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(54) PRODUCTION METHOD OF SYNTHETIC FIBER AND YARN TRAVERSE DEVICE

(57) In the process of drawing/heat treating synthetic fiber thread melted and spun via a plurality of godet rollers and subsequently winding the same, accumulation of extraneous matter on the surface of the godet rollers may be prevented by performing multistage drawing/heat treatment while reciprocating the thread in the direction of the axis of rotation of the godet roller using the godet rollers at least two of which have surfaces having the roughness of $0.5 \leq Ra \leq 5$ and one of which has a surface at a temperature of at least (melting point of synthetic fiber - 70°C), whereby occurrence of thread breakage or generation of fuzz may be prevented and synthetic fiber whereof the rate of operation can be increased and efficiency of manufacture is improved may be obtained.

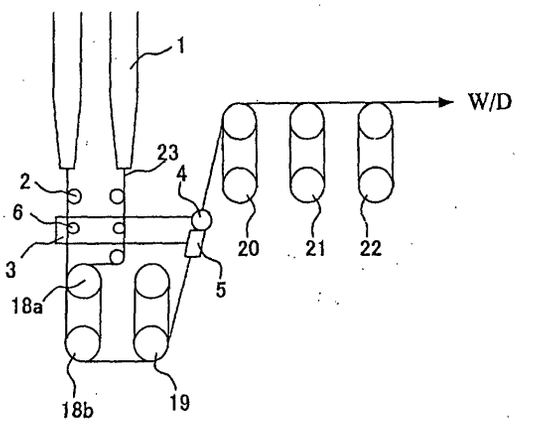

Fig. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] In the manufacture of synthetic fiber, especially, of industrial fiber formed by drawing/heat treatment of undrawn thread by the use of a plurality of godet roller groups, the present invention relates to a method of manufacturing high-strength synthetic fiber for maintaining drawing/heat treatment of synthetic fiber stable for a long term by resolving problems such as thread breakage or generation of fuzz to avoid accumulation of extraneous matters on the surface of high-temperature godet rollers, for increasing the rate of operation by reducing the number of times the machine have to be stopped for removing extraneous matters from the godet rollers , and for improving productive efficiency by reducing abrasion of the surface of the godet roller, and a thread traversing device to be used directly in the same method.

2. Description of the Related Art

[0002] In the manufacture of synthetic fiber as typified by polyamide or polyester, among others, of industrial synthetic fiber, it is required to achieve high strength by heat drawing undrawn thread under large magnification and high tensile stress generally by the use of a plurality of godet roller groups. Therefore, at least one of a plurality of godet roller groups have to be set to high temperature in order to heat setting the thread drawn into a high magnification. This drawing/heat treatment process of undrawn thread been suffering from such phenomenon that attachment and accumulation of extraneous matters dropped from the traveling thread on the surface of the godet rollers with time causes abnormal states of drawing, which has a serious impact on the quality/appearance and productive efficiency of fiber obtained.

[0003] The abnormal states of drawing here include winding of traveling thread on the godet roller, generation of fuzz due to breakage of a filament of the thread, and breakage of the thread itself due to increase in surface frictional force caused by the external matters attached and accumulated on the surface of the godet roller.

[0004] There is recognized an unfavorable phenomena that the extraneous matters attached and accumulated on the godet roller set at a high temperature near the melting point of polymer block heat transmission between the godet roller and the thread, which results in insufficient heat treatment of the thread, and thus variations in quality/appearance of the obtained drawn thread with time. Since stain on the surface of the godet roller that is set to a high temperature may occur in relatively a short time, and may cause the abnormal states of drawing as described above, the process of cutting the thread compulsory regularly or every time the abnormal states are detected, and stopping the operation of the drawing machine to remove the extraneous matters on the godet roller is made frequently. Therefore, the problem of lowering of the productive efficiency and of appearance of the product has been in the news.

[0005] The conceivable accumulated deposits on the godet roller include anchored matter generated mainly from spinning oil applied on the thread being transformed by heat on the drawing/heat treatment. roller, oligomers separated out of the thread and those heat-transformed matters, and silica contained in water.

[0006] The following related arts are disclosed as methods of avoiding and removing abnormal drawing due to accumulated deposits as described above.

[0007] For example, in Japanese Patent Laid-Open No.78364/1997 and Japanese Patent Laid-Open No. 187469/1996, systems for cleaning the extraneous matters by bringing the scraper blade or the rotating brush into contact on the surface of the godet roller are proposed respectively. However, in the manufacture of industrial fiber, a high-temperature heated roller is used as a godet roller in many cases, and thus the aforementioned scraper blade or the rotating brush cannot remove accumulated deposits easily. In addition, since the thick thread is drawn by a high tensile stress, there is also a problem in that the devices such as the scraper blade or the rotating brush mounted in the vicinity of the godet roller are frequently broken due to the thread wound on the roller after breakage of the thread.

[0008] In Japanese Patent Laid-Open No.170215/1996, a method and apparatus for reciprocating (traversing) a traveling thread on the godet roller by means of a thread guide in the field of manufacturing fiber for clothes are proposed.

[0009] However, since the denier of threads being larger than fiber for clothes, threads are normally drawn to a large magnification in the manufacture of industrial fiber, occurrence of a single filament breakage or thread breakage is distinctive in comparison with the manufacture of fiber for clothes. In addition, since the surface temperature of the godet roller is set to the higher value than that used in the manufacture of fiber for clothes, accumulation of extraneous matters on the godet roller caused by heat-transformed spinning oil is distinctive, and thus the impact on the appearance of the obtained yarn is clearly visible. Therefore, generation of transformed spinning oil cannot be sufficiently prevented simply by reciprocating the thread on the godet roller by the use of the thread guide, and thus transformed spinning

oil is accumulated on both ends of the reciprocating motion of the thread guide, which may result in increase in thread breakage or generation of fuzz with time. In order to avoid such phenomena, the machine has to be stopped many times in order to remove the extraneous matters on the godet roller, which impairs increase of the rate of operation.

[0010] In addition, in the manufacture of industrial fiber, drawing operation aiding units such as an air guide for preventing a single filament breakage on the roller, a heat treatment cylinder for fixation of a drawing point, and a heat plate and a heat treatment cylinder for aiding drawing operation are provided among a plurality of drawing rollers in many cases , and thus misalignment between these drawing operation aiding units and the traveling thread when the traveling thread is reciprocated, which may result in breakage of the traveling thread due to abrasion with these drawing operation aiding units.

SUMMARY OF THE INVENTION

[0011] Accordingly, in the manufacture of synthetic fiber, especially, of industrial fiber formed by drawing/heat treatment of undrawn thread by the use of a plurality of godet rollers, it is an object of the present invention to provide a method of manufacturing synthetic fiber for maintaining drawing/heat treatment of high-strength synthetic fiber stable for a long term by resolving problems such as thread breakage or generation of fuzz, which are distinctive in industrial fiber, to perform high-temperature large-magnification drawing while avoiding accumulation of extraneous matters on the surface of a high-temperature godet roller, for increasing the rate of operation by reducing the number of times the machine has to be stopped for removing extraneous matters from the godet roller, and for improving productive efficiency, and a thread traversing device to be used directly in the same method.

[0012] In order to achieve the aforementioned object, the invention provides a method of manufacturing synthetic fiber comprising the steps of performing multistage drawing/heat treatment on the thread of synthetic fiber formed by melt spinning using a plurality of godet rollers, and subsequently winding the obtained thread, wherein at least two sets of godet rollers of the plurality of godet rollers have surface roughness Ra in the range of 0.5 - 5μm, wherein at least one set of godet rollers out of these godet rollers have surface temperatures not less than (the melting point of the synthetic fiber - 70°C), and wherein the thread is reciprocated in the direction of the axis of rotation of the godet roller.

[0013] In a method of manufacturing synthetic fiber according to the invention, the following points (a) to (e) are preferred modes of the invention respectively, and by applying these conditions, more preferable effects can be expected.

(a) The tensile stress of the thread is not less than 1.4cN/dtex in the last drawing step of the multistage drawing;
(b) Total denier of the thread of the synthetic fiber is not less than 200 dtex;
(c) The thread is a multi-thread including at least two lines of thread;
(d) The cycle of the reciprocating motion of the thread is at least 5 seconds.
(e) The width of reciprocating motion of Y(mm) satisfies the following expression (1).

$$XF \leq Y \leq 2\,(XP - XF) \qquad (1)$$

where;

XF is the width of the thread (mm), and XP is the thread pitch (mm) between the adjacent threads.

In the manufacture of industrial fiber involving drawing operation aiding units, in order to solve the problem in that fuzz tends to be generated by abrasion of the traveling thread with the drawing operation aiding unit when the thread is moved, the invention provides a method of manufacturing synthetic fiber comprising the steps of performing drawing/heat treatment on the thread of synthetic fiber formed by melt spinning with a plurality of godet rollers, and subsequently winding the obtained thread, wherein the thread is reciprocated in the direction of the axis of rotation of the godet roller while synchronizing a thread converging guide for allowing the thread to pass through before and/or after the thread is wound around the godet roller located immediately after the spinning duct and one or plurality of drawing operation aiding units disposed between the plurality of godet rollers. In this method of manufacturing synthetic fiber, the following points (f) to (j) are preferred modes of the invention respectively, and by applying these conditions, more preferable effects can be expected.

(f) The drawing process is a multistage drawing process including at least two stages.
(g) The thread is multi-thread including at least two lines of thread.
(h) The drawing operation aiding unit is a thread entangling device.
(i) The width of reciprocating motion Y(mm) satisfies the following expression (1):

$$XF \leq Y \leq 2\,(XP - XF) \qquad (1)$$

where;

XF is the width of the thread (mm), XP is a thread pitch (mm) between the adjacent threads.

(j) The cycle of the reciprocating motion is at least 5 seconds.

The thread traversing device according to the invention is a device to be used for a method of manufacturing synthetic fiber in which the thread of synthetic fiber formed by melt spinning is drawn/heat treated and then wound by a plurality of godet rollers, comprising a thread converging guide for allowing the thread to pass through before and/or after the thread is wound around the godet roller located immediately after the spinning duct, an drawing operation aiding unit disposed between a plurality of godet rollers, and means for synchronizing the thread converging guide and the drawing operation aiding unit.

In the thread traversing device according to the invention, the following points (k) to (p) are preferredmodes respectively, and by applying these conditions, more preferable effects can be expected.

(k) means for synchronizing the thread converging guide and the drawing operation aiding unit comprises a driving motor, a shaft mounted on the driving motor in the direction of the axis of rotation of the godet roller, and means mounted on the shaft and connected to both of the thread converging guide and the drawing operation aiding unit respectively for converting rotary motion into reciprocating motion, and the thread converging guide and the drawing operation aiding unit are respectively adapted to be slid in the direction of the axis of rotation of the godet roller with these means;

(l) Means for synchronizing the thread converging guide and the drawing operation aiding unit comprises at least two driving motor, shafts respectively mounted on the respective driving motors in the direction of axis of rotation of the godet roller, and means mounted on the respective shafts and connected to the thread converging guide and the drawing operation aiding unit respectively for converting rotary motion into reciprocating motion, and the thread converging guide and the drawing operation aiding unit are respectively adapted to be slid in the direction of the axis of rotation of the godet roller with these means;

(m) Means for moving the thread converging guide and the drawing operation aiding unit simultaneously in (l) comprises at least two phase detecting means for detecting that the shaft mounted on each driving motor rotates to the prescribed position, and adapted to stop the rotation of the shaft provided with the one of the phase detecting means when the prescribed position is detected by one of the phase detecting means, and to rotate the stopped shaft when the prescribed position is detected by the other one of the phase detecting means;

(n) The cycle of the reciprocating motion of the thread converging guide and the drawing operation aiding unit is not less than 5 seconds;

(o) The thread converging guide and the drawing operation aiding unit are adopted to be used for the tread including at least two lines of thread; and

(p) The drawing operation aiding unit is a thread entangling device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a schematic front elevation of the spinning/drawing device provided with a thread traversing device according to the invention;

Fig. 2 is a schematic side view of the apparatus shown in Fig. 1;

Fig. 3 is a schematic perspective view of the thread traversing device according to the embodiment of the invention;

Fig. 4 is a schematic perspective view of the thread traversing device according to the embodiment of the invention; and

Fig. 5 is a block diagram of controlling means for a phase detecting means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The method of manufacturing synthetic fiber according to the invention and the details of the thread traversing device will be described below.

[0016] The synthetic fiber provided for the manufacturing method according to the invention includes threads formed of polyamide, polyester, polyolefin, and alamid, but it is not limited thereto as far as it is such material that the formed thread can be drawn/heat treated by the use of godet rollers.

[0017] The surface roughness Ra of at least two sets of godet rollers out of the godet rollers used in the invention have to be between 0.5 and 5μm, more preferably, between 1 and 3 μm.

[0018] A set of godet rollers here means a set of rollers having the same speed of revolution for winding the thread by more than one turn for example as the first godet roller (18a and 18b) shown in Fig. 1.

[0019] The surface roughness Ra is calculated, according to JISB0601, by providing a Surfcorder SE 1700 manu-

factured by Kosaka Lab. and measuring the section curve using a sensing pin with radius 2μm at a feeding speed of 0.5 mm/s and a cut-off of 0.8 mm or 2.5 mm to obtain the curve of the surface roughness of the godet roller.

[0020] When performing multistage drawing, if the surface of the godet rollers on which drawing is performed has roughness in this range, drawing is performed not only between rollers, but also while the thread is wound on the rollers. When Ra is smaller than 0.5μm or larger than 5μm, since the frictional force generated between the thread and the roller increases, drawing of the thread on the roller becomes increasingly difficult, and thus it becomes difficult to prevent generation of a single filament breakage to obtain a high-strength fiber. The surface roughness Ra in the range between 1 and 3μm is more preferable since the frictional force further decreases. By setting the surface temperature of at least one set of godet rollers out of two sets of godet rollers to at least (the melting point of synthetic fiber thread - 70°C), heat treatment can be performed on the surface of the roller effectively.

[0021] The melting point of the thread here is obtained from a trace of variations of heat quantity obtained by melting 2 mg of sample by the use of DSC-7 type manufactured by Perkin Elmer Inc., quenching and solidifying it by liquid nitrogen, and scanning the sample at the speed of 20°C/min., which is regarded as a temperature at a maximum endothermic peak.

[0022] The temperature below this value (the melting point of synthetic fiber thread - 70°C) is not preferable for the manufacture of industrial fiber, which is the object of the invention, from such reasons that stable drawing cannot be performed, and heat dimension stability of the drawn yarn is lowered due to insufficient heat treatment. When performing heat treatment under such a high temperature condition, a heat-transformed matter caused by spinning oil attached on the thread is accumulated on the surface of the godet roller, which leads to increase in a single filament breakage or thread breakage, but according to the invention, accumulation of such transformed spinning oil may be prevented by reciprocating the thread in the direction of the axis of rotation of the godet roller. In other words, according to the invention, transformation and accumulation of residue of spinning oil may be prevented by organic unity of the constructions described above, and thus the manufacture of high-strength industrial fiber may be performed stably. When the surface roughness Ra of the roller for performing the heat treatment is smaller than 0.5μm, the contact area between the traveling thread and the roller increases. Therefore, even when the thread is moved in the direction of the axis of rotation of the godet roller, the transformed matter sticks to the surface of the roller, and thus the transformed matter may be accumulated on both ends of the amplitude of the movement, which hinders the effect of the invention. On the other hands, when the surface roughness Ra of the roller is in the range between 0.5μm and 5μm, and the thread is moved in the direction of the axis of rotation of the godet roller, accumulation of transformed spinning oil can be prevented, thereby achieving the object of the invention. In the range between 1μm and 3μm, the effect of the invention will be more distinctive.

[0023] When the thread is reciprocated by moving the thread converging guide, occurrence of a single filament breakage due to abrasion as a result that filaments are separated during movement of the thread guide may be prevented.

[0024] The thread converging guide here serves to fix up the traveling thread during spinning and drawing of synthetic fiber, and is, more preferably, a guide for fixing up the spinning thread.

[0025] As the method of reciprocating the thread converging guide, a method using means for converting rotary motion into reciprocating motion, such as a method of converting rotary motion of the motor to reciprocating motion via a cam, a method of conversing rotary motion of the motor to reciprocating motion via a ball screw, a method of repeating linear motion of the cylinder to obtain reciprocating motion, and a method of converting to reciprocating motion via a gear provided on the stepping motor may be employed.

[0026] In the case where the total fineness is not less than 200 dtex, the amount of spinning oil attached on the roller increases, and the effect of the invention will be distinctive.

[0027] According to the invention, by setting the drawing tensile stress during the last drawing step to at least 1.4 cN/dtex, further distinctive effect may be obtained. In other words, when the drawing tensile strength is not less than this value, high-strength fiber not less than 6.0 cN/dtex can be obtained and thus the effect of the transformed spinning oil is distinctive.

[0028] The thread used in the invention is preferably multi-thread including at least two lines of thread. When it includes at least two lines of thread, a single filament breakage in each line of thread can be reduced, and thus a large interactive effect can be obtained.

[0029] The width of reciprocating motion Y (mm) of the thread preferably satisfies the following expression (1).

$$XF \leq Y \leq 2\,(XP - XF) \qquad (1)$$

where;

XF is the width of the thread (mm), and XP is the thread pitch (mm) between the adjacent threads.

[0030] This means the distance from the original position of the thread to the position where the thread leaves the

original position, that is, the distance of movement of the thread having the width XF until it reaches the position where the adjacent thread was traveling before. Accordingly, not only effective prevention of accumulated deposits is effected, but also abrasion preventing effect on the surface of the godet roller is increased.

[0031] Preferably, the cycle of the reciprocating motion of the thread converging guide is not less than 5 seconds, and more preferably, not less than 30 seconds from the viewpoint of reduction of damage of the traveling thread on the godet roller and of reduction of failure rate of the traversing device.

[0032] In the manufacture of the industrial fiber having the drawing operation aiding unit, when the thread is reciprocated in the direction of the axis of rotation of the godet roller while synchronizing the thread converging guide for allowing the thread to pass through before and/or after the thread is wound around the godet roller located immediately after the spinning duct and one or more drawing operation aiding units disposed between the plurality of godet rollers, a single filament breakage caused by abrasion between the thread and the drawing operation aiding unit may be prevented.

[0033] The drawing operation aiding unit is a generic name of devices for aiding to perform drawing operation smoothly, such as a thread entangling device for preventing a single filament breakage on the roller, a heat treatment cylinder for fixation of a drawing point, a heat plate and a heat treatment cylinder for aiding drawing operation.

[0034] The term "synchronization" in the invention means that the thread converging guide and the drawing operation aiding unit have a constant relationship during reciprocating motion, and preferably, both of the thread converging guide and the drawing operation aiding unit have a constant phase difference during reciprocating motion.

[0035] The direction of the axis of rotation of the godet roller in the invention means that one component of the movement vector is parallel with the direction of the axis of rotation of the godet roller.

[0036] The method for reciprocating the thread converging guide and the drawing operation aiding unit includes the aforementioned method of converting rotary motion of the motor to reciprocating motion via a cam, a method of converting rotary motion of the motor to reciprocating motion via a ball screw, a method of repeating linear motion of the cylinder to obtain reciprocating motion, and a method of converting to reciprocating motion via a gear provided on the stepping motor.

[0037] As the method of synchronizing the thread converging guide and the drawing operation aiding unit when using at least two motors or cylinders, a method of detecting the position of the revolving shaft of the motor or the cylinder and the position of the thread by the use of a sensor to synchronize them, and a method of taking outputs of a motor and of the cylinder out through a shaft and transmitting it to the thread converging guide and the drawing operation aiding unit via a cam or a gear to synchronize them are preferable.

[0038] The thread used in the invention is preferably multi-thread including at least two lines of thread. When the thread includes two or more lines of thread, a single filament breakage in each line of thread can be reduced, and thus a large interactive effect can be obtained. In the case of multi-thread including at least two lines of thread as described above, it is preferable to design in such a manner that the thread converging guide is mounted on each line of thread, that is, the same number as the number of the lines of thread of the thread converging guide is provided, so that all the lines of thread reciprocate simultaneously.

[0039] In the case where the drawing operation aiding unit is a thread entangling device, it is necessary to position the thread at the intersection of air blow, and accordingly, it is sensitive to the displacement of the traveling thread. Therefore, by reciprocating the thread converging guide and the thread entangling device synchronously, the effect such as reduction of breakage of filament becomes particularly distinctive.

[0040] By setting the width of the reciprocating motion Y (mm) of the thread so as to satisfy the expression (1) described above, accumulated deposits may be effectively prevented, and the effect of preventing abrasion of the surface of the godet roller may be increased.

[0041] Preferably, the cycle of the reciprocating motion of the thread converging guide is not less than 5 seconds, and more preferably, not less than 30 seconds from the viewpoint of reduction of damage of the traveling thread on the godet roller and of reduction of failure rate of the traversing device.

[0042] The thread traversing device of the invention will be described referring to the drawings.

[0043] Fig. 1 is a schematic front elevation of the spinning/drawing device provided with the thread traversing device according to the invention; Fig. 2 is a side view of the same; Fig. 3 is a schematic perspective view of the second embodiment of the thread traversing device of the invention; Fig. 4 is a schematic perspective view showing the third embodiment; and Fig. 5 is a block diagram of controlling means for a phase detecting means according to the embodiment shown in Fig. 4.

[0044] The thread traversing device of the invention is to be used directly in a method of manufacturing synthetic fiber described above for reciprocating (traversing) the converging guide for allowing the thread to pass through before and/or after the thread is wound around the godet roller located immediately after the spinning duct, and traversing one or plurality of the drawing operation aiding unit synchronously therewith.

[0045] In other words, the thread traversing device of the invention is a unit for preventing accumulation of extraneous matters on the surface of the godet roller during spinning/drawing of the thread of synthetic fiber, comprising means

for synchronously reciprocating a thread converging guide in the direction of the axis of rotation for allowing the thread to pass through before and/or after the thread is wound around the godet roller located immediately after the spinning duct, and a drawing operation aiding unit disposed between a plurality of godet rollers.

[0046] As shown in Fig. 1 and Fig. 2, each of a plurality of threads of synthetic fiber (23) is spun out from a spinning duct (1), fed with spinning oil by the oiling rollers (2), passed through the converging guides (6) mounted on the mounting board (3), pre-stretched between the first godet roller (18) and the second godet roller (19), drawn between the second godet roller (19) and the third godet roller (20) in the first stage, then drawn between the third godet roller (20) and the fourth godet roller (21) in the second stage, relaxed between the fourth godet roller (21) and the fifth godet roller (22), and wound on the winder (W/D). Between the second godet roller (19) and the third godet roller (20), there is provided a drawing operation aiding unit (5) such as a thread confounding device. However, the positions of the converging guide and the drawing operation aiding unit of the invention are not limited thereto .

[0047] As shown in Fig. 2, there is provided means for moving the converging guide (6) and the drawing operation aiding unit (5) in parallel synchronously, that is, means comprising a driving motor (4), a shaft (8) mounted on the driving motor (4) in the direction of the axis of rotation of the godet roller, and two cams (7) mounted on the shaft (8) and connected respectively to the converging guide (6) and the drawing operation aiding unit (5), and such means can move the converging guide (6) and the drawing operation aiding unit (5) accurately synchronously, so that the thread (23) reciprocates in the direction of the axis of rotation of the godet roller with respect to the traveling thread.

[0048] Fig. 3 shows the second embodiment of the thread traversing device according to the invention. In this device, the shaft (8) is mounted on the driving motor (4). Though the driving motor (4) and the shaft may be in direct contact with each other, it is preferable to provide a speed reducer (9) therebetween as shown in the figure since a desired rotational speed can be obtained, and in this arrangement, the traveling thread can be moved at sufficiently slow speed so as not to be damaged.

[0049] The shaft (8) mounted in the direction of the axis of rotation of the godet roller is provided with two cams (7a, 7b), and the drawing operation aiding unit (5) mounted on the drawing operation aiding unit mounting board (10) and the converging guide (6) mounted on the converging guide mounting board (3) are in contact with the respective cams (7a, 7b) via the sliding rollers (13a, 13b) provided respectively on the mounting board (10, 3).

[0050] The drawing operation aiding unit mounting board (10) is mounted on the stationary slide rail (11) so as to slide along the length of the shaft (8).

[0051] In addition, the converging guide mounting board (3) is mounted on the slide bearing (12), which is also stationary, by the use of a sliding shaft (14), so as to slide along the length of the shaft (8).

[0052] Therefore, with the arrangement described above, the converging guide mounting board (3) and the drawing operation aiding unit mounting board (10) are slid along the length of the shaft (8) respectively by the slide bearing (12) and the sliding shaft (14) and by the slide rail (11) in association with the movement of the sliding rollers (13a, 13b) provided on the converging guide mounting board (3) and the drawing operation aiding unit mounting board (10) along the grooves on the two cams (7a, 7b) which is rotated by the driving motor (4), and the converging guide (6) and the drawing operation aiding unit (5) are reciprocated synchronously in the direction of the axis of rotation of the godet roller.

[0053] Fig. 4 shows the third embodiment of the thread traversing device of the invention. In this device, the converging guide (6) and the drawing operation aiding unit (5) are provided respectively on the separate shafts (8a, 8b) mounted respectively on the separate motors (4a) and (4b) via the separate cams (7a, 7b) respectively so as to make a reciprocating motion, and phase detecting means for detecting that the respective cams (7a, 7b) are rotated to the prescribed positions are mounted respectively, so that the control panel (17) shown in Fig. 5 synahranizes the converging guide (6) and the drawing operation aiding unit (5) by stopping the rotation of the shaft provided with the one of the phase detecting means when the prescribed position is detected by one of the phase detecting means, and rotating the stopped shaft when the prescribed position is detected by the other one of the phase detecting means.

[0054] In other words, in the third embodiment, the converging guide (6) and the drawing operation aiding unit (5) are reciprocated in the same manner as means in the first embodiment other than the point that they are driven by the separate driving motors (4a, 4b).

[0055] The phase detecting means in the third embodiment may be constructed as follows. The cams (7a, 7b) are provided with detected portions (16a, 16b) of the proximity sensors respectively, and the proximity sensors (15a, 15b) are mounted respectively on the portions that are not rotated by the driving motors (4a, 4b) such as speed reducers (9a, 9b). The positions to which these proximity sensors (15a, 15b) are mounted are discretionary as far as they are not rotated by the driving motors (4a, 4b). For example, they may be mounted on the bearing portions as well as the speed reducers (9a. 9b), or may be mounted on the body of the drawing machine.

[0056] When the respective cams (7a, 7b) are rotated and the detected portion (16a) and the proximity sensor (15a) or the detected portion (16b) and the proximity sensor (15b) face toward each other, a signal supplied from the proximity sensor (15a, 15b) is reflected on the detected portion (16a,16b) and detected by the proximity sensor (15a,15b).

[0057] When the proximity sensor detected the opposed detected portion, a detected signal is supplied to the control

panel (17). The control panel (17) is, as shown in Fig. 5, connected to the proximity sensor (15a) and the proximity sensor (15b), and to the driving motor (4a) and the driving motor (4b),and constructed in such a manner that when a detected signal is supplied by one of the proximity sensors (15a) for example, the rotation of the driving motor (4a) provided with the one of the proximity sensors (15a) is stopped, and when a detected signal is supplied by the other proximity sensor (15b), the stopped driving motor (4a) is rotated.

[0058] The proximity sensor to be employed in the invention is preferably a photosensitive proximity sensor. However, as far as it achieves the desired object, it may be of capacitance type or magnetic type.

[0059] According to the third embodiment, the converging guide (6) and the drawing operation aiding unit (5) reciprocate in accurately synchronously. When there are provided a plurality of drawing operation aiding units, the rotation is stopped sequentially from the driving motor on which the proximity sensor which supplied a detecting signal first is mounted, and when the last detecting sigwal was supplied within one to-and-fro motion, all the driving motor which had stopped must simply be driven by the control panel.

[0060] The third embodiment is effective when both of the converging guide and the drawing operation aiding unit cannot be driven easily by one shaft.

[0061] Preferably, the cycle of the reciprocating motion of the thread traversing device according to the invention is at least 5 seconds, and more preferably, at least 30 seconds from the viewpoint of reduction of damage of the traveling thread and of reduction of failure rate of the traversing device.

[0062] In addition, in order to convert a rotational motion of the shaft (8) into a reciprocating motion, a ball screw or a gear may be employed instead of the cam (7) , and it is not limited thereto as far as it can achieve the desired object. However, the use of cam is preferable from the viewpoints of the cost and ease of access. The traversing width of the converging guide and the drawing operation aiding unit may be varied as desired by varying the shape of the cam, and the converging guide and the drawing operation aiding unit may be synchronously reciprocated with a constant phase difference by mounting the respective cams being in contact with both of them with the grooves thereof shifted with respect to the shaft.

[0063] In addition, determining the shape of the cam such that the width Y (mm) of the reciprocating motion of the thread satisfies the expression (1) described above may lead not only to effective prevention of the accumulated deposits, but also to increased effect to prevent abrasion of the surface of the godet roller.

[0064] In the converging guide and the drawing operation aiding unit according to the invention, the number of lines of thread is not limited, but preferably, the mufti-thread is used. When multi-thread is used, stain on the godet rollers appears distinctively, and thus the objective effect can be realized distinctively.

[0065] The invention will bear more preferably effect when the tread entangling unit is used as a drawing operation aiding unit. The reason is that the thread entangling unit requires that the thread is positioned at the intersection of air blow, and thus it is sensitive to the displacement of the traveling thread.

[0066] As means for reciprocating the converging guide and the drawing operation aiding unit, a fluid cylinder or the like may be used instead of means using the driving motor, the shaft and the cam. However, in terms of repair of the unit or the cost, the method described above is more preferable.

[0067] As is described thus far, according to a method of manufacturing synthetic fiber and the thread traversing unit according to the invention, the godet roller may be maintained in the initial state for a long time by preventing accumulation of extraneous matters on the godet roller, the rate of operation and productive efficiency may be increased by reducing the number of times the machine has to be stopped for removing extraneous matters, and problems such as a single filament breakage or generation of fuzz may be solved and high-strength synthetic fiber of good quality and appearance may be manufactured.

[0068] Among others, it is more effective when manufacturing industrial high-strength fiber by a high-speed direct spinning/drawing method, because accumulation of extraneous matters on the godet roller is prevented.

[Embodiment]

[0069] The invention will be described in detail referring to embodiments and comparative examples.

[0070] The evaluation of each characteristic in the following embodiments was made in the following methods.

[Surface Roughness]

[0071] The surface roughness of the godet roller was calculated, in accordance with JISB0601, by obtaining the roughness curve on the surface of the godet roller from the section curve measured by the use of Surfcorder SE1700 manufactured by Kosaka Lab. with a sensing pin of 2μm radius, a feed rate of 0.5 mm, and a cut-off of 0.8mm or 2.5 mm.

[Melting Point]

[0072] The melting point was obtained from a trace of variations in heat quantity obtained by melting 2 mg of sample by the use of DSC-7 type manufactured by Perkin Elmer Inc., quenching and solidifying it by liquid nitrogen, and scanning the sample at the speed of 20°C/min. Temperature at the maximum endothermic peak was regarded as the melting point. The melting point of the drawn yarn obtained by the invention was 250°C.

[Temperature of Godet Roller]

[0073] The temperature on the surface of the godet roller was measured by the use of a contact thermometer.

[Tensile Stress of Drawing]

[0074] The tensile stress of drawing was obtained by measuring a tensile stress of the traveling thread between the third godet roller and the fourth godet roller by the use of HS-3000, which is a tension meter manufactured by EIKO SOKKI, and then divided by the total olenier of the drawn thread.

[A single filament breakage]

[0075] The number of breakage was counted by a single filament breakage detector, and expressed by the number of breakage per 10,000,000 m.

[Contamination of the Roller]

[0076] Stain on the roller along the thread passage was visually observed every 24 hours, and classified into "lightly stained" markedwithA, "normally stained" markedwith B, "heavily stained and causing significant shaking of the tread" marked with C.

[Breakage of Thread]

[0077] The number of times of breakage of the thread per day was counted.

[Strength of yarn]

[0078] The strength of yarn was measured based on JIS L-1017 (1995). The S-S curve was obtained using Tensilon tensile tester manufactured by Orientec Co., with the sample having the length of 25 cm at the tensile speed of 30 cm/min., and read the value from the obtained S-S curve.

[Heat Shrinkage]

[0079] A skein of obtained yarn was provided and was left stand for at least 24 hours in the temperature regulated room of 20°C, 65% RH, and then was measured with a load which corresponds to 0.1g/d of the sample applied thereon. After leaving the sample having a length of L0 stand in the oven at 150 °C for 30 minutes without any tension applied thereon, it was taken out of the oven and left stand for four hours in the temperature regulated room. Then the same load as described above was applied thereon again, and the length L1 was measured. Then, the rate of shrinkage by dry heat was calculated using the following expression.

$$\text{Rate of heat shrinkage (\%)} = \{(L0-L1)/L0\}\times 100$$

[Embodiment 1]

[0080] Polyethylene terephthalate chip having intrinsic viscosity (IV) of 1.19 was fed to a extruder type melt spinning machine for spinning two lines of thread simultaneously. It was filtered through a metallic filter having a pore of 15 μm and spun through a spinneret having 72 holes at a spinning temperature of 300°C.

[0081] Then, spun thread was passed under the atmosphere at high temperature of 300°C for 350 mm from the surface of the spinneret , and then quenched and solidified by blowing cold air at about 20°C thereon. Subsequently, it is applied with spinning oil by an oiling roller, and routed to the first godet roller. The obtained undrawn thread was,

without being wound completely, pre-stretched by 1.06 times in length between the first godet roller and the second godet roller, then drawn by 3.70 times in length between the second godet roller and the third godet roller, drawn by 1.40 times in length between the third godet roller and the fourth godet roller, relaxed by 1.0% between the fourth godet roller and the fifth godet roller, and finally wound on the winder two lines of thread simultaneously at the speed of 3300 m/min., to obtain drawn yarn. The third and fourth godet rollers used here had Cr_2O_3 coated surfaces of Ra=1.0 μm.

[0082] The temperatures of the respective godet rollers were 70°C for the first godet roller, 100°C for the second godet roller, 120°C for the third godet roller, 240°C for the fourth godet roller, no heating for the fifth godet roller. The numbers of turns of the thread for the respective godet rollers were, three turns for the first godet roller, three turns for the second godet roller, four turns for the third godet roller, 7 turns for the fourth godet roller, and five turns for the fifth godet roller. A single filament breakage detector is mounted for the thread being wound on the fifth godet roller to count the number of breakage, and the number of breakage of the thread was evaluated as well.

[0083] In the drawing/heat treatment process described above, the converging guide (6) provided forwardly of the first godet roller (18) in Fig. 1 was reciprocated, and the thread (23) was traversed on the godet roller in the direction of the axis of rotation of the godet roller. The converging guide employed was configured as shown in Fig. 3.

[0084] The thread width XF was 5.0 mm, the thread pitch XP with respect to the adjacent thread was 15.0 mm, and the value of 2(XP-XF) was 20 mm.

[0085] As a mechanism for reciprocating the converging guide, the one mounted on the shaft for rotating a cam connected to the converging guide by the driving motor via the shaft, and reciprocates the converging guide in the direction of the axis of rotation of the godet roller along the groove on the cam was employed.

[0086] By setting the number of revolution of the shaft to 2 rpm by the use of the driving motor and the speed reducer, the cycle of a reciprocating motion was set to 30 seconds and the traverse width on the winding roller to 16 mm respectively. These conditions and the results of evaluation of stain on the roller, a single filament breakage, thread breakage, heat shrinkage of the obtained yarn are shown in Table 1.

[0087] In Embodiment 1, as a result of traversing the thread on the godet roller, the effects such that the condition of the surface of the godet roller can be maintained in the lightly stained state until the fourth day, and the number of occurrence of a single filament breakage or of thread was distinctively small were discernible.

[Embodiment 2]

[0088] The thread traversing device used in Embodiment 1 was replaced with the one having a structure shown in Fig. 3. The position of the converging guide, the shape of the cam, the number of revolution of the shaft were the same as in Embodiment 1. The drawing operation aiding unit was disposed between the second godet roller and the third godet roller, and reciprocated synchronously with the converging guide. These conditions and the results of evaluation of stain on the roller, a single filament breakage, and thread breakage are shown in Table 1.

[Embodiment 3]

[0089] The thread traversing unit used in Embodiment 2 was replaced with the one having a structure shown in Fig. 4. The position of the drawing operation aiding unit (5) was between the second godet roller and the third godet roller in Fig. 1. The shape of the cam and the number of revolution of the shaft were the same as in Embodiment 1. These conditions and the results of evaluation of stain on the roller, a single filament breakage, and thread breakage are shown in Table 1.

[0090] As a result, the same preferable results as in Embodiment 2 were discernible as shown in Table 1.

[Embodiment 4 - Embodiment 8]

[0091] The conditions in Embodiment 2 were changed as shown in Table 1. The obtained results are shown in Table 1.

[Comparative Example 1]

[0092] Melt-spinning process was performed on polyethylene terephthalate under the same conditions as Embodiment 1 other than those shown in Table 1, and the thread was wound on each godet roller and taken up by the winder without reciprocating the converging guide. The results of evaluation of stain on the roller, a single filament breakage, and thread breakage are shown in Table 1. Consequently, in the case where the thread was not traversed on the godet roller, the surface of the roller was maintained in lightly stained condition until the second day, but occurrence of a single filament breakage was suddenly increased on the third day, and thereafter, the thread could not taken up and occurrence of thread breakage was increased significantly.

[Comparative Example 2 - Comparative Example 6]

[0093] Melt-spinning process was performed on PET under the same conditions as in Embodiment 2 other than the conditions shown in Table 1. The results are shown in Table 1.

[Table]

		Embodi-ment 1	Embodi-ment 2	Embodi-ment 3	Embodi-ment 4	Embodi-ment 5	Embodi-ment 6	Embodi-ment 7	Embodi-ment 8	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6
Presence of Air guide		N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Presence of Traversing Unit		Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y
Traversing Width on spinning Roller (mm)		16	16	16	8	16	16	8	8	0	0	16	16	0	8
Reciprocating Cycle (second)		30	30	30	30	30	30	30	5	-	-	30	30	30	3
Stain on Roller	1st day	O	O	O	O	O	O	O	O	O	O	O	O	O	Δ
	2nd day	O	O	O	O	O	O	O	O	O	O	O	O	Δ	X
	3rd day	O	O	O	O	O	O	O	O	X	X	O	O	X	-
	4th day	O	O	O	O	O	O	O	Δ	-	-	O	Δ	-	-
	5th day	Δ	Δ	Δ	Δ	Δ	Δ	O	X	-	-	O	X	-	-
A single filament breakage (points/10000000m)	1st day	5	4	4	4	4	4	5	7	12	5	4	4	5	35
	2nd day	9	8	9	10	9	10	6	12	28	20	7	25	21	60
	3rd day	15	13	13	19	14	18	9	19	60	52	12	32	60	-
	4th day	22	20	21	26	21	26	15	32	-	-	28	36	-	-
	5th day	29	25	25	32	25	30	20	60	-	-	30	60	-	-
Thread Breakage (times/day)		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	1.0	1.0	0.2	0.5	1.4	-
Third and Fourth Godet Roller Ra (μm)		1	1	1	1	0.5	4	1	1	1	0.3	1	1	6.0	-
Temperature of Fourth Godet Roller(°C)		240	240	240	240	240	240	240	240	240	240	160	240	240	240
Magnification of Drawing (times)		5.2	5.5	5.5	5.5	5.5	5.5	5.2	5.5	4.9	4.9	4.9	4.7	4.8	4.8
denier (dtex)		1100	1100	1100	1100	1100	1100	230	1100	1100	1100	1100	1100	1100	1100
Strength (cN/dtex)		7.0	7.5	7.5	7.5	7.5	7.5	7.0	7.5	6.0	6.0	6.0	5.8	5.8	5.8
Tensile Stress (cN/dtex)		1.6	1.7	1.7	1.7	1.7	1.7	1.6	1.7	1.4	1.4	1.4	1.3	1.4	1.4
Heat Shrinkage (%)		6.2	6.7	6.5	6.5	6.6	6.5	6.2	6.5	5.5	5.5	15.5	4.5	5.5	5.5

O=A, Δ=B, X=C
*N=no, Y=yes

[Industrial Applicability]

[0094] As is described thus far, according to a method of manufacturing synthetic fiber and a thread traversing device of the invention, by preventing accumulation of extraneous matters on the godet roller, the godet roller can be maintained in the initial state for a long time and thus the number of times the machine has to be stopped for removing extraneous matter can be reduced to increase the rate of operation and productive efficiency. In addition, problems such as thread breakage or generation of fuzz are solved and thus high-strength synthetic fiber of excellent quality and appearance can be manufactured. Especially, when manufacturing industrial high-strength fiber by high-speed direct spinning/drawing method, accumulation of extraneous matter on the godet roller can be prevented, thereby being preferably applicable to a manufacturing process of industrial high-strength synthetic fiber.

Claims

1. A method of manufacturing synthetic fiber comprising the steps of performing multistage drawing/heat treatment on the thread of synthetic fiber formed by melt spinning using a plurality of godet rollers, and subsequently winding the obtained thread, wherein at least two sets of godet rollers out of the plurality of godet rollers have surface roughness in the range of 0.5 - 5μm, wherein at least one set of godet rollers out of these godet rollers having surface temperatures not less than (the melting point of the synthetic fiber - 70°C) is used, and wherein the thread is reciprocated in the direction of the axis of rotation of the godet roller.

2. A method of manufacturing synthetic fiber according to Claim 1, wherein the tensile stress of the thread is not less than 1.4cN/dtex in the last drawing step of the multistage drawing.

3. A method of manufacturing synthetic fiber according to Claim 1 or Claim 2, wherein the thread of the synthetic fiber is not less that 200 dtex.

4. A method of manufacturing synthetic fiber comprising the steps of performing multistage drawing/heat treatment on the thread of synthetic fiber formed by melt spinning using a plurality of godet rollers, and subsequently winding the obtained thread, wherein the thread is reciprocated in the direction of the axis or rotation of the godet roller while synchronizing at least one thread converging guide for allowing the thread to pass through before and/or after the thread is wound around the godet roller which wind the thread first after passing the spinning duct and one or plurality of drawing operation aiding units disposed between the plurality of godet rollers.

5. A method of manufacturing synthetic fiber according to Claim 4, wherein the drawing process is a multistage drawing process including at least two stages.

6. A method of manufacturing synthetic fiber according to any one of Claim 1 to Claim 5, wherein the thread is multi-thread including at least two lines of thread.

7. A method of manufacturing synthetic fiber according to any one of Claim 4 to Claim 6, wherein the drawing operation aiding unit is a thread entangling device.

8. A method of manufacturing synthetic fiber according to any one of Claim 1 to Claim 7, wherein the width Y(mm) of reciprocating motion satisfies the following expression (1).

$$XF \leq Y \leq 2\,(XP - XF) \qquad (1)$$

where;

XF is the width of the thread (mm), and XP is the thread pitch (mm) between the adjacent threads.

9. A method of manufacturing synthetic fiber according to any one of Claim 1 to Claim 8, wherein the cycle of the reciprocating motion is at least 5 seconds.

10. A thread traversing device to be used for a method of manufacturing synthetic fiber in which the thread of synthetic fiber formed by melt spinning is drawn/heat treated and then wound by a plurality of godet rollers, comprising at least one thread converging guide for allowing the thread to pass through before and/or after the thread is wound

around the godet roller located immediately after the spinning duct, an drawing operation aiding unit disposed between a plurality of godet rollers , and means for synchronizing the thread converging guide and the drawing operation aiding unit.

11. A thread traversing device according to Claim 10, wherein the means for synchronizing the thread converging guide and the drawing operation aiding unit comprises a driving motor, a shaft mounted on the driving motor in the direction of the axis of rotation of the godet roller, and means mounted on the shaft and connected to both of the thread converging guide and the drawing operation aiding unit respectively for converting rotary motion into reciprocating motion, and the thread converging guide and the drawing operation aiding unit are respectively adapted to be reciprocated in the direction of the axis of rotation of the godet roller.

12. A thread traversing device according to Claim 10, wherein the means for synchronizing the thread converging guide and the drawing operation aiding unit comprises at least two driving motors, shaft respectively mounted on the respective driving motors in the direction of the axis of rotation of the godet roller, and means mounted on the respective shafts and connected to both of the thread converging guide and the drawing operation aiding unit respectively for converting rotary motion into reciprocating motion, and the thread converging guide and the drawing operation aiding unit are respectively adapted to be slid in the direction of the axis of rotation of the godet roller.

13. A thread traversing device according to Claim 12, wherein the means for synchronizing the thread converging guide and the drawing operation aiding unit comprises at least two phase detecting means for detecting that the shaft mounted on each driving motor rotates to the prescribed position, and adapted to stop the rotation of the shaft provided with the one of the phase detecting means when the prescribed position is detected by one of the phase detecting means, and to rotate the stopped shaft when the prescribed position is detected by the other one of the phase detecting means.

14. A thread traversing device according to any one of Claim 10 to Claim 13, wherein a speed reducer is provided between the shaft and the driving motor.

15. A thread traversing device according to any one of Claim 10 to Claim 14, wherein the cycle of the reciprocating motion of the thread converging guide and the drawing operation aiding unit is not less than 5 seconds.

16. A thread traversing device according to any one of Claim 10 to Claim 15, wherein the thread converging guide and the drawing operation aiding unit are adopted to be used for the tread including a plurality of lines of thread.

17. A thread traversing device according to any one of Claim 10 to Claim 16, wherein the drawing operation aiding unit is a thread entangling device.

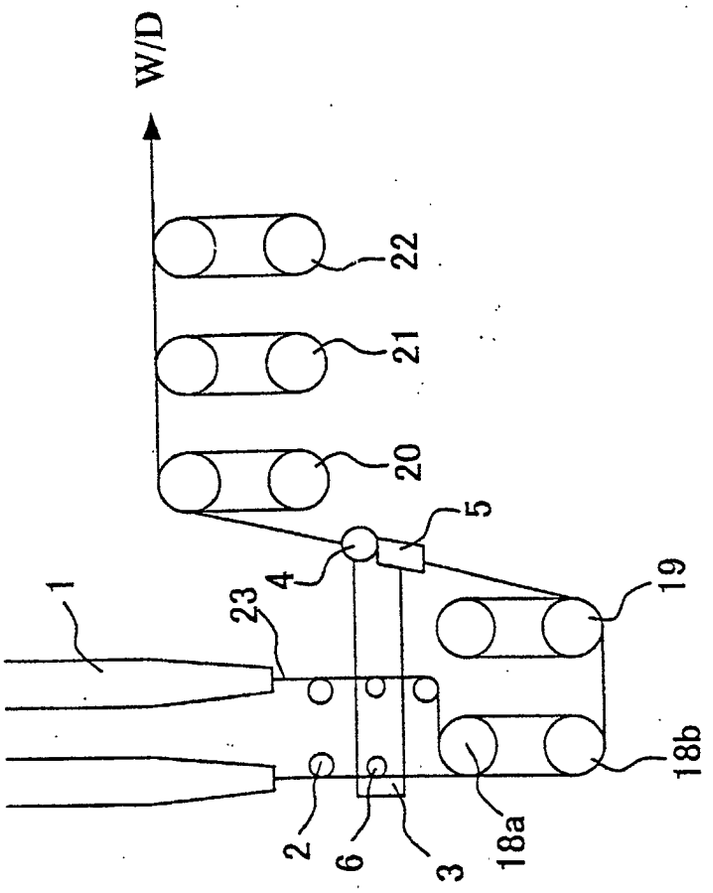

Fig. 1

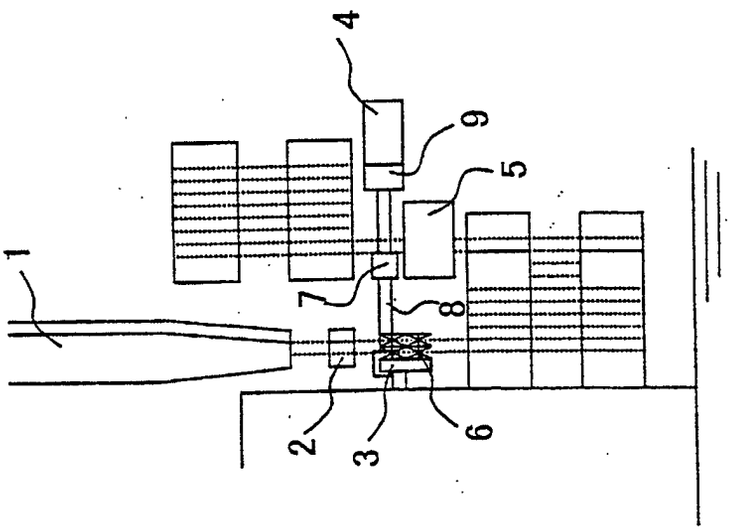

Fig. 2

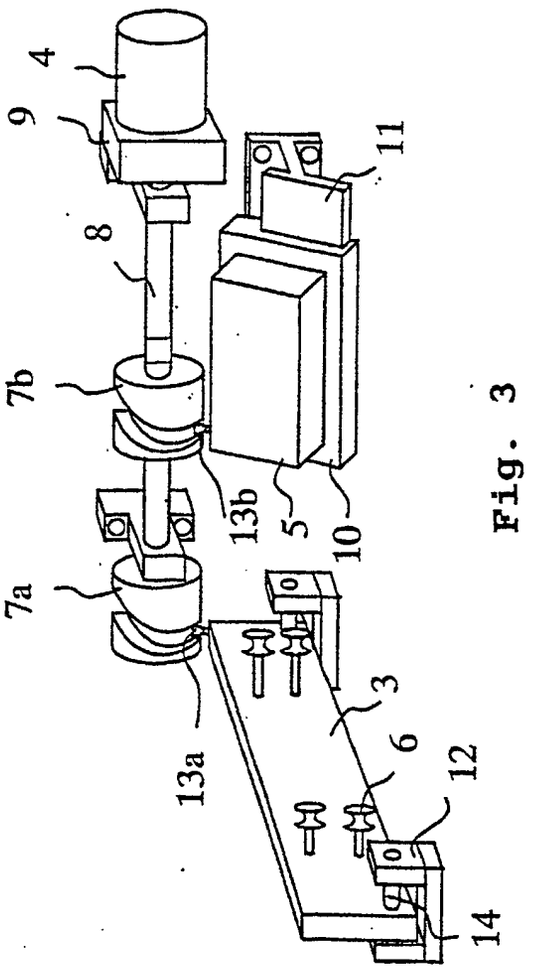

Fig. 3

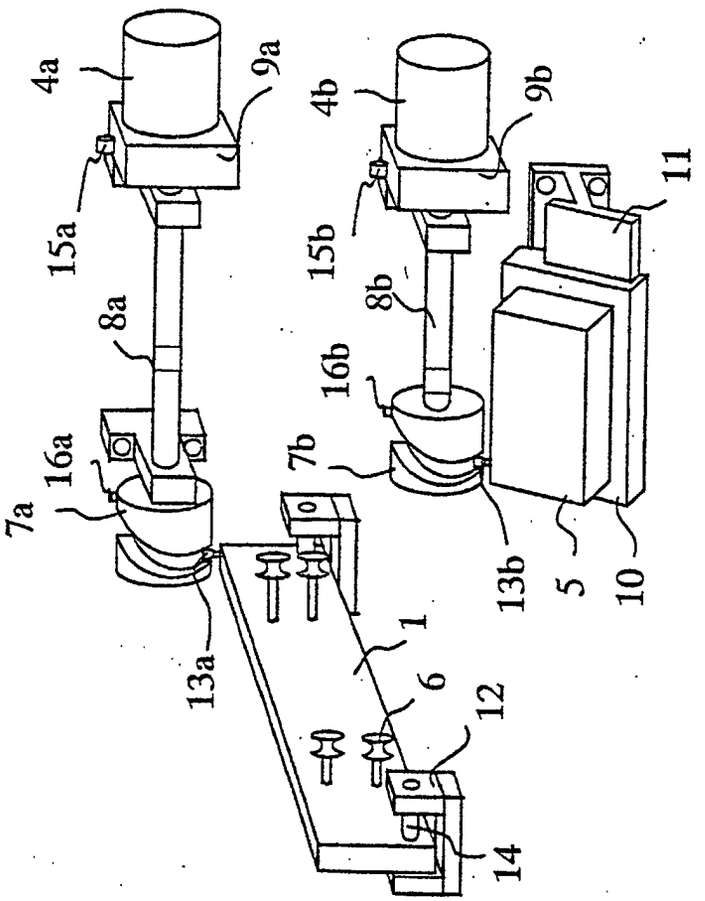

Fig. 4

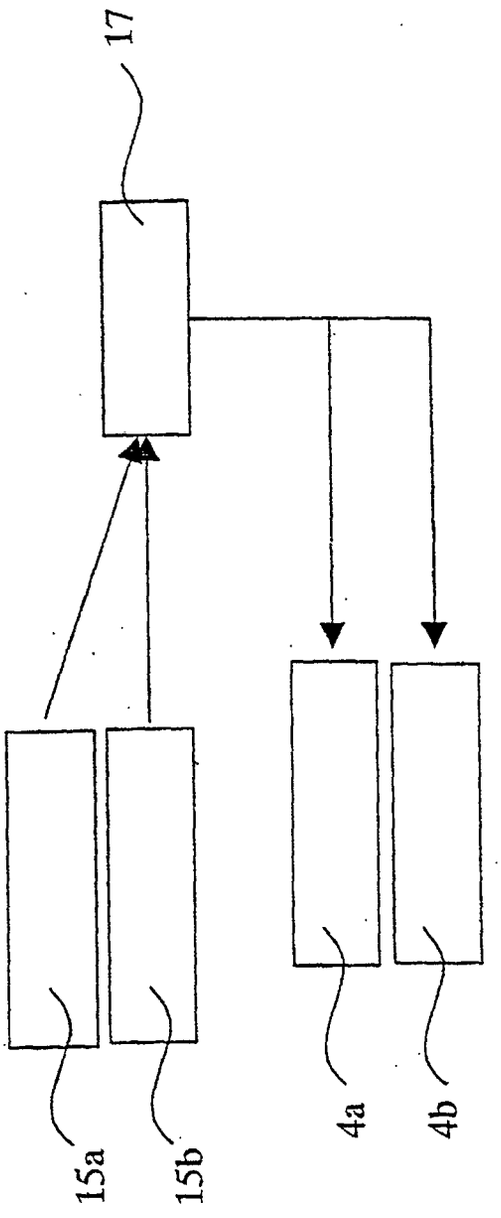

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/01440

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] D01D5/08, 10/00, 11/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] D01D5/08, 10/00, 11/00, D02J1/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 8-170215 A (Toray Industries, Inc.), 02 July, 1996 (02.07.96), Claims (Family: none)	4-12,14-16 1-3,13 17
Y A	JP 58-119554 A (Toray Industries, Inc.), 16 July, 1983 (16.07.83), Full text (Family: none)	4-12,14-16 1-3,13 17
A	JP 7-278952 A (Toray Industries, Inc.), 24 October, 1995 (24.10.95), Claims (Family: none)	1-17

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 May, 2002 (21.05.02)	04 June, 2002 (04.06.02)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/01440

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4351492 A (Teijin Ltd.), 28 September, 1982 (28.09.82), Full text & EP 10772 A & EP 10772 B & DE 2965826 G	1-17

Form PCT/ISA/210 (continuation of second sheet) (July 1998)