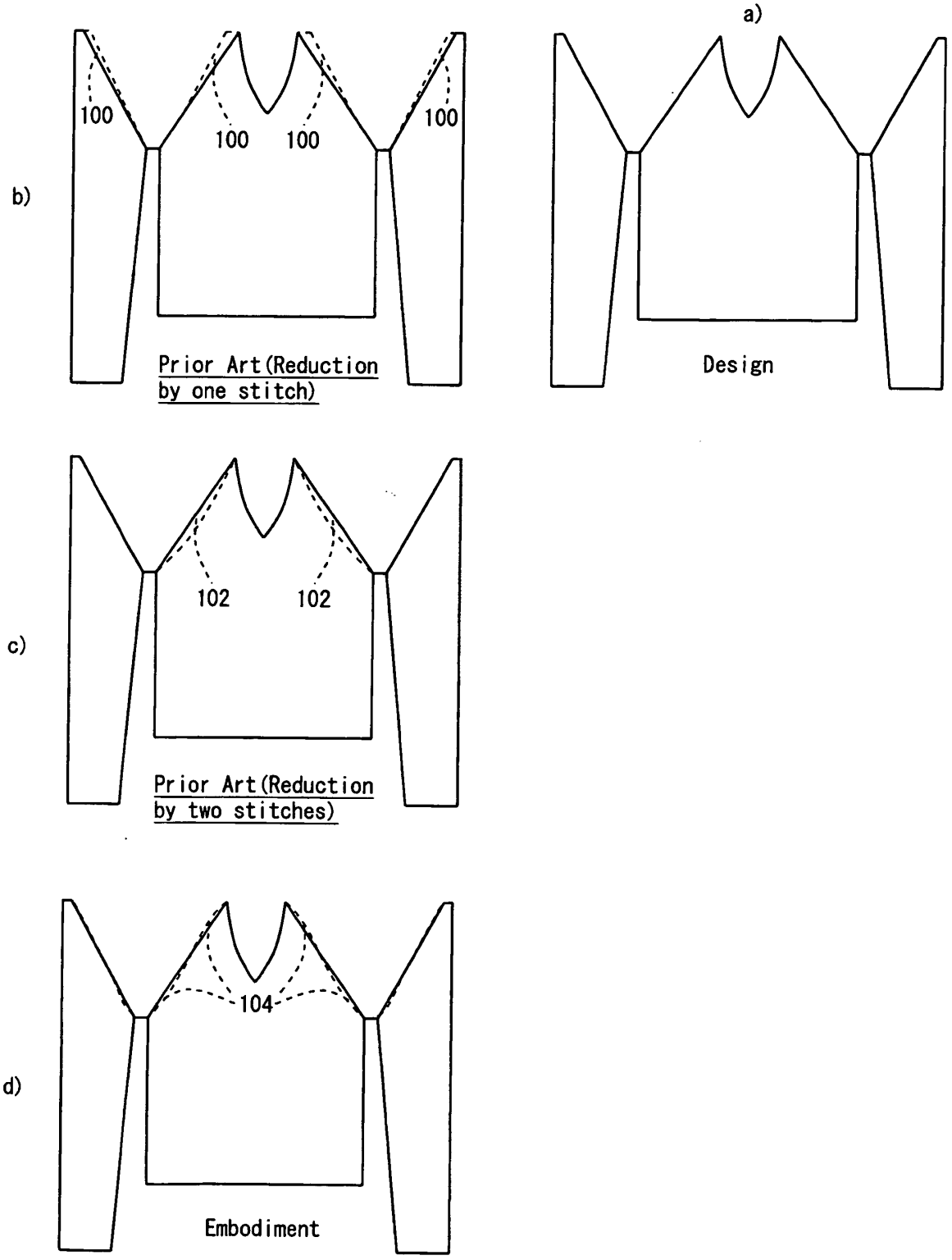


FIG. 17


a)
Design
b)
100
100
100
100
Prior Art(Reduction by one stitch)
c)
102
102
Prior Art(Reduction by two stitches)
d)
104
Embodiment

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/061323

A. CLASSIFICATION OF SUBJECT MATTER
D04B15/00(2006.01)i, *D04B35/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D04B15/00, D04B35/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009
Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 60-25781 U (Ikuyo OHASHI), 21 February, 1985 (21.02.85), Full text; Figs. 1 to 2 (Family: none)	1-3,6-8 4 5
Y A	JP 59-123185 U (Royal Industries Co., Ltd.), 18 August, 1984 (18.08.84), Full text; Figs. 1 to 11 (Family: none)	4 1-3,5-8
A	JP 63-275758 A (Kanebo, Ltd.), 14 November, 1988 (14.11.88), (Family: none)	1-8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 July, 2009 (03.07.09)	14 July, 2009 (14.07.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)