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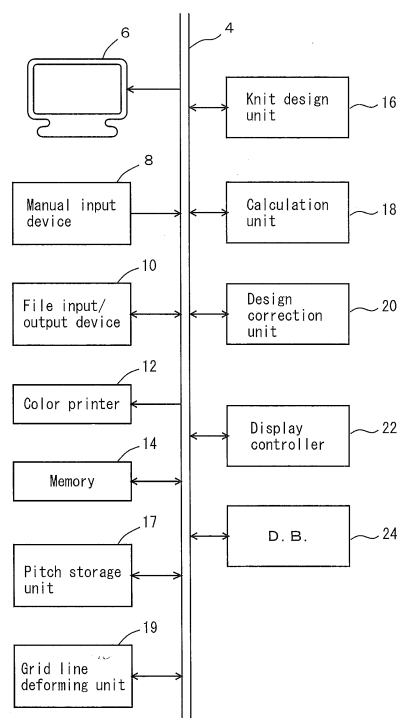
KNIT DESIGN SYSTEM AND KNIT DESIGN METHOD

(57)

It is an object of the present invention to enable knitting of a knit fabric according to a directed size without performing trial knitting.

Configuration: A knit design system (2) includes a color monitor (6), a manual input device (8), and a display controller (22) configured to perform display on the color monitor (6) and to interpret an input from the manual input device (8). The knit design system (2) is configured to output design data for designating stitch numbers, a stitch type, and connection relationship between stitches in a course direction and a wale direction of a knit fabric, based on inputs of shape data for defining a shape of the knit fabric, gauges of stitches in the course direction and the wale direction, and a knit structure. The knit design system (2) obtains calculation values of the size of a knit fabric after completion that vary depending on a knit structure, based on design data that is output or knit data, compares a directed size of the knit fabric with the calculation values of the size of the knit fabric, and corrects the shape data on the knit fabric, the design data, or the knit data so that a correction error is reduced.

FIG. 1



## Description

## Technical Field

**[0001]** The present invention relates to knit design, and particularly relates to knitting a knit fabric having a target size without trial knitting.

## Background Art

**[0002]** It is difficult to knit a knit fabric having a size substantially as directed. Accordingly, after designing a knit fabric, trial knitting and correction of the design such that an error with respect to the directed size is reduced are performed repeatedly, which wastes time and costs. In order to prevent this, a measure to make it possible to knit a knit fabric having a size substantially as directed without trial knitting has been considered.

**[0003]** Patent Literature 1 (JP 2676182B) discloses that a plurality of texture samples are knitted while controlling the loop length, and the most appropriate texture sample is selected after finish processing. By performing knitting according to the loop length of the most appropriate sample, a knit fabric that has a size close to a directed size and an excellent texture is obtained. However, by the method of Patent Literature 1, it is difficult to knit a knit fabric having a structure pattern, such as side movement, in a size close to a directed size.

**[0004]** Besides, estimating the shape of a knit fabric based on knit data has been considered. For example, in Patent Literature 2 (WO 2007/013296A), a tension, a distortion, and a flexure that are applied on each stitch are calculated, and the position of the stitch is shifted. In Patent Literature 3 (JP 4237601B), positions of stitches are shifted so that a distance between upper and lower stitches and a distance between right and left stitches approach the pitch of the stitches and the directions of right and left stitches are aligned. In both methods, in order to simulate the shape of a knit fabric, it is necessary to repeatedly perform calculation until the shape of the knit fabric converges. Furthermore, simulation is performed to understand an image of a knit fabric, such as the similarity shape of the knit fabric and the connection state of stitches, and not to obtain the size itself of the knit fabric. In other words, it is sufficient if the shape similar to the actual knit fabric is obtained, and less significance is placed on obtainment of the size itself of the knit fabric.

**[0005]** Furthermore, Patent Literature 4 (JP 2009-120987A) discloses that if it is necessary to change the course number between right and left parts of a knit fabric, that is, between a part of the knitting width and the remaining part, differences in course number are arranged in a distributed manner in the wale direction. This is usable for correcting the design in the present invention.

## Citation List

## Patent Literature

5 **[0006]**

[Patent Literature 1] JP 2676182B  
 [Patent Literature 2] WO 2007/013296A  
 [Patent Literature 3] JP 4237601B  
 10 [Patent Literature 4] JP 2009-120987A

## Summary of the Invention

**[0007]** It is an object of the present invention to estimate whether or not it is possible to knit a knit fabric having a size substantially as directed, and, if it is estimated that such knitting is impossible, to realize easy correction of design and to knit the knit fabric having a size substantially as directed without trial knitting.

20 **[0008]** It is an object of the present invention to realize knitting of a knit fabric even with a knit structure, such as side movement, in a size substantially as directed without trial knitting.

**[0009]** The present invention is directed to a knit design system that includes: a color monitor; a manual input device, and a display controller configured to perform display on the color monitor and to interpret an input from the manual input device; and that is configured to output design data for designating stitch numbers, a stitch type, and connection relationship between stitches in a course direction and a wale direction of a knit fabric, based on inputs of a directed size, a shape and a knit structure, and gauges of stitches in the course direction and the wale direction.

35 **[0010]** The knit design system of the present invention further includes:

a calculation unit configured to obtain calculation values of a size of a knit fabric after completion that vary depending on the knit structure, based on the design data that is output, or knit data; and  
 40 a design correction unit configured to compare the shape data on the knit fabric with the calculation values of the size of the knit fabric, and to correct the shape data on the knit fabric, the design data, or the knit data so that an error is reduced.

**[0011]** In a knit design method of the present invention, calculation values of a size of a knit fabric after completion that vary depending on the knit structure are obtained by the calculation unit of the knit design system, based on the design data that is output or knit data, and the shape data on the knit fabric, the design data, or the knit data is corrected by the design correction unit of the knit design system so that an error is reduced.

55 **[0012]** In the present invention, the size of a knit fabric after completion is obtained by calculation. Data to be used is design data, or knit data that is obtained by con-

verting the design data into data for driving a knitting machine. Based on the data, the construction of the knit fabric becomes clear. The sizes of stitches are defined by gauges, and, instead of directly using the gauges, the pitches of stitches that correspond to the inverses of the gauges, or the like may be used. The interaction between stitches due to side movement or the like changes the positions of stitches. By obtaining how the array of stitches changes due to the interaction between the stitches, it is possible to obtain the size of the knit fabric after completion.

**[0013]** Estimation of the size of a knit fabric includes dynamic simulation in which calculation is performed only assuming that the knit fabric is made of a yarn having a predetermined elasticity coefficient and stitches have a predetermined loop length, but the dynamic simulation needs a large calculation amount and a long processing time. The estimation further includes semiempirical simulation disclosed in Patent Literatures 2 and 3, in which a standard size of stitches is assumed to be based on gauges or the like, and a model is assumed, for example, such that stitches maintain the size and try to be aligned. By adding data on the size, such as the pitch, of stitches to the semiempirical simulation, it is possible to estimate the size of the knit fabric without keeping a user waiting for a long time. However, short time calculation is difficult. Additionally, there is a simple calculation method shown in FIGS. 9 to 16. In this calculation method, the pitch of stitches is assumed, and it is also assumed that stitches in a course are likely to move while being aligned and stitches in a wale are also likely to move while being aligned. Any calculation method may be used but it is preferable that calculation be accomplished in a short time.

**[0014]** According to the present invention, a size of a knit fabric after completion is calculated, and the design is corrected so that an error with respect to shape data for defining the shape of the knit fabric is reduced. Shape data on a knit fabric includes a target size (directed size) of the knit fabric, data on the external shape of the knit fabric, and the like. To reduce an error means, for example, to solve the error or to substantially solve the error. Preferably, the loop length of a stitch of the knit fabric is settable, and the design correction unit corrects at least one of the shape data on the knit fabric, the stitch number, the loop length of a stitch. To change the loop length substantially means to change the size of a stitch (the pitch of a stitch). As described above, in the present invention, design of a knit fabric is realized so that a knit fabric having a size substantially as directed is achieved without trial knitting. Note that in the specification, the description regarding the knit design system is also applied directly to the knit design method.

**[0015]** It is preferable that the display controller be configured to display, on the color monitor, the shape data on the knit fabric and the design data corrected by the design correction unit in an overlapping manner, and the knit design system is configured to output the corrected

design upon a user accepting the corrected design data using the manual input device, and to enable the user to further correct the corrected design data using the manual input device.

**[0016]** The design data is automatically corrected by the design correction unit and the corrected design data is displayed on the color monitor, thereby mitigating the user's burden. Then, the user changes the size of the knit fabric by changing the shape data on the knit fabric, the stitch number, the loop length of a stitch, or the like, and corrects the external shape of the knit fabric, the knit structure, or the like, thereby improving the design. Here, when the external shape of the knit fabric in the original design and the external shape of the knit fabric that was obtained by calculation are displayed while overlapping each other, it becomes clear how much extent and which part of the knit fabric should be corrected. Preferably, two screens, namely, a screen of the above-described overlapping display and a screen for inputting a correction of design of a knit fabric are displayed on the color monitor so that a user can easily correct the design.

**[0017]** It is preferable that the knit design system further include a database for storing the design data that is to be output, the loop length, and the actually measured size of the knit fabric knitted by a knitting machine, and the database is configured to be referenced when the shape data on the knit fabric is input or the design data is corrected.

**[0018]** If the size of a knit fabric that is obtained with respect to a design is recognized, it is easy for a user to correct the design data or to initially input a directed size, for example. Furthermore, if it is recognized at which position the size of a knit fabric is likely to shift from a directed size, the correction of the design becomes easier.

**[0019]** It is preferable that the calculation unit be configured to calculate a size of the knit fabric by:

generating, for each course, a grid line in the course direction indicating positions of stitches along the course of the knit fabric;

generating, for each wale, a grid line in the wale direction indicating positions of stitches along the wale of the knit fabric;

deforming the grid line in the wale direction using an average of pitches of stitches belonging to the grid line in the wale direction, the average being obtained using pitches of stitches in the course direction when face and face stitches or rear and rear stitches are connected to each other, and pitches of stitches in the course direction when face and rear stitches are connected to each other, the pitches corresponding to the gauges; and

deforming the grid line in the course direction using an average of pitches of stitches belonging to the grid line in the course direction, the average being obtained using pitches of stitches in the wale direction when face and face stitches or rear and rear stitches are connected to each other, and pitches of

stitches in the wale direction when face and rear stitches are connected to each other, the pitches corresponding to the gauges.

**[0020]** With this measure, it is possible to estimate the size of the knit fabric in a short time.

**[0021]** The present invention is further directed to a knit design system that includes: a color monitor and a display controller configured to perform display on the color monitor and to interpret an input from the manual input device; and that is configured to output design data for designating stitch numbers, a stitch type, and connection relationship between stitches in a course direction and a wale direction of a knit fabric, based on inputs of shape data for defining a shape of the knit fabric, gauges of stitches in the course direction and the wale direction, and a knit structure, characterized in that the knit design system further includes:

a calculation unit configured to obtain calculation values of a size of a knit fabric after completion that vary depending on the knit structure, based on the design data or knit data; and

that the display controller is configured to display, on the color monitor, the size of the knit fabric that was obtained by calculation and the input shape data for defining a shape of the knit fabric in an overlapping manner, and

a manual input device, and

that the knit design system is configured to enable a user to compare the shape data on the knit fabric with the calculation values of the size of the knit fabric, and to correct, using the manual input device, the shape data on the knit fabric, the design data, or the knit data so that an error is reduced.

**[0022]** With this measure, it is possible to easily perform manual correction so that a desired size is realized.

**[0023]** It is preferable that the average be a moving average along a grid line, and the average varies depending on the position on a grid line. An interaction acts on stitches that are close to each other so as to align their positions, and an interaction that acts on stitches that are apart from each other is weak. Therefore, a moving average is used to realize more exact estimation of the size of a knit fabric.

#### Brief Description of the Drawings

**[0024]**

FIG. 1 is a block diagram showing a knit design system according to an embodiment.

FIG. 2 is a diagram showing correction of knit data in the embodiment.

FIG. 3 is a diagram showing the flow from a directed size to knit data.

FIG. 4 is a diagram showing designation of a stitch

number and data for assisting simulation.

FIG. 5 is a diagram showing the types and features of simulation.

FIG. 6 is a diagram schematically showing a configuration of a database for use in the embodiment.

FIG. 7 is a diagram showing correction of design data with reference to the database.

FIG. 8 is a diagram showing a difference in simulation result of the same pattern data between a simple knit fabric and a knit fabric with a complicated structure.

FIG. 9 is a flowchart showing an algorithm for calculating an external size of a knit fabric according to a modification.

FIG. 10 is a diagram showing pitches of stitches and grid lines in the modification.

FIG. 11 is a diagram showing a method for calculating a pitch of a stitch that is moved to the side in the modification.

FIG. 12 is a diagram showing another method for calculating a pitch of a stitch that is moved to the side in the modification.

FIG. 13 is a diagram showing yet another method for calculating a pitch of a stitch that is moved to the side in the modification.

FIG. 14 is a diagram showing a method for calculating a pitch of stretched stitches in the modification.

FIG. 15 is a diagram showing deformation of the grid lines of the modification with respect to a 2×2 cable pattern.

FIG. 16 is a diagram showing deformation of the grid lines of the modification with respect to a part having a bind-off.

#### Description of Embodiments

**[0025]** Hereinafter, an optimal embodiment for carrying out the present invention will be described.

#### Embodiment

**[0026]** FIGS. 1 to 16 show an embodiment and its modification and, specifically, FIG. 1 shows a knit design system 2 according to the embodiment, in which the reference numeral 4 denotes a bus, the reference numeral 6 denotes a color monitor, the reference numeral 8 denotes a manual input device such as a stylus, a mouse, and a keyboard. The reference numeral 10 denotes a file input/output device, such as a LAN interface, a disk drive, or an external memory, that inputs/outputs a file such as a directed size, pattern data, knit design data (hereinafter, referred to as design data), or knit data (data for driving a knitting machine). The reference numeral 12 denotes a color printer, and the reference numeral 14 denotes a memory that stores arbitrary data, a database, a program, and the like. Additionally, a CPU (not shown) is provided.

**[0027]** A knit design unit 16 generates design data for a knit fabric in accordance with an input from the manual

input device 8, the file input/output device 10, or the like. During this operation, the design that is being generated is displayed on the color monitor 6, and the input from the manual input device 8 is interpreted by the display controller 22. Furthermore, a user interface for performing, for example, display on the color monitor 6 is realized by the display controller 22. Then, the knit design unit 16 converts the design data into data (knit data) for driving a knitting machine such as a flat knitting machine.

**[0028]** A calculation unit 18 calculates and estimates the size of a knit fabric after completion based on the design data or knit data. In addition to the design data and the like, data indicating the size of stitches, such as the loop length, the gauges, the pitch of the stitches, is input into the calculation unit 18.

**[0029]** A design correction unit 20 performs processing, such as comparing shape data on the knit fabric, such as a directed size, with the size of the knit fabric that was calculated by the calculation unit 18, or comparing pattern data on a target shape of the knit fabric with the size of the knit fabric that was calculated by the calculation unit 18. Accordingly, a difference between the external shape of the designed knit fabric and the external shape of the knit fabric after completion becomes clear. The design correction unit 20 performs processing, such as changing the directed size of the knit fabric, increasing/decreasing the number of stitches (hereinafter, referred to as the stitch number), or changing the loop length of stitches, so that this error is solved. If the directed size or the stitch number is changed, the shape of the knit fabric changes, and thus the design correction unit 20 also performs processing with respect to design, such as moving the position of a knit structure, or changing the positions and the number of stitches that are moved to the side. Furthermore, the arm holes of the body are often designed straight although they are intended to be curved, and thus a portion in which design should be corrected and a portion in which design does not need to be corrected are distinguished in accordance with a rule that, for example, design data on a curved arm hole is not corrected. The design corrected by the design correction unit 20 is processed again by the knit design unit 16 if needed, and is converted into design data and knit data.

**[0030]** The display controller 22 controls display on the color monitor 6, interprets an input from the manual input device 8, and provides a user interface.

**[0031]** A database 24 stores design data on a knit fabric, the actual size of a knit fabric after completion, and the like so that they are searchable. By searching the database 24, a user recognizes what extent of error occurs between design data and an actual knit fabric in what kind of design and under what kind of condition (type of the knitting machine, type of yarns, and the like). This recognition is used for design of a knit fabric, correction of design data, or the like.

**[0032]** FIG. 2 shows the flow of design in the embodiment. In order to input shape data on a knit fabric, a

directed size (a distance between main points of the knit fabric, or the like) is input or the external shape of the knit fabric is input as a graphic. Note that any method is used for inputting the shape of a knit fabric. The knit design unit 16 converts, by gauge conversion, the size of the knit fabric into the stitch number, and regards the stitch number as pattern data. Note that gauges refer to the numbers of stitches per a predetermined length in the wale direction and in the course direction, and if the size and the gauges of a knit fabric are defined, then the stitch numbers are defined. A knit structure, such as a rib, garter, tuck, miss, side movement, bind-off, stitch increasing, stitch decreasing, or the like, is input with respect to pattern data to obtain design data. Then, the design data is converted into knit data for driving a knitting machine. In the embodiment, for example, pitches of stitches (the inverses of the gauges) are used for designating the size of stitches, but the yarn length, that is, the loop length of each stitch may as well influence on the size of stitches. Accordingly, the loop length is added to the knit data, or the loop length will be added in the next simulation. Processing from input of a directed size to conversion into knit data is performed by the knit design unit 16.

**[0033]** The calculation unit 18 obtains the size of a knit fabric after completion based on the design data or the knit data, by calculation using simulation or the like. The external shape of the knit fabric is extracted from the simulation result, and the design correction unit 20 obtains an error with respect to the shape data on the knit fabric, and performs processing, such as changing the shape of the knit fabric, such as the size of the knit fabric, the stitch number, the structure of the knit fabric, or the loop length so that the error is reduced. Then, the knit design unit 16 adds necessary data to complete design data, and converts the design data into knit data, and the size of the knit fabric after completion is re-calculated. Processing regarding correction of the design data is automatically performed by the design correction unit 20, instead of in response to an instruction from a user. Note that the re-calculation of the size of the knit fabric may be omitted, and only executed in response to a user's request.

**[0034]** In order to make an error between the calculated size and the originally input shape data on the knit fabric clear, for example, a simulated image of the knit fabric and the shape data on the knit fabric or the like are displayed in an overlapping manner on the color monitor 6. If a user accepts the display, the knit data or the design data is output. If a user wants to perform correction, the user uses the color monitor 6 and the manual input device 8 to correct the shape data on the knit fabric, the pattern data, or the design data, or the knit data. With the above-described procedure, knit data for knitting a knit fabric having a size that substantially matches a directed size is obtained without trial knitting.

**[0035]** FIG. 3 shows the meaning of data at the respective stages in the embodiment. Shape data on a knit fabric

is constituted by the directed size, which designates the size of the main portion of the knit fabric, or the external shape itself of the knit fabric. Pattern data is data that is obtained by converting the shape data on the knit fabric into the stitch number, and designates the course number and the wale number. Design data designates a knit structure by designating the stitch type, the connection relationship, side movement, and the like with respect to stitches of the pattern data (stitch type and the connection relationship are not yet designated). The construction of the knit fabric is uniquely defined by the design data. Knit data is obtained by converting the design data into data for enabling knitting of a knitting machine. The size of the knit fabric is calculated by adding the loop length, the pitch of stitches, or the like to the knit data, and the necessary type of data depends on the calculating method.

**[0036]** FIG. 4 shows data that is to be input into the design system 2 and is used for calculation of the size of a knit fabric. Gauge data refers to the stitch numbers per a predetermined length in the course direction and the wale direction of a plain fabric (knit fabric constituted only by face stitches or rear stitches). Based on the gauge data, pitches of stitches become clear when the same type of stitches are continued, the pitches including a pitch in the course direction and a pitch in the wale direction.

**[0037]** Preferably, pitches of stitches in the cases where face and rear stitches are connected to each other are also input into the design system 2. The case includes two types of fabrics, namely, a rib fabric (face stitches and rear stitches are adjacent to each other in the course direction) and a garter fabric (face stitches and rear stitches are adjacent to each other in the wale direction), and each fabric has a pitch in the course direction and a pitch in the wale direction.

**[0038]** Furthermore, preferably, pitches of stitches in the course and wale directions of a fabric in which a stitch is moved to the side, that is, shifted in the course direction are input. Since there are a plurality of types of the side movement, depending on by how many stitches a stitch is to be moved to the side (by how many stitches a stitch is to be shifted), a plurality of pitches are input depending on the number of stitches a stitch is to be shifted by. The pitch when face and rear stitches are connected to each other, the pitch when a stitch is moved to the side, and the like can actually be measured by including these knit structures into texture samples as in Patent Literature 1 when they are knitted. Alternatively, the pitches may also be obtained by the calculation unit 18 using an appropriate model from gauge data, instead of inputting these types of data.

**[0039]** In addition to the construction of a knit fabric, the target loop length of stitches may influence the size of the knit fabric. The loop length is designated for each knit structure such as a plain fabric, a rib fabric, or a garter fabric. Note that the loop length may also be changed depending on the position in a knit fabric even of the same type of stitches. Estimation of the size of a knit

fabric is easier as the variety of data is larger, and if the variety of input data is small, estimation will depend on the dynamic model, resulting in an increase in calculation amount.

**[0040]** FIG. 5 shows a method for calculating the size of a knit fabric. In dynamic simulation, the shape of a knit fabric that is to be knitted according to knit data is simulated based on the loop length and the elasticity coefficient of stitches. The dynamic simulation ordinarily needs a large calculation amount. Examples of semiempirical simulation are disclosed in Patent Literatures 2 and 3. In the semiempirical simulation, a user does not need to wait for a long time, but it is impossible to say that the size of a knit fabric can be estimated in a short time. The grid model is as shown in FIGS. 10 to 16, and enable estimation of the size of a knit fabric in a short time. Which simulation to use is determined according to the calculation ability of the knit design system 2.

**[0041]** FIG. 6 shows a configuration of the database 24. Data 30 has stored, for each design of a knit fabric, design data before correction and design data after correction if any, knitting condition such as a yarn type and a knitting machine type, the actually measured size of the knit fabric after completion, a key word for searching, and the like. Actual measurement of the size of a knit fabric is ordinarily performed before mass-production. Furthermore, a key word for searching preferably includes design data, or a picture or the like of the knit fabric as a thumbnail image. A search engine 32 displays the thumbnail image or the like on the color monitor 6, and displays, on the color monitor 6, the piece of the data 30 that was selected by an input through the keyboard from the manual input device 8 or selection of the thumbnail image.

**[0042]** As shown in FIG. 7, the database 24 is used to search for a knit fabric having a similar design (step S1), and to recognize how the size of the knit fabric is likely to change from the directed size, based on the design before correction, the design after correction, the actually measured size, and the like. Furthermore, it is also recognized at which position of the knit fabric the change is likely to occur. Accordingly, the information is used, for example, for correction of the design data (step S2), and thereby it is possible to design more exact the knit fabric having a size substantially as directed.

**[0043]** FIG. 8 shows an image in which shape data (outer frame) on a knit fabric, a plain fabric (a large knit fabric in a light color based on face stitches, including a knit structure such as side movement or bind-off for structure formation), and a knit fabric (a slightly small knit fabric in a slightly dark color) with a knit structure such as a cable structure are displayed in an overlapping manner. These knit fabrics have the same directed sizes and pattern data, but have different knit structures. Furthermore, both of them are images obtained by semiempirical simulation. If a knit structure is added, the shape of the knit fabric will change. For example, even in the case of a plain fabric based on face stitches, the knit fabric shrinks

in the width direction (course direction) as compared with the shape data on the knit fabric by adding a side movement or bind-off for structure formation. Furthermore, the knit fabric tends to shrink more significantly in the knitting width direction by adding a knit structure such as a cable structure to a part of the knit fabric, such as the body. In the present invention, design correction, change of the shape, such as the size, of a knit fabric, change of the stitch number, change of a knit structure of the knit fabric, and the like are performed so as to eliminate an error between the shape data on the knit fabric and the calculated size of the knit fabric. In the embodiment, since the size of a knit fabric after completion is estimated, it is possible to knit, without trial knitting, a knit fabric having a size substantially as directed.

#### Modification

**[0044]** In the present invention, it is essential to realize short time calculation of the size of a knit fabric. A stitch is connected to adjacent stitches in the course direction and adjacent stitches in the wale direction, and thus the shape of that stitch changes under the influence of the peripheral stitches. FIGS. 9 to 16 show processing for obtaining the external size of a knit fabric in a short time while taking into consideration the influence of the peripheral stitches, without repeatedly performing calculation. Furthermore, a modification will be described only with respect to calculation of the size of a knit fabric. The processing is executed by the calculation unit 18.

**[0045]** In step S11 of FIG. 9, shape data on a knit fabric is defined based on a directed size and the like, and in step S12, the shape data on the knit fabric is converted into the stitch numbers based on gauges, the stitch numbers serving as pattern data. In step S13, design data is defined by adding a knit structure, a stitch type, and the like. Then, in step S14, the design data is converted into knit data.

**[0046]** In step S15, a grid line in the course direction and a grid line in the wale direction are deformed based on the pitch between face-rear stitches and the pitch of side movement, and more actual positions of stitches are obtained. In step S16, the external size of the knit fabric is calculated based on the obtained positions of the stitches.

**[0047]** A grid line model is shown in dashed lines in FIG. 10. Courses c1 to c4 and wales w1 to w5 are indicated, in which the wales w1 to w3 are face stitches and the wales w4 and w5 are rear stitches, and j denotes the course number and i denotes the wale number. A straight or curved line on which stitches are arranged in each of the courses c1 to c4 and the wales w1 to w5 are grid lines. Furthermore, the starting point of a knit fabric is arranged in, for example, the lower left portion of FIG. 10. The pitch between the wales w2 and w1 is assumed to be an average of pitches  $x_{pj}$  in the x direction of four stitches ( $j = 1$  to 4) of the wale w2. The pitch between the courses c1 and c2 is assumed to be an average of pitches

$y_{pi}$  in the y direction of five stitches ( $i = 1$  to 5) of the course c2. That is, stitches are not moved independently, but the grid lines in the course direction and the wale direction to which the stitches belong are deformed using an average or a moving average of pitches of stitches. Note that the pitches between the wales w1 and w2, the wales w4 and w5, and the like are equal to pitches that are defined by gauges. Furthermore, the pitch between the courses c1 and c2 is a weighted average of a pitch between face stitches  $\times 3$  and a pitch between rear stitches  $\times 2$ , in which the weight is the stitch number of that pitch. Furthermore, the pitches from between the courses c1 and c2 to between the courses c3 and c4 are the same. Data for defining grid lines is, for example, a coordinate arrangement of intersection points (stitches) of the grid lines, and deforming the grid lines refers to moving the coordinates of stitches.

**[0048]** It is natural that a short grid line is close to a straight line, and a long grid line deviates from a straight line. In other words, a pitch of one stitch must hardly influence the array of stitches that are widely distanced from that stitch. Therefore, it is preferable to use a moving average that is obtained by averaging of stitches in the number that allows the positions of the stitches to be aligned on a straight line.

**[0049]** FIG. 11 shows calculation of a pitch that is moved to the side, and when the texture sample includes a stitch to be moved to the side, a measured value is used. It is assumed that the size itself of the stitch is not changed due to side movement, and the size  $(x_p^2 + y_p^2)^{1/2}$  is not changed, where  $x_p$  and  $y_p$  respectively refer to standard pitches that correspond to the pitch between face and face stitches and the pitch between face and rear stitches (the same applies to below). Then, a stitch 71 is rotated so as to be a stitch 72 along a circle 73 centered on the reference position, such as a base end, of the stitch. Note that another model for obtaining a pitch of side movement is conceivable, and any approximating method between the model and the pitch may be used.

**[0050]** Additionally, FIGS. 12 and 13 show a method for calculating a pitch that is moved to the side. Only the direction is shown in which the pitch of the stitch that is moved to the side shrinks, and the pitch of this stitch between the wales 3 and 4 is considered, where in FIG. 12, the black circle (●) denotes the starting point of the stitch and the white circle (○) denotes the top end thereof. It is assumed that a denotes the top end position of the stitch before side movement, and a' denotes the position after side movement. It is assumed that when the position a' is on the wale 3, the pitch of this stitch between the wales 3 and 4 is 0. If x and y with respect to the position a' are defined as in FIG. 12, the pitch of this stitch between the wales 3 and 4 is  $-x_p + x$  (where  $x_p$  is a standard pitch), and the pitch between the courses 2 and 3 is y. Then, x and y are obtained assuming that the position a' is located on the line connecting between the base end and the position a and the distance between the position a' and the base end is equal to  $y_p$ . FIG. 13 shows the same

calculation example with respect to another stitch.

**[0051]** FIG. 14 shows a way of thinking of the pitch of a stretched stitch, and it is assumed that the top end of this stitch converges from a position b to a position b'. The pitch of this stitch between the courses 3 and 4 is considered, and it is assumed that the pitch is 0 when the top end position b' is located on the grid line of  $j = 3$ . Since the top end position b' converges on the grid line of  $j = 2$ , it is assumed that the pitch between the courses 3 and 4 is  $-yp$ .

**[0052]** The models of FIGS. 12 and 13 are used to calculate pitches between courses and pitches between wales in FIG. 15. A course 1 and the like of FIG. 15 denotes a pitch between the courses 1 and 2, and the like. Furthermore, a to d are reference numerals of stitches. Note that the pitch between the wales 2 and 3 ( $xp + xp - (xp - xpa) + xp$ )/4 is obtained assuming that there are two stitches of a pitch  $xp$ , and the stitch a has a pitch  $-(xp - xpa)$ , and the base end of the stitch c contributes the pitch  $xp$ . However, the detail of the calculation method may be changed arbitrarily.

**[0053]** The model of FIG. 14 and the model of FIG. 12 and the like are used to calculate pitches in FIG. 16. The pitch between the courses 3 and 4 is  $(2ypa + 0)/3$ , and contribution of the stitch a and the stitch of the same shape as that of the stitch a is  $2ypa$ , and the top end of a stitch e is likely to converge on the grid line of  $j = 3$ , and thus contribution to the pitch is 0. The pitch between the courses 4 and 5, and the like are calculated in a similar manner. The pitch between the wales 1 and 2 is  $(2xp + xpa)/3$  that is obtained by averaging, since the number of ordinary stitches is two and the contribution is  $2xp$  and the contribution of the stitch a is  $xpa$ .

**[0054]** In this manner, pitches of each stitch in the course and wale directions are obtained and averaged for each grid line indicated by a dashed line, and thereby the position of the grid line after deformation is defined. Note that FIGS. 15 and 16 show a simple average, but a moving average is preferable if the grid line is long.

**[0055]** As described above, pitches in the case of side movement are:

- measured using a texture sample; or
- obtained directly using the model of FIGS. 12, 13, or 14, or using a model obtained by correcting that model of FIGS. 12, 13, or 14.

**[0056]** These pitches are stored in a pitch storage unit 17, or obtained each time by calculation of a grid line deforming unit 19. Furthermore, it is assumed that miss and tuck stitches are irrelevant to deformation of grid lines, but an appropriate model may also be defined separately. When it is determined how the grid line is deformed, the positions of stitches are defined. This processing is executed in a short time without repeated calculation, and thus the external size of a knit fabric is obtained in a short time.

**[0057]** In the embodiment and the modification, the fol-

lowing effects are achieved.

- 1) The size of a knit fabric after completion is estimated by the calculation unit 18 without trial knitting.
- 2) Design data and the like are corrected by the design correction unit 20 so that an error with respect to a directed size or the like is solved.
- 3) The design corrected by the design correction unit 20 is accepted or edited by a user.
- 4) The database 24 enables searching for which extent of an error in shape occurs at which position with respect to which design and under which knitting condition.
- 5) In the processing in FIGS. 9 to 16, the size of a knit fabric is calculated in a short time, and thus easy design correction is achieved.

**[0058]** Note that the present invention is applicable not only to design using a plurality of types of knitting yarns, but also to design in which loop lengths are different between a part of a knit fabric and the remaining part. Furthermore, any type of data may be input for estimation of the size of the knit fabric. A knitting machine is not limited to a flat knitting machine, and may also be another knitting machine such as a circular knitting machine.

#### Reference Signs List

#### [0059]

|          |                                       |
|----------|---------------------------------------|
| 2        | Knit design system                    |
| 4        | Bus                                   |
| 6        | Color monitor                         |
| 8        | Manual input device                   |
| 10       | File input/output device              |
| 12       | Color printer                         |
| 14       | Memory                                |
| 16       | Knit design unit                      |
| 17       | Pitch storage unit                    |
| 18       | Calculation unit                      |
| 20       | Design correction unit                |
| 22       | Display controller                    |
| 24       | Database                              |
| 30       | Data                                  |
| 32       | Search engine                         |
| c1 to c5 | Course                                |
| w1 to w5 | Wale                                  |
| xp       | Standard pitch along wale direction   |
| yp       | Standard pitch along course direction |

#### Claims

1. A knit design system (2) that comprises: a color monitor (6); a manual input device (8); and a display controller (22) configured to perform display on the color monitor (6) and to interpret an input from the manual input device (8); and that is configured to output de-

sign data for designating stitch numbers, a stitch type, and connection relationship between stitches in a course direction and a wale direction of a knit fabric, based on inputs of shape data for defining a shape of the knit fabric, gauges of stitches in the course direction and the wale direction, and a knit structure,

**characterized in that** the knit design system (2) further comprises:

a calculation unit (18) configured to obtain calculation values of a size of a knit fabric after completion that vary depending on the knit structure, based on the design data that is output, or knit data; and

a design correction unit (20) configured to compare the shape data on the knit fabric with the calculation values of the size of the knit fabric, and to correct the shape data on the knit fabric, the design data, or the knit data so that an error is reduced.

2. The knit design system (2) according to claim 1, **characterized in that** the knit design system (2) is capable of setting a loop length of a stitch of the knit fabric, and

the design correction unit (20) is configured to correct at least one of the shape data on the knit fabric, the stitch number, and the loop length of a stitch.

3. The knit design system (2) according to claim 1 or 2, **characterized in that** the calculation unit (18) is configured to re-calculate a size of the knit fabric after completion based on the design data that is output based on the data corrected by the design correction unit (20), or the knit data,

the display controller (22) is configured to display, on the color monitor (6), the shape data on the knit fabric that was originally input and the size of the knit fabric after completion that was re-calculated by the calculation unit (18), in an overlapping manner, and the knit design system (2) is configured to output the corrected design upon a user accepting the corrected design data using the manual input device (8), and to enable the user to further correct the corrected design data using the manual input device (8).

4. The knit design system (2) according to any one of claims 1 to 3,

**characterized in that** the knit design system (2) further comprises a database (24) for storing the design data that is to be output, the loop length, and an actually measured size of the knit fabric knitted by a knitting machine, and the database (24) is configured to be referenced when the shape data on the knit fabric is input or the design data is corrected.

5. The knit design system (2) according to any one of

claims 1 to 4,

**characterized in that** the calculation unit (18) is configured to obtain calculation values of the size of the knit fabric by:

generating, for each course, a grid line in the course direction indicating positions of stitches along the course of the knit fabric;

generating, for each wale, a grid line in the wale direction indicating positions of stitches along the wale of the knit fabric;

deforming the grid line in the wale direction using an average of pitches of stitches belonging to the grid line in the wale direction, the average being obtained using a pitch of stitches in the course direction when face and face stitches or rear and rear stitches are connected to each other, and a pitch of stitches in the course direction when face and rear stitches are connected to each other, the pitches corresponding to the gauges; and

deforming the grid line in the course direction using an average of pitches of stitches belonging to the grid line in the course direction, the average being obtained using a pitch of stitches in the wale direction when face and face stitches or rear and rear stitches are connected to each other, and a pitch of stitches in the wale direction when face and rear stitches are connected to each other, the pitches corresponding to the gauges.

6. A knit design method for designing a knit fabric using a knit design system (2) including: a color monitor (6); a manual input device (8); a display controller (22) configured to perform display on the color monitor (6) and to interpret an input from the manual input device (8); and a knit design unit configured to output design data for designating stitch numbers, a stitch type, and connection relationship between stitches in a course direction and a wale direction of a knit fabric, based on inputs of shape data for defining a shape of the knit fabric, gauges of stitches in the course direction and the wale direction, and a knit structure, the method comprising steps for:

a calculation unit (18) of the knit design system (2) obtaining calculation values of a size of a knit fabric after completion that vary depending on the knit structure, based on the design data that is output, or knit data; and

a design correction unit (20) of the knit design system (2) comparing the shape data on the knit fabric with the calculation values of the size of the knit fabric, and correcting the shape data on the knit fabric, the design data, or the knit data so that an error is reduced.

7. A knit design system (2) that comprises: a color monitor (6) and a display controller (22) configured to perform display on the color monitor (6) and to interpret an input from the manual input device (8); and that is configured to output design data for designating stitch numbers, a stitch type, and connection relationship between stitches in a course direction and a wale direction of a knit fabric, based on inputs of shape data for defining a shape of the knit fabric, gauges of stitches in the course direction and the wale direction, and a knit structure, **characterized in that** the knit design system (2) further comprises:

a calculation unit (18) configured to obtain calculation values of a size of a unit fabric after completion that vary depending on the knit structure, based on the design data or knit data; and that the display controller (22) is configured to display, on the color monitor (6), the size of the knit fabric that was obtained by calculation and the input shape data for defining a shape of the knit fabric in an overlapping manner; and that the knit design system (2) is configured to enable a user to compare the shape data on the knit fabric with the calculation values of the size of the knit fabric, and to correct, using the manual input device (8), the shape data on the knit fabric, the design data, or the knit data so that an error is reduced.

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FIG. 1

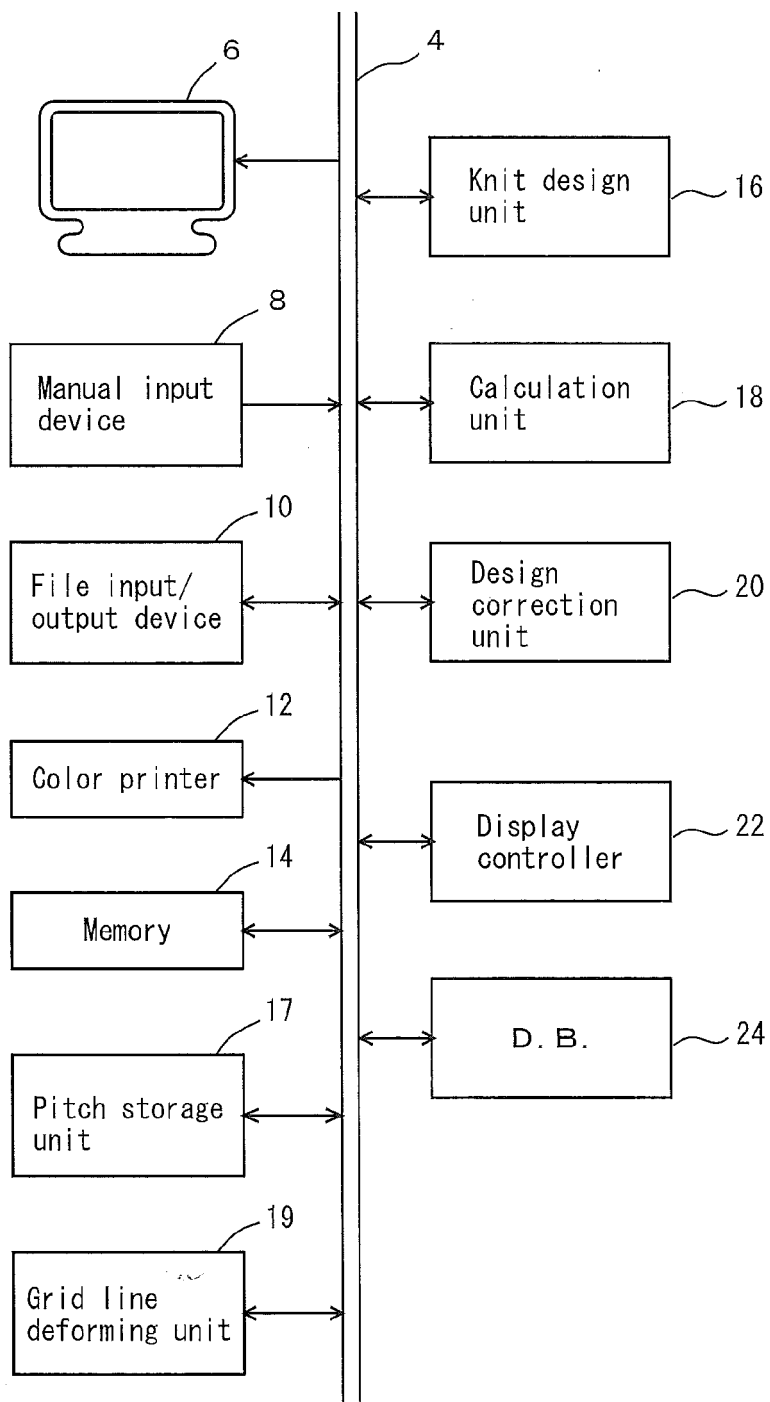


FIG. 2

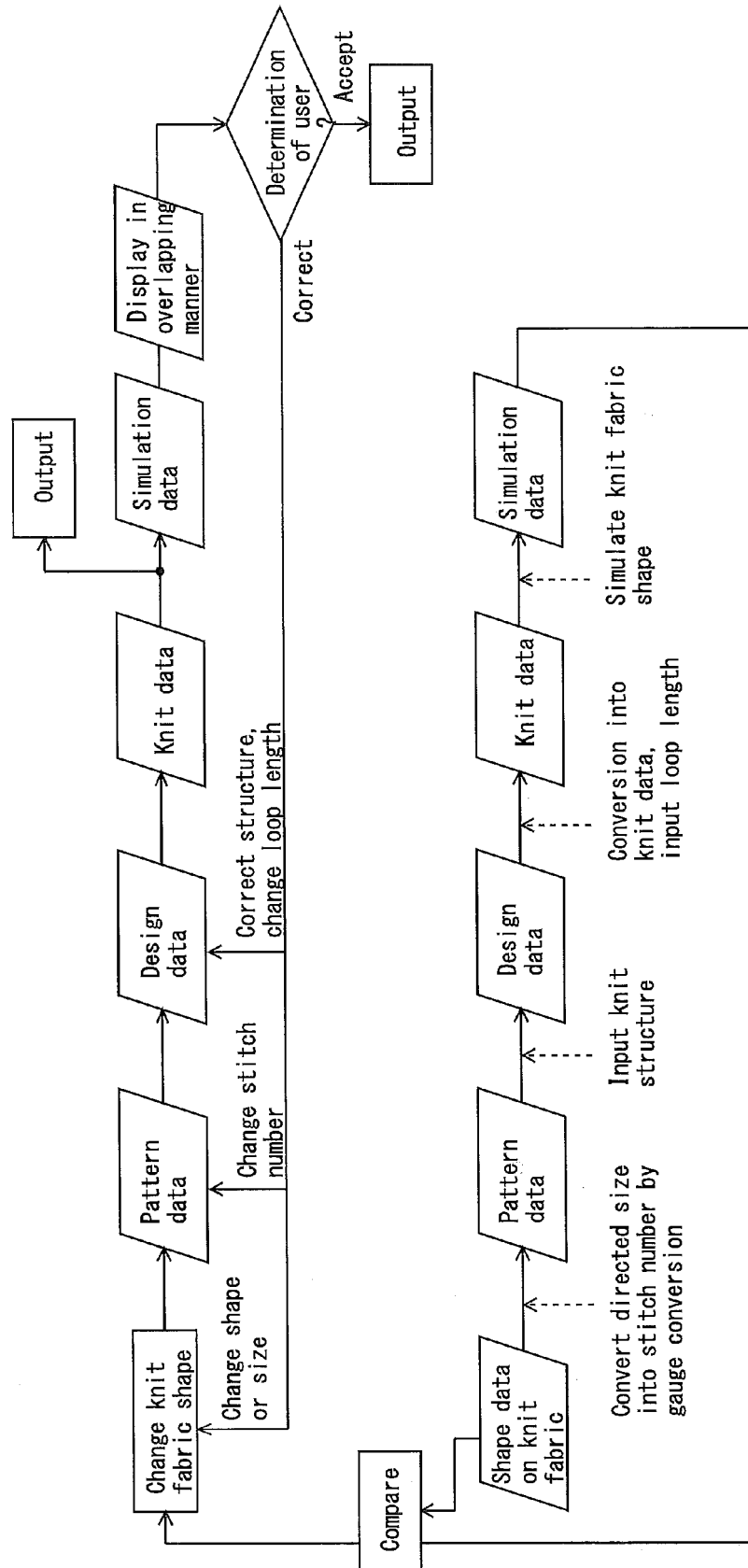


FIG. 3

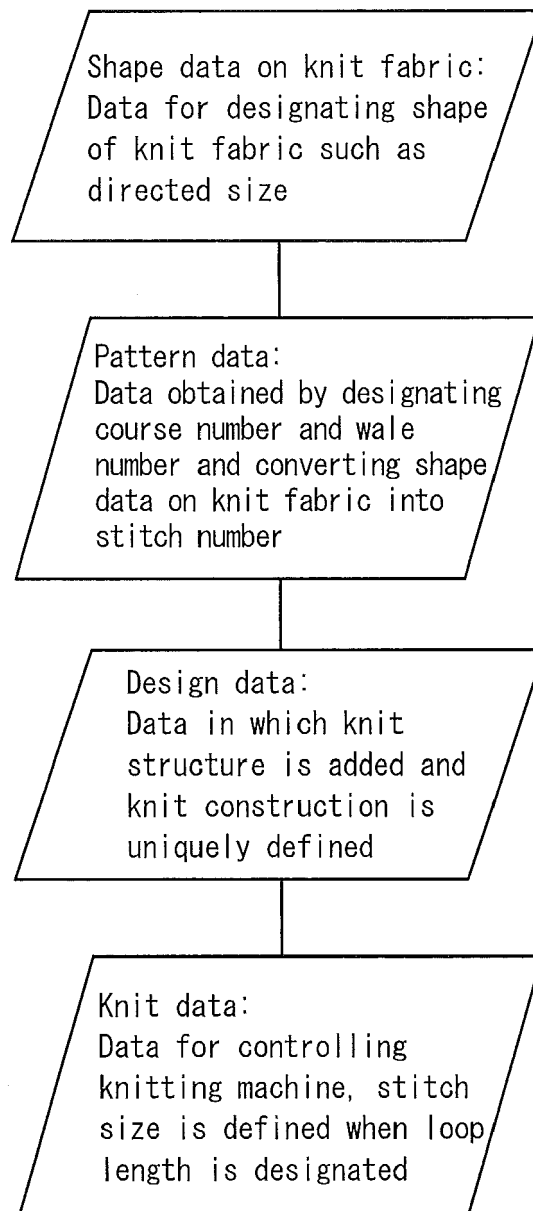


FIG. 4

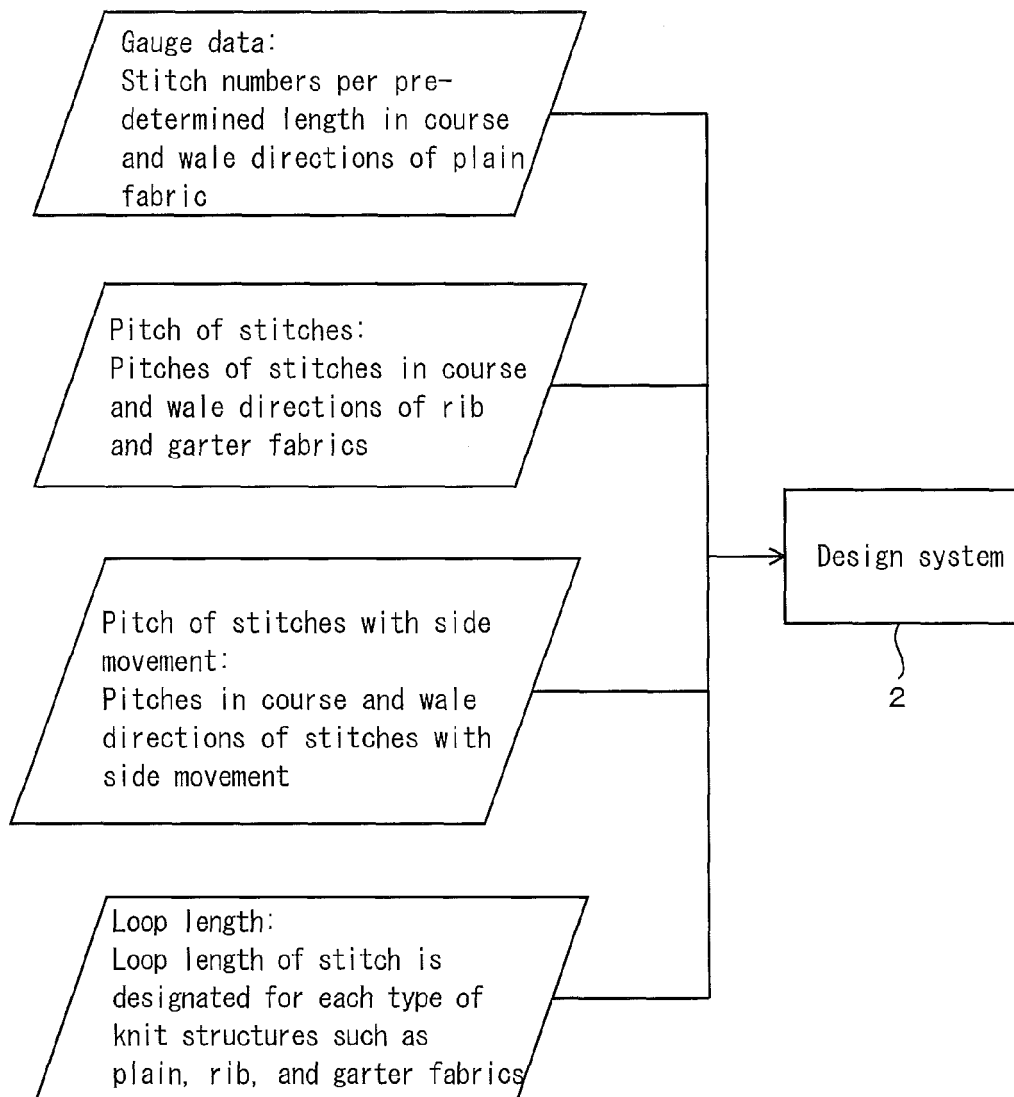


FIG. 5

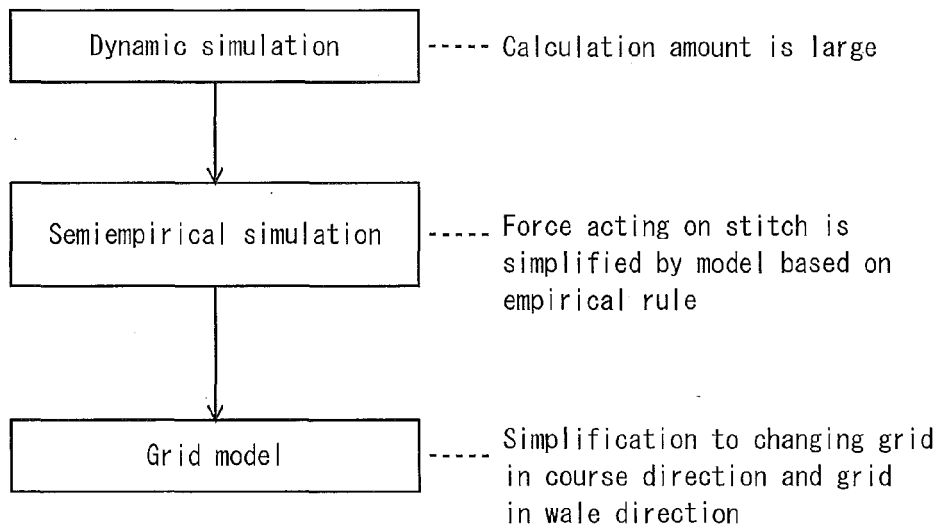


FIG. 6

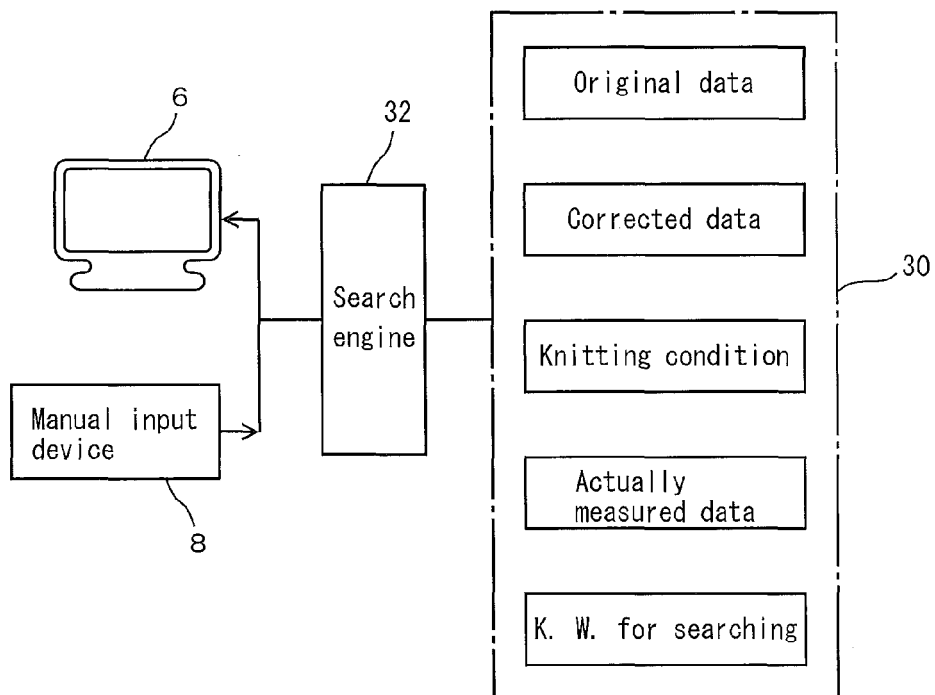


FIG. 7

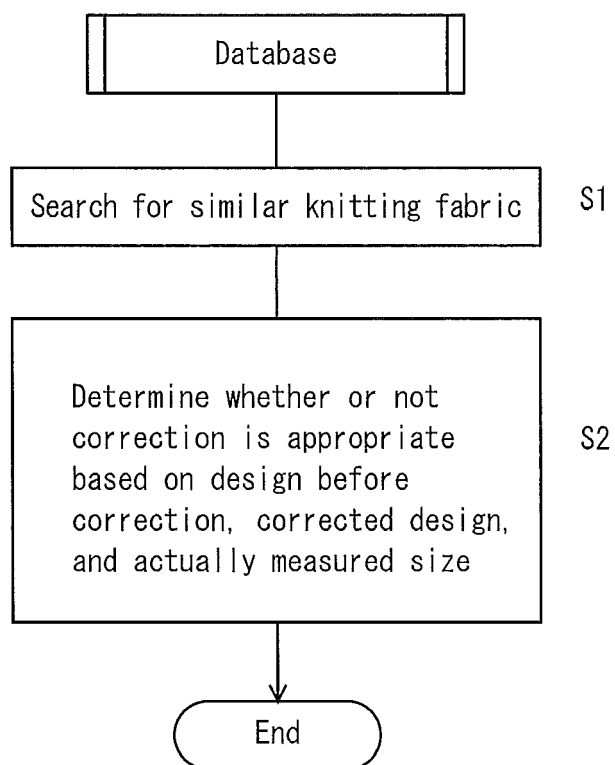


FIG. 8



FIG. 9

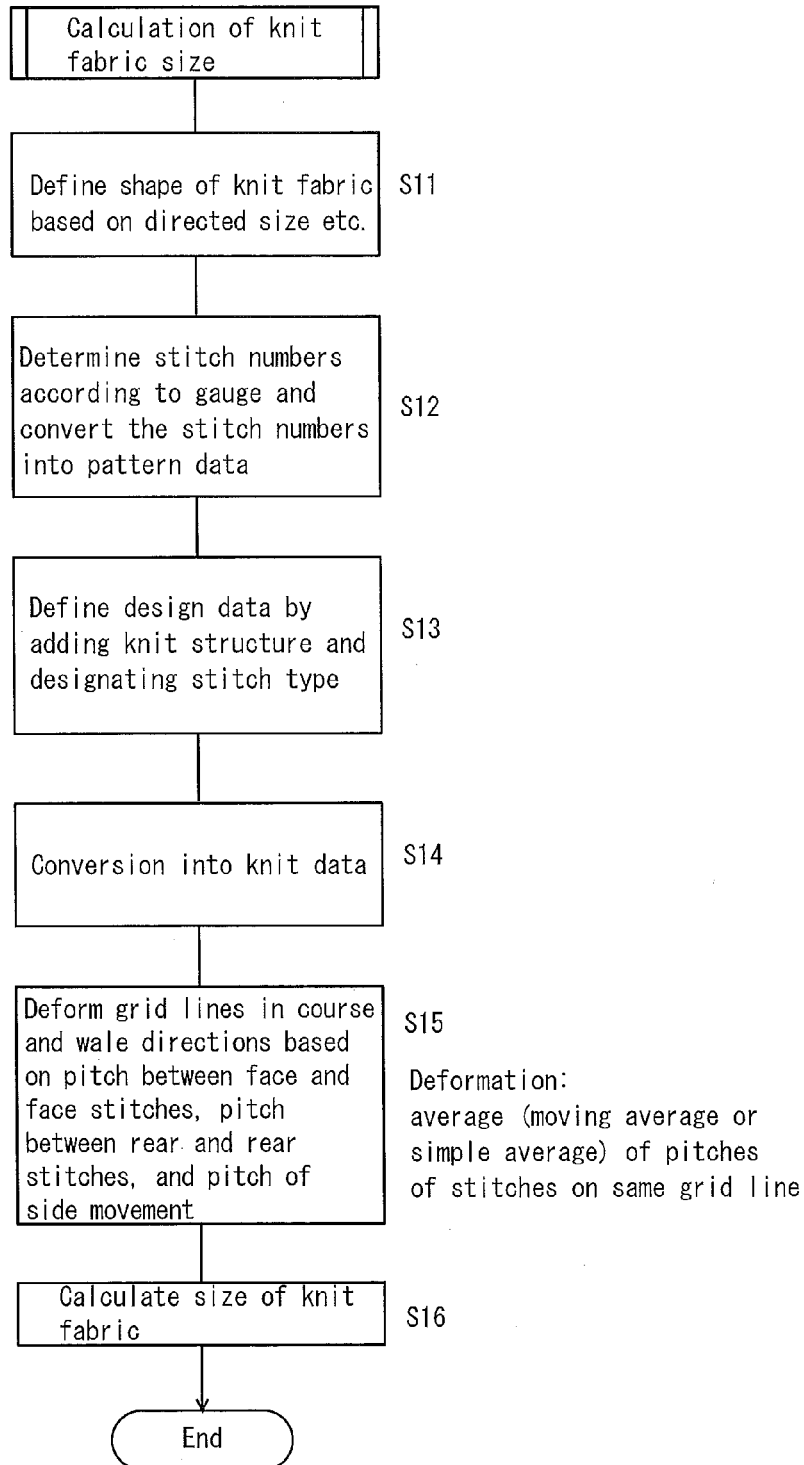




FIG. 11

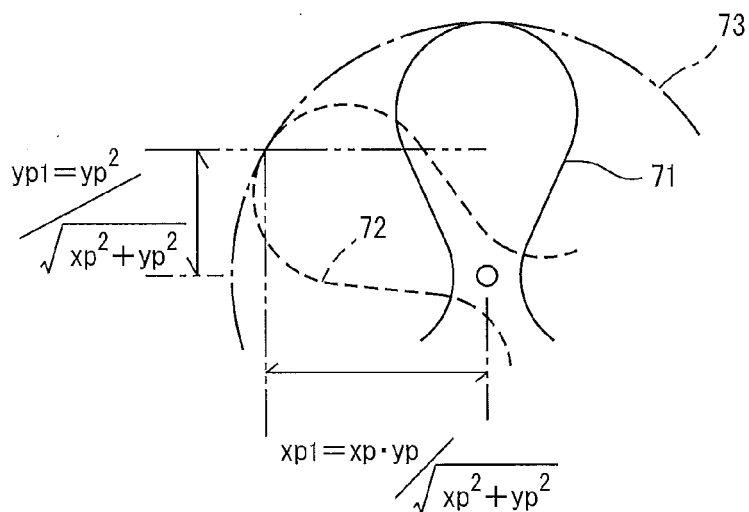
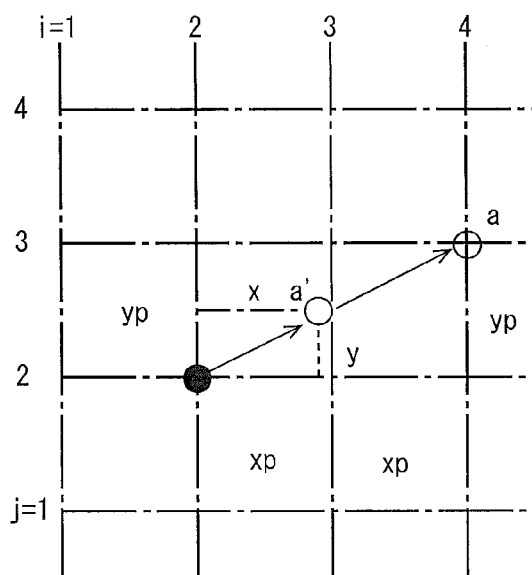


FIG. 12



$$x : y = 2x_p : y_p$$

$$x^2 + y^2 = y_p^2$$

$$\therefore x = \frac{2x_p \cdot y_p}{\sqrt{4x_p^2 + y_p^2}}$$

$$\therefore y = \frac{y_p^2}{\sqrt{4x_p^2 + y_p^2}}$$

FIG. 13

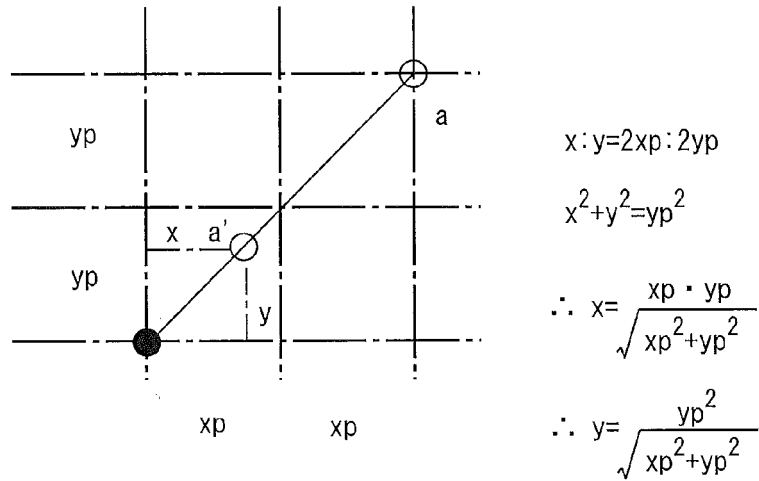


FIG. 14

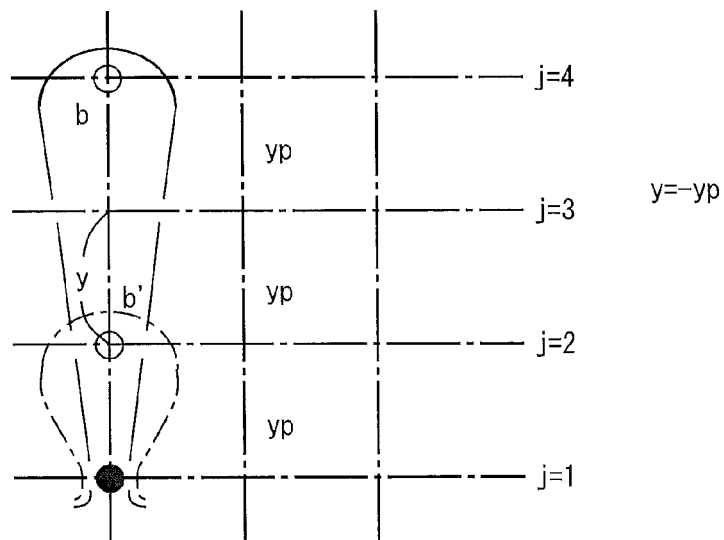


FIG. 15

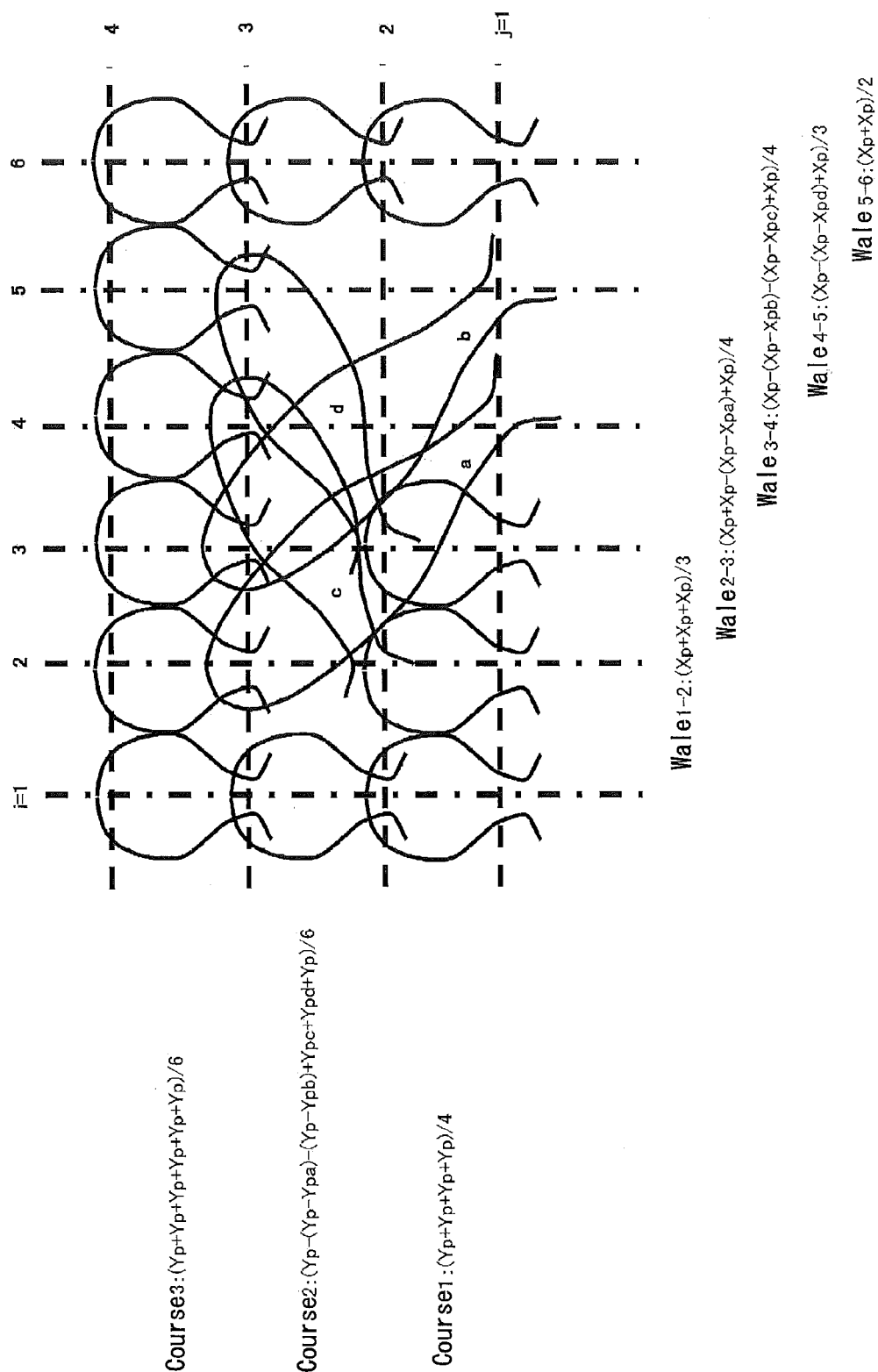
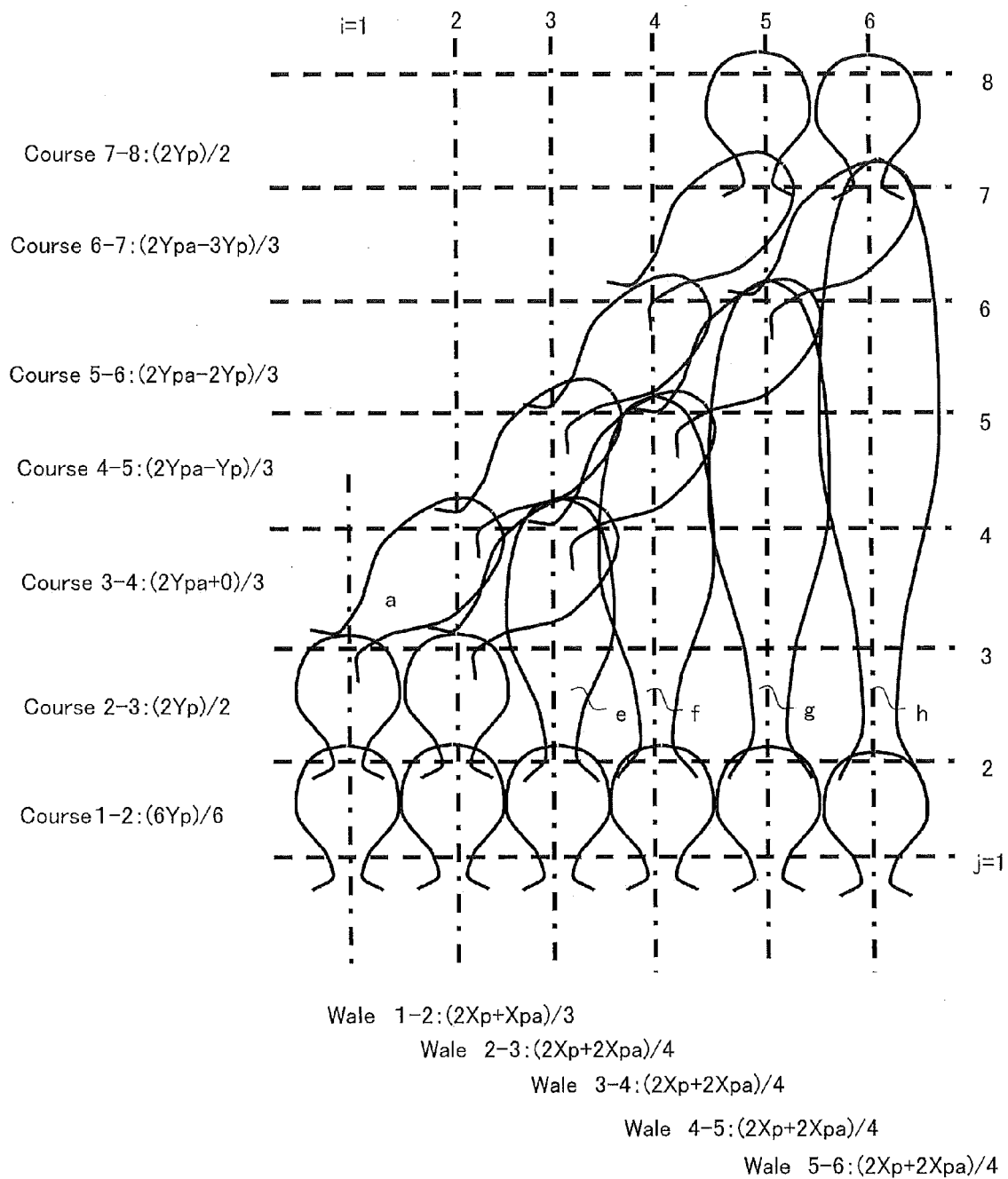


FIG. 16





## EUROPEAN SEARCH REPORT

Application Number  
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                                                           |                                                                                                                                                                                                                                                                              |                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                             | Relevant to claim                                                                                                                                                                                                                                                            | CLASSIFICATION OF THE APPLICATION (IPC) |
| X                                                                                                                                                                                                                                                      | WO 2009/039668 A1 (SMARTPATTERNS INC [CA]; KIREFU HUSEIN [CA]; ABDULRAHEM MESBAH [CA]) 2 April 2009 (2009-04-02)                                                          | 7                                                                                                                                                                                                                                                                            | INV.<br>D04B37/02                       |
| A                                                                                                                                                                                                                                                      | * paragraph [0007] - paragraph [0022]; figures 1, 6-17, 22-41 *                                                                                                           | 1-6                                                                                                                                                                                                                                                                          |                                         |
| A                                                                                                                                                                                                                                                      | * paragraph [0079] - paragraph [0146] *                                                                                                                                   |                                                                                                                                                                                                                                                                              |                                         |
| A                                                                                                                                                                                                                                                      | EP 0 652 317 A1 (SHIMA SEIKI MFG [JP]) 10 May 1995 (1995-05-10)<br>* abstract; figure 5 *                                                                                 | 1-7                                                                                                                                                                                                                                                                          |                                         |
| A                                                                                                                                                                                                                                                      | EP 2 085 898 A1 (DIGITAL FASHION LTD [JP]; TOYOTA TSUSHO CORP [JP] TOYOTA TSUSHO CORP []) 5 August 2009 (2009-08-05)<br>* paragraph [0006] - paragraph [0011]; figure 4 * | 1-7                                                                                                                                                                                                                                                                          |                                         |
|                                                                                                                                                                                                                                                        |                                                                                                                                                                           |                                                                                                                                                                                                                                                                              | TECHNICAL FIELDS SEARCHED (IPC)         |
|                                                                                                                                                                                                                                                        |                                                                                                                                                                           |                                                                                                                                                                                                                                                                              | D04B                                    |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                                           |                                                                                                                                                                                                                                                                              |                                         |
| Place of search<br>Munich                                                                                                                                                                                                                              |                                                                                                                                                                           | Date of completion of the search<br>16 June 2015                                                                                                                                                                                                                             | Examiner<br>Braun, Stefanie             |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                           | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                         |

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 15 9441

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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16-06-2015

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| WO 2009039668 A1                          | 02-04-2009          | US 2009112353 A1           | 30-04-2009          |
|                                           |                     | WO 2009039668 A1           | 02-04-2009          |
| EP 0652317 A1                             | 10-05-1995          | AU 682537 B2               | 09-10-1997          |
|                                           |                     | AU 7745694 A               | 18-05-1995          |
|                                           |                     | CA 2135318 A1              | 09-05-1995          |
|                                           |                     | CN 1107912 A               | 06-09-1995          |
|                                           |                     | DE 69410932 D1             | 16-07-1998          |
|                                           |                     | DE 69410932 T2             | 08-10-1998          |
|                                           |                     | EP 0652317 A1              | 10-05-1995          |
|                                           |                     | ES 2117217 T3              | 01-08-1998          |
|                                           |                     | JP 2676182 B2              | 12-11-1997          |
|                                           |                     | JP H07133562 A             | 23-05-1995          |
|                                           |                     | TR 28085 A                 | 27-12-1995          |
|                                           |                     | TW 246698 B                | 01-05-1995          |
|                                           |                     | US 5511394 A               | 30-04-1996          |
| EP 2085898 A1                             | 05-08-2009          | EP 2085898 A1              | 05-08-2009          |
|                                           |                     | JP 4963707 B2              | 27-06-2012          |
|                                           |                     | US 2010063789 A1           | 11-03-2010          |
|                                           |                     | WO 2008062793 A1           | 29-05-2008          |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2676182 B [0003] [0006]
- WO 2007013296 A [0004] [0006]
- JP 4237601 B [0004] [0006]
- JP 2009120987 A [0005] [0006]