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

(11) EP 0 684 329 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
02.12.1998 Bulletin 1998/49

(51) Int Cl.6: **D04B 9/02**

(21) Application number: **95107920.1**

(22) Date of filing: **23.05.1995**

(54) Knitting machine and method of fabricating knitted fabrics

Strickmaschine und Verfahren zur Herstellung von Strickwaren

Métier à tricoter et procédé pour la fabrication d'articles tricotés

(84) Designated Contracting States:
DE FR GB

(30) Priority: **26.05.1994 JP 136418/94**

(43) Date of publication of application:
29.11.1995 Bulletin 1995/48

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EP-A- 0 260 062
GB-A- 2 022 871
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- **DATABASE WPI Week 9406 Derwent Publications Ltd., London, GB; AN 94-045881 & JP-A-06 002 280 (MUSHA) , 11 January 1994**

EP 0 684 329 B1

Description

The invention relates to a knittting machine for fabricating knitted fabrics.

In conventional knitting machines, the distance or separation between all knitting needles is kept constant, while the feed speed of a yarn used for knitting and the rotational speed of a needle cylinder are linked with each other in order to fabricate a knitted fabric having a constant loop size. In other cases, knitting needles are removed from the knitting machine at fixed intervals or at random intervals in order to impart a certain irregularity to the knitted fabric.

The European Patent Application EP-A-0 260 062 discloses a control system for a circular knitting machine which comprises a dial and cylinder cooperating together to produce a tubular workpiece. A former controls a desired variable feed rate of the yarn, while the axial movement of the cylinder can also be varied in synchronisation with the yarn feed speed.

The UK Patent Application GB-A 2 022 871 discloses a knitting machine. Signals from a random pulse generator are used to control the selection of stitch-forming tools of the knitting system. The random pulses are taken at instants controlled by a synchronisation pulse generator so as to be in synchronisation with the machine speed.

The United States Patent US-A 4,495,560 discloses a fluctuating drive system comprising a random generating means adapted to generate a physical quantity having a spectral density for each frequency with a relationship $1/f^k$ (where k is a non-zero arbitrary value). Control means are provided for controlling the randomly varying physical quantity, where amplifying means are provided for amplifying the controlled physical quantity. Driving means are provided to drive energy generating means which generate energy in accordance with the amplified physical quantity.

In such conventional knitting machines, the problem arises that the density of the knitted loops in the knitted fabric is constant or varies at random, resulting in that the knitted fabric does not have the natural irregular feel of a hand-knitted fabric; hence it is not very comfortable to a wearer.

The object underlying the present invention is to provide a knitting machine by means of which knitted fabrics can be produced which have a natural irregular feel that is comfortable to a wearer.

The object underlying the present invention is solved in a satisfying and advantageous manner by the knitting machine of the invention as defined in claim 1.

The yarn is fed to the needles at a speed having a 1/f fluctuation, and also the axial movement of the cam co-operating with the needles varies with a 1/f fluctuation. Hence, a knitted fabric is obtained in which the loop density along the length of the fabric varies with a 1/f fluctuation.

One advantage of the present invention resides in that a knitted fabric is obtained by means of a machine, at low cost and on an industrial scale, wherein the knitted loops are neither all the same nor do they vary randomly. Rather, the knitted loops vary with a specific correlation, namely a correlation with a 1/f fluctuation, thus imparting to the knitted fabric a feel with the natural irregularity of a hand-knitted fabric, which provides a special esthetic beauty and is comfortable to wear.

In the present application, the expression "1/f fluctuation" is defined and understood as a power spectrum, with a frequency component f, which is proportional to $1/f^k$, wherein k is approximately 1, and as a power spectrum which is similar to the above.

The invention will be explained in more detail below by means of preferred embodiments and with reference to the accompanying drawings, wherein

- Fig. 1 shows an overview diagram of the main components of a knitting machine according to an embodiment;
- Fig. 2 shows the arrangement of an IRO tape of a yarn feed unit provided in the knitting machine;
- Fig. 3 shows the configuration of a pulley and the IRO tape in the yarn feed unit;
- Fig. 4 shows an overview of a knitting unit of the knitting machine;
- Fig. 5 shows the arrangement of a knitting needle and a cam;
- Fig. 6 shows a chain arrangement of a stitch mechanism in the knitting machine;
- Fig. 7 shows an overview illustrating the up and down movement of the stitch mechanism;
- Fig. 8 illustrates a melody with a 1/f fluctuation;
- Fig. 9 shows the relationship between a numerical sequence with a 1/f fluctuation and a yarn feed speed; and
- Fig. 10 shows an example of a knitted fabric having a 1/f fluctuation.

<u>General Concept of the Knitting Maching (Fig. 1)</u>

An example of a circular knitting machine 1 is shown in Fig. 1 of the drawings, wherein a plurality of bobbins 21 are provided and arranged around the perimeter in the upper portion of the knitting machine 1 in order to supply yarn 22 for knitting. In particular, the knitting machine 1 comprises the following components:

- a yarn feed unit 2 which controls and feeds yarn 22 from the bobbins 21,

- a knitting unit 3 in which needles 31 knit the yarn 22 into a knitted fabric 51,
- a stitch mechanism 4 controlling the movement of the needles 31,
- a take-up unit 5 which takes up the knitted fabric 51 fabricated in the knitting unit 3, and
- a controller unit 6 which controls the various units of the knitting machine 1.

Of course, the invention is not restricted to a circular knitting machine 1 as outlined above, rather it can also be applied to a weft knitting machine, a warp knitting machine or any other type of knitting machine.

<u>Yarn Feed Unit (Figs. 1 to 3)</u>

The yarn feed unit 2 supplies yarn 22 from the bobbins 21 to the knitting unit 3. A plurality of threads of yarn 22 are supplied from a plurality of bobbins 21 to the respective needles 31 in the knitting unit 3. For this purpose, a top stopper 23 and a pulley 25 are provided. As shown diagrammatically in Fig. 1 of the drawings, a yarn feed motor 26 connected to the controller unit 6 drives and controls an IRO tape 24 according to signals from the controller unit 6. Hence, a plurality of pulleys 25 are controlled and rotated, thereby adjusting the amount of yarn 22 being supplied to the respective needles 31.

<u>Knitting Unit (Figs. 4 and 5)</u>

In the knittitng unit 3, a large number of cam grooves 36 is formed around the circumference of a needle cylinder 38 in the axial direction, for example a number of 2088 cam grooves 36 is provided. The knitting needles 31 are maintained to be movable within a corresponding cam groove 36. Each knitting needle 31 comprises a butt 34, provided at the bottom for engagement with a corresponding cam groove 36, as well as a hook 32 and a latch 33, onto which the yarn 22 is looped and knitted. A cam holder 37 encloses the outer circumference of the needle cylinder 38, and a cam 35 is positioned inside the cam holder 37, wherein the butt 34 of the respective needle 31 interlocks in the cam groove 36. The cam 35 moves up and down in accordance with the action of the stitch mechanism 4.

Apart from a single knitting machine, such a configuration is also applicable to a double knitting machine of any generally-known configuration, such as a dial and cylinder knitting machine. In such a dial and cylinder knitting machine, for example, in addition to the set of knitting needles 31 arranged axially around the needle cylinder 38, there is another set of needles 31 arranged radially on the upper face of a dial, wherein a cam is set on the dial upper face.

The cam 35 has a pattern corresponding to the stitching mode. For example, a knit stitch patterrn is mountain-shaped having a peak at the center, a tuck stitch pattern is plateau-shaped, and a welt stitch pattern is formed by a flat cam groove. As the needle cylinder 38 is rotated by a main motor 61 provided in the controller unit 6, the butt 34 of the needle 31 moves up and down along the cam groove 36 forming a knitted fabric 51 corresponding to the pattern of the cam groove 36.

<u>Stitch Mechanism (Figs. 1, 4, 6 and 7)</u>

The stitch mechanism 4 is the same as that in general use, wherein a cam 35 moves up and down relative to the needle cylinder 38 according to the rotation of an adjustment screw 43. The adjustment screw 43 is rotated by a stitch motor 47, and the adjustment screw 43 automatically controls the up and down movement of the cam 35. The stitch motor 47 is controlled by the controller unit 6 to move in synchronization with the rotation of the feed motor 26 for the yarn 22. In order to move the cam 35 up and down, the control of the stitch motor 47 is employed, wherein the rotation of the adjustment screw 43 rotates a chain 45 to drive a sprocket 44 and move a mobile cam ring 42 up and down relative to a fixed cam ring 41. The distance of this up and down movement of the cam 35 can be measured by means of a dial gauge 46.

<u>1/f Fluctuation</u>

One of the present inventors, Toshimitsu MUSHA, was the first in the world to discover that a 1/f fluctuation would impart a particularly comfortable feel to human beings. The results were published in a paper entitled "Seitai Seigyo to 1/f Yuragi" (Biocontrol and 1/f Fluctuation), Journal of Japan Society of Precision Machinery, 1984, Vol. 50, No. 6, and another paper entitled "Seitai Joho to 1/f Yuragi" (Bioinformation and 1/f Fluctuation), Applied Physics, 1985, pp. 429 to 435, as well as in a recent publication called "Yuragi no Hassou" (The Concept of Fluctuations), published by NHK Publishers in 1994.

The abstracts of these publictions read as follows: "The 1/f fluctuation provides a comfortable feeling to human beings; the reason is that the variations in the basic rhythm of the human body have a 1/f spectrum. From another perspective, the human body eventually becomes tired of a constant stimulation from the same source, but conversely, the body feels uncomfortable if the stimulations were to change too suddenly. Therefore, a 1/f fluctuation is a fluctuation of the right proportion between these two extremes."

In addition, an excerpt from "Yuragi no Sekai" (The World of Fluctuations), published by Kodansha Publishers in 1980, reads as follows: "For example, the rhythms exhibited by the human body such as heart beats, hand-clapping to music, impulse-release period of neurons, and α rhythms observed in the brain, are all basically 1/f fluctuations, and it has been shown experimentally that if a body is stimulated by a fluctuation like these biorhythmic 1/f fluctuations, it would feel comfortable."

Fluctuations or variations exist in various forms throughout the nature, but the murmur of a brook, a breeze of wind, and other phenomena that impart a comfortable feeling to human beings have a 1/f fluctuation, while typhoons and other strong winds that impart uneasiness do not have a 1/f fluctuation.

1/f Fluctuation Numerical Sequence (Figs. 8 and 9)

A 1/f fluctuation numerical sequence is determined from y_1, y_2, y_3, formed by multiplying $\underline{n}$ coefficients a_1, a_2, a_3, ... a_n with numbers x_1, x_2, x_3, ... Generally, y_j can be expressed by Equation 1 specified below. It should be noted herein that the sequence of numerical values forming y_1, y_2, y_3, ... has a 1/f spectrum. For further details, reference is made to Seitai shingou (Biological Signaling), Chapter 10, "Seitai Rizumu to Yuragi" (Biological Rhythms and Fluctuations), published by Corona Publishers, Ltd. in 1989.

Equation 1:

$$y_j = x_j + \left(\frac{1}{2}\right) x_{j+1} + \left(\frac{1\cdot 3}{2^2\cdot 2!}\right) x_{j+2} + \left(\frac{1\cdot 3\cdot 5}{2^3\cdot 3!}\right) x_{j+3} + \cdots$$

$$\cdots + \left(\frac{1\cdot 3\cdot 5\cdot \ldots \cdot (2n-1)}{2^{n-1}\cdot (n-1)!}\right) x_{j+n-1} \quad .$$

A 1/f fluctuation numerical sequence is usually obtained in two steps. In a first step, a computer, for example, generates a sequence of random numbers. In a second step, a certain number $\underline{n}$ of coefficients a - which are stored in a memory device - are successively multiplied with the random numbers, and then, by a linear transformation, a sequence of numerical values y is obtained. This numerical sequence has a 1/f spectrum, and can be used as a 1/f numerical sequence.

In this context, a melody having a 1/f fluctuation can be generated from this sequence of numerical values y having a 1/f sequence. For this purpose, at first the scale and the range with a lowest frequency fL and a highest frequency fU are determined. Then, a 1/f sequence of y values is derived, and a linear transformation is performed so that the upper and lower limits become the lowest frequency fL and the highest frequency fU, respectively. The values of the sequence y so derived are regarded as acoustic frequencies, and are substituted for the frequency of the music scale they most closely approximate.

In other words, they are arranged, for example, as quarter notes, between or on the lines of a staff on music paper. Fig. 8 of the drawings shows a portion of a melody derived using this method. An example of a numerical sequence derived by assigning numerical values corresponding to the notes of the melody shown in Fig. 8, wherein a value of 1 is given to the reference note, is shown in Fig. 9 of the drawings.

Knitted Fabric - Example (Figs. 9 and 10)

The yarn feed unit 2 adjusts the amount of yarn 22 which is fed to the knitting needles 31. From the controller unit 6, 1/f fluctuation signals are supplied to the yarn feed unit 2 in order to control the yarn feed motor 26 which rotates the IRO tape 24. Also, the stitch motor 47 of the stitch mechanism 4 is controlled by 1/f fluctuation signals synchronized with the feed motor 26, wherein the stitch mechanism 4 moves the needles 31 up and down with a 1/f fluctuation. All the needles 31 arranged around the circumference of the needle cylinder 38 move up and down with this 1/f fluctuation. As a result, along the width of the fabric 51 fabricated thereby, the mesh along the entire width is uniformly enlarged or uniformly compacted, while along the length of the fabric 51, the density of the loops has a 1/f fluctuation.

The knitted fabric 51 is obtained using a yarn feed speed having a 1/f fluctuation derived from the numerical sequence with a 1/f fluctuation, as shown for example in Fig. 9 of the drawings. The yarn feed speed is expressed as the length in mm per 100 wales. In this embodiment, the number 13 of the numerical sequence is set to correspond to 285 mm/100 wales, whereas the number 2 of the numerical sequence is set to correspond to 225 mm/100 wales.

The intervening values 3 to 12 of the numerical sequence are computed proportionally to derive the feed speed of Fig. 9. The yarn feed speed is set to correspond in this manner for each revolution of the needle cylinder 38, and the stitch mechanism 4 and the yarn feed speed of the yarn feed unit 2 are controlled to be in synchronization, thereby imparting a 1/f fluctuation to the knitted fabric 51. A knitted fabric 51, obtained in this manner using a cotton thread comber 30/1 and forming a dappled purl knit, is shown in Fig. 10 of the drawings.

Claims

1. A knitting machine having

a plurality of knitting needles (31) mounted substantially axially and in parallel about the outer circumference of a needle cylinder (38) around which a cam (35) is disposed or having a plurality of knitting needles (31) mounted substantially axially and in parallel about the outer circumference of a needle cylinder (38) around which a cam (35) is disposed and another set of needles (31) mounted radially on the upper face of a dial on which another cam is disposed;

wherein the knitting machine comprises a yarn feed unit (2) which feeds yarn (22) to the needles (31) and a knitting unit (3) in which the yarn (22) is knit by the needles (31) as the needle cylinder (38) or the cylinder and dial are rotated relative to the cam (35),

wherein a stitch mechanism (4), set within the knitting unit (3), synchronizes the axial movement of the cam (35) with the yarn feed speed

characterised in that

the yarn feed unit (2) is controlled to feed yarn to the needles (31) at a speed having a 1/f fluctuation, and

the stitch mechanism (4) is controlled to move the cam (35) such that its axial motion varies with a 1/f fluctuation,

whereby a knitted fabric (51) is produced whose loop density along the length of the fabric varies with a 1/f fluctuation.

Patentansprüche

1. Wirk- oder Strickmaschine, die folgendes aufweist:

- eine Vielzahl von Wirk- oder Stricknadeln (31), die im wesentlichen axial und parallel um den Außenumfang eines Nadelzylinders (38) herum angebracht sind, um den herum ein Schloßteil (35) angeordnet ist, oder eine Vielzahl von Wirk- oder Stricknadeln (31), die im wesentlichen axial und parallel um den Außenumfang eines Nadelzylinders (38) herum angebracht sind, um den herum ein Schloßteil (35) angeordnet ist, und einen weiteren Satz von Nadeln (31), die radial an der oberen Fläche einer Rippscheibe angebracht sind, an der ein weiteres Schloßteil angeordnet ist;
- wobei die Wirk- oder Strickmaschine folgendes aufweist: eine Garnzuführungseinheit (2), die den Nadeln (31) Garn (22) zuführt, und eine Wirk- oder Strickeinheit (3), in der das Garn (22) von den Nadeln (31) gewirkt oder gestrickt wird, während der Nadelzylinder (38) oder der Zylinder und die Rippscheibe relativ zu dem Schloßteil (35) gedreht werden,

wobei ein Maschenmechanismus (4), der im Inneren der Wirk- oder Strickeinheit (3) angeordnet ist, die Axialbewegung des Schloßteils (35) mit der Garnzuführungsgeschwindigkeit synchronisiert,
dadurch gekennzeichnet,

daß die Garnzuführungseinheit (2) so gesteuert wird, daß sie den Nadeln (31) Garn mit einer Geschwindigkeit zuführt, die eine Schwankung von 1/f hat, und daß der Maschenmechanismus (4) so gesteuert wird, daß er das Schloßteil (35) derart bewegt, daß sich seine Axialbewegung mit einer Schwankung von 1/f ändert, so daß eine Maschenware (51) hergestellt wird, deren Maschendichte sich entlang der Länge der Maschenware mit einer Schwankung von 1/f ändert.

Revendications

1. Machine à tricoter, comprenant

une pluralité d'aiguilles à tricoter (31), montées sensiblement axialement et parallèlement sur la circonférence extérieure d'un cylindre à aiguilles (38) autour duquel est disposée une came (35), ou présentant une pluralité d'aiguilles à tricoter (31), montées sensiblement axialement et parallèlement sur la circonférence extérieure d'un cylindre à aiguilles (38) autour duquel est disposée une came (35), et un autre jeu d'aiguilles (31) montées radialement sur la face supérieure d'un cadran, sur lequel est disposée une autre came ;
dans laquelle la machine à tricoter comprend une unité d'amenée de fil (2) qui fournit du fil (22) aux aiguilles (31), et une unité de tricotage (3), dans laquelle le fil (22) est tricoté par les aiguilles (31) lorsque le cylindre à aiguilles (38) ou le cylindre et le cadran sont entraînés en rotation par rapport à la came (35),
dans laquelle un mécanisme de mailles (4), placé à l'intérieur de l'unité de tricotage (3), synchronise le mouvement axial de la came (35) sur la vitesse d'amenée de fil,

caractérisée en ce que

l'unité d'amenée de fil (2) est commandée de manière à fournir le fil aux aiguilles (31) à une vitesse ayant une variation 1/f, et
en ce que le mécanisme de mailles (4) est commandé pour déplacer la came (35) de telle manière que son mouvement axial varie d'une fluctuation 1/f,
permettant ainsi la fabrication d'un tricot (51) dont la densité de boucles varie, dans le sens de la longueur du tricot, selon une fluctuation 1/f.

Fig. 1

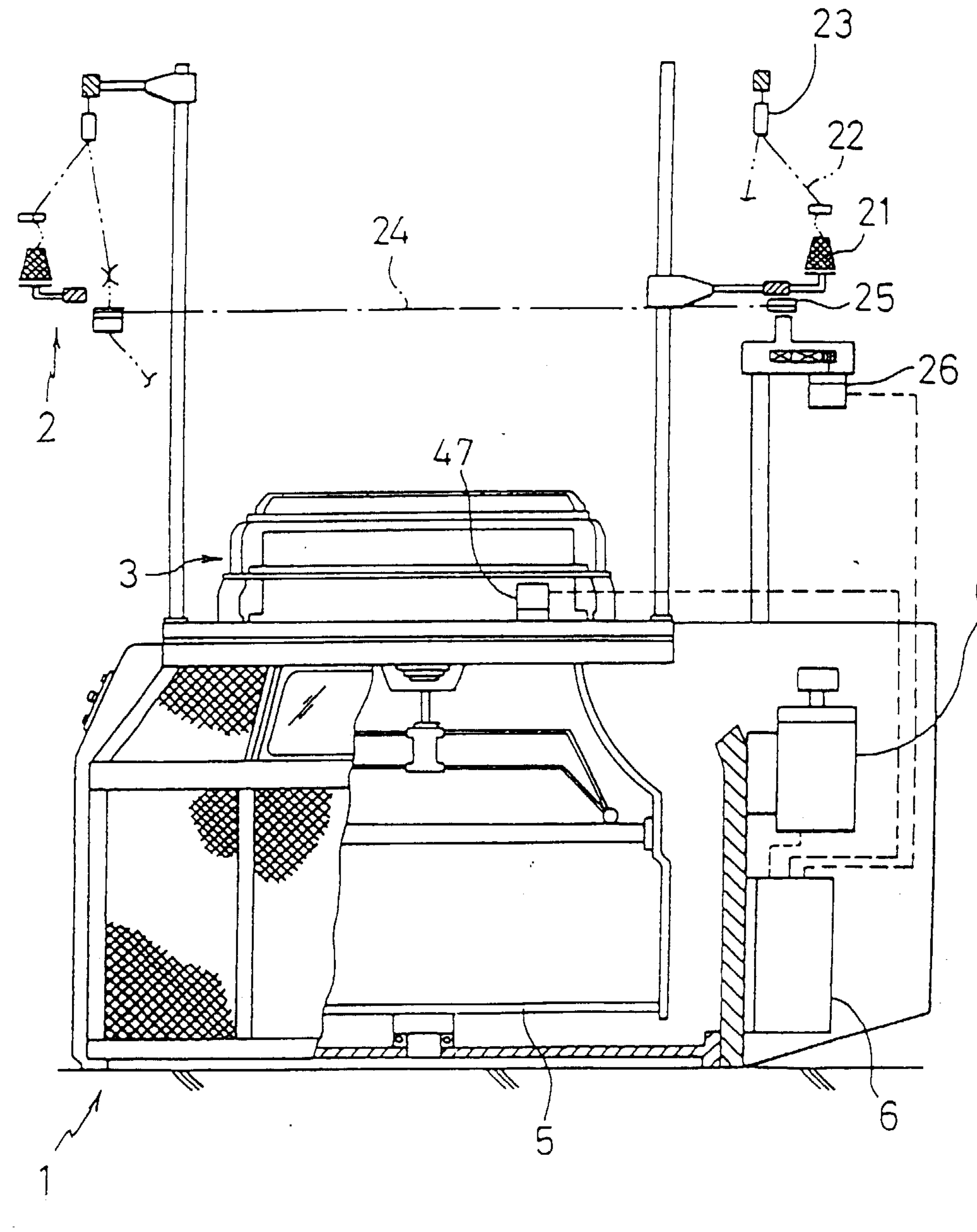

Fig. 2

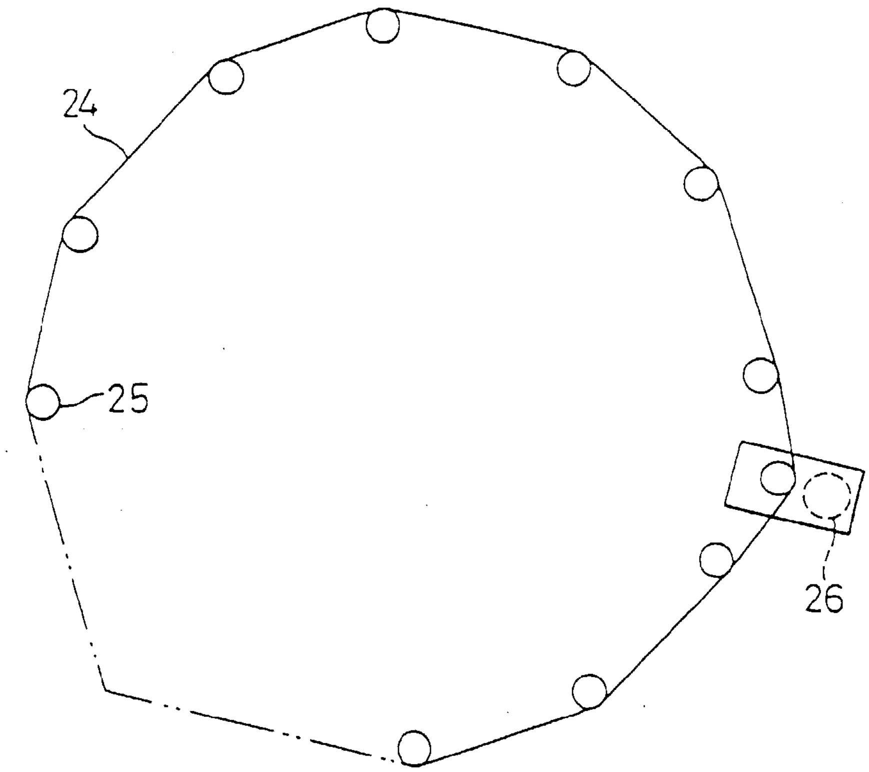

Fig. 3

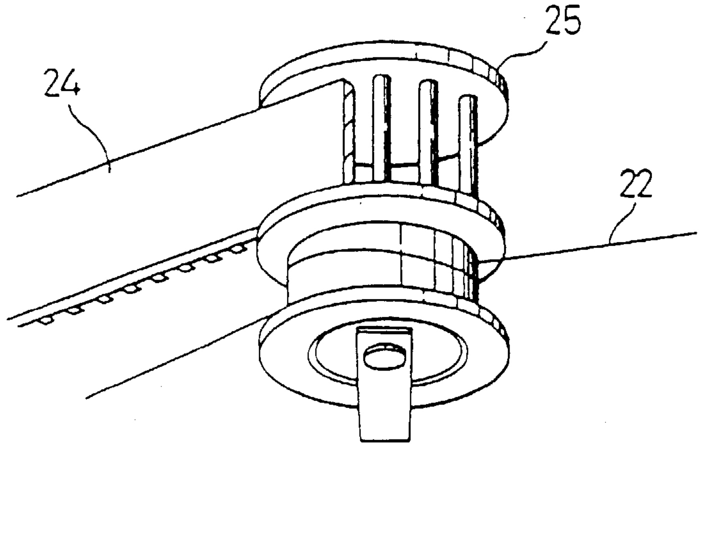

Fig. 4

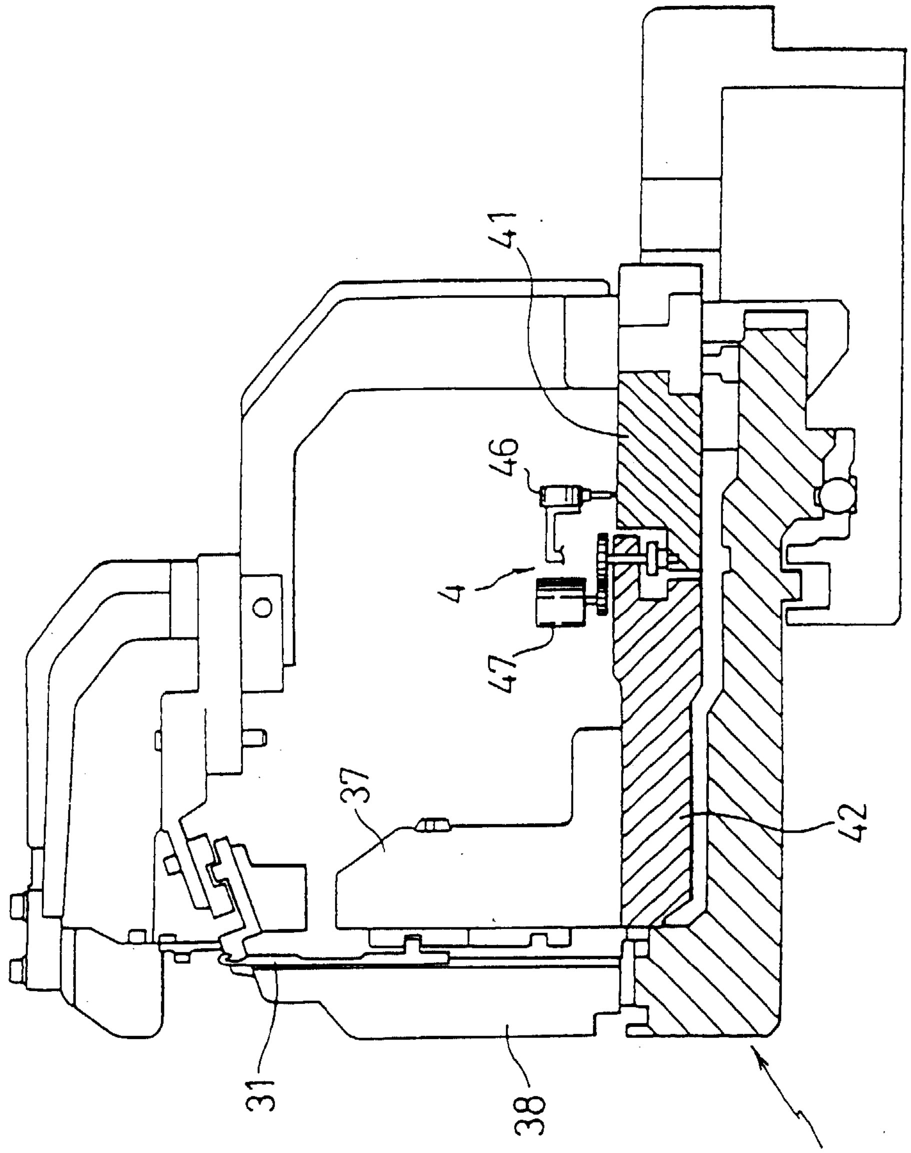

Fig. 5

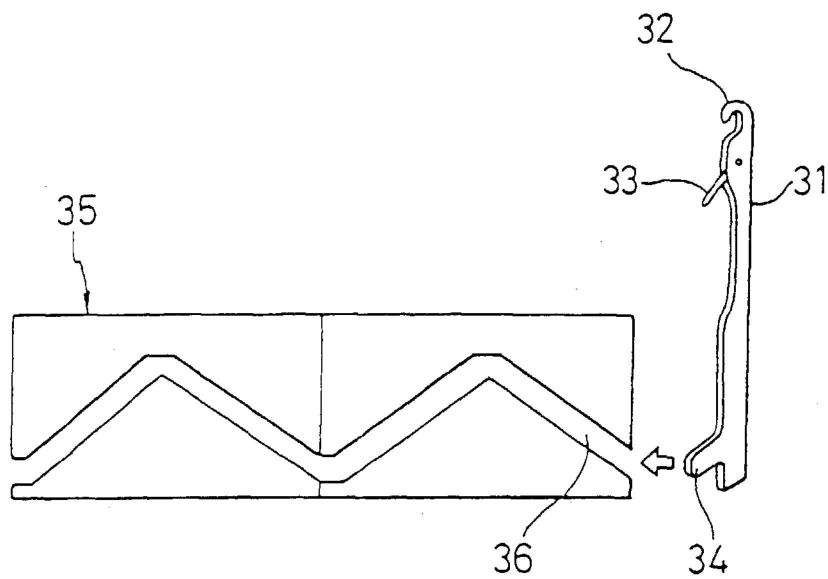

Fig. 6

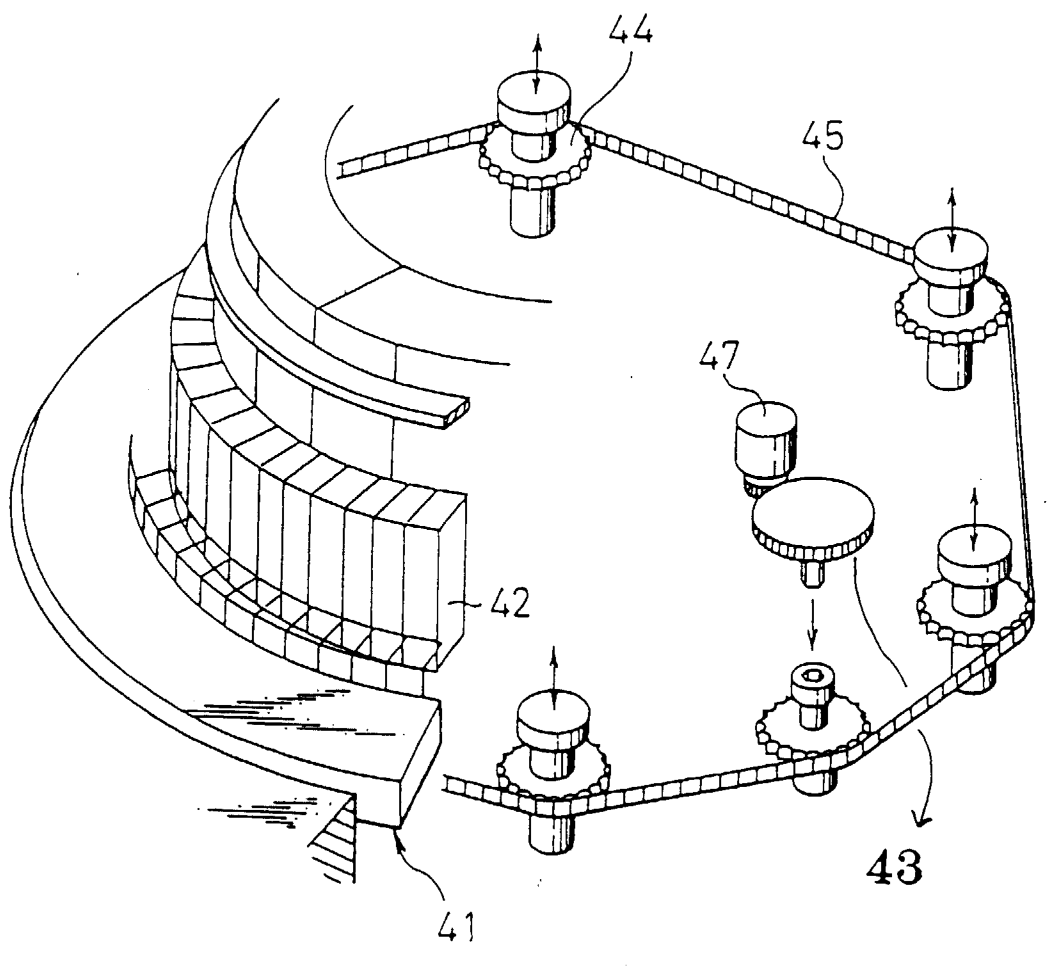

Fig. 7

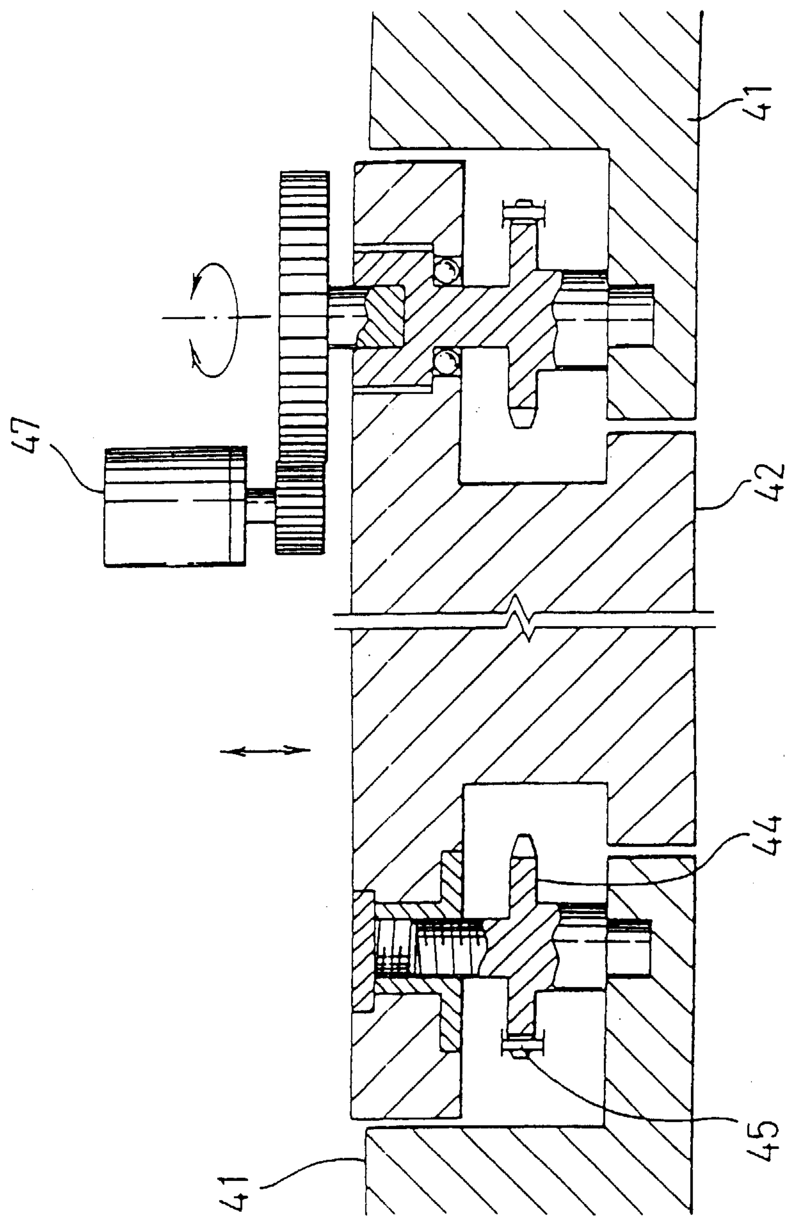

Fig. 8

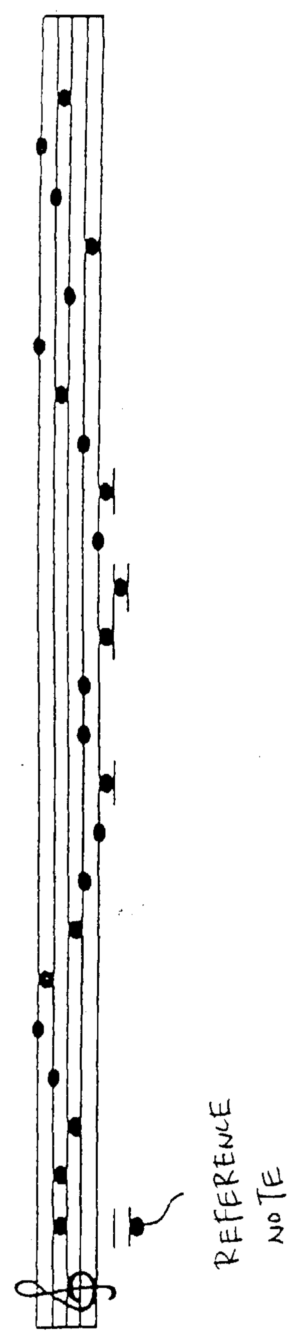

Fig. 9

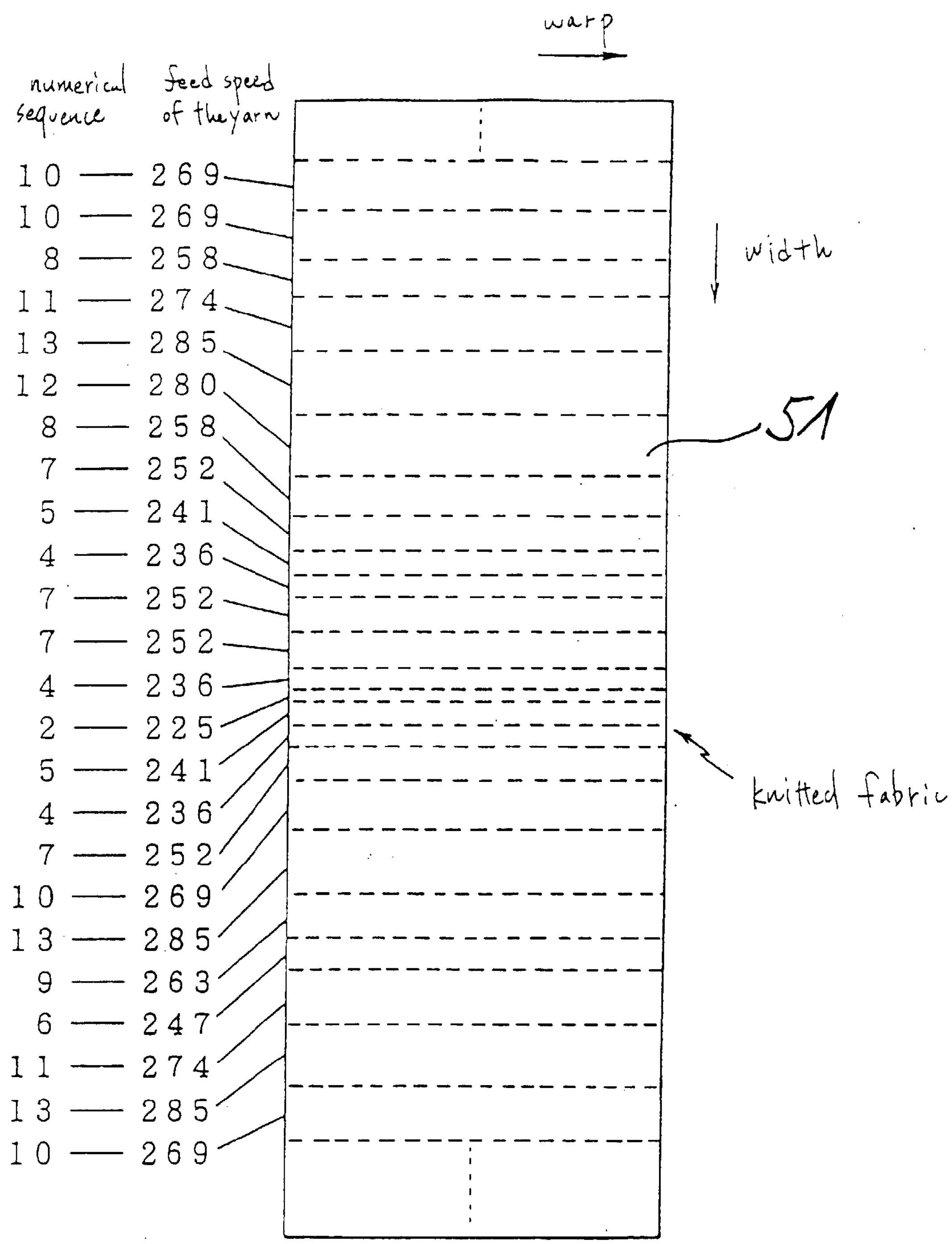
warp
numerical sequence
feed speed of the yarn
10 — 269
10 — 269
8 — 258
11 — 274
13 — 285
12 — 280
8 — 258
7 — 252
5 — 241
4 — 236
7 — 252
7 — 252
4 — 236
2 — 225
5 — 241
4 — 236
7 — 252
10 — 269
13 — 285
9 — 263
6 — 247
11 — 274
13 — 285
10 — 269
width
51
knitted fabric

Fig. 10