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(54) KNITTING MACHINE WITH RADIAL KNITTING NEEDLES

STRICKMASCHINE MIT RADIAL-STRICKNADELN

MACHINE A TRICOTER A AIGUILLES A TRICOTER RADIALES

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Description

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a new type of knitting machine for manufacturing a knitted fabric.

(2) Description of the Related Art

A known knitting fabric hereinbefore is knitted by moving a plurality of knitting needles arranged linearly in a needle bed fixed on a frame of a knitting machine into a knitting position, a tuck position, or a welt position, either by a plurality of cams arranged in a carriage moving reciprocally along the needle bed, or by a plurality of disks for linearly moving a corresponding knitting needle, or by a plurality of actuators, one for each needle, for linearly moving a corresponding knitting needle.

The shape, the manner of moving, and the bed of a knitting needle, which is the primary unit in the manufacture of a knitted fabric and thereby the main portion of a knitting machine, is based on U.S. Patent 39 934 granted in 1863 to the American inventor I.W. Lamb. Since the knitting needles according to this invention make linear movements they are arranged in rectangular slabs, which have a rectangular cross section, and transversally incised grooves functioning as needle beds, hence such a machine is called the flat knitting machine. The knitting needle of the circular knitting machine makes linear movements also, the only difference being the needle bed is of a cylindric shape.

There are several restrictions in the knitting of the knitted fabric performed by the knitting machine have the above-mentioned constitution, and these restrictions will be explained hereinafter.

The linear movement of the needle in the needle bed groove results in friction between these two elements, both of these being made of steel and sliding against each other. This friction increases with increased speed in the movement of the needle, which leads to an increased loss of mechanical energy, the energy being converted to heat, increased abrasion of the said elements, and subsequently to a shorter life of the knitting machine. Therefore friction in the needle bed groove by the linear movement of the needle is the most important factor in determining the maximal working speed of the machine. Good lubrication can reduce this friction, but then the entire machine is covered with a layer of lubricant on which falls lint and dust produced by the knitting process, which reduces the effects of lubrication and makes maintenance more difficult.

Further, when a needle makes a linear motion to obtain a knitting movement, the sliding movement of the moving member of the needle has to be equal to the sliding movement of the loop forming member, since these two members are on the same straight line, directly connected by the stem of the needle, and there is no transmission unit between to change the transmission ratio.

Furthermore, to provide a stable guide for the knitting needle in the needle bed and to satisfy technological conditions in manufacturing of needle beds, the thickness of the wall between two adjacent knitting needles has to be larger than the width of the groove of the needle bed, which limits the density of the arrangement of the knitting needles in the needle bed. If the above-mentioned machine be required to knit a fabric in two or more planes, which is necessary when knitting fully fashioned knitted fabric, then the patterning of the knitting machine is drastically reduced. In order to knit by the said machine knitted fabric in two or more planes, making thereby use of all the options for more complicated patterning, it is necessary to at least double the number of needles per unit length of the machine, maintaining thereby the nominal gauge of the needle, e. g., for the knitting machine having the needle gauge 7, fourteen needles of gauge 7 have to be arranged per one inch of length, which creates a large problem in the process of manufacturing needle beds, considering the width of the grooves in the needle bed and the thickness of the wall between adjacent needles.

Further, the length, the width, and the height of the needle bed are in the ratio of approximately 100 : 10 : 1, consequently the needle bed has a small moment of inertia making an angle of about 35 degrees with the horizontal plane, which causes bending of the needle bed. To secure the stability of the needle bed and to prevent undesired change of shape, the knitting machines are provided with a massive frame, which greatly increases the weight of the needle bed and the cost of manufacture.

Further, a knitting machine with the individual operation of the knitting needle, each having an actuator for linearly moving a corresponding knitting needle, as disclosed in Japanese Patent Application JP 29519/86, faces difficulties because its actuator is of a linear type having more complicated workmanship, larger dimensions and higher manufacturing costs than the actuator of a rotational type. Because of the lack of space the actuators are arranged in a multistage manner, in the upper and lower stages and beside each other which requires complicated straight and folded arm mechanisms to connect actuators to the corresponding knitting needle. All these increases the mass of the running mechanism and thereby the moment of inertia, which deteriorates the dynamic characteristics of a driving system.

Also, there have been some attempts to avoid the above-noted problems by introducing a new form of a knitting needle which have a curved profile as described in BE-A-535 955. This needle in its preferred form is characterized in that a stem he knitting needle, between its needle turning member and its loop forming member, whereon slides a loop in the process of forming a knitted

fabric, has a curved profile and by its shape represents an arc of a circle having its centre in the needle axle around which it can make an angular motion, whereby the distance between the stem of the knitting needle and the needle axle is a radius of the knitting needle, hence the above-mentioned knitting needle will hereinafter be referred to as a radial knitting needle, or in the abbreviated form RKN, having the central angle RKN defined by the end points of the circular arc; and the needle axle which bears the RKN mounted to the frame of the knitting machine allowing the RKN an angular motion in the plane perpendicular to the needle axle, whereby the RKN is connected to the needle axle by a knitting needle turning member, which is a lever whereon acts a mechanical force creating torque at a point that can be at a distance smaller or greater than the radius of the RKN, so that said RKN in one loop forming cycle makes an angular vibratory motion.

These solutions offer a new possibility for bearing the knitting needle on a knitting axle, thus reducing abrasion, however, the art of moving such a needle, because of its profile, requires a more complicated cam.

SUMMARY OF THE INVENTION

An object of the present invention is to overcome the above-noted problems by introducing an actuator which is associated to each radial knitting needle (RKN) in such a way that the actuator integrates several functions and represents one knitting module suitable to be used as a driver and carrier of the knitting needle, in order to increase the knitting speed and the density of the arrangement of the knitting needles per unit length of the knitting machine, and to reduce the manufacturing cost.

A further object of the present invention is to provide a flat knitting machine capable of employing the above-mentioned knitting module.

A further object of the present invention is to provide a circular knitting machine capable to implementing the above-mentioned knitting module.

According to the present invention there is provided an actuator, one for each radial knitting needle (RKN), which can produce an independent angular motion of said RKN. In its preferred form the actuator is a rotary electric motor characterized in that the magnetic flux of a stator is common for all the actuators lying on the same axis of the flat knitting machine or in the same circle of the circular knitting machine and being produced by the plurality of the permanent magnets having the shape of a section of a circle, arranged in parallel, side by side, along the axle of a rotor of the flat knitting machine, or radially in the circular knitting machine, separated by an air gap, with the direction of magnetic polarization parallel with the axle of the rotor and so magnetically oriented that the magnetic fluxes of the individual permanent magnets are connected to each other in series, creating a common direct current magnetic flux of the stator of all the actuators producing in every air gap a homogenous magnetic field of the same density; the rotor of the actuator consisting of a V-shaped carrier, between the arms of which is mounted a coreless type coil resembling by its form an isosceles trapeze and placed in the air gap between two permanent magnets, and of an RKN, which is mechanically supported on one arm of the carrier at a distance from the centre of rotation equal to the radius of the RKN, so that the needle axle is at the same time the axle of the rotor of the actuator; an incremental type position controller of the rotor attached to the stator of the actuator for the reading of a perforated tape attached to the edge of the rotor; a position controller for controlling the position of the actuator which is able to turn the rotor of the actuator to any position within the central angle of the RKN; and since the described actuator incorporates RKN, the incremental type position controller of the rotor and position controller, hereinafter it will be referred to as a knitting module, or in the abbreviated form KM, whereby the thickness of one KM corresponds with a needle gauge.

According to a further object of the present invention there is provided a flat knitting machine including at least one thread feeding unit, characterized in that said knitting machine comprises a plurality of KMs arranged in parallel, side by side, extending in either direction along the needle axle, and mounted on the frame of the knitting machine in such a way that every KM can have its own needle axle or several KMs can form a segment, sharing the same needle axle, all the needle axles lying thereby on the same axis and supported by the housing of KM; all the KMs are linked to the central parallel bus system of the knitting machine integrating thus all electronic nodes of the system.

According to a further object of the present invention there is provided a circular knitting machine including at least one thread feeding unit, comprising a plurality of KMs arranged radially, side by side, in a circle the diameter of which is equal to the diameter of the circular knitting machine and mounted on the frame of the machine, whereby every KM has its own needle axle supported on the housing of the KM and all the KMs are connected to the central parallel bus system of the knitting machine integrating thus all electronic nodes of the system.

A particular advantage of the described angular vibratory motion of the RKN consists in the fact that the RKN turns on a ball bearing mounted on the needle axle which now functions as a guide of the RKN in the loop forming process, whereby the resulting friction is reduced to a minimum, lubrication of the knitting machine becomes unnecessary, and a higher speed in the movement of the knitting needle is obtained with minimal abrasion. Besides ball bearings sliding bearings can be used.

It is a further object of the present invention to provide an actuator which can be used as a driving unit for several different devices in addition to knitting ma-

chines.

It is a further object of the present invention to provide an actuator, for use with numerous different devices apart from knitting machines, which is a rotary electric motor characterized in that the magnetic flux of a stator is common for all of the actuators lying on a same axis of a device or in a same plane of a circular device, the magnetic flux being produced by a plurality of permanent magnets having the shape of a section of a circle, arranged in parallel, side by side, along the axle of a rotor of a flat device, or radially in a circular device, separated by an air gap, with the direction of magnetic polarization being parallel with the axle of the rotor and so magnetically orientated that the magnetic fluxes of the individual permanent magnets are connected to each other in series, creating a common direct current magnetic flux of the stator of all of the actuators, producing in every air gap a homogenous magnetic field of the same density; the rotor of the actuator including a V-shaped carrier, between the arms of which is mounted a coreless type coil resembling by its form an isosceles trapeze and placed in the air gap between two permanent magnets.

Further, the particularly convenient form of the RKN turning member, having the shape of a simple lever and connecting the RKN to its bed on the needle axle, allows for reduction of the working motion of the RKN torque producing member, because the RKN makes only an angular movement, hence only the turning angle of the RKN is of importance, while the working motion of the RKN torque producing member depends on the distance from the force striking point on the lever arm to the centre of rotation, so that a transmission ratio can be adjusted by using a simple lever principle.

Furthermore, the RKNs offer a considerable advantage by their ability to be arranged very closely to each other on the needle axle increasing thereby the density of arrangement of RKNs per unit length of the needle axle, considering that between two RKNs there is a carrier of the needle axle, the thickness of which is not to be greater than 1/4 the thickness of the RKN and which functions as a connection between the needle axle and the machine frame, defining thereby the distance between two adjacent RKNs. Moreover, the short knitting machines provide an opportunity for mounting the needle axle at its end sides on the frame of the knitting machine by only two supporting members, so that the RKNs can be arranged side by side on the needle axle between the carriers realizing thereby the maximal density of the arrangement.

In order to produce a knitting fabric by the RKNs it is necessary to turn a plurality of RKNs around the needle axle into a knitting position, a tuck position or a welt position either by plurality of cams arranged in a carriage moving along the needle axle, or by plurality of disks for angularly moving a corresponding knitting needle, or by plurality of actuators, one for each needle, for angularly moving a corresponding knitting needle.

A significant advantage is obtained with KM, where the RKN is firmly attached to a rotor of an actuator, uniting thereby two members in one element, namely the RKN turning member and the loop forming member, the needle axle thus becoming also the axle of the rotor of the actuator whereby good dynamic characteristics of the actuator are achieved since a moment of inertia of the running mechanism is reduced to a minimum, and the thickness of one KM is not to be greater than the distance between two adjacent RKNs.

Through a special design of the stator of the KM, as described hereinbefore, it is possible to arrange a plurality of KMs in limited space. Magnetic flux of the permanent magnet of the stator of every KM, arriving from an adjacent permanent magnet, and having passed through an air gap flows into one of its sides, runs through the said permanent magnet and continues to flow through the air gap into the permanent magnet of KM on the other side of the said KM establishing thus a common magnetic flux of stator of all the KMs lying on the same line or on the same circle. In this way a sizable space is being saved, a very good use of a magnetic material is made, and a strong and homogenous magnetic field of equal density in every air gap is created, which is necessary in order to produce in the coil of the rotor torques of sufficient strength, considering that the coil of the rotor is placed in the air gap causing a turn of the RKN, and to every air gap is attached one coil and one rotor of KM, respectively. Because the rotational angle of the rotor is less than 180 degrees, the rotor is designed without a commutator and the power is supplied to the coil through a flexible cable.

A special design of the carrier of the rotor of KM, a part of which arc is perforated, allows for an easy reading of the position of the rotor through an incremental pulse emitter.

By employing the above-mentioned KMs it is very easy to assemble a flat knitting machine, since the KM comprises all the necessary elements for forming the loops, namely the loop forming member and the needle turning member, the only unit to be added to produce a knitted fabric being a thread feeding unit. The KMs are arranged in parallel, side by side and mounted on the flat base of the machine frame whereon is attached a printed circuit board with a connector for each KM connecting through a parallel bus system all the KMs to each other and with the main computer of the knitting machine. Since the flat knitting machine is built according the modular principle, the production of the knitting machine is simplified and its maintenance is made easy.

Furthermore, by employing the above-mentioned KMs, in an easy way it is possible to produce a circular knitting machine, the only difference being that the KMs are arranged radially, side by side.

DESCRIPTION OF THE DRAWINGS

The present invention will now be described with

reference to the drawings illustrating embodiments of the knitting machine.

Fig. 1 is a side view illustrating a radial knitting needle (RKN);
Fig. 2 is a perspective view illustrating one segment comprised of the RKNs;
Figs. 3(a) through 3(d) are the views illustrating a working cycle of the RKN when forming a knew knit loop in a typical knitting example;
Figs. 4(a) through 4(d) are the views illustrating a working cycle of the RKN when forming a tuck loop;
Figs. 5(a) through 5(e) are the views illustrating a working cycle of the RKN when transferring a loop;
Fig. 6 is a side view of a knitting module (KM);
Fig. 7 is a cross sectional view taken along a line A-A of the magnetic circle illustrated in Fig. 6;
Fig. 8 is a perspective view illustrating a flat knitting machine comprised of KMs according to Fig. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 1 through Figs. 5 are shown the form, the manner of moving, and the bed of the RKN in accordance with the present invention.

According to Fig. 1, three functional elements can be recognized of the RKN:

a) The stem of the RKN 2 with a loop forming member 2a and 2b,
b) The RKN turning member 3 with a butt 3a,
c) The bearing of the RKN 8

The stem of the RKN 2 has a form of an arc of a circle with a radius rn and a central angle QN at which one end there is a hook 2b and a latch 2a representing a loop forming member, whereas the other end is connected to a lever representing a turning member 3. The stem of the RKN 2 may also comprise a spring 28 for the transfer of a loop. An optimum ratio between the length of the arc representing the stem of RKN 2 and the radius is 1 : 1, resulting thus in the central angle of exactly 1 rad, so that for a stem of RKN having the length of 40 mm, being approximately the required length for the illustrated RKN, the radius of the RKN is also 40 mm.

The RKN turning member is lever 3 connecting the RKN 2 with its bearing 8 on a needle axle 6 and whereon acts a force Fn through a butt 3a causing a turn of the RKN 2 around a needle axle 6 in the direction of an arrow A or B, as the direction of the force Fn. The length of the butt 3a is approximately 1/2 of the radius of the RKN 2, so that the working motion of the RKN 2 turning member is equal to one half of the length of the stem of the RKN 2.

The bearing of the RKN 8 is impressed into the RKN turning member 3 and pulled over the needle axle 6 allowing the RKN to make turns around the needle axle 6 with minimal friction. The bearing 8 can be a miniature ball bearing the thickness of which depends on the gauge of the knitting machine and varies from 1 mm for gauge 24 to 8 mm for gauge 2.

The needle axle 6 is mounted through supporting plates 7 on a machine frame 5 and the supporting plates 7 traverse between the two RKNs 2 embracing the needle axle 6, as illustrated in Fig 2. To make the supporting plates 7 as thin as possible, the needle axle 6 is shared by as many RKNs 2 as can be placed within 1 inch, whereby the number of RKNs 2 on one axle can be greater or smaller, depending on the gauge of the knitting machine, thus the RKNs 2 arranged on one needle axle 6 represent one segment (Fig. 2).

To make possible the knitting of rib type of stich, two segments lying in the same plane are arranged opposite to each other at a distance *u* between a needle axle X1 and X2 (Fig. 2) so that tangents drawn on the circles circumscribing the RKN in a point wherein the circles intersect, make an angle of approximately 110 degrees.

One working cycle of the RKN 2 when forming a loop is illustrated in Fig. 3. Fig. 3(a) shows the RKN 2 in its starting position, so that the hook 2b is at the same height as the limiting member 39 and holding the just knitted loop 80. If the RKN 2 be turned for angle 2L around the needle axle 6 in the direction of arrow A, reaching the position shown in Fig. 3(b), then, because of the relative movement of the RKN 2 to the loop 80, the latch 2a will turn approximately 180 degrees relative to the longitudinal axis of the RKN 2 in the opposite direction of the hook 2b, opening thus the hook 2b, whereby the loop 80 is outside the radius of the latch 2a. At that moment the needle changes its moving direction beginning to turn in the direction of arrow B and reaches the position shown in Fig. 3c, at the moment when in the hook 2b a new thread 81 is being fed, the turning angle measured from the starting point being 2T. The RKN 2 continues to move in the direction of the arrow B, whereby the latch 2a will turn for approximately 180 degrees in the direction of the hook 2b as a result of the motion of the loop 80, which will now slide over the latch 2a and the hook 2b forming thereby with the already laid thread a new loop 81, as shown in Fig. 3(d).

When forming a tuck loop the RKN 2 turns for the angle 2T from the starting position shown in Fig. 4(a) to the position shown in Fig. 4(b), whereby because of the relative movement of the RKN 2 in relation to the loop 80 the latch 2a will turn for approximately 180 degrees relative to the longitudinal axis of the RKN 2 in the direction opposite to the hook 2b, opening thus the hook 2b. At that moment approaches the thread feeding unit feeding new thread 81 in the hook 2b of the RKN 2 (Fig. 4(c)), upon which the RKN 2 changes its moving direction and begins to turn in the direction of arrow B, arriving to the position shown in Fig.4(d), whereby the previous loop80 and the new loop81 are being held by the hook 2b of the RKN 2.

When transferring a loop, as shown in Fig. 5(a), the delivering and the receiving RKNs 2 are in the starting

position holding the corresponding just knitted loops 80 and 82. Then the delivering RKN 2 turns for the angle 2TR in the direction of arrow A around the needle axle 6 arriving into position shown in Fig. 5(b), whereby the loop 80 slides over the stem of RKN 2 entering in the area of a transferring spring. In that moment the receiving RKN 2 begins to turn for the angle 2TK in the direction of the arrow A, so that the hook 2b of the receiving RKN 2 passes through a gap of the delivering RKN 2 and through the delivering loop 80 respectively, as shown in Fig. 5(c). Upon that the delivering RKN 2 turns in the direction of arrow B toward the starting position, whereby the delivering loop 82 slides from the delivering RKN 2 passing entirely over into the receiving RKN (Fig. 5(d)). Then the receiving RKN 2 retracts into its starting position shown in Fig.5(e), where the delivering loop 82 is found in the hook 2b of the receiving RKN 2.

In Figs. 6 through 8 is shown the preferred embodiment of the knitting module (KM) 1, which integrates an actuator 9 as the driving element for turning the RKN 2 and also the RKN 2 itself, being integrated into the KM 1.

In Fig. 6 is shown the KM 1 comprising the following components:

a) Actuator 9
b) RKN 2
c) Position controlling apparatus 4

Subsequently, each component of the KM 1 will be described in more detail.

a) Actuator

The actuator 9, as illustrated in Fig. 6, is a direct current electric motor with permanent magnets 36a and 36b supported on the stator of KM 30 and a movable coreless type coil 42 attached to the rotor 40, which rotor 40 is without a commutator because the rotational angle of the rotor 40 is less than 180 degrees.

The distance between two adjacent KMs 1 corresponds to the gauge of a knitting machine, which is defined by the number of knitting needles per inch, thus in a knitting machine having gauge 14 it is necessary to arrange 14 KMs 1 per inch, and consequently one KM 1 would have a thickness of 1.81 mm. Since the walls of the stator 30 and the rotor 40 of KM 1 are very thin and together cannot exceed 1.81 mm for the knitting machine of the said gauge, the magnetic circuit of stator 30, created by the permanent magnets 36a and 36b, is not closed in each KM 1 individually but it is common for all the KMs 1 lying along the same axis X1, as shown in Fig. 7. Direction of the magnetic polarization of the permanent magnet 36a is facing with its south pole the coil 42, whereas the permanent magnet 36b is facing the coil 42 with its north pole, thus the magnetic flux F_{PM} runs from the far left plate 101 through the permanent magnets 36b of the KM 1-1, then through the air gap rair of KM 1-1 to the permanent magnets 36b of KM 1-2 and so continues to the far right plate 10r which closes the magnetic flux F_{PM} between permanent magnets 36b and 36a at the far right KM 1-n, and then it runs through the permanent magnets 36a back to the far left plate 101 which closes the magnetic flux F_{PM} between the permanent magnets 36a and 36b at the far left KM 1-1, which was the starting point of the described magnetic flux F_{PM}. The ratio of thickness of the permanent magnet r_{mag} to the width of the air gap rair is approximately 60% to 40%, which means that for the knitting machine having gauge 14 the thickness of the permanent magnet is r_{mag}= 1.1 mm and the air gap should be r_{air}=0.7 mm. In an air gap of this kind it is possible, without difficulty, to produce magnetic induction of the magnitude of about 0,5T by using Nd-FeB permanent magnet.

Permanent magnets 36a and 36b by their shape represent a section of a circle where:

Ro: external radius
ri: internal radius
r_m: central radius
A: central angle of the permanent magnet

Permanent magnets 36a and 36b are impressed in the body of the stator 30, which is made of nonmagnetic material.

In a homogenous magnetic field ϕS with the air gap r_{air} wherein exists a magnetic flux density Bs there are coils 42a and 42b which have the shape of an isosceles trapeze mounted on the carriers 40a and 40b. That the rotor 40 could turn between the permanent magnets 36a and 36b, the width of the air gap r_{air} is 5% greater than the thickness b_a of the carriers 40a and 40b, whereas the thickness b_c of the coils 42a and 42b is 5% smaller than the thickness b_a of the carriers 40a and 40b so that the coils 42a and 42b are safely protected from undesired mechanical contact with the permanent magnets 36a and 36b(Fig. 7).

If through the coils 42a and 42b consisting of N turns, the current Ic runs in the direction shown in Fig. 7, that current Ic being supplied from the position controlling apparatus 4 through a flexible cable 101, then the coil produced magnetic field ϕS will work upon the coils 42a and 42b by a force *Fc,* resulting in a torque Mr on the lever arm r_m which will affect the RKN 2 in accordance with the well known formula:

$$Mr = 2BlINrm$$

where

B: Magnetic induction in the air gap rair originat-

ing from the magnetic flux Fs
I: Current in coils 42a and 42b
l: Length of coil affected by the magnetic field of the permanent magnets 36a and 36b
N: Number of turns of the coils 42a and 42b
rm: Central radius of the permanent magnet

In order that the position controlling apparatus 4 could position and control the motion of the rotor 40, information about the actual position of the rotor is provided by an incremental controller (Fig. 6), comprising two optocouplers 91 and 92, attached to the stator 30 and thus, through the obtained signals, making it possible to recognize the rotational direction of the rotor 40. The controller reads from a perforated tape 95 which extends between two arms of the rotor 40a and 40b. Module of the perforated tape is M = 0.12 so that is possible to read off a shift of the rotor 40 with a radius rn of 0.1 mm.

b) RKN

RKN 2 has a form as described in Fig. 1 whereby the function of a turning member and of a bearing assumes the rotor 40, since the RKN 2 is through a pin 48 supported to the rotor 40. In order to prevent bending of the RKN 2 at its open end in the area of the loop forming member 2a and 2b, the stem of the RKN 2 leans against a limiting member 39 which is an extension of the stator 30 of KM (Fig. 6). Against the tip of the limiting member 39 also leans the loop 80 when forming a new loop 81 (Fig. 3).

c) Position Controlling Apparatus

Position controlling apparatus 4 (hereinafter, referred to in abbreviated form as PCA) has a function to control and regulate the position of the rotor 40 in the loop forming process and comprises a microcontroller that is through a bus system connected with a main computer 100, operating as a host computer, from which it receives the information about a form of turning to be executed within the given parameters of [for] the turning angles, so that the PCA 4 is capable of turning independently the rotor 40 in accordance with the given position. Information about the actual position of the rotor 40 the PCA 4 receives from the incremental pulse emitter. Power supply and the link with the main computer 100 are realized through a connector 105.

In Fig. 8 is shown a flat knitting machine for knitting of rib knitted fabrics, which is comprised of KM 1_{-1}, 1_{-2}, 1_{-3}, .., 1_{-n} being arranged in parallel side by side along an [the] axis X1 and X2, respectively, and mechanically attached to a machine frame 5 supported at its ends 5c and 5d by two legs 60 and 60', a running device 70 mounted on a supporting rail 85 having at least one thread feeding unit 84 and reciprocally moving along the machine frame 5 feeding a thread 83 to the RKN 2, and a host computer 100 which controls the knitting process synchronizing operation of the KMs 1_{-1}, 1_{-2}, 1_{-3},.., 1_{-n} and of the running device 70. At the ends of the axes X1 and X2 are attached the limiting side frames 10l and 10r whereby is defined the length of the working area and through which is being closed the magnetic flux of the permanent magnets 36a and 36b. The KMs 1 are grouped in segments the width of which corresponds with the width of one holding member 51 whereby the KMs are supported on the machine frame 5. All the KMs 1 of one segment have the needle axle 6 in common.

All the KMs 1-1, 1-2, 1-3,.., 1-n are connected through a parallel bus-system with each other and with the main computer 100. Bus system is built as a printed circuit board having connectors for every KMs 1 making thus each KMs 1 easily replaceable. Besides the parallel bus system it is possible also to employ a serial bus system whereby a speed for transfer of data is [being] reduced.

Claims

1. A knitting machine comprising a plurality of knitting needles (2) which have a curved profile, each knitting needle being connected with a needle axle (6) mounted to the machine frame (5), allowing each one of the said knitting needles an angular motion in a plane perpendicular to the said needle axle, and at least one thread feeding unit (84), characterized in that to every said knitting needle is associated one actuator (9) which can produce an independent angular motion of the said knitting needle.

2. A knitting machine according to claim 1, characterized in that said knitting needle (2) is firmly-attached to a rotor (40) of an actuator (9), thus the needle axle (6) being at the same time the axle of the rotor of the actuator.

3. A knitting machine according to claims 1 and 2, characterized in that said actuators (9) are rotary direct current motors having a common magnetic flux (F_{PM}) of the stator (30) of all the actuators, which derives from a plurality of permanent magnets (36a,36b) having the shape of a section of a circle, arranged in parallel side by side along the axle of the rotor (6) and separated by an air gap (r_{air}), whereby the number of the air gaps corresponds to the number of the said knitting needles in the machine, with the direction of the magnetic polarization parallel with the axle of the rotor (6), and so magnetically oriented as to connect in series the magnetic fluxes of the individual permanent magnets creating thereby a common direct magnetic flux (F_{PM}) of the stator (30), which in every air gap produces a homogenous magnetic field (>>>) of

equal density, whereby each air gap is provided with one coil (42a,42b) of the corresponding actuator.

4. A knitting machine according to claims 1 through 3, characterized in that said rotor (40) of the actuator is comprised of a V-shaped carrier (40a,40b) attached to a ball bearing on the needle axle (8), whereby the thickness of the carrier is smaller than the width of the air gap (r_{air}) between the permanent magnets (36a,36b), and made out of a non-magnetic material, the ends of which are connected by an arc of a section of a circle; the said knitting needle which is mechanically, firmly attached to said carrier; and of a coreless type coil (42a,42b), whereby the external contours of the coil precisely correspond to the internal contours of said carrier (40a, 40b), securing thus the said coil between the internal walls of the carrier.

5. A knitting machine according to claims 1 through 4, characterized in that a rotor (40) of the actuator (9) is designed without a commutator because the rotational angle of the rotor is less than 180 degrees, whereby said coil (42a,42b) of the rotor is connected through a flexible cable with a power supply.

6. A knitting machine according to claims 2 through 5, characterized in that a pulse controller is of an incremental type which reads the perforated tape (95) on the edge of the rotor (40).

7. A knitting machine according to claims 1 through 6, characterized in that to every actuator (9) is associated one position controlling apparatus (4), each of them capable of independently turning the rotor (40) of the actuator (9) to any position in accordance with the information received from the main computer (100).

8. A knitting machine according to claim 7, characterized in that, said knitting needle (2), said actuator (9), said position controlling apparatus (4), and said incremental control are mounted on the machine frame (5) made of nonmagnetic material forming one knitting module (1), (in abbreviated form (KM), the thickness of which is equal to a quotient of one inch divided by the number of the said knitting needles of that length, whereby each KM (1-1 1-2, 1-3,...1-n) can have its own needle axle or several KMs can share the same needle axle.

9. A flat knitting machine according to claims 1 through 8, characterized in that the KMS (1) are arranged in parallel, side by side extended in either direction along the needle axle (6) and mounted on the machine frame (5), whereby each KM can have its own axle or several KMs can share the same axle thus forming one segment.

10. A circular knitting machine according to claims 1 through 9, characterized in that the KMs (1) are arranged radially side by side on a circle, the diameter of which is equal to a diameter of the circular knitting machine and mounted on the machine frame (5), whereby each KM has its own needle axle (6) which is supported on the housing of the KM.

11. A knitting machine according to claims 1 through 10, characterized in that on the machine frame (5) carrying the KMs (1) is attached a printed circuit board extending along the KMs and integrating addresses, data and control-bus of the main computer with a bus of the same name of each and every KM and also the KMs with each other, providing power supply for each KM, whereby the KMs are through a connector linked to the printed circuit board.

Patentansprüche

1. Strickmaschine mit mehreren Stricknadeln (2), welche ein gekrümmtes Profil aufweisen, wobei jede Stricknadel mit einer an dem Maschinengestell (5) montierten Nadelachse (6) verbunden ist und jeder Stricknadel eine Winkelbewegung in einer Ebene senkrecht zur Nadelachse ermöglicht wird, und mindestens einer Fadenzufuhreinheit (84), dadurch gekennzeichnet, daß jeder Stricknadel ein Betätigungsglied (9) zugeordnet ist, welches eine unabhängige Winkelbewegung der Stricknadel erzeugen kann.

2. Strickmaschine nach Anspruch 1, dadurch gekennzeichnet, daß die Stricknadel (2) fest an einem Rotor (40) eines Betätigungsglieds (9) befestigt ist, so daß die Nadelachse (6) gleichzeitig die Achse des Rotors des Betätigungsglieds ist.

3. Strickmaschine nach den Ansprüchen 1 und 2, dadurch gekennzeichnet, daß die Betätigungsglieder (9) Dreh-Gleichstrommotoren mit einem gemeinsamen magnetischen Fluß (F_{PM}) des Stators (30) aller Betätigungsglieder sind, welcher von mehreren Permanentmagneten (36a,36b) stammt, welche die Form eines Kreissektors haben, parallel Seite an Seite entlang der Achse des Rotors (6) angeordnet sind, und durch einen Luftspalt (r_{Luft}) getrennt sind, wobei die Anzahl der Luftspalten der Anzahl der Stricknadeln in der Maschine entspricht, und wobei die Richtung der magnetischen Polarisierung parallel zu der Achse des Rotors (6) und derart magnetisch gerichtet ist, daß die magnetischen Flüsse der einzelnen Permanentmagneten in Reihe verbunden werden, wobei ein gemeinsam-gerichteter magnetischer Fluß (F_{PM}) des Stators (30) erzeugt wird, welcher in jedem Luftspalt ein homogenes Magnetfeld (>>>) gleicher Dichte hervorruft, wobei jeder

Luftspalt eine Wicklung (42a,42b) des entsprechenden Betätigungsglieds aufweist.

4. Strickmaschine nach den Ansprüchen 1 bis 3, dadurch gekennzeichnet, daß der Rotor (40) des Betätigungsglieds aufweist: einen V-förmigen Träger (40a,40b), welcher an einem Kugellager an der Nadelachse (8) befestigt ist, wobei die Dicke des Trägers kleiner ist als die Breite des Luftspalts (r_{Luft}) zwischen den Permanentmagneten (36a,36b), und welcher aus nichtmagnetischem Material hergestellt ist, wobei seine Enden durch einen Kreissektorbogen verbunden sind; die Stricknadel, welche mechanisch fest mit dem Träger verbunden ist; und eine kernlose Wicklung (42a,42b), wobei der äußere Umriß der Wicklung genau dem inneren Umriß des Trägers (40a,40b) entspricht, so daß die Wicklung zwischen den inneren Wandungen des Trägers gehalten wird.

5. Strickmaschine nach den Ansprüchen 1 bis 4, dadurch gekennzeichnet, daß ein Rotor (40) des Betätigungsglieds (9) ohne Kommutator ausgestaltet ist, weil der Drehwinkel des Rotors kleiner als 180° ist, wobei die Wicklung (42a,42b) des Rotors über ein flexibles Kabel mit einer Energieversorgung verbunden ist.

6. Strickmaschine nach den Ansprüchen 2 bis 5, gekennzeichnet durch eine Inkremental-Pulssteuerung, welche das perforierte Band (95) am Rand des Rotors (40) liest.

7. Strickmaschine nach den Ansprüchen 1 bis 6, dadurch gekennzeichnet, daß jedem Betätigungsglied (9) eine Positionssteuerungsvorrichtung (4) zugeordnet ist, welche jeweils entsprechend der von dem Hauptrechner (100) empfangenen Information unabhängig den Rotor (40) des Betätigungsglieds (9) in eine beliebige Position drehen kann.

8. Strickmaschine nach Anspruch 7, dadurch gekennzeichnet, daß die Stricknadel (2), das Betätigungsglied (9), die Positionssteuerungsvorrichtung (4) und die Inkremental-Steuerung am aus nichtmagnetischem Material hergestellten Maschinengestell (5) angeordnet sind, wobei ein Strickmodul (1) (abgekürzt KM) ausgebildet wird, dessen Dicke gleich einem Quotienten aus einem Inch geteilt durch die Anzahl der Stricknadeln auf dieser Länge ist, wobei jedes KM (1-1, 1-2, 1-3, ... 1-n) seine eigene Nadelachse aufweisen kann, oder sich mehrere KMs die gleiche Nadelachse teilen können.

9. Flachstrickmaschine nach den Ansprüchen 1 bis 8, dadurch gekennzeichnet, daß die KMs (1) parallel, sich Seite an Seite in beide Richtungen entlang der Nadelachse (6) erstreckend angeordnet, und an dem Maschinengestell (5) montiert sind, wobei jedes KM seine eigene Achse aufweisen kann, oder sich mehrere KMs die gleiche Achse teilen können, wodurch ein Segment gebildet wird.

10. Rundstrickmaschine nach den Ansprüchen 1 bis 9, dadurch gekennzeichnet, daß die KMs (1) radial Seite an Seite an einem Kreis angeordnet sind, dessen Durchmesser gleich dem Durchmesser der Rundstrickmaschine ist, und an dem Maschinengestell (5) montiert sind, wobei jedes KM seine eigene Nadelachse (6) aufweist, welche vom Gehäuse des KMs getragen wird.

11. Strickmaschine nach den Ansprüchen 1 bis 10, dadurch gekennzeichnet, daß an dem Maschinengestell (5), welches die KMs (1) trägt, eine gedruckte Schaltungsplatine befestigt ist, welche sich entlang der KMs erstreckt und einen Adressen-, Daten- und Steuerbus des Hauptcomputers mit einem gleichnamigen Bus von jedem KM, und außerdem die KMs untereinander verbindet, wobei für jedes KM eine Energieversorgung zur Verfügung gestellt wird, und wobei die KMs durch eine Steckverbindung an der gedruckten Schaltungsplatine angeschlossen sind.

Revendications

1. Machine à tricoter comprenant une pluralité d'aiguilles (2) qui ont un profil courbe, chaque aiguille étant reliée à un axe d'aiguille (6) monté sur le bâti (5) de la machine, en permettant à chacune desdites aiguilles de décrire un mouvement angulaire dans un plan perpendiculaire audit axe d'aiguille, et au moins une unité (84) d'alimentation en fil, caractérisé en ce qu'à chacune desdites aiguilles est associée à un actionneur (9) qui peut produire un mouvement angulaire indépendant de ladite aiguille.

2. Machine à tricoter selon la revendication 1, caractérisé en ce que ladite aiguille (2) est fixée rigidement à un rotor (40) d'un actionneur (9), l'axe d'aiguille (6) étant ainsi en même temps l'axe du rotor de l'actionneur.

3. Machine à tricoter selon les revendications 1 et 2, caractérisée en ce que lesdits actionneurs (9) sont des moteurs rotatifs à courant continu ayant un flux magnétique commun (F_{PM}) du stator (30) de tous les actionneurs, qui est issu d'une pluralité d'aimants permanents (36a, 36b] ayant la forme d'un secteur de cercle, disposés parallèlement, côte à côte, le long de l'axe du rotor (6) et séparés par un entrefer (rair), le nombre des entrefers corres-

pondant au nombre desdites aiguilles de la machine, la direction de la polarisation magnétique étant parallèle à l'axe du rotor (6) et orientée magnétiquement de manière à accoupler en série les flux magnétiques des aimants permanents individuels en créant de cette façon un flux magnétique continu commun (F_{PM}) du stator (30) qui, dans chaque entrefer, produit un champ magnétique homogène (>>>) d'égale densité, chaque entrefer étant muni d'une bobine (42a, 42b) de l'actionneur correspondant.

4. Machine à tricoter selon les revendications 1 à 3, caractérisée en ce que ledit rotor (40) de l'actionneur est composé d'un support (40a, 40b) en forme de V fixé à un roulement à billes monté sur l'axe d'aiguille (8), support dont l'épaisseur est inférieure à l'épaisseur de l'entrefer (rair) entre les aimants permanents (36a, 36b) et qui est fait d'une matière non magnétique, les extrémités de ce support étant reliées par un arc d'un secteur de cercle ; ladite aiguille qui est fixée mécaniquement, rigidement audit support ; et d'une bobine (42a, 42b), du type sans noyau, les contours extérieurs de la bobine correspondant précisément aux contours intérieurs dudit support (40a, 40b) en fixant ainsi ladite bobine entre les parois intérieures du support.

5. Machine à tricoter selon les revendications 1 à 4, caractérisée en ce qu'un rotor (40) de l'actionneur (9) est construit sans collecteur parce que l'angle de rotation du rotor est inférieur à 180°, de sorte que ladite bobine (42a, 42b) du rotor est connectée à une source d'alimentation par un câble souple.

6. Machine à tricoter selon les revendications 2 à 5, caractérisée en ce qu'un contrôleur d'impulsions est d'un type incrémentel qui lit la bande perforée (95) prévue sur le bord du rotor (40).

7. Machine à tricoter selon les revendications 1 à 6, caractérisée en ce qu'à chaque actionneur (9) est associé un appareil (4) de commande de position, chacun de ces appareils étant capable de faire tourner indépendamment le rotor (40) de l'actionneur (9) pour le placer dans une position quelconque en fonction de l'information reçue en provenance de l'ordinateur principal (100).

8. Machine à tricoter selon la revendication 7, caractérisée en ce que ladite aiguille (2), ledit actionneur (9), ledit appareil de commande de position (4) et ladite commande incrémentielle sont montés sur le bâti (5) de la machine, fait d'une matière non magnétique, en formant ainsi un module de tricotage (1), (en abrégé (KM)), dont l'épaisseur est égale au quotient de 1 pouce divisé par le nombre desdites aiguilles de cette longueur, de sorte que chaque KN (1-1, 1-2, 1-3, ..., 1-n) peut avoir son propre axe d'aiguille ou que plusieurs KN peuvent partager le même axe d'aiguille.

9. Machine à tricoter rectiligne selon les revendications 1 à 8, caractérisée en ce que les KM (1) sont agencés en parallèle, côte à côte, s'étendant dans les deux sens le long de l'axe d'aiguille (6) et montés sur le bâti (5) de la machine, chaque KM pouvant avoir son propre axe ou plusieurs KM pouvant partager le même axe en formant ainsi un segment.

10. Machine à tricoter circulaire selon les revendications 1 à 9, caractérisée en ce que les KM (1) sont disposés radialement côte à côte sur un cercle dont le diamètre est égal au diamètre de la machine à tricoter, et sont montés sur le bâti (5) de la machine, chaque KM possédant son propre axe d'aiguille (6) qui est monté sur le corps du KM.

11. Machine à tricoter selon les revendications 1 à 10, caractérisé en ce que, sur le bâti (5) de la machine qui porte les KM (1), est fixée une carte de circuit imprimé qui s'étend le long des KM et qui intègre des bus d'adresses, de données et de commande de l'ordinateur principal, dont un bus de même nom pour chaque KM, et qui intègre aussi les KM les uns avec les autres, en apportant ainsi une alimentation pour chaque KM, les KM étant connectés à la carte de circuit imprimé par un connecteur.

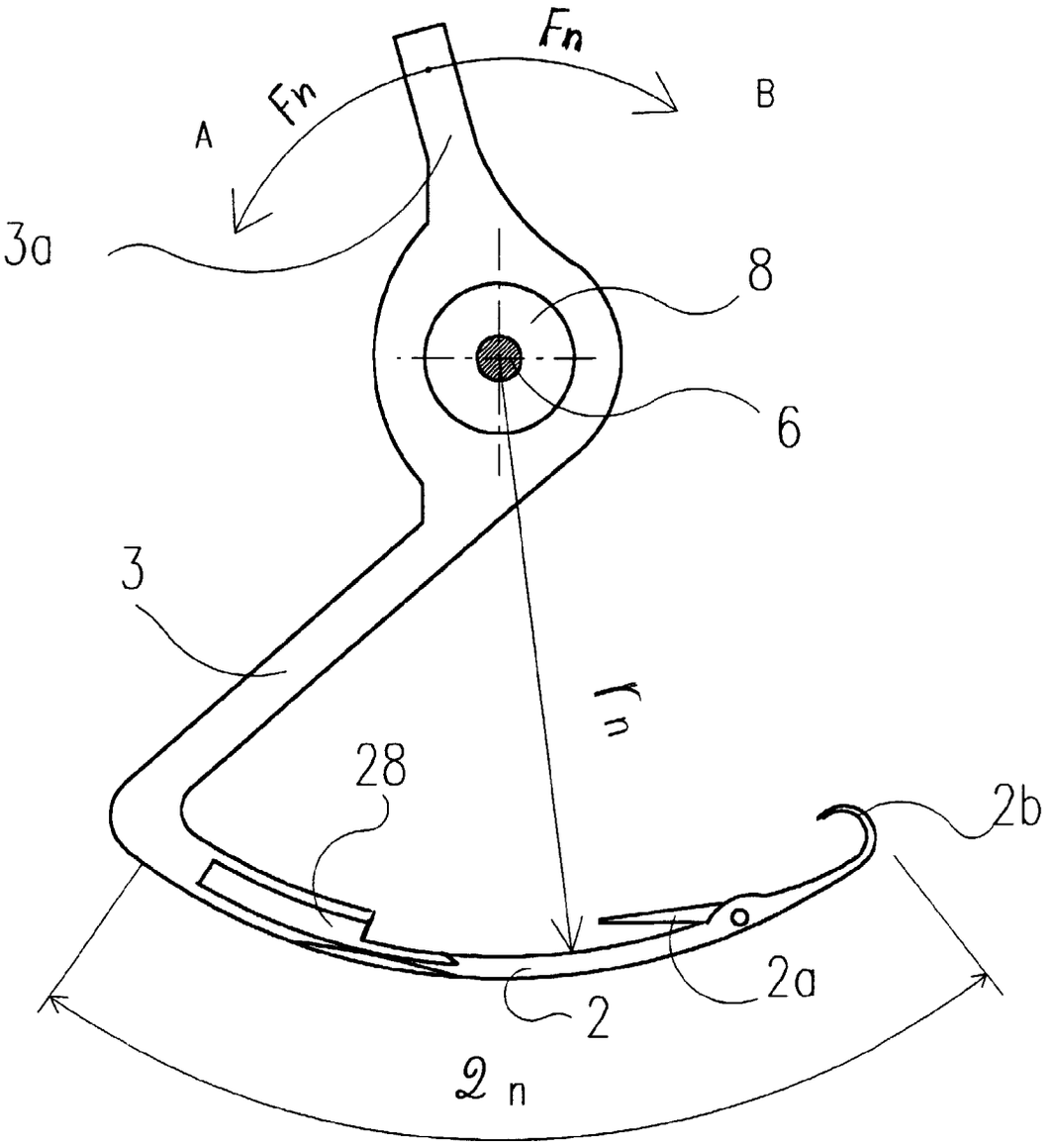


Fig.1

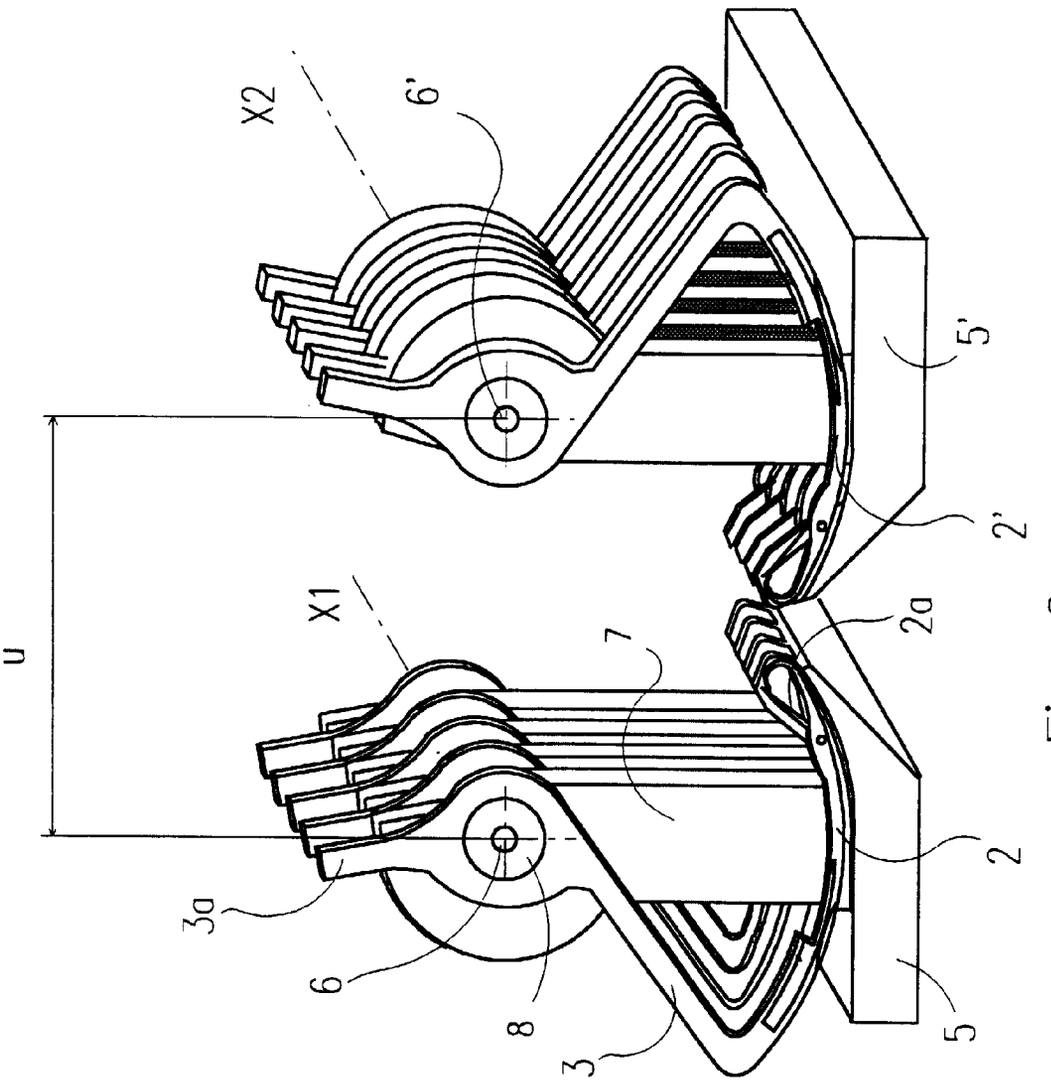


Fig. 2

Fig. 3

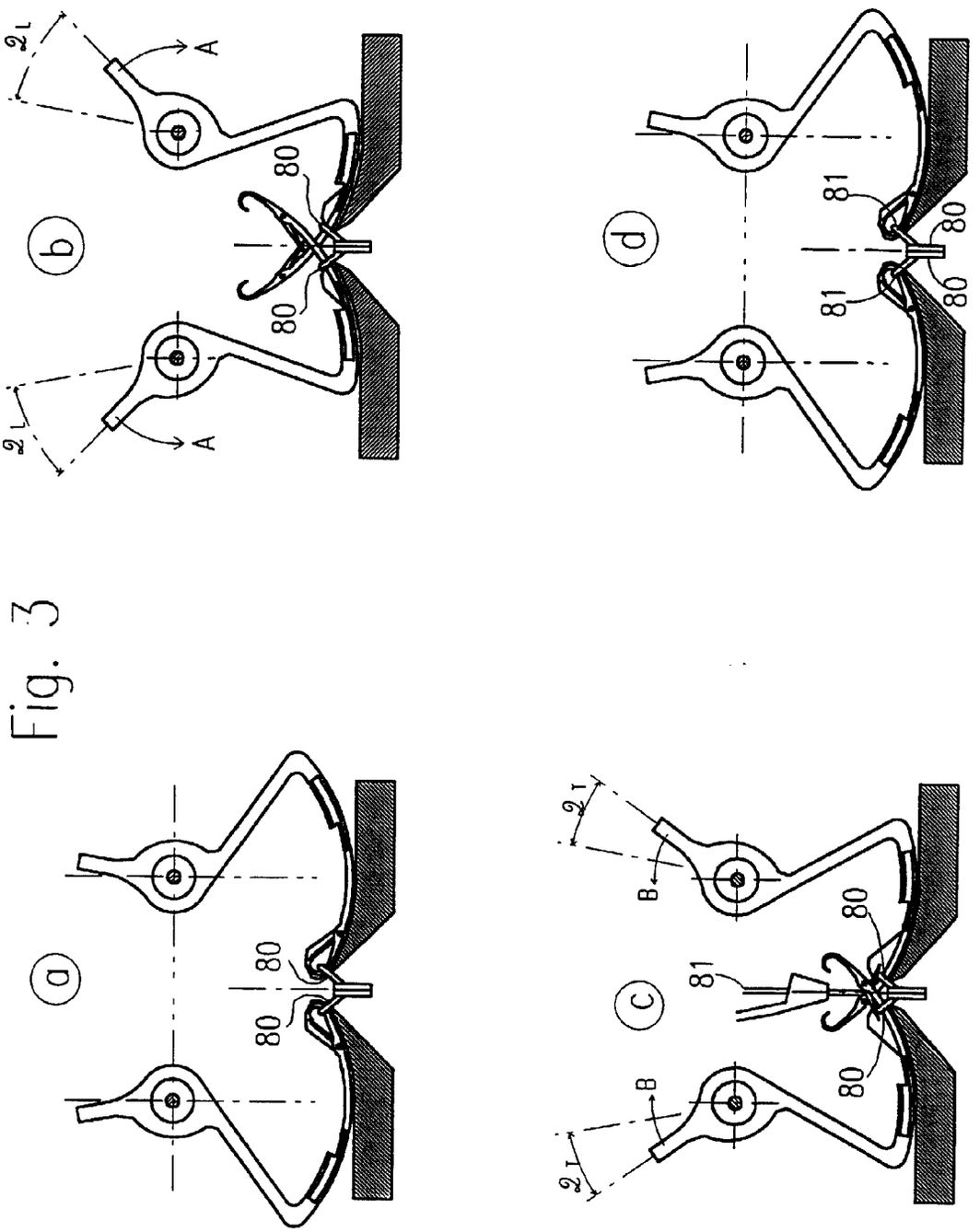
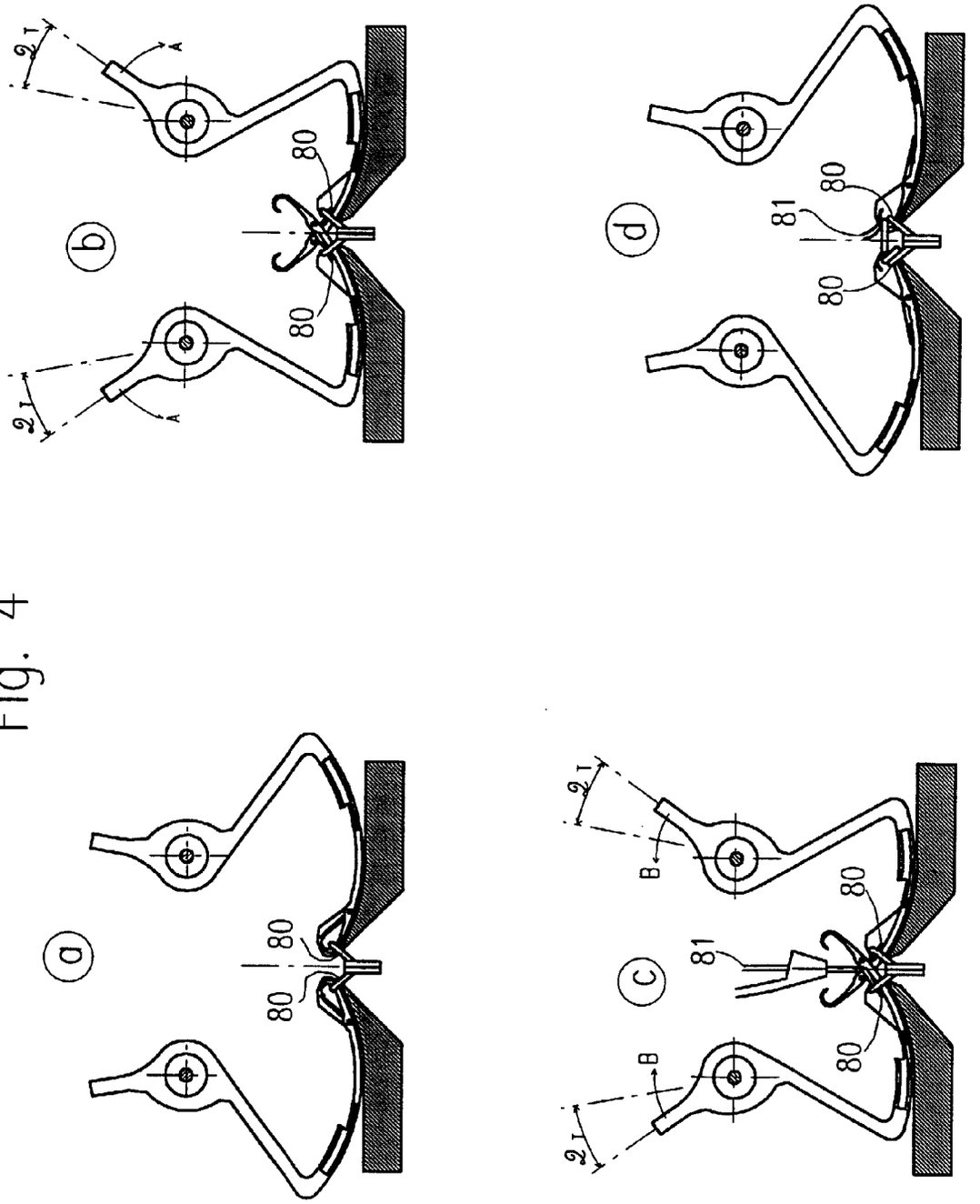


Fig. 4



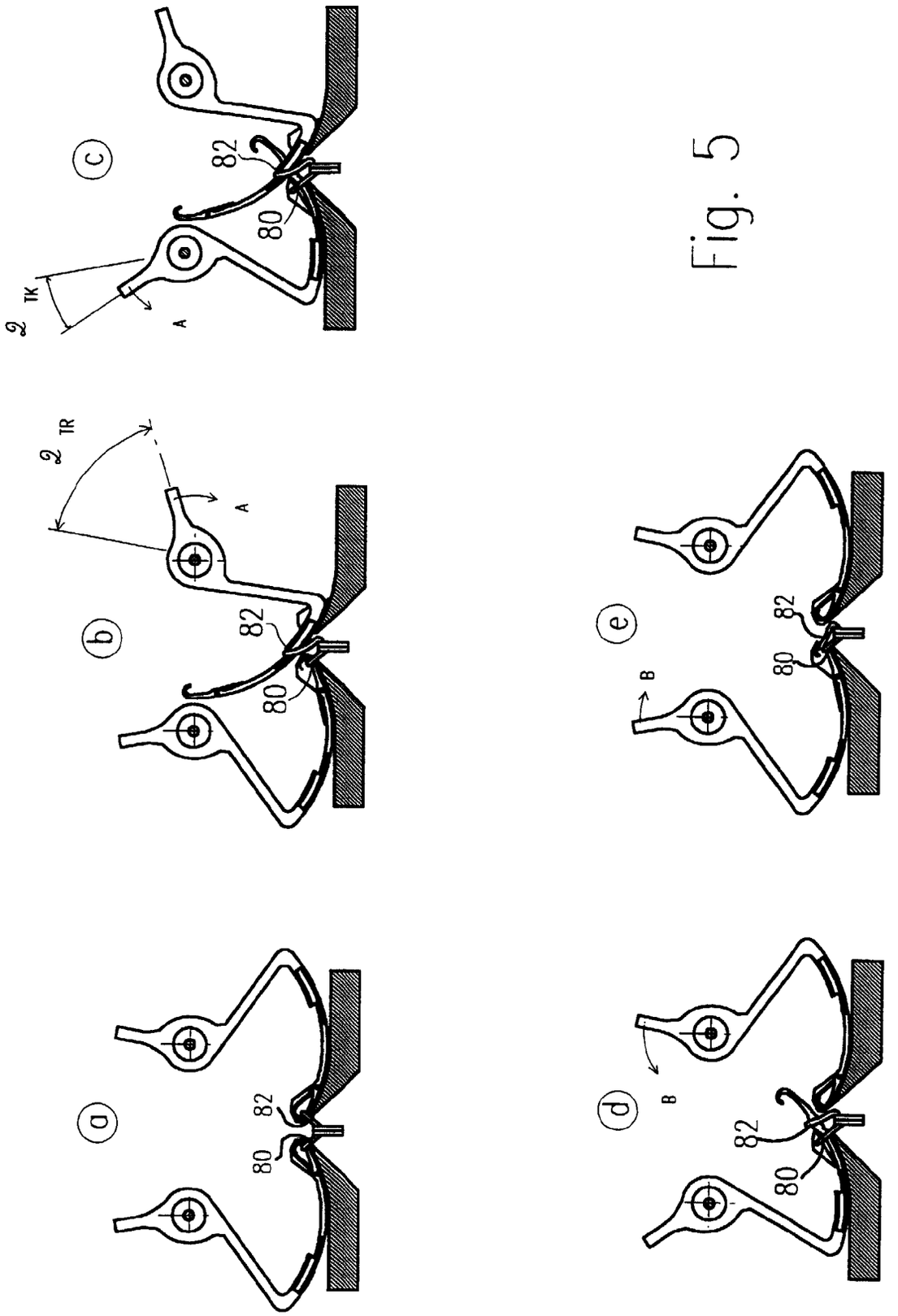
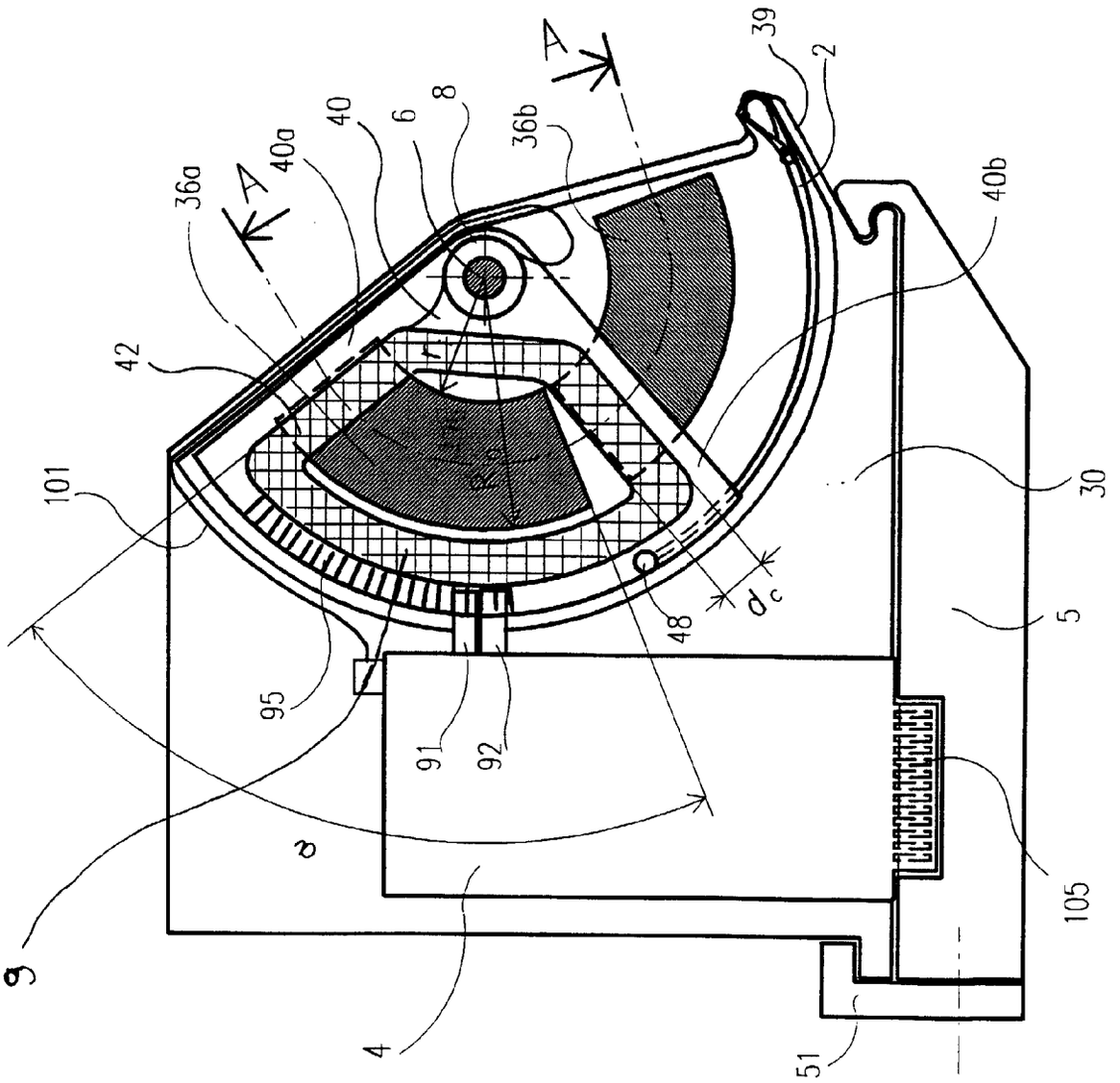


Fig. 5

Fig. 6



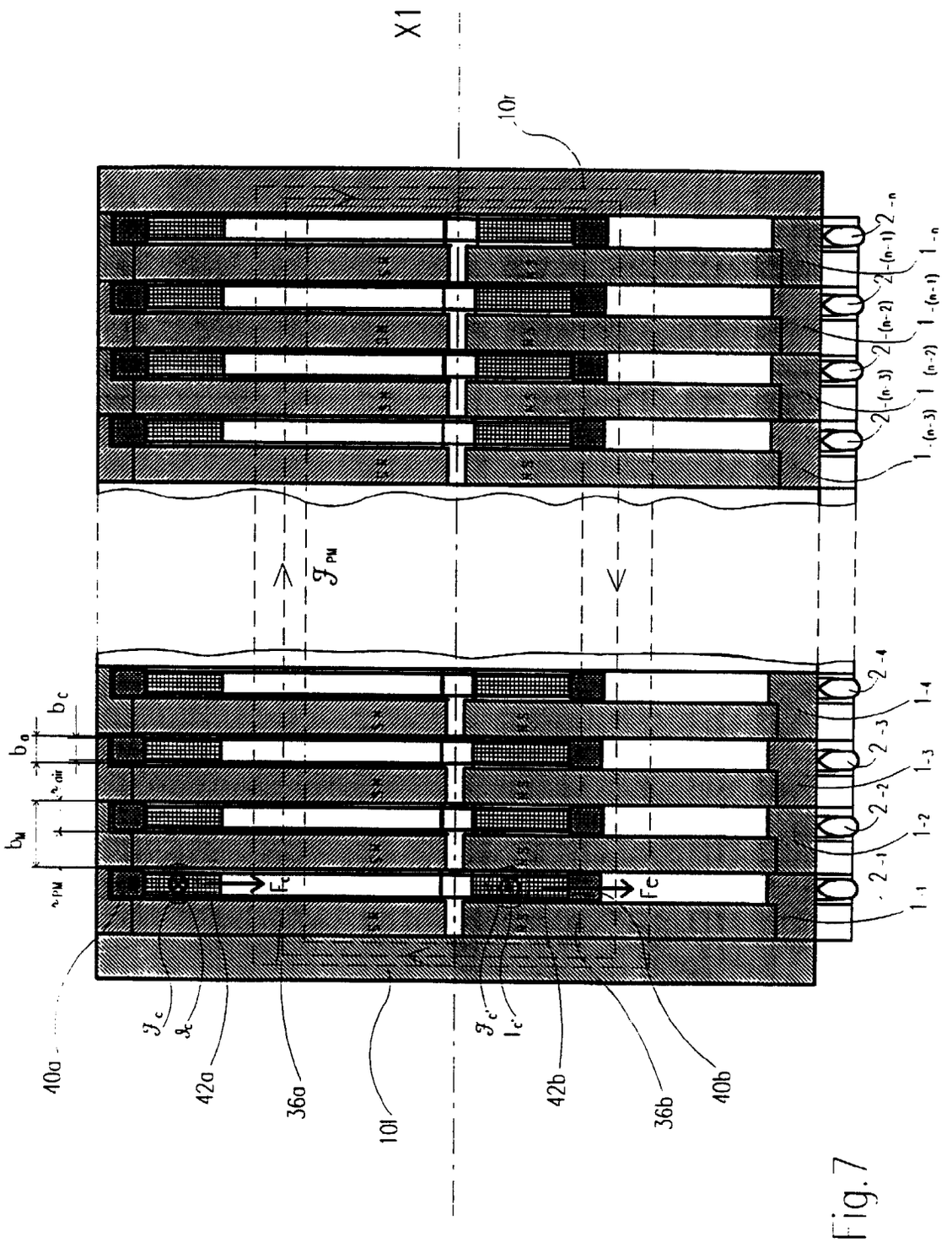

X1
10r
10l
40a
40b
42a
42b
36a
36b
$\mathcal{J}_{PM}$
F_c
b_c
b_a
b_M
τ_{PM}
τ_{air}
$\mathcal{J}_c$
$\mathcal{J}_{c'}$
I_c
$I_{c'}$
1-1
1-2
1-3
1-4
1-(n-3)
1-(n-2)
1-(n-1)
1-n
2-1
2-2
2-3
2-4
2-(n-3)
2-(n-2)
2-(n-1)
2-n

Fig. 7

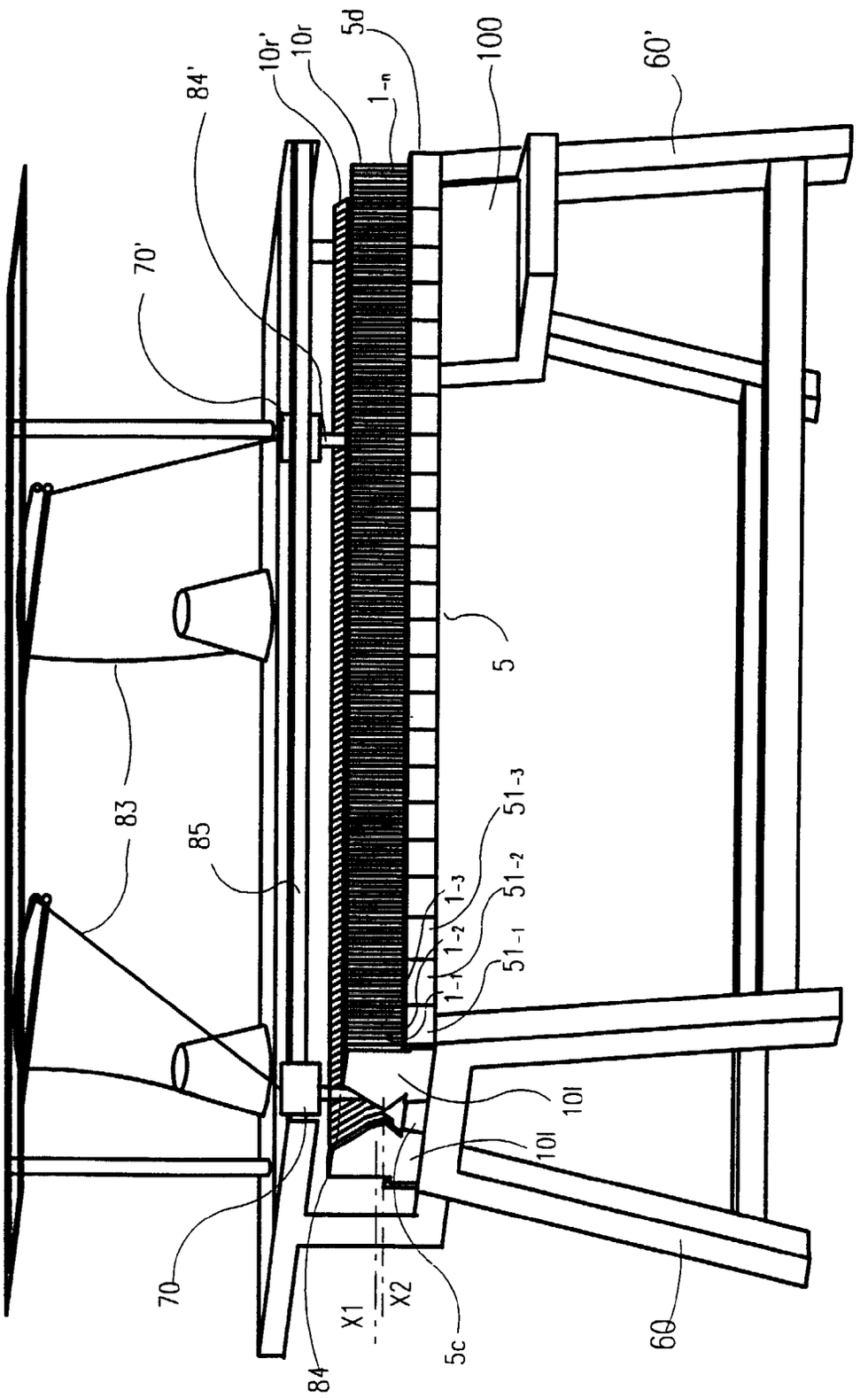

84'
10r'
10r
5d
1-n
100
60'
70'
5
83
85
51-3
51-2
1-3
1-2
51-1
1-1
10l
10l
70
X1
X2
5c
84
60

Fig.8