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(71) Applicant: **SHIMA SEIKI MANUFACTURING, LTD.**
Wakayama (JP)

(72) Inventors:
- **Nishitani, Hirokazu**
  Arita-city, Wakayama (JP)
- **Sasaki, Takashi**
  Arita-gun, Wakayama (JP)
- **Komura, Yoshiyuki**
  Wakayama (JP)

(74) Representative: **Tomlinson, Kerry John**
Frank B. Dehn & Co.
European Patent Attorneys
Imperial House
15-19 Kingsway
London WC2B 6UZ (GB)

(54) Methods of controlling yarn length in flat knitting machines and devices therefor

(57) For an intarsia part, a representative yarn is selected from multiple yarns to be used. A loop length routine is done for the representative yarn, and the stitch cams are adjusted. For each course, actual stitch cam values are determined by adding said adjustment values to the values of stitch cams obtained from the knitting data, and the standard garment is knitted. Under the same conditions, a subsequent garment is knitted, and the yarn length consumed is compared with the yarn length consumed by the standard garment to update stitch cam adjustment values.

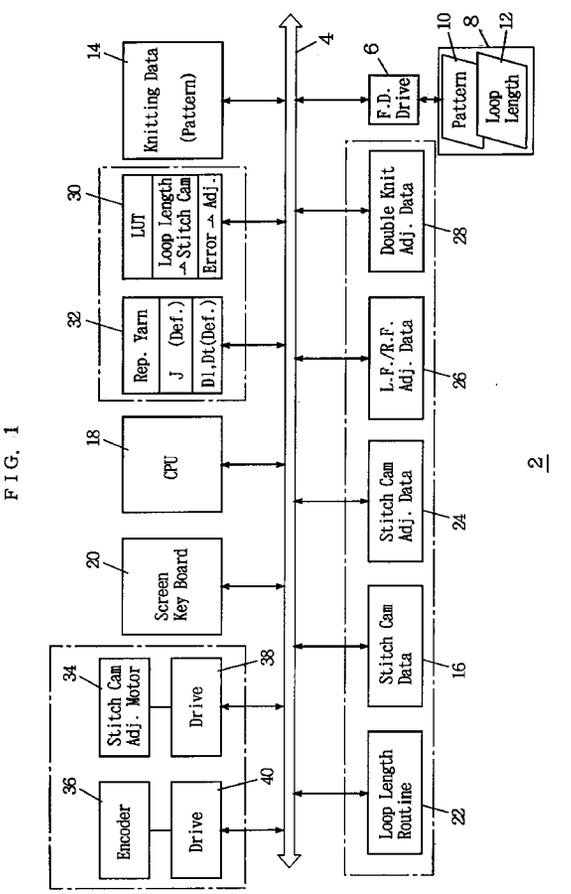

FIG. 1

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EP 0 699 792 A1

Description

The present invention relates to control of yarn length in intarsia knits, integral knits, whole garment knits, etc., and in particular, yarn length control when one carriage course knits, using one cam lock, plural stitch rows.

The applicant proposed to knit with a flat knitting machine while measuring the yarn length (Japanese Provisional Patent Publication No. SHO-62-62977 and No. HEI-6-25953, and Japanese Patent No. HEI-1-49816). According to the Patent No. SHO-62-62977, a rotary encoder is used to measure the yarn length fed to the carrier, and a feed-back is given to the stitch cams of the carriage to bring the yarn length to the target. This produces a knitted fabric with the desired loop length. According to the Patent No. HEI-1-49816, the tension in the yarn to be fed to the carrier is controlled according to the yarn length measured. Furthermore, according to the Patent No. HEI-6-25953, the moving average method is used to compare the target yarn length and the actual yarn length. For example, the yarn length is compared for every span of about 10 meters, and yarn lengths of the past spans of about 30 meters are used for comparison.

These prior arts assume that the number of yarns used in knitted is relatively small. They also assume that the yarn length of every yarn used is measured and the result is fed back to the stitch cam or the tension. Such yarn length control techniques pose problems to intarsia knits, integral knits and whole garment knits. A large number of yarns are generally used in these knits. When the yarn length is controlled for every yarn, the preparatory work before actual knitting will increase, and in turn, the quantity of yarns consumed by the preparatory work will increase. To knit while controlling the yarn length, it is necessary to make test knitting by several courses for each yarn and determine the stitch cam conditions for knitting with the target loop length. In the present specification this work is called loop length routine.

In intarsia knits, integral knits and whole garment knits, one cam rock may use plural yarns in one knitting course (one travel of the carriage). In this case, if two yarns are passed through one carrier and used at the same time, then it will not pose any problem. However, if a yarn A knits one stitch row and a yarn B knits another stitch row, it poses a problem. Because of the structure of the flat knitting machine, it is difficult to alter the value of the stitch cam in the middle on one knitting course. Suppose that the consumption of the yarn A and the consumption of the yarn B are to be measured respectively. Then we must select between controlling the stitch cam value on the basis of the yarn A and controlling the stitch cam value on the basis of the yarn B.

Another problem is that the loop length varies depending on the feeding condition. The feeding condition is the direction of yarn feeding relative to the direction of travelling of the carriage. For example, when the carriage shifts from the left to the right, feeding yarn from the left is pull knitting, and feeding yarn from the right is push knitting. When the carriage shifts from the right to the left, feeding yarn from the right is pull knitting, and feeding yarn from the left is push knitting. When the stitch cam condition is identical, the loop length increases in push knitting relative to pull knitting. When a large number of yarns were used in, for example, intarsia knits, both push knitting and pull knitting were present in one carriage course, and the loop length of the push knitting portion increased relative to the loop length of the pull knitting portion, resulting irregular loop sizes in the knitted fabric.

The present inventor further examined the yarn length control of double knits. To make a double knit, a carriage having plural cam locks is used, and a leading cam lock is used to knit one course and a tailing cam lock is used to knit the next one course. Thus, in double knitting, two courses are knitted concurrently. In double knitting, the tailing cam lock knits the next course on the course still being knitted on the leading side.

One object of the present invention is to achieve yarn length control with less preparatory work and less consumption of yarn when one stitch cam knits plural stitch rows in a carriage course of a garment. A secondary object of the present invention is to prevent the yarn length from varying in carriage courses in which a yarn being fed from the left side of the needle bed and a yarn being fed from the right side thereof are present. Another secondary object of the present invention is to provide an effective method of controlling the yarn length for double knitting and a device therefor.

The method of controlling yarn length according to the present invention uses a flat knitting machine having a needle bed, a carriage with multiple stitch cams and plural carriers for feeding yarns to the needles of the needle bed, in which plural yarns are fed from carriers to needles to knit, and a garment has carriage courses in which a single stitch cam knits plural stitch rows. The present invention is characterized by the following steps of

a: a step of designating at least one yarn out of the above-mentioned plural yarns as a representative yarn;

b: a step of determining the stitch cam conditions for the designated representative yarn to knit with the desired yarn length;

c: a step of knitting one standard garment on the determined stitch cam conditions and storing the yarn length used for the standard garment;

d: a step of knitting a next garment on the same stitch cam conditions as the standard garment, measuring the yarn length used for the next garment, comparing the measured yarn length with that of the standard garment, and

updating the stitch cam conditions so that the yarn length would coincide with that of the standard garment;

e: a step of further knitting a next garment on the updated stitch cam conditions, measuring the yarn length used for the garment, comparing the measured yarn length with that of the standard garment, and updating the stitch cam conditions so that the yarn length would coincide with that of the standard garment; and

f: a step of repeating the above-mentioned step e.

In the present context, a garment means a major part of one cloth, such as a front body, a back body or sleeves. A whole garment knit literally means one complete cloth. A garment normally includes a rib part such as bottom rib and other parts. It is preferable that, at least one representative yarn is designated for a rib part of which appearance is important and of which knitting method differs from other parts, and another representative yarn is designated for parts other than the rib. Next, the used yarn length for the control of the standard garment and the subsequent garments is preferably the total yarn length of the rib part and the total yarn length of the other parts, or the total yarn length of the rib part and the yarn length of the representative yarn for parts other than the rib part.

When multiple yarns are used, yarns are fed in many cases from both the sides of the needle bed. This is because the number of yarns actually used is greater than the number of yarns that can be fed from one side of the bed. Now, the side from which yarns including the representative yarn are fed is assumed to be one end of the bed, and the side from which the remaining yarns are fed is assumed to be the other end of the bed. Each yarn is fed through a carrier to needles of the needle bed. Preferably, when yarns are fed from both ends of the bed, the stitch cam conditions are adjusted in such a way that the yarn length used increases when the carriage shifts from the other end to one end relative to when the carriage shifts from the one end to the other end.

When the above-mentioned flat knitting machine can produce double knits by allocating some of the above-mentioned stitch cams as leading cams and some of the above-mentioned stitch cams as tailing cams, preferably, the stitch cam conditions are determined for single knit in the above-mentioned step b, stitch cam adjustment data are stored for tailing cams so that the yarn length used in double-knitting is virtually equal to that used in single-knitting, and the stitch cam conditions are adjusted for tailing cams by using said stored data when double-knitting is done in the above-mentioned steps c through e.

The present invention is characterized in that a yarn length control device is provided with a memory for storing data of at least one of multiple yarns to be fed to needles of the needle bed as a representative yarn,

a memory for storing stitch cam conditions for knitting with a desired yarn length of the above-mentioned representative yarn,

a yarn length measuring means, at least for the representative yarn, to measure the feed of the yarn, and a memory for storing the yarn length determined by the yarn length measuring means.

Preferably, there is further provided

a memory for storing adjustment data for yarns fed to the needle bed from the side opposite to the above-mentioned representative yarn, and

an adjustment means for adjusting the stitch cam conditions according to the above-mentioned adjustment data in such a way that the yarn length used is decreased when the above-mentioned carriage travels away from the side from which the representative yarn is fed relative to the case when the carriage travels away from the opposite side.

Preferably, the above-mentioned flat knitting machine can produce double knits by allocating some of the above-mentioned stitch cams as leading cams and some of the above-mentioned stitch cams as tailing cams, and is provided with

a memory for storing stitch cam adjustment data for tailing cams so that the yarn length used in double-knitting is virtually equal to that used in single-knitting, and

a double knit adjustment means for adjusting stitch cam conditions for tailing cams by using said data stored in the memory when double-knitting is done.

According to the present invention, a representative yarn is selected from multiple yarns used in, for example, an intarsia part. Similarly, when different yarns are used for the body and the sleeves, respectively, in an integral knit or the like, a representative yarn is selected. In addition to these parts, some garments such as sweaters have a rib part for the bottom rib. As a rib part differs in knitting structure from other parts, at least one representative yarn is preferably designated for the rib part.

According to the present invention, multiple stitch cams are adjusted by using the representative yarns to obtain stitches of the desired loop length. The stitch cam adjustment corrects the dispersion among the stitch cams. According to the present invention, variations in the loop length or changes in the yarn length due to, for example, different slippages of yarns may not be compensated. However, when multiple yarns are used in one carriage course and plural yarns are processed without changing the stitch cam data, changes in the yarn lengths due to differing properties of the respective yarns may not be prevented. Changes in the loop length due to different properties of yarn materials can be compensated

by changing the garment design. For instance, for a yarn which tends to produce a smaller loop length, the number of courses may be increased. Or the stitch cam conditions may be changed for the entire garment to produce larger loops.

The loop length varies depending on the properties of the yarn material, such as thickness and coefficient of friction. It is rare to use plural yarns of which properties are extremely different to each other in one garment. Hence the dispersion among stitch cams has a greater effect on the garment. Moreover. even if plural yarns of which properties are extremely different to each other are to be used, their use may be taken into consideration at the design stage. The number of courses may be increased for a yarn which tends to produce a shorter loop length; thus the size of the part may be enlarged. Similarly. when the loop size from a yarn of which property is different from that of the representative yarn and inadequate, the standard garment may be knitted again to increase the loop sizes of the yarns including the representative yarn.

When a representative yarn is determined, the standard garment is knitted. As multiple yarns besides a representative yarn are used for the intarsia part, etc. of the standard garment, the yarn length can not be fed back to the stitch cam data during the knitting of the standard garment. However, it is possible to knit a garment identical to the standard garment. This can be done by using the same stitch cam data, measuring the yarn length used for an appropriate span, for example, a yarn length of 100 meters or over, or for the entire garment, and making feedback to the stitch cam adjustment data so that the measured yarn length of an actual garment (any garments subsequent to the standard garments) coincides with that of the standard garment.

With these arrangements, according to the present invention, the yarn lengths can be controlled even when, in one carriage course, one stitch cam is used to knit plural stitch rows. The stitch cam adjustment before knitting the standard garment (the loop length routine in the embodiment) is needed only for the representative yarn. Furthermore, the consumption of yarns during the stitch cam adjustment is limited. Moreover, according to the present invention, garments identical to the standard garment can be produced consistently.

Another problem of using multiple yarns is the presence of left-feeding yarns and right-feeding yarns. The loop lengths of the left-feeding yarns differ from those of the right-feeding yarns. The cause is the difference between push knitting and pull knitting. If a representative yarn is a left-feeding yarn, a right-feeding yarn is push-knitted when the carriage travels to the right, and the loop length increases. The yarn is pull-knitted when the carriage travels to the left, and the loop length decreases. The difference between push-knitting and pull-knitting concentrates in the yarns being fed from the side opposite to the representative yarn, and the loop size variations are conspicuous. In contrast to it, according to the present invention, the loop size variations due to the directions of the carriage travel are dispersed in the right-feeding loops and the left-feeding loops to make loop size variations inconspicuous. In the present invention, adjustment is made in the following manner. The stitch cam conditions are adjusted according to the above-mentioned adjustment data so that the yarn length used is increased when the carriage travels towards the side from which the representative yarn is fed in comparison with when the carriage travels in the opposite direction.

In double-knitting, the leading cam lock knits a new loop course. Before this course is completed, the tailing cam lock knits the next course. According to the present invention, stitch cam adjustment data for making the yarn length used in double-knitting substantially equal to that used in single-knitting are stored, and the stitch cam conditions are adjusted with these data. As the above-mentioned difference is more significant on the tailing side, adjustment data are stored at least for the tailing side, and preferably, adjustment data are stored for both the leading side and the tailing side.

A preferred embodiment of the present invention will now be described by way of example only, and with reference to the accompanying drawings, in which:

Fig. 1: A block diagram of an embodiment.

Fig. 2: A front view of a flat knitting machine having a yarn length control device of the embodiment.

Fig. 3: A partial development of the carriage of the flat knitting machine.

Fig. 4: A plan view of a garment to be knitted in the embodiment.

Fig. 5 - Fig. 10: Flowcharts of the yarn length control method of the present invention.

Fig. 6 shows the sampling routine of adjustment data for yarn feeding conditions;

Fig. 7 shows the sampling routine of adjustment data for double-knitting;

Fig. 8 shows the knitting routine of a standard garment;

Fig. 9 shows the knitting routine of subsequent garments; and

Fig. 10 shows the readjustment routine of stitch cam data.

Fig. 1 through Fig. 10 show an embodiment. Fig. 1 shows the block diagram of a yarn length control device 2. 4 is a bus, and 6 is a floppy disc drive. Knitting data are inputted from a floppy disc 8. In place of the floppy disc drive 6, other input/output equipment such as an optomagnetic disc drive and a modem may be used. The floppy disc 8 stores knitting data; the data is divided into files such as a pattern data file 10, a loop length file 12 designating loop lengths of the respective carriage courses. The inputted pattern data file is stored in a pattern data memory 14. The loop length file is converted into stitch cam data for respective carriage courses by referring to a look up table (LUT) 30 which will be explained later. The converted data are stored in a stitch cam data memory 16.

18 denotes a central processing unit (CPU) that makes judgements and computations required for the yarn length

control, as well as the overall control of the flat knitting machine. 20 is an interactive input/output device. It consists of an LCD screen for data display and a keyboard for inputting commands to the flat knitting machine. 22 is a ROM that stores the loop length routine, a program for determining stitch. cam adjustment data for a representative yarn which will be described later.

24 is a stitch cam adjustment data memory that stores stitch cam adjustment data obtained by the loop length routine for the respective stitch cams of the carriage of the flat knitting machine. For instance, if a carriage is provided with two cam locks for the front bed and for the back bed, respectively, then a total number of stitch cams is eight. Then eight stitch cam adjustment values are stored. 26 is a left feeding/right feeding adjustment data memory that stores the loop length changing ratio J of push knitting and pull knitting. 28 is a memory for stitch cam adjustment data for double knit. It stores stitch cam adjustment values Dl and Dt for double knit; they are used for obtaining the same loop length in double-knitting as the normal single-knitting. Dl is the adjustment value for the leading cam, and Dt is the adjustment value for the tailing cam.

30 is the look up table (LUT) that contains a table for converting loop lengths designated in the loop length file 12 into stitch cam data, and a table for feeding back the shifts of the measured loop lengths from the theoretical values to the stitch cam data. 32 is a memory for constants. It stores encoder numbers or carrier numbers corresponding to the respective representative yarns. Encoders will be explained later. The memory stores representative yarns by converting the data into these numbers. When a rib part is present in a garment, at least one representative yarn is to be designated for the rib part of the garment. At least one representative yarn is to be designated for parts other than the rib part. Preferably, only one representative yarn is designated for parts other than the rib part. In addition to them, the memory for constants 32 stores the default value for the left feeding/right feeding adjustment value J and the default values for the adjustment values Dl and Dt of double knitting. Moreover, the memory 32 stores the loop length routine and yarn consumptions of the standard garment and actual garments.

34 is a stitch cam adjustment motor and is provided for each stitch cam of the flat knitting machine. It operates and adjusts the stitch cam value when the direction of the carriage travel is switched over. 36 is an encoder for measuring yarn length. It measures the length of a yarn fed from a carrier to needles of the needle bed. A rotary encoder may be used as an encoder 36. For instance, it may be located between a side tension and a carrier of the flat knitting machine. Feeding of the yarn rotates the rotary encoder to measure the yarn length. Any encoder may be used as an encoder 36 provided that the encoder can measure the yarn length fed. 38 and 40 are drives. When a command is given by the CPU 18, the drive 38 will activate the stitch cam adjustment motor 34. The drive 40 transfers the data of the encoder 36 to the CPU 18. One pair of encoders 36 are provided, for example, on both the right and left ends of the flat knitting machine. Encoders 36, however, may be installed only on one end of the machine, for instance, on the left end. In Fig. 1, the areas enclosed by chain lines correspond to the yarn length control device. Other parts are common parts of the flat knitting machine.

Fig. 2 shows a flat knitting machine 50 which is provided with the yarn length control device 2. 52 is a needle bed. A pair of needle beds, front and back, are actually used, but here only the front needle bed is illustrated. The possible number of needle beds is not limited to two. Four beds, six beds, etc. may be used. 54 and 55 are, for example, a pair of carriages that travel over the needle beds. The carriages may be driven, for example, by a belt drive system. A pair of carriages 54 and 55 may be connected directly to each other and driven together. Or they may be separated from each other and driven as two carriages independent to each other. Carriages 54, 55 may be reduced to one carriage. 56 is a carrier for feeding a yarn to a needle bed. For example, eight carriers are arranged over, for example, four rails 58. 60 is a cone for feeding a yarn to a carrier 56. A yarn from a cone 60 is fed, for example, through a top tension assembly 62, a side tension assembly 64 and said encoder 36, to a carrier 56. In the embodiment, encoders 36, 36 are provided on both the right end and the left end of the flat knitting machine 50. However, an encoder, for example, the encoder 36 on the right end, may be eliminated.

Fig. 3 shows the arrangement of stitch cams 70 for one carriage. The carriage 54 has, for example, four cam locks 71. There are two stitch cams 70 for every cam lock 71. Hence there are a total of, for example, eight stitch cams 70. Of the eight stitch cams 70, four cams are arranged on the front bed (F) side and four cams on the back bed (B) side. As shown in Fig. 3, when the carriage 54 travels from the left to the right, a stitch cam 70 on the left side of each cam lock 71 is actuated. When the carriage 54 travels from the right to the left, a stitch cam 70 on the right side of each cam lock 71 is actuated. Each of eight stitch cams 70 is provided with a stitch cam adjustment motor 34, and the value of each stitch cam 70 is adjusted whenever the direction of travel of carriages 54 and 55 is switched over.

Memories 24, 26 and 28 are made to store, as shown on the left of Fig. 3, for each stitch cam 70, stitch cam adjustment data for the representative yarn of the rib part and stitch cam adjustment data for the representative yarn of the intarsia part. In addition to them, the memories are made to store adjustment data J, Dl and Dt.

A garment 80 to be knitted is schematically shown in Fig. 4. The garment 80 is, for example, a front body of a sweater. 82 is a rib part, and 84 is an intarsia part. All the garment except the rib part 82 is to be intarsia-knitted. Marks A through F indicate kinds of yarns to be used for the respective parts. Of these yarns, yarns C, D and F with an asterisk are yarns of the right feeding to be fed by the encoder on the right side of the flat knitting machine 50. Other yarns A, B

and E are of the yarns of the left feeding to be fed by the encoder on the left side.

Concerning representative yarns, one kind for the rib part, and here the yarn E, and one kind for the intarsia part 84, here the yarn A, are selected. Designation of the representative yarns is made by the user, and they are stored in the memory for constants. In the present specification, a garment means any major part of one cloth, such as the front body, the back body, the right and left sleeves. When the respective parts are to be knitted continuously, such as is the case of a whole garment, it literally means one whole cloth.

In Fig. 5 through Fig. 10, an embodiment of the method of controlling the yarn length is shown. Prior to knitting, the knitting data are completed. The data consist of a pattern data file 10, a loop length file 12, etc. In the pattern data file 10, data such as the movements of the carriages 54, 55 and the rackings of the needle bed 52 are designated for every knitting course. In the loop length file 12, the loop length for every knitting course is designated. The pattern data file 10 is stored in the pattern data memory 14, and the loop lengths of the loop length file 12 are converted, with reference to the look up table 32, into stitch cam values of the stitch cams 70, and the values are stored in the stitch cam data memory 16.

Necessary data for yarn length control prior to knitting are stitch cam adjustment values for the respective stitch cams 70 for the representative yarns A and E, the adjustment value J between the left feeding yarn and the right feeding yarn, and when double knitting is made, the adjustment values for double knitting, Dl and Dt. The default value for the adjustment value J is 2 %. The default values for the adjustment values Dl and Dt are -1 and 2 in terms of stitch cam adjustment value; they are approximately -1 % and 2 % in terms of a change in the loop length. Values J, Dl and Dt are stored in the memory for constants 32. On the leading side of the double knitting, the loop length tends to get longer. Hence the default value was set so that the loop length would be reduced by 1 %. On the tailing side, the loop length tends to get shorter. Hence the default value was set so that the loop length would be increased by 2 %. In the embodiment, the adjustment values J, Dl and Dt are to be measured actually.

Fig. 6 shows the routine for computing the adjustment value J between the left feeding yarn and the right feeding yarn. One kind of yarn is selected from the yarns of the left feeding, and one kind of yarn is selected from the yarns of the right feeding. Then with one common stitch cam value for these selected yarns, several courses are knitted. Assume the carriage 54 travels from the left to the right. The yarns of the left feeding are pull-knitted, and the yarns of the right feeding are push-knitted. Similarly, when the carriage 54 travels from the right to the left, the yarns of the right feeding are pull-knitted, and the yarns of the left feeding are push-knitted. Even when the conditions of the stitch cam 70 are the same, the loop length for push-knitting differs from that for pull-knitting. The loop length for push-knitting is generally longer by about 2 % than that for pull-knitting. Hence this value was selected as the default value. This is because the direction of the tension in the yarn relative to the loop formation direction for push-knitting is opposite to that for pull-knitting. Hence for two yarns of push-knitting and pull-knitting, the yarn length consumed by push-knitting courses and that consumed by pull-knitting courses are measured. The differences are calculated, and the differences are averaged. The difference thus obtained is divided by the yarn length, for example, the yarn length for pull-knitting courses to obtain the adjustment value J between the right feeding yarn and the left feeding yarn.

The yarn length control device 2 asks the user to designate the representative yarns through the interactive input/output device 20. The representative yarns are the yarn E to be used for the rib part 82, and one kind of yarn, for example, the yarn A, to be used for the intarsia part 84. The selection of a representative yarn for the intarsia part 84 is discretionary. For instance, in the garment 80 of Fig. 4, the yarns E and F are used much more than the yarn A through D, but the yarn A was selected as the representative yarn for the intarsia part 84. When the yarns A, E are selected as the representative yarns, the memory 32 stores the selection data by converting the data into the numbers of carriers 56 corresponding to the yarns A, E or the numbers of slots through which the yarns A, E are passed at the encoders 36. Moreover, the yarn length control device 2 asks the user whether the adjustments with the above-mentioned J, Dl and Dt are needed or not.

The loop length routine is carried out for every representative yarn. As the representative yarn A is designated for the intarsia part 84, the representative yarn A is used to make jersey knitting by several courses for each cam lock 71. The loop length in the knitting process is actually measured by the encoder 36, and the difference between the measured value and the specified yarn length is determined. The stitch cam adjustment motor 34 is actuated to make the difference converge, for example, within plus minus 1 %. Then the stitch cam value is determined. The difference between the determined stitch cam value and the specified loop length being converted. with reference to the look up table 30, into a stitch cam value is the stitch cam adjustment value. The dispersion of each stitch cam 70 can be adjusted by obtaining the stitch cam adjustment value. The stitch cam adjustment value thus obtained is stored in the memory 24 as the initial value of the stitch cam adjustment value. The stitch cam adjustment value is stored for every stitch cam 70. Similarly, the representative yarn E for the rib part 82 is rib-knitted by about several courses for every cam lock 71 to determine stitch cam adjustment values for the rib part 82. The adjustment values are stored in the memory 24.

After the loop length routine is carried out, if necessary, the algorithm of Fig. 7 is used to determine adjustment values Dl, Dt for double knitting. For example, the yarns A, B are used to make double-knitting by about several courses. Then stitch cam values are determined with which the loop length is substantially the same with that of the single knitting

case. The differences in stitch cam values from those of the single knitting case are adjustment values Dl , Dt.

Next, with the algorithm of Fig. 8, a standard garment is knitted. First, the yarn E is used to knit the rib part 82, and the stitch cam adjustment value is determined by the loop length routine based on the representative yarn E. Next, the intarsia part 84 is knitted with the yarns A through F; the stitch cam adjustment value, which was determined by the loop length routine based on the representative yarn A, is used. Here the stitch cam values S are the following two kinds, depending on the travelling directions of the carriages 54, 55, and it is assumed that the representative yarn A is a left feeding yarn and the loop length increases when the stitch cam value S increases:

$$S = SO + C \quad (1)$$

$$S = SO + C + J \quad (2)$$

In the formulas (1), (2), SO is a loop length found in the loop length file and converted into a stitch cam value. C is the stitch cam adjustment value for the representative yarn A. J is the adjustment value between right feeding yarn and left feeding yarn. The formula (1) is applied to courses in which the carriages 54, 55 travel from the left to the right. The gists of the formulas (1), (2) are that the stitch cam adjustment value C based on the representative yarn A is applied to all the courses, and that the stitch cam adjustment value is changed by J depending on the travelling direction of carriages 54, 55. As the loop length routine is done in such a way that when the formula (1) only is applied to all the courses, the correct loop length can be obtained for left feeding yarns irrespective of the carriages 54, 55 travelling to the right or to the left, relative values of loop lengths are as follows:

Left feeding yarns:	Carriage travelling	
	to the right	1
	to the left	1
Right feeding yarns:	Carriage travelling	
	to the right	1 + J
	to the left	1 - J

Such changes are generated because, for the right feeding yarns, carriages' travelling to the right means push knitting and the loop length increases, and carriages' travelling to the left means pull knitting and the loop length decreases. Changes in loop length depending on the carriages' travelling direction are concentrated in the loops of the right feeding yarns, and changes in loop length become conspicuous for the right feeding yarns. On the other hand, in the embodiment, the relative values of loop lengths are as follows:

Left feeding yarns:	Carriage travelling	
	to the right	1
	to the left	1 + J
Right feeding yarns:	Carriage travelling	
	to the right	1 + J
	to the left	1

In the embodiment, the changes in loop length due to the travelling direction of carriages 54, 55 are dispersed into the loops of right feeding yarns and the loops of left feeding yarns: as a result, the errors become inconspicuous. For the adjustment in the formula (2), there is no need of using the exact value of J. For instance, a value in the range from 0.5 J to 1.5 J may be used. In the embodiment, the adjustment is given when the carriages 54, 55 travel to the left. The adjustment, however, may be given when the carriages travel to the right or when the carriages travel to the right and to the left.

For double knitting, the courses are knitted by adding Dl on the leading side, and Dt on the tailing side, to the stitch cam values determined by the formulas (1), (2). Triple knitting and further knittings are treated in a similar manner, and in the case of triple knitting, three adjustment values are used; Dl (leading), Dm (middle) and Dt (tailing). After knitting of a standard garment is completed, the total yarn length of the rib part 82 and the total yarn length of the intarsia part

84, or the total yarn strength of the representative yarn A in the intarsia part 84 are stored in the memory 32.

Fig. 9 shows the knitting algorithm for the subsequent garments. This algorithm is identical to the algorithm for the standard garment in that while one garment is knitted the stitch cam adjustment value C is not adjusted and the target of knitting is to knit a garment identical to the standard garment. It has been confirmed by knitting the standard garment that dispersions of multiple stitch cams 70 are adjusted by the loop length routine and under this condition a desirable garment can be obtained. If the standard garment is not satisfactory, for example, when an inadequate garment is produced because the yarn A is used as the representative yarn and other yarns are neglected, the knitting conditions should be altered to knit another standard garment; this process should be continued till a satisfactory standard garment is produced. The present inventor found that in the course of knitting one garment, changes in the conditions of stitch cams 70 are small and it is sufficient, after knitting one garment, to readjust the stitch cam adjustment values.

Hence, preferably, in the course of knitting one garment, stitch cam adjustment values are not updated, and after knitting the garment, if the yarn length shifts by plus minus 1 % or over from the target, the stitch cam adjustment value C is readjusted with reference to the look up table 30 and the next garment is knitted. Regarding the yarn length to be used here, for example, for the rib part 82, the total yarn length for that part is used to update the stitch cam adjustment values (r1 through r8) for the rib part 82. For the intarsia part 82, the total yarn length for the part or the yarn length of the representative yarn A is used to update the stitch cam adjustment values (C1 through C8) for the intarsia part 82.

In the middle of knitting the standard garment, the yarn length may be stored, for example, for the intarsia part 84, the yarn length of every section of a certain size, for example, 100 meters or over in yarn length, may be compared with that of a corresponding section of the standard garment to update the stitch cam adjustment values (C1 through C8). However, updating the stitch cam adjustment values (C1 through C8) after knitting one garment better prevents changes in loop size due to changes in stitch cam adjustment values within one garment; thus variations in loop size within one garment can be made smaller.

Claims

1 A method of controlling yarn length in a flat knitting machine having a needle bed (52), a carriage (54,55) with multiple stitch cams (70), and plural carriers (56) for feeding yarns to the needles of the needle bed, comprising feeding plural yarns from the carriers to the needles for knitting a garment having carriage courses in which a single stitch cam knits plural stitch rows, characterized in that

said method includes the following steps

a: a step of designating at least one yard (A,E) out of the above-mentioned plural yarns as a representative yarn;

b: a step of determining the stitch cam conditions for the designated representative yarn to knit with the desired yarn length;

c: a step of knitting one standard garment on the determined stitch cam conditions and storing the yarn length used for the standard garment;

d: a step of knitting a next garment on the same stitch cam conditions as the standard garment, measuring the yarn length used for the next garment, comparing the measured yarn length with that of the standard garment, and updating the stitch cam conditions so that the yarn length would coincide with that of the standard garment;

e: a step of knitting a further next garment on the updated stitch cam conditions, measuring the yarn length used for the garment, comparing the measured yarn length with that of the standard garment, and updating the stitch cam conditions so that the yarn length would coincide with that of the standard garment; and

f: a step of repeating the above-mentioned step e.

2 A method of controlling yarn length in a flat knitting machine as described in Claim 1, being characterized in that said garment includes a rib part (82) and parts (84) other than the rib part, and at least one yarn is designated for the rib part as said representative yarn and a yarn is designated as a representative yarn for the parts other than the rib part.

3 A method of controlling yarn length in a flat- knitting machine as described in Claim 2, being characterized in that the total yarn length of the rib part (82) and the total yarn length of the parts (84) other than the rib part are used as the above-mentioned used yarn length.

4 A method of controlling yarn length in a flat knitting machine as described in Claim 2, being characterized in that the total yarn length of the rib part and the yarn length of a representative yarn of the parts other than the rib part are used as the above-mentioned used yarn length.

5 A method of controlling yarn length in a flat knitting machine as described in any preceding claim, being characterized in that

the above-mentioned representative yarn and some of the remaining of said plural yarns are fed from one end of the needle bed to needles, and other yarns are fed from the other end of the needle bed to needles, and

the stitch cam conditions are adjusted in such a way that the yarn length used increases when the carriage travels from the above-mentioned other end to the one end rather than when the carriage travels from the one end to the other end.

6 A method of controlling yarn length in a flat knitting machine as described in any of Claim 1 through Claim 5, being characterized in that

the above-mentioned flat knitting machine can double knit by allocating some of the above-mentioned stitch cams to leading cams and some of the above-mentioned stitch cams to tailing cams, the stitch cam conditions are determined for single knit in the above-mentioned step b, stitch cam adjustment data are stored for the tailing cams so that the yarn length used in double-knitting is substantially equal to that used in single-knitting, and the stitch cam conditions are adjusted for the tailing cams by using said stored data when double-knitting is done in the above-mentioned steps c through e.

7 A yarn length control device in a flat knitting machine having a needle bed (52), a carriage (54,55) with multiple stitch cams (70), and plural carriers (56) for feeding yarns to the needles of the needle bed, being characterized in that

said device is provided with

a memory (32) for storing data of at least one of multiple yarns to be fed as a representative yarn,

a memory (16) for storing stitch cam conditions for knitting with a desired yarn length of the above-mentioned representative yarn,

a yarn length measuring means (36), at least for the representative yarn, tomeasure the feed of the yarn, and

a memory for storing the yarn length determined by the yarn length measuring means.

8 A yarn length control device in a flat knitting machine as described in Claim 7, being characterized in that

the device is further provided with

a memory (26) for storing adjustment data for feeding yarns from both directions of the needle bed, and

an adjustment means (34) for adjusting the stitch cam conditions according to the above-mentioned adjustment data in such a way that when the above-mentioned carriage travels towards the end from which the representative yarn is fed, the yarn length used is increased relative to the case when the carriage travels towards the opposite end.

9 A yarn length control device in a flat knitting machine as described in Claim 7 or Claim 8, being characterized in that

the above-mentioned flat knitting machine can double knit by allocating some of the above-mentioned stitch cams as leading cams and some of the above-mentioned stitch cams as tailing cams, and the device is further provided with

a memory (28) for storing stitch cam adjustment data for the tailing cams so that the yarn length used in double-knitting is substantially equal to that used in single-knitting, and

a double knit adjustment means for adjusting stitch cam conditions for the tailing cams by using said stored data when double-knitting is done.

FIG. 1

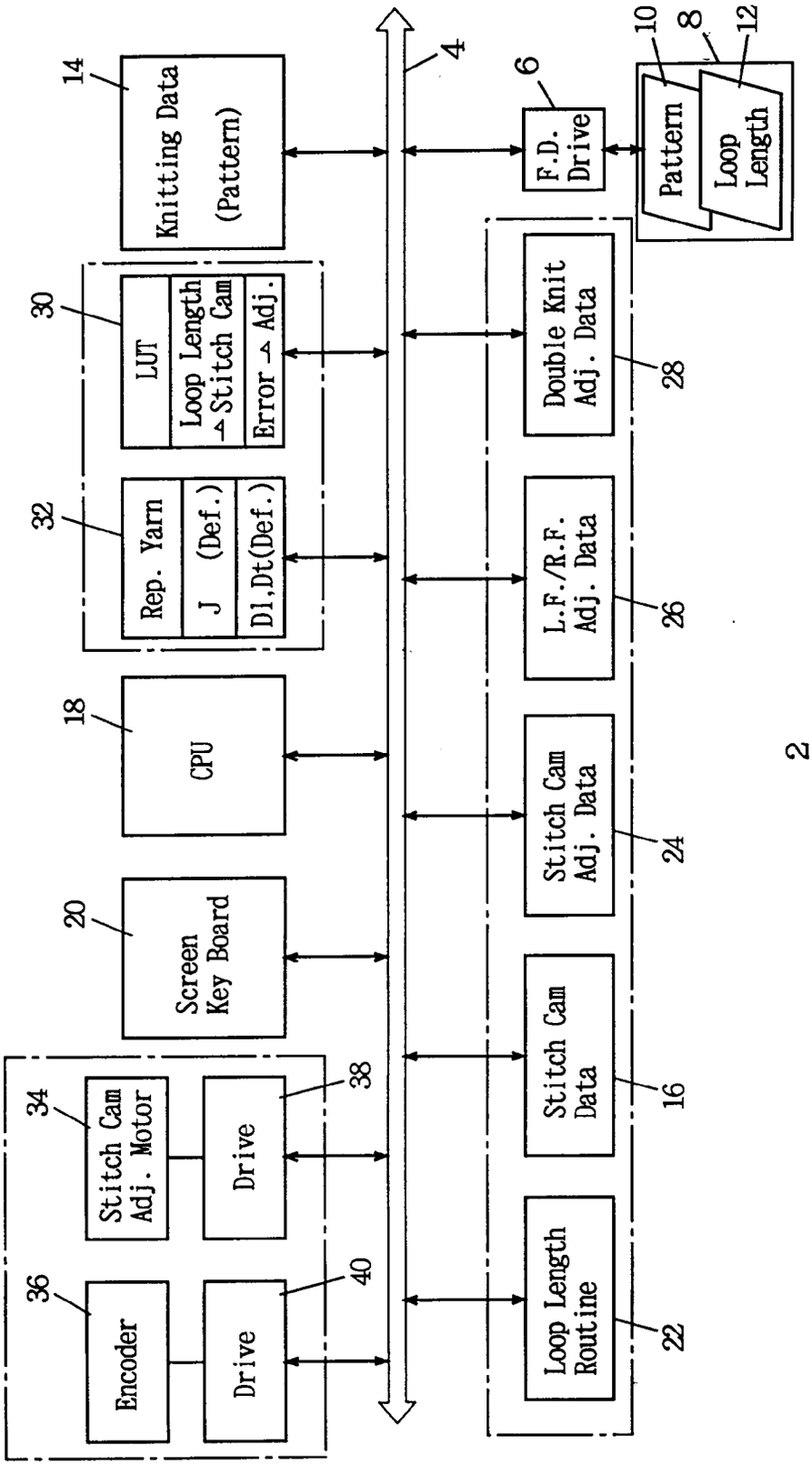

2
4
6
F.D. Drive
8
Pattern
10
Loop Length
12
14
Knitting Data (Pattern)
30
LUT
Loop Length ⊿Stitch Cam
Error ⊿ Adj.
32
Rep. Yarn
J (Def.)
D1,Dt(Def.)
18
CPU
20
Screen Key Board
34
Stitch Cam Adj. Motor
Drive
38
36
Encoder
Drive
40
22
Loop Length Routine
16
Stitch Cam Data
24
Stitch Cam Adj. Data
26
L.F./R.F. Adj. Data
28
Double Knit Adj. Data

FIG. 2

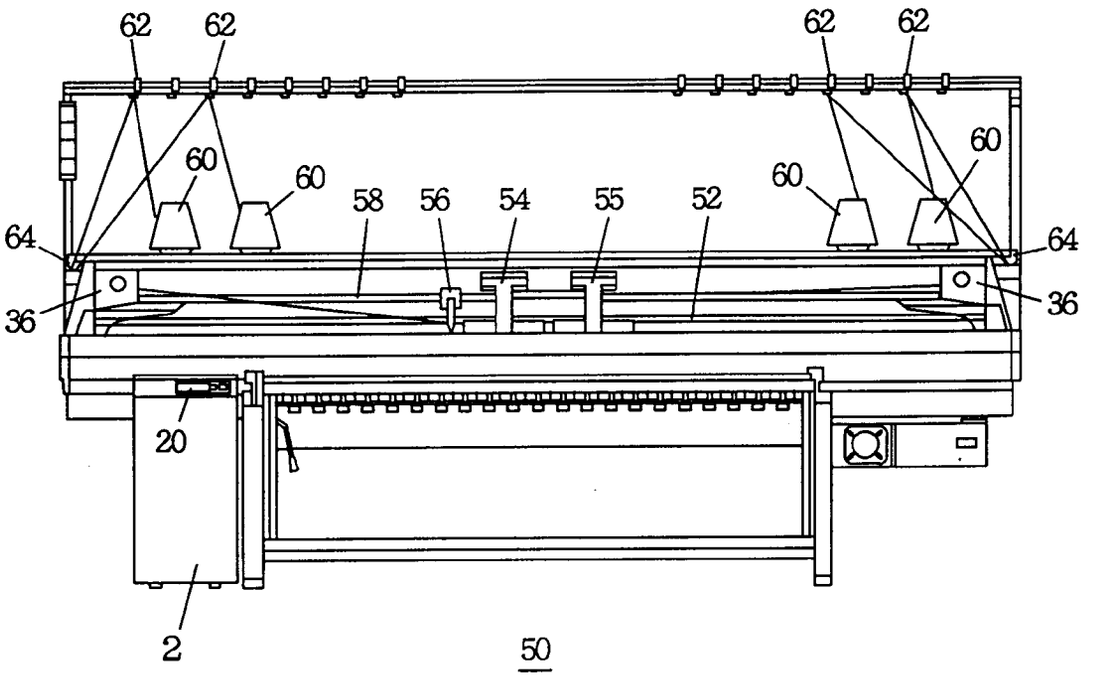
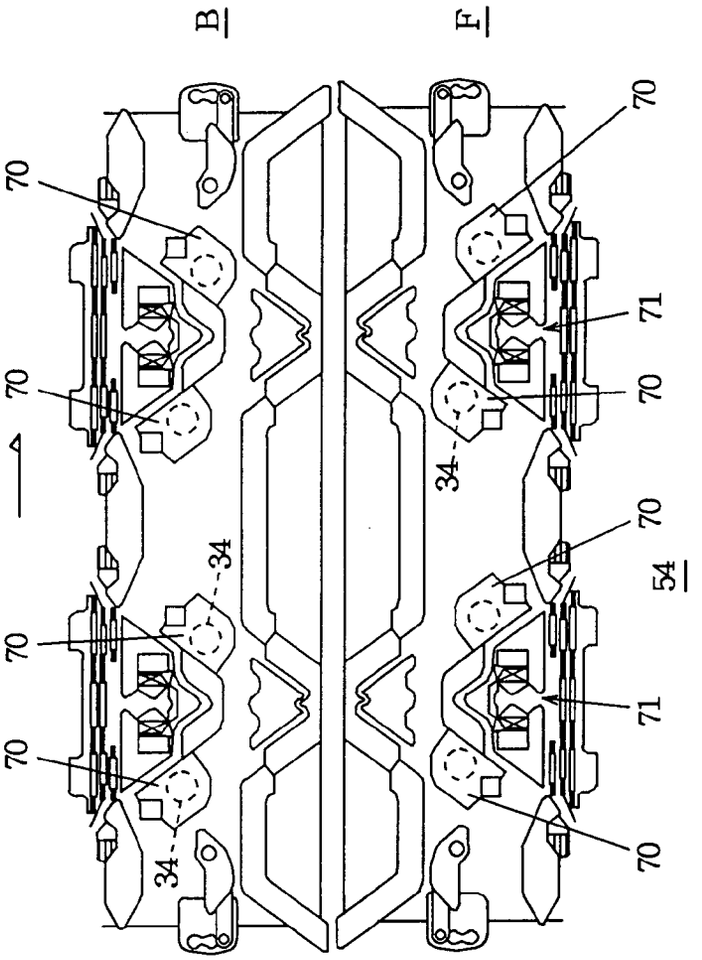
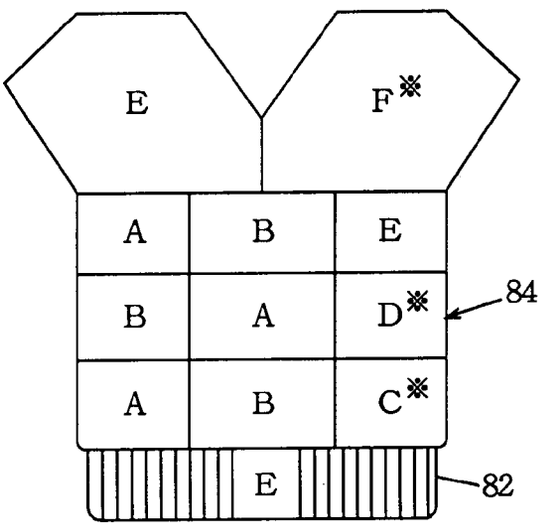


FIG. 3



Cam No.	Stitch Cam Adj.	
1	C1	r1
2	C2	r2
:	:	:
8	C8	r8
J,	D1,	Dt

FIG. 4



80

FIG. 5

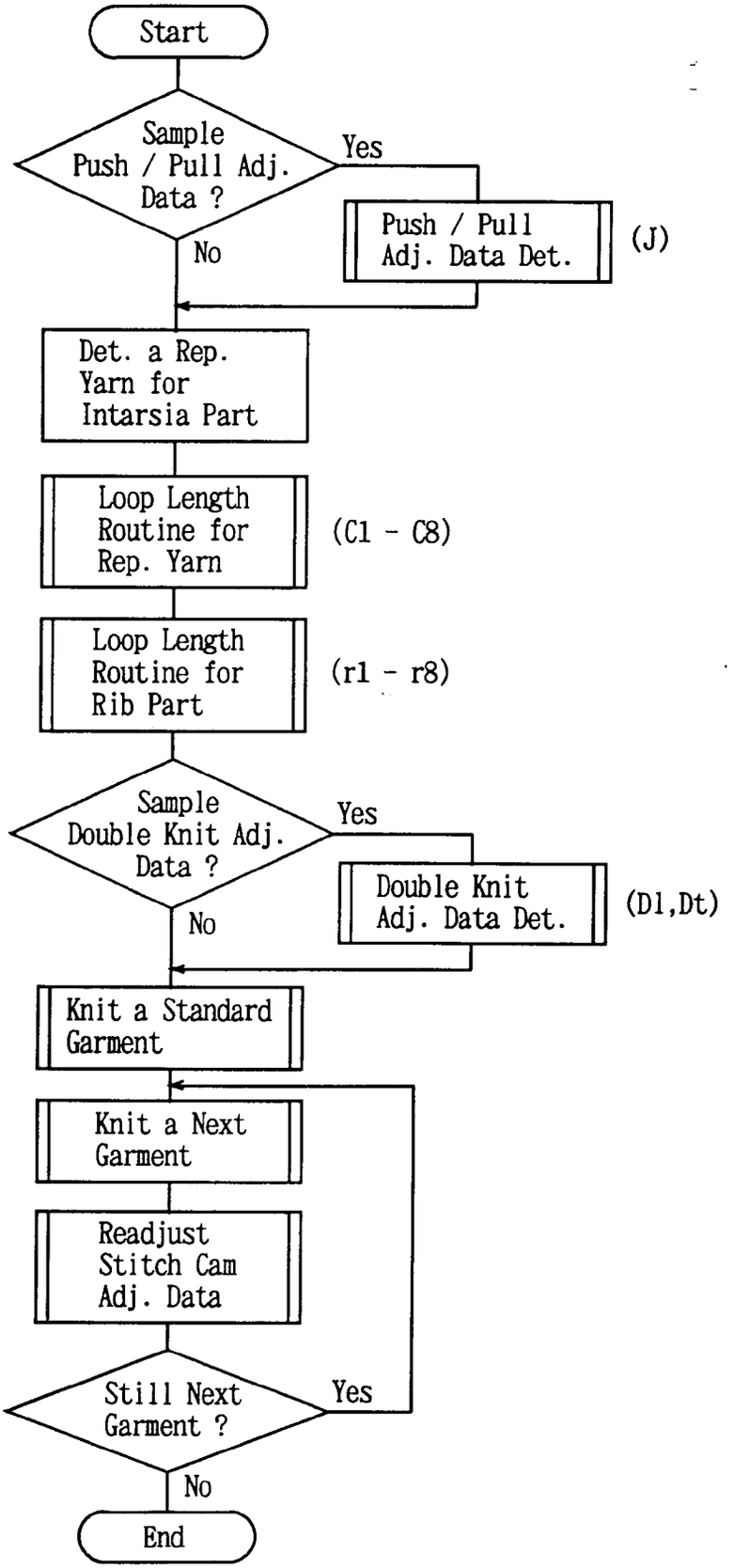

Start
Sample Push / Pull Adj. Data ?
Yes
No
Push / Pull Adj. Data Det.
(J)
Det. a Rep. Yarn for Intarsia Part
Loop Length Routine for Rep. Yarn
(C1 - C8)
Loop Length Routine for Rib Part
(r1 - r8)
Sample Double Knit Adj. Data ?
Yes
No
Double Knit Adj. Data Det.
(D1,Dt)
Knit a Standard Garment
Knit a Next Garment
Readjust Stitch Cam Adj. Data
Still Next Garment ?
Yes
No
End

FIG. 6

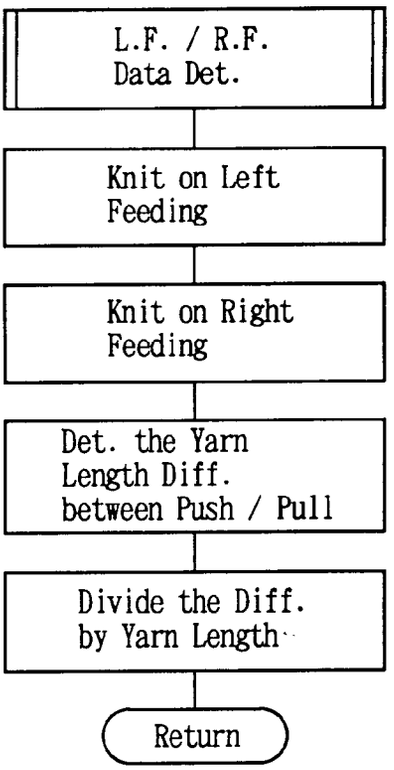

L.F. / R.F.
Data Det.
Knit on Left
Feeding
Knit on Right
Feeding
Det. the Yarn
Length Diff.
between Push / Pull
Divide the Diff.
by Yarn Length
Return

FIG. 7

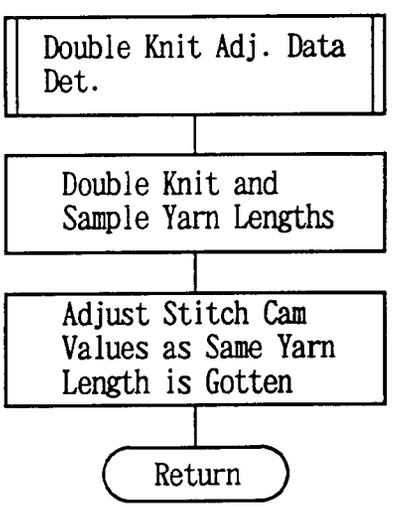

Double Knit Adj. Data
Det.
Double Knit and
Sample Yarn Lengths
Adjust Stitch Cam
Values as Same Yarn
Length is Gotten
Return

FIG. 8

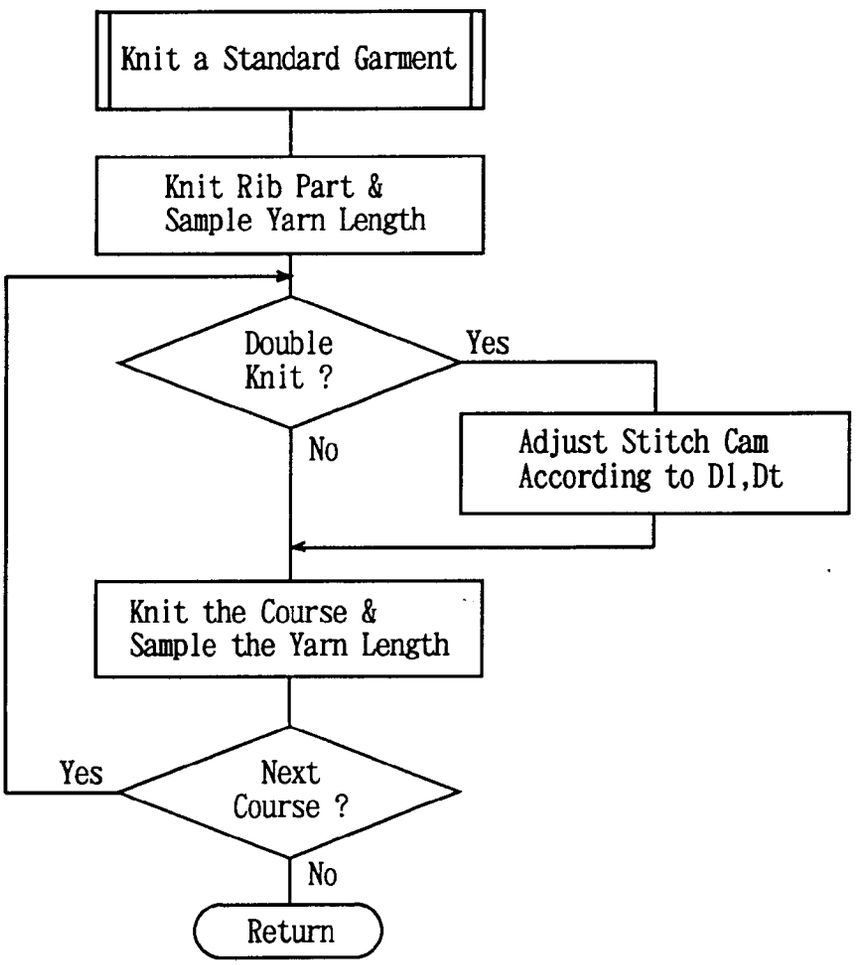

Knit a Standard Garment
Knit Rib Part &
Sample Yarn Length
Double
Knit ?
Yes
No
Adjust Stitch Cam
According to Dl,Dt
Knit the Course &
Sample the Yarn Length
Yes
Next
Course ?
No
Return

FIG. 9

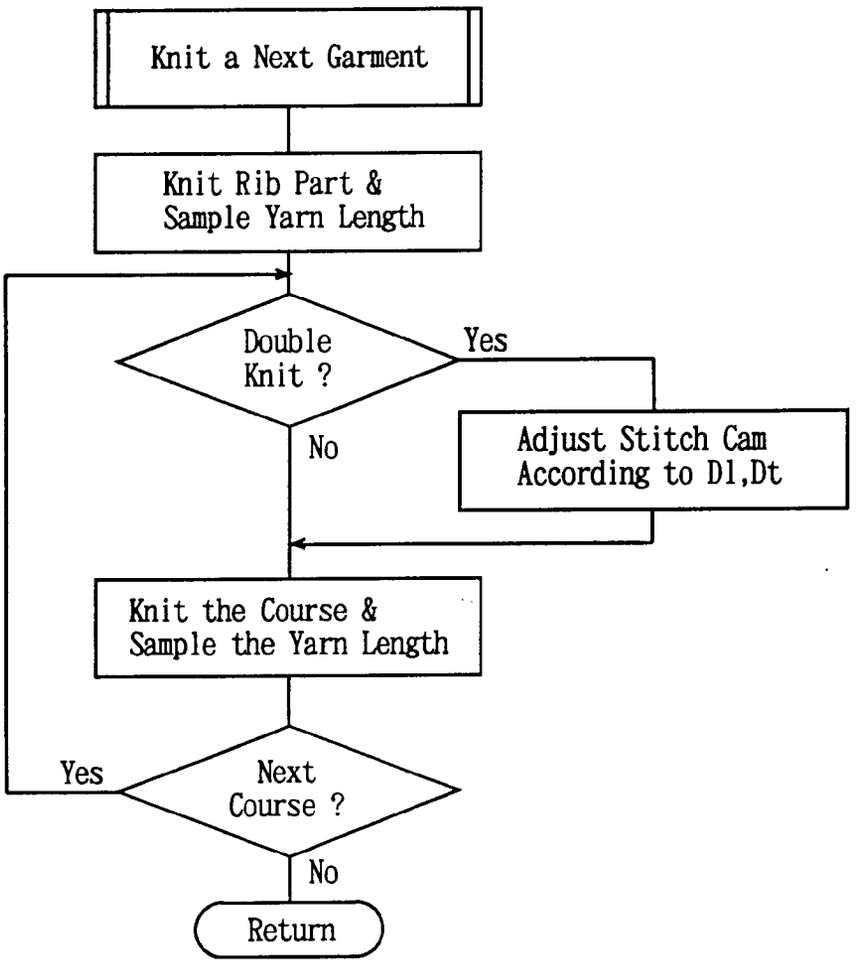
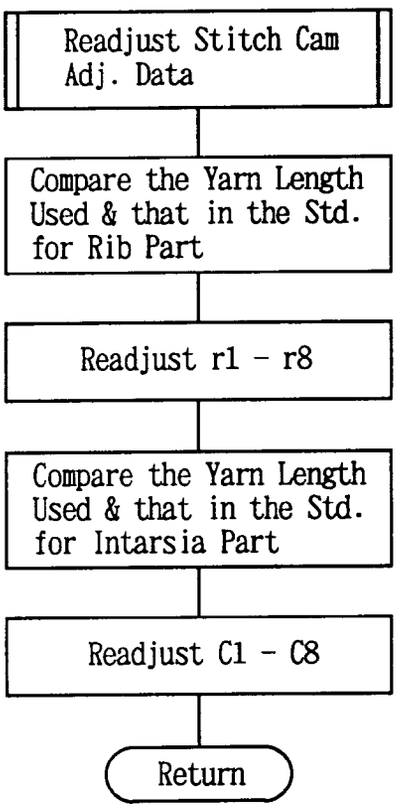

Knit a Next Garment
Knit Rib Part &
Sample Yarn Length
Double
Knit ?
Yes
No
Adjust Stitch Cam
According to Dl,Dt
Knit the Course &
Sample the Yarn Length
Yes
Next
Course ?
No
Return

FIG. 10


Readjust Stitch Cam Adj. Data
Compare the Yarn Length Used & that in the Std. for Rib Part
Readjust r1 - r8
Compare the Yarn Length Used & that in the Std. for Intarsia Part
Readjust C1 - C8
Return

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 6139

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 489 307 (INTERNATIONAL TRADING S.R.L.) * claims 1,2; figure 1 *	1	D04B15/38 D04B7/26
D,A	EP-A-0 506 322 (SHIMA SEIKI MFG., LTD.) & JP-A-06 025 953		
A	EP-A-0 452 800 (BAREA)		
D,A	DATABASE WPI Week 8717 Derwent Publications Ltd., London, GB; AN 87-119308 & JP-A-06 262 977 (SHIMA IDEA CENT KK) , 19 March 1987 * abstract *		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) D04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	3 January 1996	Van Gelder, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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