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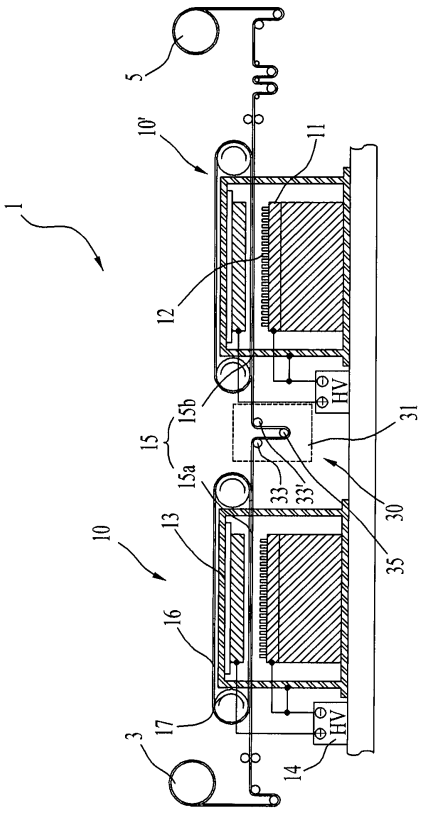
# (54) ELECTROSPINNING APPARATUS

(57) The present invention relates to an electrospinning apparatus, and the purpose of the present invention is to provide an electrospinning apparatus capable of: forming a buffer section between the respective units of the electrospinning apparatus and installing a vertically movable adjustment roller in the buffer section so as to adjust the transfer speed and time of a long sheet, which passes through the respective units, for each section and thus prevent the crumpling, sagging, snapping, breakage, and damage of the elongated sheet; solving the problem of the abnormal transfer of the elongated sheet which may occurs due to electrostatic attraction during electrospinning and, in a nanofiber production step, disposing an apparatus for detecting the sagging of the elongated sheet before and after a spinning zone, detecting the sagging of the elongated sheet, and transmitting the signal to an apparatus for assisting the transfer of the elongated sheet so as to adjust the transfer speed of the elongated sheet, which is fixed by means of electrostatic attraction to a collector, on the basis of the detected signal and automatically improve the sagging of the sheet and thereby effectively prevent the problem caused by the sagging of the sheet; and thus mass-producing nanofiber of uniform quality.

FIG. 2

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## Description

### Technical Field

**[0001]** The present invention relates to electrospinning apparatus capable of: sensing a sagging of an elongated sheet which carries electrospinned polymer spinning solution so as to adjust the carrying speed and time of the elongated sheet, assisting carrying of the sheet, controlling the carrying speed, discharging amount of a nozzle block, and voltage intensity, thereby mass-producing of nanofiber having uniform air permeability and uniform thickness.

### Background Art

**[0002]** Generally, Nano Fiber refers to a Micro Fiber having an average diameter of tens to hundreds nm, products including nanofiber such as non-woven fabric, membrane, and braid are widely used as consumer goods, agricultural, clothing, and industrial ways.

**[0003]** Moreover, nanofiber is used in various fields such as artificial leather, suedette, sanitary pads, clothing, diapers, packing materials, general goods materials, various filter materials, medical use materials in gene transporting, bulletproof jacket, and other national defense use materials. As stated above, nanofiber is produced by electric field. In other words, nanofiber applies polymer substance which is raw material to high voltage electric field occurring electric repulsive force inside polymer substance, so molecular agglomerate, split into nano size thread, and nanofiber is manufactured and produced.

**[0004]** In this case, as the stronger electric field is, polymer substance can be thinly torn, 10 to 1000nm thickness of nanofiber can be acquired.

**[0005]** The electrospinning apparatus which manufactures and produces nanofiber with such thickness comprises a spinning solution main tank filling spinning solution, a metering pump for the required amount of spinning solution, a nozzle block with several nozzles arranged and installed to discharge spinning solution, and a collector located at the bottom of nozzle integrated spinning fiber and a power supply device generating voltage.

**[0006]** Nanofiber manufacturing method comprising the structure stated above is disclosed in US NO. 4,044,404. Also, The electrospinning apparatus made up of the structure as described above is illustrated in FIG. 1, comprising a spinning solution main tank(not shown) filled spinning solution, a metering pump(not shown) which is for the required amount of supply on polymer spinning solution inside the spinning solution main tank, a nozzle block(111) discharging polymer spinning solution inside the spinning solution main tank, and arranged and installed several nozzles(112) in pin form, and a collector(113) located above the nozzle(112) to integrate jetted polymer spinning solution and has predetermined space separated from the nozzle(112), and a unit(110) including a power supply device(114) generated high voltage at the collector(113).

**[0007]** Nanofiber manufacturing method by the electrospinning apparatus (100) includes the step of: consecutively supplying the required amount of spinning solution by metering pump from the spinning solution main tank into several nozzles(112) provided high voltage, forming a nanofiber web by spinning and aggregating the spinning solution supplied through several nozzles(112) on the collector with high voltage, forming nanofiber web on the elongated sheet(115) carried through the electrospinning apparatus's (100) units(110), the elongated sheet which laminating formed the nanofiber web passes through each unit(110), repeatedly laminating the nanofiber web and producing non-woven fiber by laminating, embossing, or needle punch.

**[0008]** Here, the electrospinning apparatus is divided into a bottom-up electrospinning apparatus, a top-down electrospinning apparatus, and a parallel electrospinning apparatus by the located direction on a collector. In other words, the electrospinning apparatus is divided into a bottom-up electrospinning apparatus which includes a collector located over a nozzle and can produce equal and relatively thin nanofiber, a top-down electrospinning apparatus which includes a collector located below the nozzle, produces relatively thick nanofiber, and can increase the production of nanofiber per hour, and a parallel electrospinning apparatus which comprises nozzles and collector arranged in parallel direction. Meanwhile, the electrospinning apparatus comprises composition of jetting spinning solution by a nozzle block's nozzle, and jetted spinning solution laminates on upper side or lower side of a member forming a nanofiber web.

**[0009]** According to the composition as stated above, the electrospinning apparatus inside which one unit jets spinning solution by a nozzle, carrying the elongated sheet which laminating forms a nanofiber web to the inside of a different unit, the elongated sheet which is carried to the inside of a different unit jets spinning solution by the nozzle and again laminating forming a nanofiber web, by repeatedly performing the process produces a nanofiber web.

**[0010]** However, in the electrospinning apparatus's each of the unit, in the case carrying speed of the elongated sheet on which a nanofiber web is laminated and formed is different according to each section, there are problems such as the elongated sheet is wrinkled, or slacked, etc.

**[0011]** In other words, in the case of carrying speed of the elongated sheet laminating forming a nanofiber web in the unit located at the electrospinning apparatus front-end and carrying speed of the elongated sheet laminating forming a

nanofiber web in the unit located at the rear-end are different, there are problems such as the elongated sheet is wrinkled, or slacked, etc., and because of this, there are problems such as the elongated sheet is cut, or a property of matter is debased, or device driving is stopped.

**[0012]** In more detail, in the case of carrying speed of the elongated sheet laminating forming a nanofiber web in the unit located at the electrospinning apparatus front-end is fast, and carrying speed of the elongated sheet laminating forming a nanofiber web in the unit located at the rear-end is slow, there are problems such as the elongated sheet is wrinkled, or slacked. On the other hand, in the case of carrying speed of the elongated sheet laminating forming a nanofiber web in the unit located at the electrospinning apparatus front-end is slow, and carrying speed of the elongated sheet laminating forming a nanofiber web in the unit located at the rear-end is fast, there are problems such as the elongated sheet is cut, or a device driving is stopped, and because of this, overall a nanofiber web's property of matter is debased.

**[0013]** Meanwhile, as stated above, when manufacturing a nanofiber using the electrospinning apparatus, spinning solution is consecutively supplied to a nozzle high voltage is applied to and there is problem such as provided electric force's effect is lowered.

**[0014]** In other words, as electric force provided at nozzle is jetted as spinning solution, electric force can't overcome spinning solution's interfacial tension, and fiber forming effect by electric force is lowered. So, Droplet phenomenon which spinning solution, fell in droplet form is occurred, product quality is debased, and there is difficulty in nanofiber mass production which makes commercialization impossible.

**[0015]** In order to solve this problem, if maximize effect of electric force which is provided to the electrospinning apparatus's nozzle block, electric force is larger than spinning solution's interfacial tension, and fiber forming effect is increased. This enables mass production of nanofiber, prevent droplet phenomenon effectively, and suggests bottom-up and top-down electrospinning apparatus which produce high quality nanofiber. By flowing high voltage each to the collector and the nozzle block discharging spinning solution, fiber forming effect can be enhanced. However, electrostatic attraction is increased due to high voltage, the elongated sheet on which a nanofiber web is stacked is attached to the collector, only with the elongated sheet carrying device included in the electrospinning apparatus, it is hard to overcome such electrostatic attraction, so nanofiber cannot be mass produced.

**[0016]** In order to solve this problem, an auxiliary carrying device is suggested which comprising an auxiliary belt assisting an elongated sheet carrying between a collector with high voltage and a nozzle block. However, in order to rotate the auxiliary belt according to the elongated sheet carrying speed, not only a driving device which directs the electrospinning apparatus but also separate driving device should be installed in addition. Therefore, there are problems such as the process is complex and the cost is increased.

**[0017]** Meanwhile, when manufacturing nanofiber, in the case the elongated sheet attached to the collector is slacked, due to nanofiber uneven stack, there is problem such as the quality is decreased. In the case of winding the elongated sheet which is slacked, there is difference in firmness of winding occurs, so a wound roll is modified, or wrinkled.

**[0018]** In order to solve this, as one method to sense slacking of carrying elongated sheet, Japanese laid-open Patent Publication No. 2011-33229 discloses a method of assessing slaking of an elongated sheet by sending compressed air to a elongated sheet. However, there are problems such as air pollutant attaches to an air outlet opening sending compressed air, diameter of a hole is changed, measurement error occurs.

**[0019]** Here, in order to sense slacking of an elongated sheet, Korean laid-open Patent Publication No. 2010-0123820 discloses technology of assessing a sheet slacking by pressing and putting a touch roller on the surface of an elongated sheet, and measuring displacement of a touch roller in order to sense slacking of carrying elongated sheet. However, because an elongated sheet tension is evaluated using a contact roller, there are problems such as pollution and modification of nanofiber property of matter as according to electro spinning direction, spin nanofiber contacts a roller.

**[0020]** Meanwhile, when manufacturing nanofiber through the electrospinning apparatus, factors determining nanofiber feature are matter feature such as spinning material concentration, dielectric property, and surface tension, and control parameter such as distance between a nozzle and a collector, voltage between a nozzle and a collector, charge density of electrical field, electrostatic pressure in a nozzle, and injection speed of spinning material. Japanese laid-open Patent publication No. 2008-274522 discloses manufacture of nanofiber with uniform matter by adjusting such spinning condition. However, since it is not easy to constantly maintain electro spinning condition for a long time, mass production of nanofiber with uniform air permeability and thickness is still difficult.

## Disclosure

### Technical Problem

**[0021]** The present invention is contrived to solve the problem stated above, buffer section is formed between the electrospinning apparatus each of the unit. By installing an adjusting roller which is movable between upper and lower side in buffer section, carrying speed and carrying time of an elongated sheet going through each unit could be adjustable

according to section, and the crumpling, sagging, snapping, breakage, and damage of the elongated sheet are prevented. In the process of electrospinning, solve the elongated sheet not smoothly carrying problem occurred due to electrostatic attraction, and allocate device sensing slacking of the elongated sheet near spinning zone. By sensing sagging of the elongated sheet, transmit the signal to device assisting the elongated sheet carrying, based on the sensing signal, adjusting carrying speed of the collector fixed with the collector by electrostatic attraction, automatically improve sheet slacking and prevent problem due to slacking of sheet. Accordingly, the electrospinning apparatus aims to produce nanofiber with uniform quality.

**[0022]** Also, an auxiliary belt assisting carrying of the elongated sheet eliminates separate driving device, and instead supported by a roller having low friction coefficient. The auxiliary belt could be rotated only with driving force of conventionally installed elongated sheet carrying roller, and by solving the elongated sheet carrying problem, mass-producing of nanofiber with uniform quality is possible without auxiliary power. To solve not smoothly carrying problem of an elongated sheet caused by an electrostatic attraction in electro spinning process, auxiliary carrying device is allocated in spinning zone, and roller with low friction coefficient is used to comprise an auxiliary carrying device, it aims to provide an electrospinning apparatus which can carry an elongated sheet without separate driving device.

**[0023]** Moreover, it aims to provide a carrying speed(V) control device which control carrying speed(V) based on air permeability value and thickness value of nanofiber, which stacked on an elongated sheet carrying in desired speed(V), measured by using air permeability measuring device and ultrasound thickness measuring device respectively, and the electrospinning apparatus which can mass-produce nanofiber with uniform air pearmeability and thickness by controlling discharge amount jetted from a nozzle block and the number of nozzle.

## Technical Solution

**[0024]** To attain the purpose stated above, the present invention is the electrospinning apparatus for manufacturing nanofiber by jetting spinning solution on the elongated sheet on the collector in each of the unit through nozzle, comprising one or more in series arranged unit; provided in unit, a case comprising electric conductor or non-conductor; provided in the case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects- terminal to the nozzle block and +(plus) terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated on; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt, and further comprising buffer section formed between each of the unit, a pair of support roller supporting the elongated sheet on the buffer section, and an elongated sheet carrying speed adjusting system including one or more adjusting roller which is installed between a pair of support roller, movable between upper and lower side, and winding the elongated sheet, and according to the movement of each adjusting roller, the elongated sheet carrying speed according to each of the unit is adjusted.

**[0025]** Here, elongated sheet carrying speed adjusting system further comprises a sensing sensor for sensing carrying speed of the elongated sheet inside each of the unit, and a main control device which controls an adjusting roller movement according to sensed elongated sheet carrying speed in each unit.

**[0026]** Moreover, carrying speed is sensed by the sensing sensor, in the case carrying speed of the elongated sheet located in the unit of front-end is faster than carrying speed of the elongated sheet located in the unit of rear-end of the unit, the main control device moves the adjusting roller provided between a pair of the support roller to lower side, carrying speed of the elongated speed located in the unit of front-end and the carrying speed of the elongated sheet located in the unit of rear-end are modified and controlled to the same level.

**[0027]** Also, carrying speed is sensed by the sensing sensor, in the case by the sensing sensor carrying speed of the elongated sheet located in the unit of front-end is slower than carrying speed of the elongated sheet located in the unit of rear-end, the main control device moves the adjusting roller provided between a pair of the support roller to upper side, carrying speed of the elongated speed located in the unit of front-end and the carrying speed of the elongated sheet located in the unit of rear-end are modified and controlled to the same level. Meanwhile in the electrospinning apparatus comprising one or more in series arranged unit; provided in unit, a case comprising electric conductor or non-conductor; provided in the case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects- terminal to the nozzle block and + terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated on; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt, the auxiliary belt roller comprises a roller with low friction coefficient, and without separate driving device, assists carrying of the elongated sheet.

**[0028]** Here, one or more auxiliary belt roller is provided. Moreover, the auxiliary belt roller comprises one among low friction coefficient rolling bearing, oil bearing, ball bearing, roller bearing, sliding bearing, sleeve bearing, hydrodynamic journal bearing, hydrostatic journal bearing, pneumatic bearing, air dynamic bearing, air static bearing, or air bearing.

**[0029]** In addition, through adjusting the auxiliary belt roller upper and lower level, discharge amount of nanofiber stacked on the elongated sheet is adjusted.

**[0030]** Meanwhile, in the electrospinning apparatus comprising one or more in series arranged unit; provided in unit, a case comprising electric conductor or non-conductor; provided in the case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects- terminal to the nozzle block and + terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt, further comprising a sheet slacking sensing device which senses slacking of the elongated sheet in front and rear side of each unit; and an auxiliary belt driving device which receives signal from the auxiliary belt driving device and controls the speed of the auxiliary belt roller in each unit.

**[0031]** Here, the sheet slacking sensing device is among one of optic sensor, ultrasonic sensor, image sensor, or tension meter. Also, the auxiliary belt driving device is motor.

**[0032]** In the electrospinning apparatus comprising one or more in series arranged unit; provided in unit, a case comprising electric conductor or non-conductor; provided in case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; and spins and jets; a voltage generating device which connects- terminal to the nozzle block and + terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt, further comprising a sheet slacking sensing device which senses slacking of the elongated sheet in front and rear side of each of the unit.

**[0033]** Here, the sheet slacking sensing device is among one of optic sensor, ultrasonic sensor, image sensor, or tension meter. Also, the auxiliary belt driving device is motor.

**[0034]** Meanwhile, in the electrospinning apparatus comprising one or more in series arranged unit; provided in unit, a case comprising electric conductor or non-conductor; provided in the case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects- terminal to the nozzle block and + terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt, further comprising air permeability measuring device for measuring permeability of nanofiber laminating formed on the elongated sheet in each unit, carrying speed of the elongated sheet which nanofiber is laminated and formed is controlled, or the nozzle block discharge amount is controlled, or the voltage generating device voltage is controlled.

**[0035]** Here, the elongated sheet carrying speed control or the nozzle block discharge amount control or the voltage generating device voltage control is based on deviation between air permeability measured from the permeability measuring device and desired goal permeability-

**[0036]** In this case, the air permeability measuring device measures air permeability of nanofiber laminating forming on the elongated sheet by ultrasonic wave.

**[0037]** Meanwhile, the electrospinning apparatus comprising one or more in series arranged unit; provided in unit, a case comprising electric conductor or non-conductor; provided in the case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects- terminal to the nozzle block and + terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated;; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt, further comprising a thickness measurement device for measuring thickness of nanofiber laminating forming on the elongated sheet in each unit, carrying speed of the elongated sheet laminating forming nanofiber is controlled, or the nozzle block discharge amount is controlled, or voltage from the voltage generating device is controlled.

**[0038]** Here, the elongated sheet carrying speed control or the nozzle block discharge amount control or the voltage generating device voltage control is based on deviation between thickness measured from the thickness measurement device and desired goal thickness.

**[0039]** In this case, the thickness measurement device measures thickness of nanofiber laminating forming on the elongated sheet by measuring longitudinal wave and transverse wave of ultrasound.

## Advantageous Effects

**[0040]** The present invention having the structure as explained above, could adjust carrying speed and carrying time of the elongated sheet going through each unit, because of this, it can prevent the crimpling, sagging, snapping, breakage, and damage of the elongated sheet carried from each unit. Also, the carrying speed of the elongated sheet in the unit of front end and that of rear-end unit could respectively be adjusted and controlled, not only variously adjust thickness of the nanofiber web laminated on the elongated sheet but also form uniform distribution of nanofiber web laminated on upper side of the elongated sheet. Moreover, nanofiber web matter could be improved, device operation convenience and nanofiber web product reliability could be enhanced. Even more, by automatically sensing and solving of the slacking of the elongated sheet, uniformity spinning of nanofiber due to the elongated sheet carrying problem is prevented, and therby high quality nanofiber with uniform matter can be manufactured.

**[0041]** In addition, in the present invention, solving the problem of slowed carry of the elongated sheet caused by attaching to the collector, it prevents lack of uniformity spinning of nanofiber due to the elongated sheet carry imbalance, moves the auxiliary belt in upper and lower direction, adjusts the distance with the spinning nozzle, effectively controls nanofiber stack amount, and manufactures high quality nanofiber with uniform matter. Moreover, based on permeability and thickness measured by the permeability measuring device and the thickness measurement device, enables to control the elongated sheet carrying speed and the nozzle block, and enables mass-producing of nanofiber having uniform permeability and thickness during long time electro spinning.

## Brief Description of the Drawings

**[0042]**

FIG. 1 is a drawing schematically illustrating an electrospinning apparatus according to the related art,
FIG. 2 is a drawing schematically depicting an elongated sheet carrying speed adjusting system according to the first exemplary embodiment of the present invention,
FIG. 3 and FIG. 4 are drawings schematically showing the elongated sheet carrying speed adjusting system operation process, in the case carrying speed of the elongated sheet located at the unit of the front end is faster than the elongated sheet located at the unit of the rear end according to the first exemplary embodiment of the present invention,
FIG.5 and FIG. 6 are drawings schematically showing the elongated sheet carrying speed adjusting system operation process, in the case carrying speed of the elongated sheet located at the unit of front end is slower than the elongated sheet located at the unit of the rear end according to the first exemplary embodiment of the present invention,
FIG. 7 is a drawing schematically depicting an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient according to the second exemplary embodiment of the present invention,
FIG. 8 is a drawing schematically showing three auxiliary belt rollers in an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient according to the second exemplary embodiment of the present invention,
FIG. 9 is a drawing schematically depicting four auxiliary belt rollers in an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient according to the second exemplary embodiment of the present invention,
FIG. 10 is a drawing schematically depicting five auxiliary belt rollers in an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient according to the second exemplary embodiment of the present invention,
FIG. 11 is a drawing schematically showing bearing included in an auxiliary belt roller with low friction coefficient according to the second exemplary embodiment of the present invention,
FIG. 12 is a drawing schematically illustrating an elongated sheet slacking sensing device in an auxiliary belt device having three auxiliary belt rollers according to the third exemplary embodiment of the present invention,
FIG. 13 is a drawing schematically depicting an elongated sheet slacking sensing device in an auxiliary belt device having five auxiliary belt rollers according to the third exemplary embodiment of the present invention,
FIG.14 is a drawing schematically showing the elongated sheet slacking sensing device provided with the electrospinning apparatus according to the third exemplary embodiment of the present invention,
FIG. 15 is a process schematic diagram schematically showing the third exemplary embodiment of the present invention,
FIG. 16 is a process schematic diagram schematically showing the fourth embodiment of the electrospinning apparatus,
FIG. 17 is a schematic diagram schematically illustrating a nozzle block of the electrospinning apparatus according to the fourth embodiment of the electrospinning apparatus,

FIG. 18 is a process schematic diagram schematically showing the fifth embodiment of the electrospinning apparatus,

**Description of Reference Numbers of Drawings**

**[0043]**

1: electrospinning apparatus,
3: supply roller,
5: winding roller,
10, 10' , 10" , 10''' : unit,
11: nozzle block,
12: nozzle,
13: collector,
14: voltage generating device,
15, 15a, 15b: elongated sheet
16: auxiliary belt,
17: carrying roller,
17': auxiliary belt roller,
18: auxiliary belt driving device,
19a: sheet slacking sensing device,
19b: air permeability measuring device,
19c: thickness measurement device,
23, 28: auxiliary roller,
24, 25, 26, 27: driving roller
29: heating device,
30: elongated sheet carrying speed adjusting system
31: buffer section,
33, 33': support roller,
35: adjusting roller,
41: overflow solution storage tank,
43: tubular body,
44: polymer solution storage tank,
45: polymer solution circulation pipe,
50: main control device,
60: nozzle block discharging amount control device,
61: nozzle block discharging amount control device connection.

**Detailed Description of the Preferred Embodiments**

**[0044]** Below reference to a drawing attaching a desirable embodiment of the present disclosure and explains in detail. Also, the present embodiment doesn't limit the present disclosure extent of a right, but merely suggests an example, various modifications in the extent of not leaving the technological main point is possible.

**[0045]** FIG. 2 is a drawing schematically depicting an elongated sheet carrying speed adjusting system, FIG. 3 and FIG. 4 are drawings schematically showing the elongated sheet carrying speed adjusting system operation process, in the case of carrying speed of the elongated sheet located at the unit of front-end is faster than the elongated sheet located at the unit of rear-end, FIG.5 and FIG. 6 are drawings schematically showing the elongated sheet carrying speed adjusting system operation process, in the case of carrying speed of the elongated sheet located at the unit of front-end is slower than the elongated sheet located at the unit of rear-end, FIG. 7 is a drawing schematically depicting an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient, FIG. 8 is a drawing schematically showing three auxiliary belt rollers in an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient, FIG. 9 is a drawing schematically depicting four auxiliary belt rollers in an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient, FIG. 10 is a drawing schematically depicting five auxiliary belt rollers in an auxiliary belt device comprising an auxiliary belt roller with low friction coefficient, FIG. 11 is a drawing schematically showing bearing included in an auxiliary belt roller with low friction coefficient, FIG. 12 is a drawing schematically illustrating an elongated sheet slacking sensing device in an auxiliary belt device having three auxiliary belt rollers, FIG. 13 is a drawing schematically depicting an elongated sheet slacking sensing device in an auxiliary belt device having five auxiliary belt rollers, FIG. 14 is a drawing schematically showing the elongated sheet slacking sensing device provided with the electrospinning apparatus, FIG. 15 is a process schematic diagram schematically showing the embodiment of the electrospinning ap-

paratus, FIG. 16 is a process schematic diagram schematically showing the fourth embodiment of the electrospinning apparatus, FIG. 17 is a schematic diagram schematically illustrating a nozzle block of the electrospinning apparatus, and FIG. 18 is a process schematic diagram schematically showing the fifth embodiment of the electrospinning apparatus.

**[0046]** As illustrated in the drawing, the electrospinning apparatus(1) according to the present invention of the first embodiment comprises the elongated sheet carrying speed adjusting system(30) which is installed in the electrospinning apparatus(1), adjusts and controls the carrying speed and carrying time of the elongated sheet(15, 15') carried from each of the unit (10, 10') according to each of the unit (10, 10')

**[0047]** Here, the electrospinning apparatus(1) comprises a spinning solution main tank(not shown) which fills spinning solution inside, a metering pump(not shown) to supply the required amount of polymer spinning solution filled in the spinning solution main tank, a nozzle block(11) having plurality of pin type formed nozzles(12) to discharge polymer spinning solution inside the spinning solution main tank, a collector(13) which is installed separately in predetermined space from the nozzle(12) to collect spinning solution jetted from the nozzle bock (11)'s nozzle(12) and a unit(10) containing inside a power supply device(14) which generates voltage to the collector(13). Meanwhile, spinning solution supplied through the nozzle(12) inside the unit(10) is composed of solute and solvent, for solute is polymer including siloxane alone or combination of siloxane and selected coupler among monomethacrylate, vinyl, hydride, distearate, bis(1,2-hydroxymethyl), methoxy, ethoxylate, propoxylate, diglycidyl ether, monoglycidyl ether, monohydroxyalkyl, bishydroxyalkyl, chlorine and bis((aminoethyl-aminopropyl)dimethoxysilyl)ether. It is preferably selected one or more among polyvinylidene fluoride, polyvinylidene fluoride- hexafluoropropylene copolymer, composite composition thereof, polyamide, polyimide, polyamideimide, poly(meta-phenylene isophthalamide), metaaramid, poly Ethylene ChloroTriFluoroEthylene, polyChloroTriFluoroEthylene, Poly(methyl methacrylate), polyacrylonitrile, polyvinylidene chloride-acrylonitrile copolymer and polyacrylamide. Solvent is preferably composed of one or more among phenol, formic acid, sulfuric acid, m-cresol, trifluoroacetic anhydride / dichloromethane, water, N-methylmorpholine N- oxide, chloroform, tetrahydrofuran, and an aliphatic ketone group such as methyl isobutyl ketone and methyl ethyl ketone, an aliphatic hydroxyl group such as m-butyl alcohol, isobutyl alcohol, methyl alcohol and ethanol,an aliphatic compound group such as hexane, tetrachloroethylene and acetone, a glycol group such as propylene glycol, a diethylene glycol and ethylene glycol, a halogencompound group such as trichloroethylene and dichloromethane, an aromatic compound group such as toluene and xylene, an alicyclic compound group such as cyclohexanone, cyclohexane, a ester group such as n- butyl acetate and ethyl acetate, an aliphatic ether group such as butyl cellosolve, acetic acid2-ethozyethanol and 2-ethoxyethanol, and an amide group such as dimethylformamide and dimethylcetamide.

**[0048]** The electrospinning apparatus(1) by the structure according to the first exemplary embodiment of the present invention, fixed amount of spinning solution filled in the spinning solution main tank inside the unit(10) is consecutively provided in the several nozzles(12) provided with high voltage through a metering pump, polymer's spinning solution is provided by the nozzle(12) spins and collects on the collector(13) with high voltage flowing through the nozzle(12) and nanofiber web(not shown) is formed, formed nanofiber web is laminating and produced to non-woven fabric, filter, etc.

**[0049]** In this case, on the electrospinning apparatus'(1) collector(13) is provided with the elongated sheet(15) for preventing sagging and carrying a nanofiber web which is formed on the collector(13) when jetting spinning solution, the elongated sheet(15) is wound by the supply roller(3) which is provided on the one side of an electrospinning apparatus and the winding roller(5) provided on the other end.

**[0050]** In the embodiment of the present invention, though polymer spinning solution is jetted on the elongated sheet(15) located on the collector (13) through the electrospinning apparatus(1) nozzle(12) and comprised forming a nanofiber web, it is possible that seperate supporter(not shown) is supplied on the elongated sheet(15), separate supply roller(not shown) is provided for providing the supporter, the nozzle(12) spinning solution is jetted on the supporter to form a nanofiber web.

**[0051]** Here, the supporter laminating polymer spinning solution which is jetted from the electrospinning apparatus(1) the nozzle(12) is preferably comprising non-woven fabric or fabric etc, but it is not limited to this.

**[0052]** Meanwhile, the collector(13) outer side is provided with the auxiliary belt(16), the collector(13) both ends in the direction of length are each provided with a carrying roller(17), the auxiliary belt(16) is driven by the carrying roller's(17) rotation, by driving of the auxiliary belt(16) the elongated sheet(15) is carried from the front of the electrospinning apparatus(1) to the rear.

**[0053]** According to the structure, spinning solution filled in the inside of the electrospinning apparatus(1) unit's spinning solution main tank is jetted on the collector's (13) elongated sheet(15) by the nozzle(12), nanofiber web is formed as spinning solution jetted on the elongated sheet(15) is laminated, the elongated sheet(15) is carried by the auxiliary belt(16) driving by the carrying roller(17) rotation provided with on both ends of the collector (13) and located inside another unit(10'), by repeatedly performing the process a final production is produced.

**[0054]** In this case, the nozzle block's (11) nozzle's(12) outlet is formed in the upward direction, the collector(13) is located in the upper side of the nozzle block(11) and spins spinning solution in the upward direction. In the embodiment of the present invention, the electrospinning apparatus(1) is composed of a bottom-up electrospinning apparatus which spins spinning solution in the upward direction, but it is also possible to comprise a top-down electrospinning apparatus

which spins spinning solution in the downward direction.

**[0055]** Here, the elongated sheet carrying speed adjusting system(30) comprises a buffer section (31) formed between each of the unit(10, 10') of the electrospinning apparatus(1), a pair of support roller(33, 33') which supports the elongated sheet(15) provided on the buffer section (31), and an adjusting roller(35) provided between the pair of the support roller(33, 33')

**[0056]** In this case, the support roller(33, 33') supports carrying of the elongated sheet(15) when carrying the elongated sheet(15) on which a nanofiber web is laminated and formed by nozzle jetted spinning solution in each of the unit(10, 10'), each of them is provided in front-end and rear-end of the buffer section(31) formed between each of the unit(10, 10').

**[0057]** Moreover, the adjusting roller(35) is provided between a pair of the support roller(33, 33'), the elongated sheet(15) is winding, by the adjusting roller(35) upper, lower movement, the carrying speed and carrying time of the elongated sheet(15a, 15b) according to each of the unit (10, 10') are adjusted.

**[0058]** For this, a sensing sensor(not shown) for sensing the elongated sheet(15a, 15b) carrying speed in each of the unit(10, 10') is provided, and the main control device(50) is provided as illustrated in FIG. 16 in order to control the adjusting roller(35) movement according to carrying speed of the elongated sheet (15a, 15b) in each of the unit (10, 10') sensed by the sensing sensor.

**[0059]** Though in the embodiment of the present invention, carrying speed of the elongated sheet(15a, 15b) in each of the unit(10, 10') is sensed, according to the sensed carrying speed of the elongated sheet(15a, 15b), the main control device(50) controls the adjusting roller(35) movement, in order to carry the elongated sheet(15a, 15b), an auxiliary belt(16) provided on one side of the collector(13), or a carrying roller(17) for driving the auxiliary belt(16), or a motor(not shown) driving speed is sensed, and according to this, it is possible to comprise the main control device(50) controlling the movement of the adjusting roller(35).

**[0060]** By the structure stated above, by the sensing sensor, in the case of carrying speed of the elongated sheet(15a) located in front-end of the unit(10) is faster than carrying speed of the elongated sheet(15b) located in the unit of rear end(10'), the main control device(50) moves the adjusting roller(35) provided between a pair of the support roller(33, 33') to lower side, carrying speed of the elongated speed(15a) located in the unit of front end (10) and the carrying speed of the elongated sheet(15b) located in the unit of rear-end(10')are modified and controlled to the same level.

**[0061]** In other words, in the case of sensed carrying speed of the elongated sheet(15a) located in the unit of front-end (10) is faster than carrying speed of the elongated sheet(15b) located in the unit of rear-end(10'), in order to prevent slacking of the elongated sheet(15a) carried in the unit(10) located in front-end, the adjusting roller(35), provided between a pair of the support roller(33, 33') and wind the elongated sheet, is moved to the lower side, among the elongated sheet (15) carried from the unit (10) located in front-end to the unit(10') located in rear-end, the elongated sheet(15a), carried to outer side of the unit(10) in front-end and excessively carried to the buffer section(31) located between each of the unit, is pulled, carrying speed of the elongated speed located in front-end of the unit and the carrying speed of the elongated sheet located in rear-end of the unit are modified and controlled to the same level, and thereby slacking and crumpling of the elongated sheet(15a) are prevented.

**[0062]** According to the structure stated above, by adjusting carrying speed of the elongated sheet(15a) carried in the unit of front end(10) among each of the unit(10, 10'), carrying speed of the elongated speed in front-end of the unit and carrying speed of the elongated sheet in rear-end of the unit become to the same level.

**[0063]** Meanwhile, by the sensing sensor, in the case carrying speed of the elongated sheet(15a) located in the unit of front-end(10) is slower than carrying speed of the elongated sheet(15b) located in the unit of rear-end(10'), the main control device(50) moves the adjusting roller(35) provided between a pair of the support roller (33, 33') to upper side, carrying speed of the elongated sheet (15a) located in the unit of front-end (10) and the carrying speed of the elongated sheet(15b) located in the unit of rear-end(10') are modified and controlled to the same level.

**[0064]** In other words, in the case of sensed carrying speed of the elongated sheet(15a) located in front-end of the unit(10) is slower than carrying speed of the elongated sheet(15b) located in rear-end of the unit(10'), in order to prevent snapping of the elongated sheet(15b) carried in the unit of rear-end (10'), the adjusting roller(35), provided between a pair of the support roller(33, 33') and wind the elongated sheet, is moved to the upper side, among the elongated sheet(15) carried from the unit(10) in front-end to the unit(10') in rear-end, the elongated sheet (15a), carried to outer side of the unit(10) in front-end and wound in the buffer section(31) located between each of the unit (10, 10') by the adjusting roller (35), is fastly provided to the unit(10') in rear-side, carrying speed of the elongated sheet(15a) located in the unit of front-end(10) and the carrying speed of the elongated sheet(15b) located in the unit of rear end(10') are modified and controlled to the same level, and snapping of the elongated sheet(15b) is prevented.

**[0065]** According to the structure stated above, among each of the unit(10, 10'), by adjusting carrying speed of the elongated sheet(15a) carried in the rear-end of the unit(10'), carrying speed of the elongated sheet(15b)in rear-end of the unit (10') and carrying speed of the elongated sheet(15a) in front-end of the unit(10) become to the same level.

**[0066]** Below statement explains operation process of the elongated sheet adjusting system of the electrospinning apparatus according to the present invention.

**[0067]** First, according to the present invention through the supply roller provided in the electrospinning apparatus'(1)

front-end, the elongated sheet(15) is supplied to the electrospinning apparatus' (1) unit(10).

**[0068]** Thus, the elongated sheet(15) which is supplied to the electrospinning apparatus'(1) unit(10) through the supply roller(3) is located on the collector(13), the voltage generating device's (14) high voltage is occurred on the collector(13) through the nozzle(12), polymer spinning solution filled in spinning solution main tank(not shown) is jetted on the elongated sheet(15) which is on the collector(13) occurring high voltage through the nozzle block's(11) nozzle.

**[0069]** Here, spinning solution filled in the spinning solution main tank is consecutively supplied in the required amount in a plurality of nozzles(12) with high voltage through the metering pump(not shown), spinning solution supplied to each of the nozzle(12) is spun and line-focused on the collector(13) applied high voltage through the nozzle(12), jetted on the elongated sheet(15) and nanofiber web is laminated and formed.

**[0070]** As stated above, the elongated sheet(15), which laminating a nanofiber web located in the unit(10) of front-side among the electrospinning apparatus' (1) each unit (10, 10'), is carried from the unit(10) of front-side to the unit (10') located on the rear-side by the carrying roller(17) operated by the motor's(not shown) driving and auxiliary belt(16) driven by rotation of the feed roller(17), as the process is repeated a nanofiber web is laminating formed on the elongated sheet(15).

**[0071]** In this case, among each of the unit (10, 10') the elongated sheet(15) carried from the unit(10) in front-end to the unit in rear-end(10') is conveyed through a pair of support roller(33, 33') provided in the buffer section(31) between each of the unit(10, 10'), and simultaneously carried and wound by the adjusting roller(35) provided between a pair of the support roller(33, 33')

**[0072]** Here, carrying speed of the elongated sheet(15) in each of the unit (10, 10') comprises 0.2 to 100m/s, in the case of carrying speed of the elongated sheet(15a) located in the unit of front-side (10) and carrying speed of the elongated sheet(15b) located in the unit of rear-side (10') are same, it operates well.

**[0073]** However, in the case of carrying speed of the elongated sheet(15a) located in the unit of front-side (10) and carrying speed of the elongated sheet (15b) located in the unit of front-side (10) are different, according to the elongated sheet carrying speed adjusting system(30) of the present invention, carrying speed of the elongated sheet(15a) carried from the unit(10) located in front-end among each of the unit(10, 10') or carrying speed of the elongated sheet(15b) carried from the unit(10') located in rear-end is adjusted, and carrying speed of the elongated sheet(15a, 15b) going through each of the unit(10, 10') are modified and controlled to the same level.

**[0074]** For example, if carrying speed of the elongated sheet(15a, 15b) carried in each of the unit(10, 10') is 1, in the case of carrying speed of each of the elongated sheet(15a, 15b) in unit(10) located in front-end and unit located in rear-end(10') among each of the unit(10, 10') is all 1, it operates well.

**[0075]** However, in the case of sensed carrying speed of the elongated sheet(15a) located in the unit of front-side (10) is faster than carrying speed of the elongated sheet(15b) located in the unit of rear-side (10') is sensed, for example, in the case of the elongated sheet(15a) in unit(10) located in the unit located in front-end among each of the unit is 1, and the elongated sheet(15b) in the unit located in rear-end is 0.7, the adjusting roller(35) winding the elongated sheet is moved to the lower side, among the elongated sheet(15) carried from the unit(10) located in front side to the unit(10') located in rear-side, the elongated sheet(15a), excessively carried to the buffer section(31) in the unit of front-side located between each of the unit, is pulled, carrying speed of 0.3 is modified and controlled, carrying speed of the elongated sheet (15a) located in the unit of front side(10) and carrying speed of the elongated sheet(15b) located in the unit of rear side (10') are modified and controlled to the same level, and slacking and crumpling of the elongated sheet(15a) is prevented.

**[0076]** Also, sensed carrying speed of the elongated sheet(15a) located in the unit of front side(10) is slower than carrying speed of the elongated sheet (15b) located in the unit of rear side (10'), for example, in the case of the elongated sheet(15a) in unit(10) located in front-end among each of the unit is 0.7, and the elongated sheet (15b) in unit located in rear-end is 1, the adjusting roller(35) winding the elongated sheet is moved to the lower side, among the elongated sheet(15) carried from the unit(10) located in front side to the unit(10') located in rear-side, extra elongated sheet(15a) wound in the adjusting roller(35) is rapidly supplied to the unit(10') in rear end, carrying speed of 0.3 is modified and controlled, carrying speed of the elongated sheet(15a) located in the unit of front side(10) and carrying speed of the elongated sheet(15b) located in the unit of rear side(10') are modified and controlled to the same level, and snapping, breakage, and damage of the elongated sheet(15b) is prevented. As stated above, the elongated sheet(15),on which a nanofiber web is electrospun, going through each of the unit(10, 10') of the electrospinning apparatus(1) to perform post-process such as laminating, and the final product is manufactured.

**[0077]** In this case, defect-checking of air permeability of produced nanofiber is possible using an air permeability measuring device(not shown), using separate device for other post processing, process is performed, and the final product is manufactured.

**[0078]** Meanwhile, reference to FIG. 7 to FIG. 11, the electrospinning apparatus(1) according to the second embodiment of the present invention provided with the elongated sheet(15) going through between nozzle(12) and nozzle block (11) connected to minus terminal and collector(13) connected to plus terminal in desired carrying speed, in order to make it easier to desorption and carry of the elongated sheet(15) attached to the collector(13) by electrostatic attraction, auxiliary

belt(16), rotating synchronized with carrying speed of the elongated sheet(15), and auxiliary carrying device, supporting the auxiliary belt(16) and comprising the auxiliary belt roller(17') to assist rotation, are provided. In this case, it is preferable the auxiliary belt roller(17') comprising roller with low friction coefficient, if a roller with low friction coefficient is applied, other various rollers can be applied, and a bearing(not shown) with low friction coefficient can be provided.

**[0079]** Here, the nozzle block(11) comprises a plurality of nozzles, the nozzle block's(11) polymer solution discharge toward the collector from an outlet as nanofiber, nonofiber stacked on the elongated sheet(15), the elongated sheet(15) maintains uniform thickness and moves.

**[0080]** Here, according to the electrospinning apparatus(1), average diameter of nanofiber laminating formed on the elongated sheet(15) is tens to thousands nm, synthetic resin possible of electro spinning is not separately limited otherwise, for example, polypropylene(PP), polyethylene terephthalate(PET), polyvinylidene fluoride, nylon, polyvinyl acetate, polymethyl methacrylate, polyacrylonitrile(PAN), polyurethane(PUR), polybutylene terephthalate(PBT), polyvinyl butyral, polyvinyl chloride, polyethyleneimine, polyolefins, poly (lactic acid) (PLA), polyvinyl acetate (PVAc), polyethylene naphthalate (PEN), polyamide (PA), polyvinyl alcohol (PVA), polyethylene imide (PEI), polycaprolactone (PCL), polylactic glycolic acid (PLGA), silk, cellulose, and chitosan, and among them the material of polypropylene (PP) and heat-resistant polymer matter such as polyamide, polyimide, polyamideimide, poly (meta-phenyleneisophthalamide), polysulfone, polyether ketone, polyetherimide, aromatic polyester such as polyethylene terephthalate, polytrimethylene terephthalate, polyethylene naphthalate, poly-phosphazenesuch as polytetrafluoroethylene, polydiphenoxyposphazene, poly-bis[2-(2-methoxyethoxy)phosphazene], and polyurethane copolymer including polyurethane and polyether urethane, cellulose acetate, cellulose acetate butyrate, polymers of the group consisting of cellulose acetate propionate are used commercially and widely, does not limited thereto.

**[0081]** In this case, polymer solution is solution with dissolving polymer which is synthetic resin matter possible of electro spinning dissolved in suitable solvent, also the kind of solvent, as long as it can dissolve the polymer, are not limited, for example, phenol, formic acid, sulfuric acid, m-cresol, trifluorineaceticanhydride/dichloromethane, water, N-methylmorpholine N- oxide, chloroform, tetrahydrofuran and aliphatic ketone group such as methyl isobutyl ketone and methyl ethyl ketone, aliphatic hydroxyl group such as m - butyl alcohol, isobutyl alcohol, isopropyl alcohol, methyl alcohol, ethanol, aliphatic compound group such as haxane, tetrachlorethylene, acetone, glycol group such as propylene glycol, diethylene glycol, ethylene glycol, halogen compound group such as trichloroethylene, dichloromethane, aromatic compound group such as toluene, xylene, alicyclic compound group such as cyclohexanone, cyclohexane, and an ester group such as n-butylacetate and ethyl acetate, aliphatic ether group such as butylcellosolve, acetic acid 2-ethoxy ethyl ethanol, 2-ethoxyethanol, amide such as dimethylformamide, dimethylacetamide can be used, and can be used by mixing plural kinds of the solvent, the polymer solution can also contain an additive such as a conductivity-enhancing agent, does not limited thereto.

**[0082]** Moreover, temperature of each unit(10, 10') where polymer spinning solution is jetted through the electrospinning apparatus(1), for example, could be set to 25°C, and humidity of each unit (10. 10'), for example, could be set to 30%, but does not limit to this.

**[0083]** Meanwhile, the auxiliary carrying device(not shown) is additionally provided to each of the unit (10, 10') of the electrospinning apparatus(1) according to the second embodiment of the present invention, smoothly adjusts the elongated sheet(15) carrying, the elongated sheet(15) is attached to the collector(13), and prevents polymer spinning solution from uneven spinning due to uneven carrying.

**[0084]** In this case, as illustrated in FIG. 7, the auxiliary carrying device has the auxiliary belt(16) operated by two auxiliary belt roller(17') rotation, each of the auxiliary belt roller(17') comprises roller with low friction coefficient.

**[0085]** Meanwhile, in the second embodiment of the present invention, though the number of the auxiliary carrying device's auxiliary belt roller (17') is two, as illustrated in FIG. 8 to FIG. 10, the number of the auxiliary carrying device's auxiliary belt roller (17') can be three, four or five, and the elongated sheet(15) carrying could be smoothly adjusted.

**[0086]** In this case, the electrospinning apparatus(1) auxiliary carrying device not only assists carrying of the elongated sheet(15) attached to the collector(13) with electrostatic attraction through the roller with low friction coefficient, but also adjusts stack amount of nanofiber laminated and formed on the elongated sheet(15) by adjusting the elongated sheet(15) height upper and lower side.

**[0087]** Here, for conditions of adjusting stack amount of nanofiber laminated and formed on the elongated sheet(15) are voltage adjusting, adjustment of polymer solution viscosity, adjustment of polymer solution temperature, adjustment of number of nozzle(12) which is outlet, and adjustment of distance between the nozzle block(11) and the elongated sheet(15) which nanofiber is stacked, and among them the most simple method to adjust stack amount maintaining nanofiber matter is adjusting the distance between the nozzle block (11) and the elongated sheet(15). Though conventional art needs separate equipment to adjust the elongated sheet(15) location, and it is hard to control the location of the elongated sheet(15) because the elongated sheet(15)is attached to the collector(13) with electrostatic force in conventional art, the electrospinning apparatus(1) of the present invention is for separating the elongated sheet(15) with the collector(13) and carrying, the elongated sheet(15) location can be easily controlled.

**[0088]** In the embodiment, by adjusting the auxiliary carrying device location to upper or lower side, the elongated

sheet(15) location is changed and nanofiber stack amount is adjusted, by moving location of the auxiliary belt roller(17') provided in the auxiliary carrying device, the elongated sheet(15) height could be adjusted.

**[0089]** Also, though in the embodiment, the auxiliary carrying device of electrospinning apparatus(1) comprises the auxiliary belt(16) and the auxiliary belt roller(17') with low friction coefficient, as illustrated in FIG. 11, each of the unit (10, 10') of the electrospinning apparatus(1) front and rear side is provided the roller (17') with low friction coefficient, and enables to assist carrying of the elongated sheet(15). In the embodiment(in the second embodiment of the present invention), as an example of the roller with low friction coefficient, a roller comprising ball bearing is shown, if comprising with a roller with low friction coefficient, the form and composition of a roller is not limited, more detail bearing such as rolling bearing, oil bearing, ball bearing, roller bearing, sliding bearing; sleeve bearing, hydrodynamic journal bearing, hydrostatic journal bearing, pneumatic bearing, air dynamic bearing, air static bearing, and air bearing could be comprised, and roller with low friction coefficient including material and additives such as plastic and emulsifier could be comprised.

**[0090]** Meanwhile, reference to FIG. 12 to FIG. 15, the electrospinning apparatus(1) according to the third embodiment of the present invention has the elongated sheet(15) carrying in desired speed between the nozzle(12) and nozzle block (11) connected to minus terminal and the collector(13) connected to plus terminal, in order to make easily of desorption and carrying of the elongated sheet(15) attached to the collector(13) with electrostatic attraction, auxiliary belt(16), rotating synchronized with carrying speed of the elongated sheet(15), and auxiliary belt roller (17'), supporting the auxiliary belt(16) and assisting rotation, are provided, the auxiliary belt device(not shown) has the auxiliary belt driving device(18) as one among the auxiliary belt roller(17'), among the auxiliary belt device's auxiliary belt roller (17') one or two or more auxiliary belt roller (17') is driving roller(not shown) and the other auxiliary belt roller(17') is preferably comprising driven roller(not shown), but does not limit to this.

**[0091]** In this case, in the auxiliary belt driving device(18) provided in each of the unit (10, 10', 10" , 10"') of the electrospinning apparatus(1), the sheet slacking sensing device(19a) which senses sagging of the elongated sheet(15), controls the speed, and receives signal controlling the speed is additionally connected and provided, controls the elongated sheet(15) carrying speed, automatically restores sagging of the elongated sheet(15), and enables mass-producing of nanofiber.

**[0092]** Meanwhile, as illustrated in FIG. 12, the auxiliary belt device provided in each of the unit (10, 10') of the electrospinning apparatus (1) comprises three auxiliary belt roller(17'), among three auxiliary belt roller(17'), one is driving roller comprising the auxiliary belt driving device(18), the other two auxiliary belt roller(17') comprises driven roller, using the sheet slacking sensing device(19a) provided between each of the unit(10, 10'), sagging of the elongated sheet(15) is sensed, and according to this, signal adjusting speed is transferred to the auxiliary belt driving device(18).

**[0093]** Here, the auxiliary belt driving device(18) including the auxiliary belt roller(17') preferably comprises the auxiliary belt roller(17') and the driving device which rotates the auxiliary belt(16), the auxiliary belt driving device(18) is preferably operated by a motor.

**[0094]** The sheet slacking sensing device preferably comprises contact type or noncontact type of device sensing sagging of the elongated sheet(15), preferably comprises one among optic sensor, ultrasonic sensor, image sensor, or tension meter, as illustrated in FIG. 14, more preferably the sheet slacking sensing device(19a) senses the location of the sheet exactly using ultrasonic sensor.

**[0095]** Meanwhile, in the third embodiment of the present invention, the auxiliary belt device provided in each of the unit(10, 10") of the electrospinning apparatus(1) comprises three auxiliary belt roller(17'), among three auxiliary belt roller(17') one is driving roller comprising auxiliary belt driving device(18), and the other two are driven roller. As illustrated in FIG. 13, auxiliary belt device provided in each unit(10, 10', 10") comprises five auxiliary belt roller(17'), among five auxiliary belt roller(17'), one is driving roller comprising auxiliary belt driving device(18), and the other four could be driven roller.

**[0096]** According to the structure stated above, because of problem such as the sheet slacking sensing device(19a) located between each of the unit(10, 10', 10") arranged in series, senses sagging of the elongated sheet (15) in noncontact type, such signal is transferred from the unit(10', 10") located in rear-end to the auxiliary belt driving device of the unit(10, 10') located in front-end, by enhancing the rotation speed of the auxiliary belt driving device(18), the elongated sheet(15) sagged in front-end and the elongated sheet(15) attached to the collector(13) are effectively pulled and transferred to rear-end.

**[0097]** Meanwhile, as illustrated in FIG. 15, the sheet slacking sensing device(19a) is provided between each unit (10, 10', 10" 10"') arranged in series, where the elongated sheet is carried with desired speed and desired direction, the elongated sheet(15) supplied from the supply roller(3) is provided certain height and direction through the auxiliary roller(23), by the driving roller (24, 25, 26, 27), maintains desired carrying speed, and moves forward toward the winding roller (5).

**[0098]** In this case, in the case of electrostatic attraction between the collector(13) of each of the unit(10, 10', 10", 10"') and the elongated sheet(15) is bigger than feed force of each driving roller(24, 25, 26, 27), the elongated sheet(15) is attached to the collector(13), and doesn't smoothly carried to the winding roller(5), when the elongated sheet is pulled to each of the driving roller (24, 25, 26, 27) by force in the state of the elongated sheet(15) is attached, there could be

problem such as the elongated sheet(15) is ruptured. Therefore, in each of the unit (10, 10', 10" , 10'''), to assist carrying of the elongated sheet to each of the unit(10, 10', 10", 10"'), the auxiliary belt device comprises the auxiliary belt (16); the auxiliary belt roller (17'), and auxiliary belt driving device(18) provided one among the auxiliary belt roller(17'),the sheet slacking sensing device senses sagging of the elongated sheet(15) and adjusts speed of the auxiliary belt device, thereby the elongated sheet(15) in each of the unit (10, 10', 10" , 10"') of the electrospinning apparatus(1) is smoothly carried.

**[0099]** As stated above, through each of the unit(10, 10', 10", 10''') of the electrospinning apparatus(1), the elongated sheet(15) on which nanofiber stacked and formed finalize nanofiber-manufacture through the heating device(29), in this case heating temperature could be set differently according to the elongated sheet(15) or type of nanofiber. For example, through the heating device(29), it could be heated by heating temperature from 40 to 400°C.

**[0100]** The elongated sheet(15) passes through the heating device(29), the location of the elongated sheet(15) is modified in certain direction through the auxiliary roller(28), wound by the winding roller(5), nanofiber stacked and laminating on the elongated sheet(15) is manufactured to nanofiber non-woven fabric.

**[0101]** Meanwhile, though in the third embodiment of the present invention, the sheet slacking sensing device(19a) is provided between each of the unit (10, 10', 10" , 10''') of the electrospinning apparatus(1), as illustrated in FIG. 16, the air permeability measuring device(19b) could be consecutively arranged and installed between each of the unit(10, 10', 10", 10''') of the electrospinning apparatus(1).

**[0102]** In other words, to measure air permeability of nanofiber laminated on the elongated sheet(15) of the electrospinning apparatus(1), the air permeability measuring device(19b) is each provided between each of the unit(10, 10', 10", 10''') of the electrospinning apparatus(1) according to the fourth embodiment of the present invention.

**[0103]** In this case, the electrospinning apparatus(1) comprises bottom-up or top-down electrospinning apparatus, the electrospinning apparatus(1) provided in each of the unit(10, 10', 10" , 10''') is installed in the case(not shown) comprising conductor or non-conductor.

**[0104]** Here, in the electrospinning apparatus(1) according to the embodiment of the present invention, in each of the unit(10, 10', 10" , 10'''), the auxiliary belt(16), provided between the collector(13) and the elongated sheet(15), and the elongated sheet(15) on which nanofiber is stacked and formed are carried in horizontal direction the auxiliary belt roller(17') is an automatic roller with very low frictional force, by operating the auxiliary belt(6) provided between the collector(13) and the elongated sheet(15), the elongated sheet(15) is smoothly carried without pulling by the collector(13) with high voltage.

**[0105]** Meanwhile, based on air permeability value measured by the permeability measuring device(19b) provided between each of the unit(10, 10', 10" , 10''') of the electrospinning apparatus(1), the elongated sheet(15) carrying speed and the nozzle block(11) discharging amount are controlled.

**[0106]** In other words, in the case air permeability value of nanofiber, stacked and formed on the elongated sheet(15) passing through each of the unit(10, 10', 10" , 10''') of the electrospinning apparatus(1), is large, smaller air permeability can be attained by increasing discharged amount of nanofiber per unit area of the elongated sheet(15) thereby increasing stacked amount on the elongated sheet(15). To increase discharged amount of nanofiber per unit area of the elongated sheet(15), carrying speed of the elongated sheet(15) in the unit(10', 10", 10''') located in rear-end of the control device(50) could be slowed, the voltage intensity of the voltage generating device(14) could be controlled, or through the nozzle block discharging amount control device(60) discharged amount from the nozzle block(11) is increased. In the case air permeability value of nanofiber, stacked and formed on the elongated sheet(15) passing through each of the unit(10, 10', 10" , 10''') of the electrospinning apparatus (1), is small, larger air permeability can be attained by decreasing discharged amount of nanofiber per unit area of the elongated sheet(15) thereby decreasing stacked amount on the elongated sheet(15). To decrease discharged amount of nanofiber per unit area of the elongated sheet(15), carrying speed of the elongated sheet(15) in the unit (10',10",10''') located in rear-end of the control device(50) could be faster, the voltage intensity of the voltage generating device(14) could be controlled, or through the nozzle block discharging amount control device(60) discharged amount from the nozzle block(11) is decreased. Thereby, nanofiber with uniform air permeability can be stacked and formed on the elongated sheet(15).

**[0107]** Here, the air permeability measuring device(19b) is preferably measuring device with ultrasonic method, but it is not limited to this.

**[0108]** In this case, in the nozzle block (11) of the electrospinning apparatus(1) according to the embodiment, as illustrated in FIG. 17, provided a plurality of nozzle(12) is provided, a plurality of tubular body (43) having the nozzle(12) for spinning polymer spinning solution upward or downward from the outlet(not shown) is arranged and installed, polymer spinning solution spun from the plurality of nozzle(12) outlet could be overflow and reused, through the nozzle block discharging amount control device(60) connected to the tubular body (43) having the plurality of nozzle(12) with the nozzle block discharging amount control device connection (61), polymer spinning solution discharging amount from the polymer solution storage tank(44) connected to each of the nozzle(12) with the polymer solution circulation pipe(45)could be automatically controlled.

**[0109]** Meanwhile, air permeability of the elongated sheet(15) on which nanofiber is stacked and formed means air

permeability value measured in the state of nanofiber layer laminated and formed on the elongated sheet(15) on which nanofiber is stacked and formed.

**[0110]** According to the structure stated above, in the case the nanofiber air permeability deviation is less than a desired value, the main control device(50) doesn't change carrying speed from initial value, in the case the deviation is more than a desired value, the main control device (50) could be controlled by changing carrying speed from initial value, and carrying speed control can be simplified.

**[0111]** Moreover, in the case of the nanofiber air permeability deviation is less than a desired value, the nozzle block discharging amount control device(60) doesn't change the nozzle block(11) discharging amount from initial value, and simultaneously doesn't change voltage intensity from initial value. In the case of the nanofiber air permeability deviation is more than a desired value, through the nozzle block discharging amount control device(60) and the main control device(50), the nozzle block(11) discharging amount and voltage intensity could be controlled by changing from initial value, control of the nozzle block(11) discharging amount and voltage intensity could be simplified.

**[0112]** Below statement specifically explains the embodiment. However, the embodiment is an example of the present invention, the present invention scope is not limited to this.

1. air permeability measurement

**[0113]** Permeability measuring tester does reciprocating motion in desired cycle according along the elongated sheet(15) width direction, through an ultrasonic sensor, measures the elongated sheet(15) air permeability. Air permeability measurement according to the air permeability measuring tester is carried out, for example, every 10ms.

2. Average air permeability(P)

**[0114]** Take an average of measured air permeability in desired cycle using the permeability measuring tester, and calculate average air permeability.

3. Deviation ($\Delta$P)

**[0115]** A deviation between the average air permeability(P) and desired goal air permeability ($\Delta$P).

4. Carrying speed(V) control

**[0116]** Based on the deviation ($\Delta$P), carrying speed(V) is controlled.

5. Nozzle block discharging amount and voltage control

**[0117]** Based on the deviation ($\Delta$P), nozzle block discharging amount and voltage are controlled.

[Embodiment 1]

**[0118]** Installing five units, the elongated sheet(15) is carried in desired carrying speed from the supply roller(3) toward the winding roller(5), laminating nanofiber in order.

**[0119]** In this case, measuring air permeability of the elongated sheet(15) laminating formed nanofiber from the unit(10, 10', 10") of front-end according to the electrospinning apparatus, simultaneously based on measured air permeability by the air permeability measuring device(19b), carrying speed is controlled, after laminating nanofiber on the elongated sheet(15) consecutively in the unit (10', 10", 10'") of rear-end, air permeability is measured, repeatedly carrying speed is controlled, and nanofiber is laminated.

[Embodiment 2]

**[0120]** Installing five units, the elongated sheet(15) is carried in desired carrying speed from the supply roller(3) toward the winding roller(5), laminating nanofiber in order.

**[0121]** In this case, measuring air permeability of the elongated sheet(15) laminating formed nanofiber from each of the unit(10, 10', 10" , 10'"), simultaneously based on measured air permeability according to the air permeability measuring device(19b), the nozzle block(11) discharging amount and the voltage generating device(14) voltage intensity are controlled, after laminating nanofiber on the elongated sheet(15) consecutively in the unit of rear-end(10', 10" , 10"'), air permeability is measured, repeatedly the nozzle block(11) discharging amount and the voltage generating device(14) voltage intensity are controlled, and nanofiber is laminated.

[Comparative example 1]

**[0122]** Installing five units, the elongated sheet(15) is carried in desired carrying speed from the supply roller(11) toward the winding roller(12), laminating nanofiber in order.

**[0123]** After successively laminating nanofiber, carrying speed(V) is not controlled, after the last unit, air permeability is measured.

[Table 1]

| | Embodiment 1 | Embodiment 2 | Comparative example 1 |
|---|---|---|---|
| Control number | 4 | 3 | 0 |
| Final air permeability deviation ($\Delta$P) | +1 | +0.5 | +11.4 |

**[0124]** As known in the result, through the main control device(50) of the embodiment, by controlling the elongated sheet(15) carring speed and the voltage generating device (14) voltage intensity, simultaneously by controlling the nozzle block(11) discharging amount through the nozzle block discharging amount control device(60), nanofiber with uniform air permeability could be manufactured.

**[0125]** Meanwhile, in the fourth embodiment of the present invention, the air permeability measuring device(19b) is provided between each of the unit (10, 10', 10" , 10"') of the electrospinning apparatus(1), as illustrated in FIG. 18, the thickness measurement device(19c) could be successively arranged and installed between each of the unit(10, 10', 10", 10"') of the electrospinning apparatus(1).

**[0126]** In other words, to measure the thickness of nanofiber laminated and formed on the elongated sheet(15) of the electrospinning apparatus(1), the thickness measurement device(19c) is each provided between each of the unit(10, 10', 10" , 10"') of the electrospinning apparatus(1) according to the fifth embodiment of the present invention.

**[0127]** According to the structure stated above, based on the thickness value measured by the thickness measurement device(19c) provided between each of the unit(10, 10', 10" , 10"') of the electrospinning apparatus(1), the elongated sheet(15) carrying speed and the nozzle bock (11) discharging amount can be controlled.

**[0128]** In other words, in the case thickness value of nanofiber, stacked and formed on the elongated sheet(15) passing through each of the unit(10, 10', 10" , 10"') of the electrospinning apparatus(1), is measured thinner than deviation, thicker thickness value can be attained by increasing discharged amount of nanofiber per unit area of the elongated sheet(15) thereby increasing stacked amount on the elongated sheet(15).

**[0129]** To increase discharged amount of nanofiber per unit area of the elongated sheet(15), carrying speed of the elongated sheet(15) in the unit(10',10",10"') located in rear-end of the control device(50) could be slowed, the voltage intensity of the voltage generating device(14) could be controlled, or through the nozzle block discharging amount control device(60) discharged amount from the nozzle block(11) could be increased. In the case thickness value of nanofiber, stacked and formed on the elongated sheet(15) passing through each of the unit(10, 10', 10" , 10"') of the electrospinning apparatus(1), is measured thicker than deviation, thinner thickness value can be attained by decreasing discharged amount of nanofiber per unit area of the elongated sheet(15) thereby decreasing stacked amount on the elongated sheet(15). To decrease discharged amount of nanofiber per unit area of the elongated sheet(15), carrying speed of the elongated sheet(15) in the unit (10', 10", 10"') located in rear-end of the control device(50) could be faster, the voltage intensity of the voltage generating device(14) could be controlled, or through the nozzle block discharging amount control device(60) discharged amount from the nozzle block(11) is decreased. Thereby, nanofiber with uniform thickness can be stacked and formed on the elongated sheet(15).

**[0130]** Here, the thickness measurement device(19c) is arranged in opposite sides between the elongated sheet(15), using ultrasonic measuring method, thickness measuring tester(not shown), which measures the distance to the elongated sheet(15) and comprising a pair of ultrasonic, longitudinal wave, and transverse wave measuring method, is provided, based on measured distance according to the thickness measurement device(19c), the elongated sheet(15) thickness could be calculated.

**[0131]** In other words, the thickness measurement device(19c) uses ultrasonic longitudinal wave and transverse wave to calculate the thickness of a subject. The thickness measurement device(19c) projects ultrasonic longitudinal wave and transverse wave together on the elongated sheet(15) laminating nanofiber, after measuring reciprocating motion time of each ultrasonic signal of longitudinal wave and transverse wave from the elongated sheet(15), in other words, after measuring each propagation time of longitudinal wave and transverse wave, the thickness of a subject can be calculated from predetermined formula using propagation time of measured longitudinal wave and transverse wave, propagation speed of measured longitudinal wave and transverse wave in reference temperature of the elongated

sheet(15) laminating nanofiber, and a temperature constant of propagation speed of longitudinal wave and transverse wave.

**[0132]** In other words, in the thickness measurement device(19c) using ultrasonic longitudinal wave and transverse wave, after measuring each propagation time of longitudinal wave and transverse wave, the thickness of the elongated sheet(15) laminating nanofiber can be calculated from predetermined formula using propagation time of measured longitudinal wave and transverse wave, propagation speed of measured longitudinal wave and transverse wave in reference temperature of the elongated sheet(15) laminating nanofiber, and a temperature constant of propagation speed of longitudinal wave and transverse wave. The thickness could be accurately measured even in the state of uneven inner temperature by self compensating error made by change of propagation speed according to change of temperature, thereby the thickness could be accurately measured even though there is temperature distribution in any form inside nanofiber in the thickness measurement device(19c).

**[0133]** In the embodiment, in this case in the nozzle block (11) of the electrospinning apparatus(1) according to the embodiment, as illustrated in FIG. 17, provided a plurality of nozzle(12) is provided, a plurality of tubular bodies (43) having the nozzle(12) for spinning polymer spinning solution upward or downward from the outlet(not shown) is arranged and installed, polymer spinning solution spun from the plurality of nozzle(12) outlet could be overflow and reused, through the nozzle block discharging amount control device(60) connected to the tubular body (43) having the plurality of nozzle(12) with the nozzle block discharging amount control device connection (61), polymer spinning solution discharging amount from the polymer solution storage tank(44) connected to each of the nozzle(12) with the polymer solution circulation pipe(45)could be automatically controlled.

**[0134]** Here, thickness of the elongated sheet(15) on which nanofiber is stacked and formed means measured thickness value in state of nanofiber layer laminated and formed on the elongated sheet(15) on which nanofiber is stacked and formed.

**[0135]** According to the structure stated above, in the case the nanofiber thickness deviation is less than a desired value, the main control device(50) doesn't change carrying speed from the initial value, and in the case the thickness deviation is more than a desired value, the main control device (50) controls to change carrying speed from the initial value, so carrying speed control are simplified.

**[0136]** Moreover, in the case of nanofiber thickness deviation is less than a desired value, the nozzle block discharging amount control device(60) doesn't change the nozzle block (11) discharging amount from the initial value, simultaneously the main control device(50) doesn't change voltage intensity from the initial value, and in the case of the thickness deviation is more than a desired value, through the nozzle block discharging amount control device(60) and the main control device(50), the nozzle block(11) discharging amount and voltage intensity could be controlled to be changed from the initial value, so the nozzle block(11) discharging amount and voltage intensity control are simplified.

**[0137]** Below statement more specifically explains than the embodiment. However, the embodiment is merely an example of the present invention, the present invention scope is not limited to this.

1. Goal thickness measurement(do)

**[0138]** Manufactured nanofiber thickness is set to goal thickeness.

2. Thickness measurement

**[0139]** The thickness measurement tester does reciprocating motion in desired cycle along the elongated sheet(15) width direction, through an ultrasonic sensor, measures the elongated sheet(5) thickness. Thickness measurement using the thickness measurement device is carried, for example, every 10ms.

3. Average thickness(d)

**[0140]** Take an average of measured thickness measured by the thickness measurement device in desired cycle, and calculate average thickness.

4. Deviation($\Delta$d)

**[0141]** A deviation between the average thickness(d) and desired goal thickness ($d_0$).

5. Carrying speed(V) control

**[0142]** Based on the deviation ($\Delta$d), carrying speed(V) is controlled.

6. Nozzle block discharging amount and voltage control

**[0143]** Based on the deviation (Δd), nozzle block discharging amount and voltage are controlled.

[Embodiment 3]

**[0144]** Installing five units, the elongated sheet(15) is carried in desired carrying speed(V) from the supply roller(3) toward the winding roller(5), laminating nanofiber in order.

**[0145]** In this case, measuring thickness of the elongated sheet(15) on which nanofiber is laminated and formed from the unit of front-end (10, 10', 10") according to the electrospinning apparatus, simultaneously based on measured thickness according to the thickness measurement device(19c), carrying speed is controlled, after laminating nanofiber on the elongated sheet(15) consecutively from the unit of rear-end(10, 10', 10"), thickness is measured, repeatedly carrying speed is controlled, and nanofiber is laminated.

[Embodiment 4]

**[0146]** Installing five units, the elongated sheet(15) is carried in desired carrying speed(V) from the supply roller(3) toward the winding roller(5), laminating nanofiber in order.

**[0147]** In this case, measuring thickness of the elongated sheet(15) on which nanofiber is laminated and formed from each of the unit(10, 10', 10", 10'"), simultaneously based on measured thickness according to the thickness measurement device(19c), the nozzle block(11) discharging amount and the voltage generating device(14) voltage intensity are controlled, after laminating nanofiber on the elongated sheet(15) consecutively from the unit of rear-end(10, 10', 10"), thickness is measured, repeatedly the nozzle block(11) discharging amount and the voltage generating device(14) voltage intensity are controlled, and nanofiber is laminated.

[Comparative example 2]

**[0148]** Installing five units, the elongated sheet(15) is carried in desired carrying speed from the supply roller(11) toward the winding roller(12), laminating nanofiber in order.

**[0149]** After successively laminating nanofiber, carrying speed is not controlled, after the last unit, thickness is measured.

[Table 2]

| | Embodiment 3 | Embodiment 4 | Comparative example 2 |
|---|---|---|---|
| Control number | 5 | 4 | 0 |
| Final thickness deviation (Δd) | 0.1 | +0.3 | +13.3 |

**[0150]** As known in the result, through the main control device(50) of the embodiment, by controlling the elongated sheet(15) carrying speed and the voltage generating device(14) voltage intensity, simultaneously by controlling the nozzle block(11) discharging amount through the nozzle block discharging amount control device(60), nanofiber with uniform thickness could be manufactured.

**[0151]** While the present invention is described with reference to particular embodiments thereof, it will be understood by those skilled in the art that variations or amendment may be made therein without departing from the sprit and scope of the invention. The scope of the present invention is not limited by those variations or amendments, but by the following claims.

## Claims

**1.** An electrospinning apparatus for producing nanofiber, comprising:

one or more in series arranged unit; a case is provided in the unit and comprising electric conductor or non-conductor; a nozzle block is provided in the case, in which a plurality of nozzles in pin form are arranged; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle

block with a predetermined distance apart; a voltage generating device which connects minus terminal to the nozzle block and plus terminal to the collector; an elongated sheet is located between the nozzle block and the collector, and is moved in desired speed, on which polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt for moving the elongated sheet in desired carrying speed; and an auxiliary belt roller for supporting and simultaneously operating the auxiliary belt; and thereby jetting spinning solution on the elongated sheet in upper side of the collector through the nozzle in each of the units,
further comprising an elongated sheet carrying speed adjusting system, including buffer section formed between each of the unit, a pair of support roller supporting the elongated sheet on the buffer section, and one or more of adjusting roller provided between a pair of the support roller, movable between upper or lower side, winding the elongated sheet, thereby the carrying speed of the elongated sheet according to each of the unit is adjusted.

**2.** The electrospinning apparatus of claim 1, wherein the elongated sheet carrying speed adjusting system further comprises a sensing sensor for sensing carrying speed of the elongated sheet inside each of the unit, and a main control device which controls movement of an adjusting roller according to sensed carrying speed of the elongated sheet in each unit by the sensing sensor.

**3.** The electrospinning apparatus of claim 2, wherein in the case sensed carrying speed of the elongated sheet located in the unit of front-end is faster than sensed carrying speed of the elongated sheet located in the unit of rear-end by the sensing sensor, the main control device moves the adjusting roller provided between a pair of the support roller to lower side, so that carrying speed of the elongated speed located in the unit of front-end and the carrying speed of the elongated sheet located in the unit of rear-end are modified and controlled to the same level.

**4.** The electrospinning apparatus of claim 2, wherein in the case carrying speed of the elongated sheet located in the unit of front-end is slower than speed of the elongated sheet located in the unit of rear-end by the sensing sensor, the main control device moves the adjusting roller provided between a pair of the support roller to upper side, so that speed of the elongated speed located in the unit of front-end and the carrying speed of the elongated sheet located in the unit of rear-end are modified and controlled to the same level.

**5.** An electrospinning apparatus for producing nanofiber, comprising:

one or more in series arranged unit; a case is provided in the unit and comprising electric conductor or non-conductor; a nozzle block is provided in the case, in which a plurality of nozzles in pin form are arranged; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects minus terminal to the nozzle block and plus terminal to the collector; an elongated sheet is located between the nozzle block and the collector, and is moved in desired speed, on which polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt for moving the elongated sheet in desired carrying speed; and an auxiliary belt roller for supporting and simultaneously operating the auxiliary belt,
wherein the auxiliary belt roller comprising a roller with low friction coefficient so that assists the carrying of the elongated sheet without separate driving device.

**6.** The electrospinning apparatus of claim 5, wherein the auxiliary belt roller is provided with one or more the auxiliary belt rollers.

**7.** The electrospinning apparatus of claim 5, wherein the auxiliary belt roller is selected from the group consisting of low friction coefficient rolling bearing, oil bearing, ball bearing, roller bearing, sliding bearing, sleeve bearing, hydro-dynamic journal bearing, hydrostatic journal bearing, pneumatic bearing, air dynamic bearing, air static bearing, or air bearing.

**8.** The electrospinning apparatus of claim 5, wherein nanofiber discharging amount staked on the elongated sheet is adjusted by adjusting the auxiliary belt roller upper and lower level.

**9.** An electrospinning apparatus for producing nanofiber,, comprising:

one or more in series arranged unit; provided in the unit, a case comprising electric conductor or non-conductor; provided in the case, a nozzle block which arranges a plurality of nozzles in pin form; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined

distance apart; a voltage generating device which connects minus terminal to the nozzle block and plus terminal to the collector; an elongated sheet located between the nozzle block and the collector, moves in desired speed, and polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated on; an auxiliary belt which moves the elongated sheet in desired carrying speed; and an auxiliary belt roller which supports and simultaneously operates the auxiliary belt,
further comprising a sheet slacking sensing device which senses slacking of the elongated sheet in front and rear side of each unit; and an auxiliary belt driving device which receives signal from the auxiliary belt driving device and controls the speed of the auxiliary belt roller in each unit.

**10.** The electrospinning apparatus of claim 9, wherein the sheet slacking sensing device is one among optic sensor, ultrasonic sensor, image sensor, or tension meter. Also, the auxiliary belt driving device is motor.

**11.** An electrospinning apparatus for producing nanofiber, comprising:

one or more in series arranged unit; a case is provided in the unit and comprising electric conductor or non-conductor; a nozzle block is provided in the case, in which a plurality of nozzles in pin form are arranged; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects minus terminal to the nozzle block and plus terminal to the collector; an elongated sheet is located between the nozzle block and the collector, and is moved in desired speed, on which polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt for moving the elongated sheet in desired carrying speed; and an auxiliary belt roller for supporting and simultaneously operating the auxiliary belt,
further comprising the sheet slacking sensing device for sensing the slacking of the elongated sheet in front and rear side of each of the unit.

**12.** The electrospinning apparatus of claim 11, wherein the sheet slacking sensing device is one among optic sensor, ultrasonic sensor, image sensor, or tension meter, and the auxiliary belt driving device is motor.

**13.** An electrospinning apparatus for producing nanofiber, comprising:

one or more in series arranged unit; a case is provided in the unit and comprising electric conductor or non-conductor; a nozzle block is provided in the case, in which a plurality of nozzles in pin form are arranged; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects minus terminal to the nozzle block and plus terminal to the collector; an elongated sheet is located between the nozzle block and the collector, and is moved in desired speed, on which polymer spinning solution nanofiber discharged from the nozzle block is stacked and laminated; an auxiliary belt for moving the elongated sheet in desired carrying speed; and an auxiliary belt roller for supporting and simultaneously operating the auxiliary belt,
further comprising air permeability measuring device for measuring air permeability of nanofiber laminating formed on the elongated sheet of each unit is installed, so that carrying speed of the elongated sheet laminating forming nanofiber is controlled, or the nozzle block discharge amount is controlled, or the voltage generating device voltage is controlled.

**14.** The electrospinning apparatus of claim 13, wherein the elongated sheet carrying speed control or the nozzle block discharging amount control or the voltage generating device voltage control is based on deviation between air permeability measured from the air permeability measuring device and desired goal air permeability.

**15.** The electrospinning apparatus of claim 13, wherein the air permeability measuring device measures air permeability of nanofiber laminating forming on the elongated sheet by ultrasonic wave.

**16.** An electrospinning apparatus for producing nanofiber, comprising:

one or more in series arranged unit; a case is provided in the unit and comprising electric conductor or non-conductor; a nozzle block is provided in the case, in which a plurality of nozzles in pin form are arranged; a collector collecting spun and jetted polymer spinning solution which is located and installed over the nozzle block with a predetermined distance apart; a voltage generating device which connects minus terminal to the nozzle block and plus terminal to the collector; an elongated sheet is located between the nozzle block and the collector, and is moved in desired speed, on which polymer spinning solution nanofiber discharged from the

nozzle block is stacked and laminated; an auxiliary belt for moving the elongated sheet in desired carrying speed; and an auxiliary belt roller for supporting and simultaneously operating the auxiliary belt,
further comprising a thickness measurement device for measuring thickness of nanofiber laminating forming on the elongated sheet in each unit, so that carrying speed of the elongated sheet laminating forming nanofiber is controlled, or the nozzle block discharge amount is controlled, or the voltage generating device voltage is controlled.

**17.** The electrospinning apparatus of claim 16, wherein the elongated sheet carrying speed control or the nozzle block discharge amount control or the voltage generating device voltage control is based on deviation between thickness measured from the thickness measuring device and desired goal thickness.

**18.** The electrospinning apparatus of claim 16, wherein the thickness measurement device measures thickness of nanofiber laminating forming on the elongated sheet by ultrasonic, longitudinal wave and transverse wave.

FIG.1

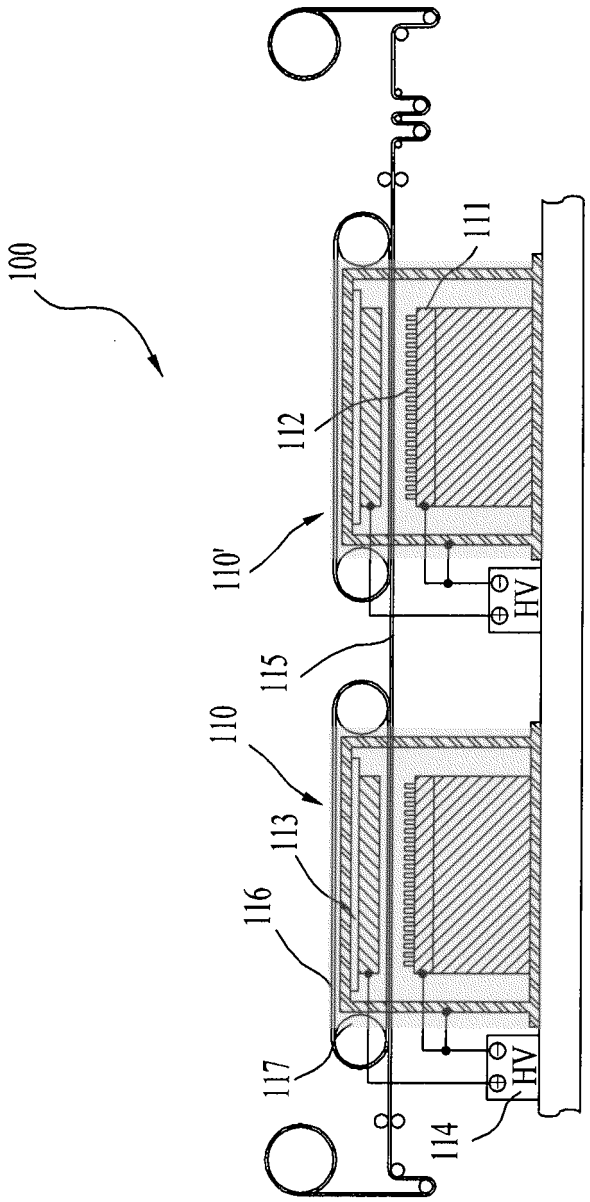


FIG.2

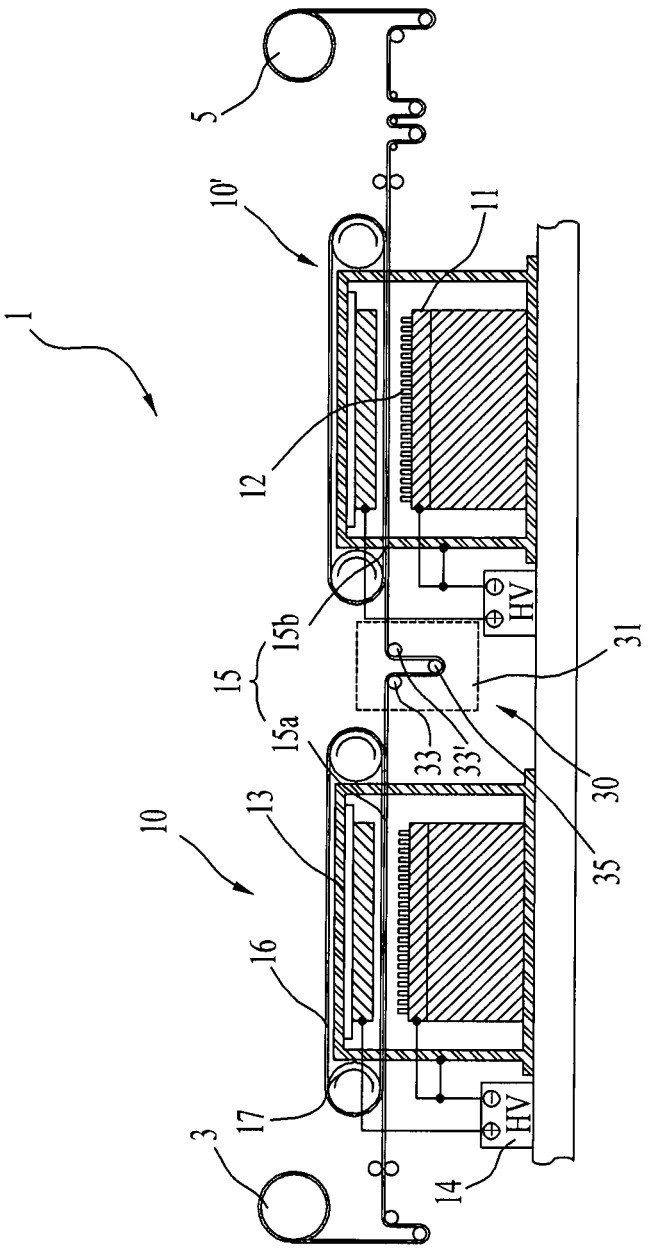


FIG.3

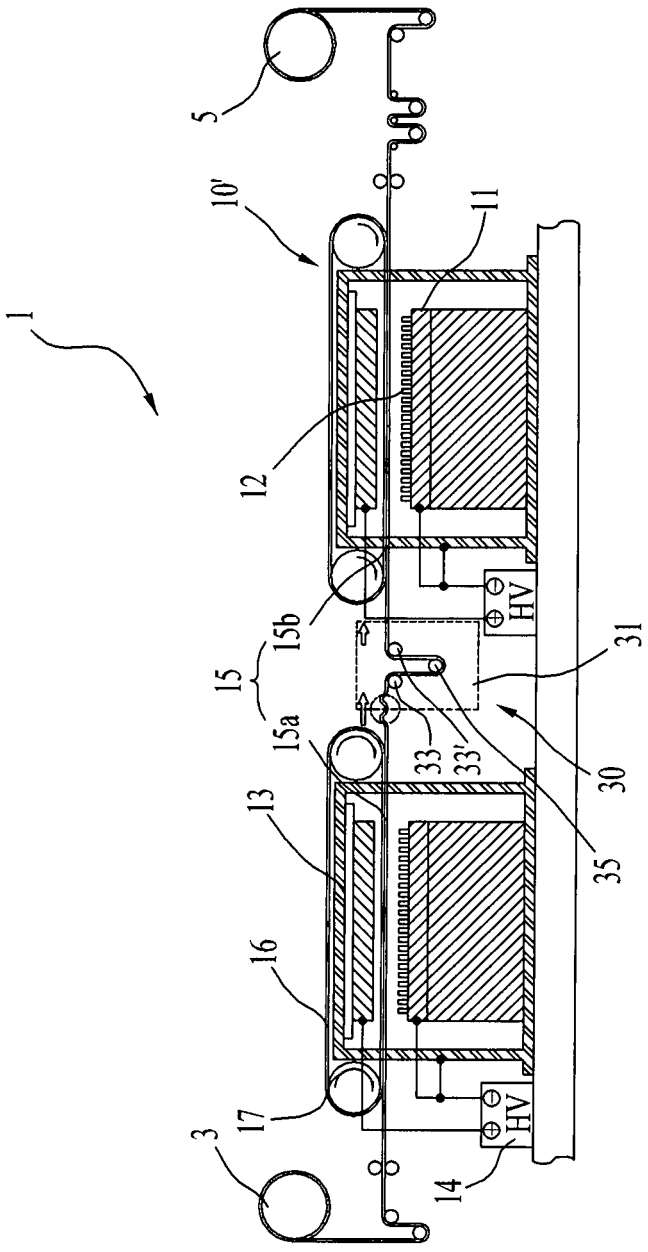


FIG.4

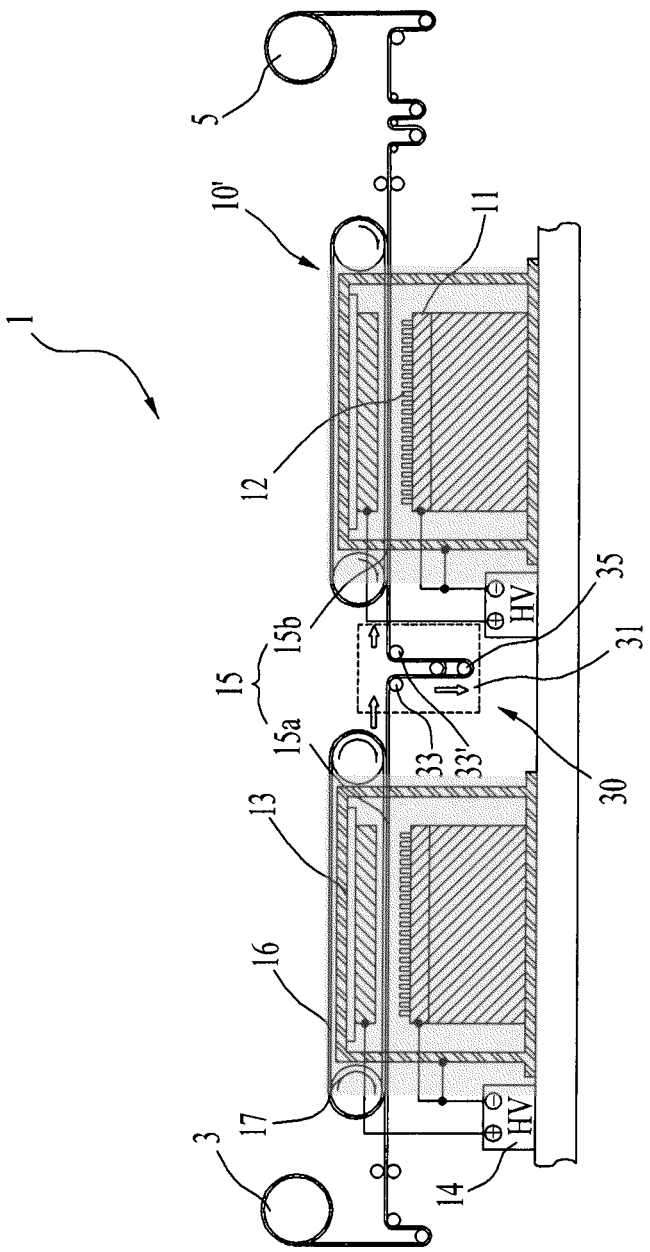


FIG.5

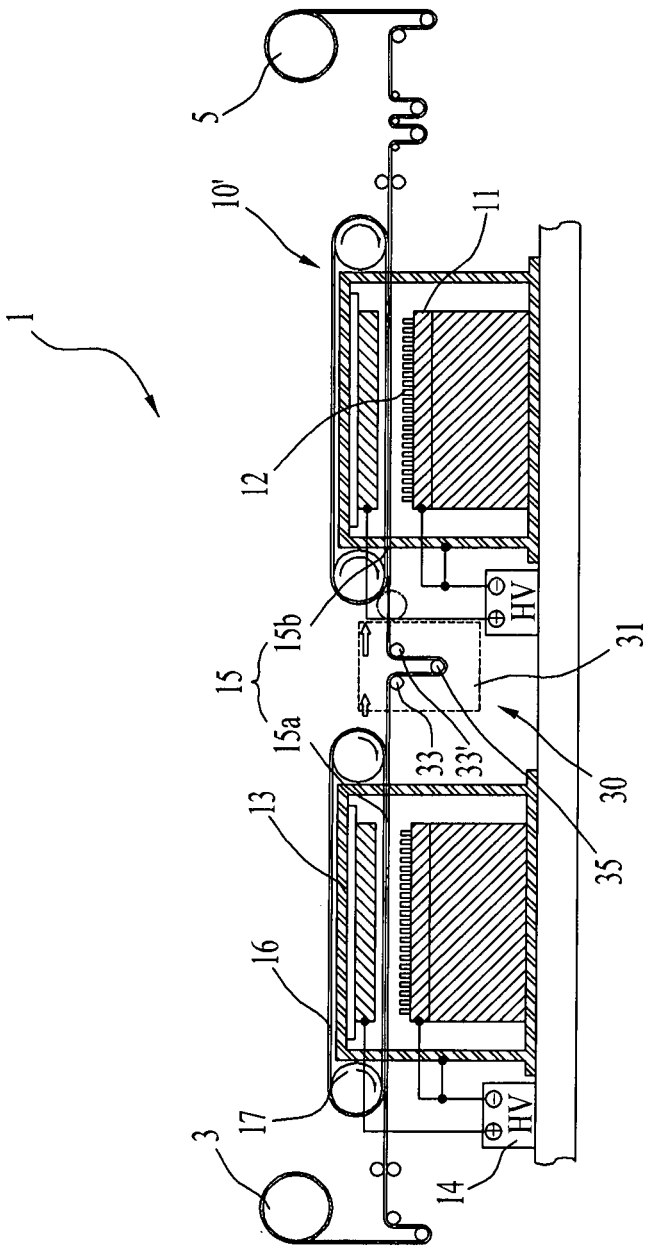


FIG.6

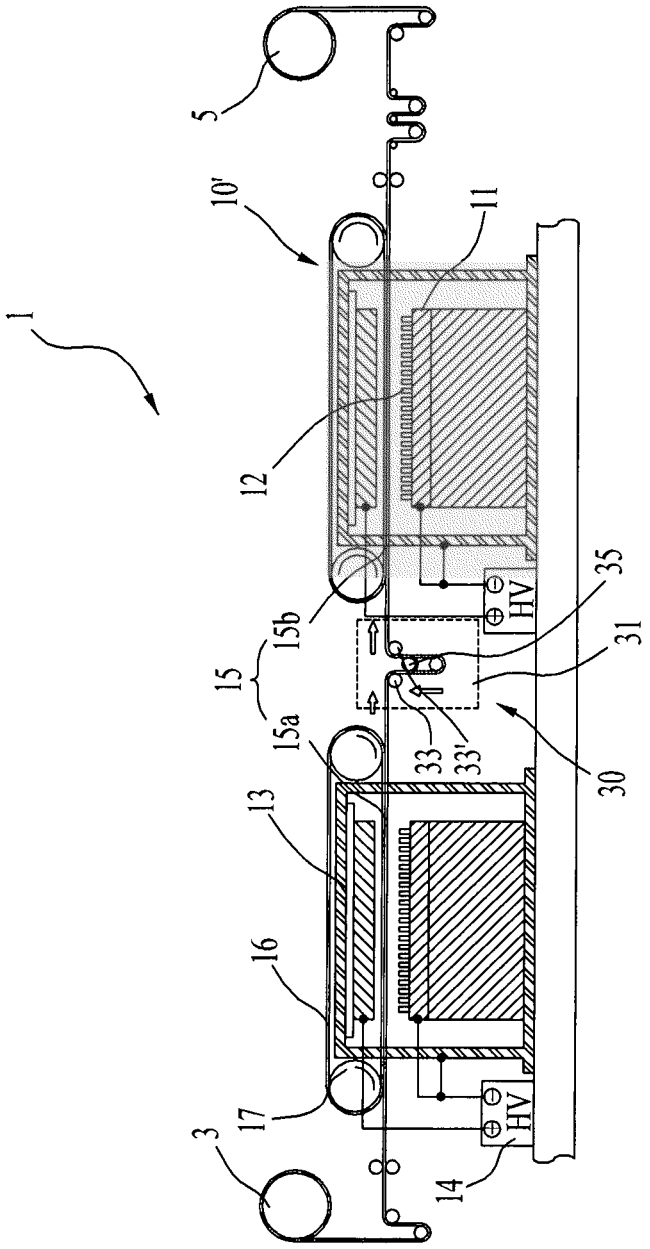


FIG.7

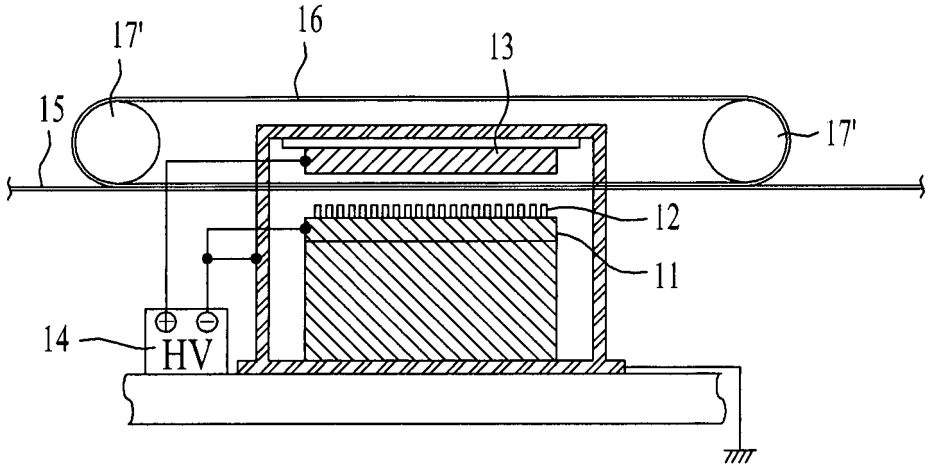



FIG.8

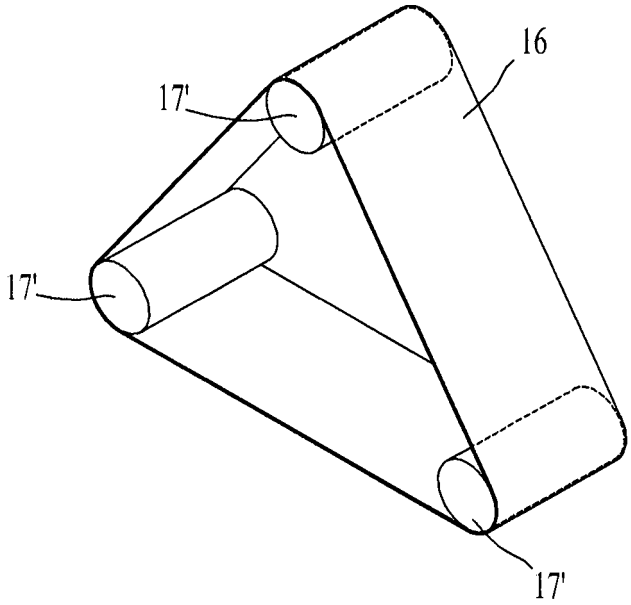


FIG.9

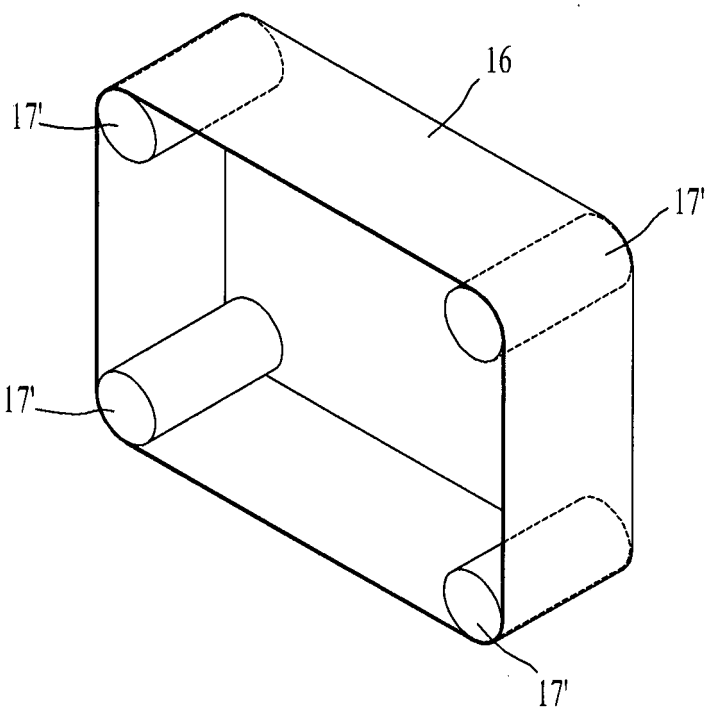


FIG.10

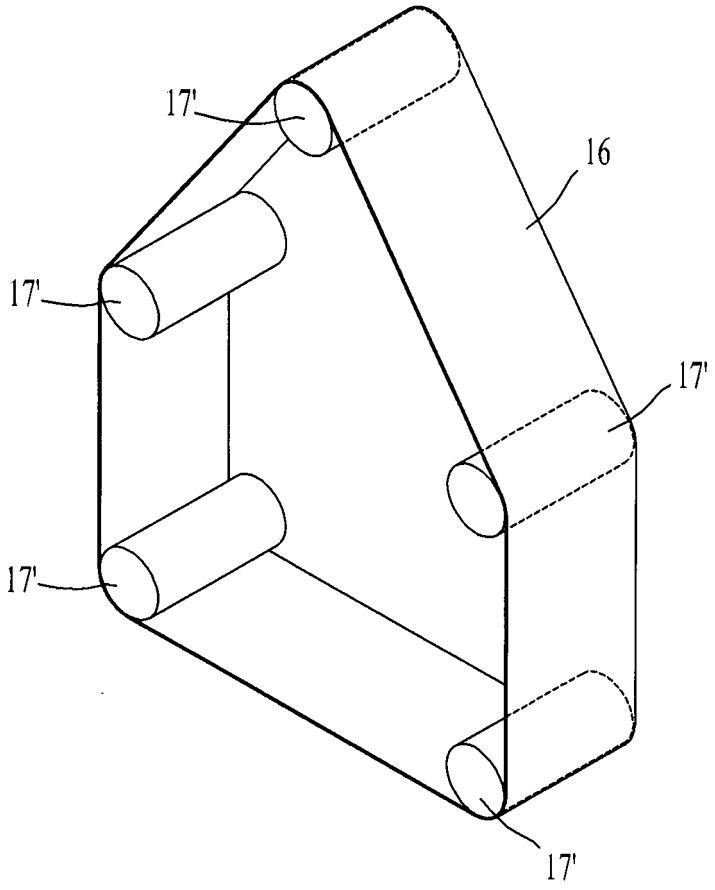


FIG.11

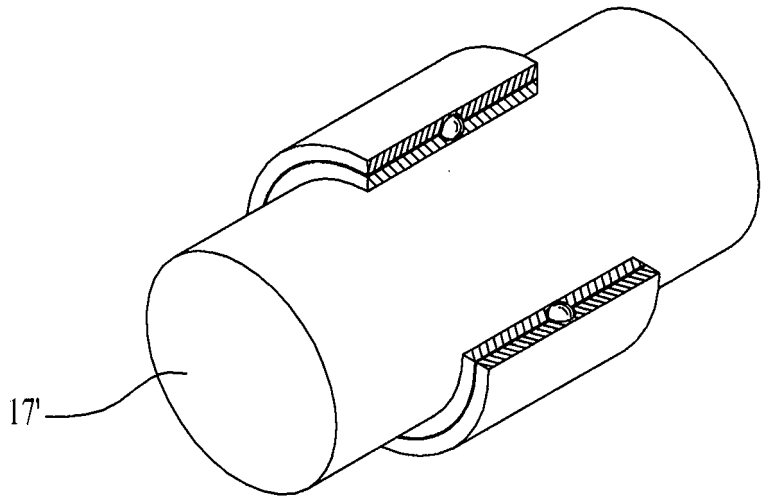


FIG.12

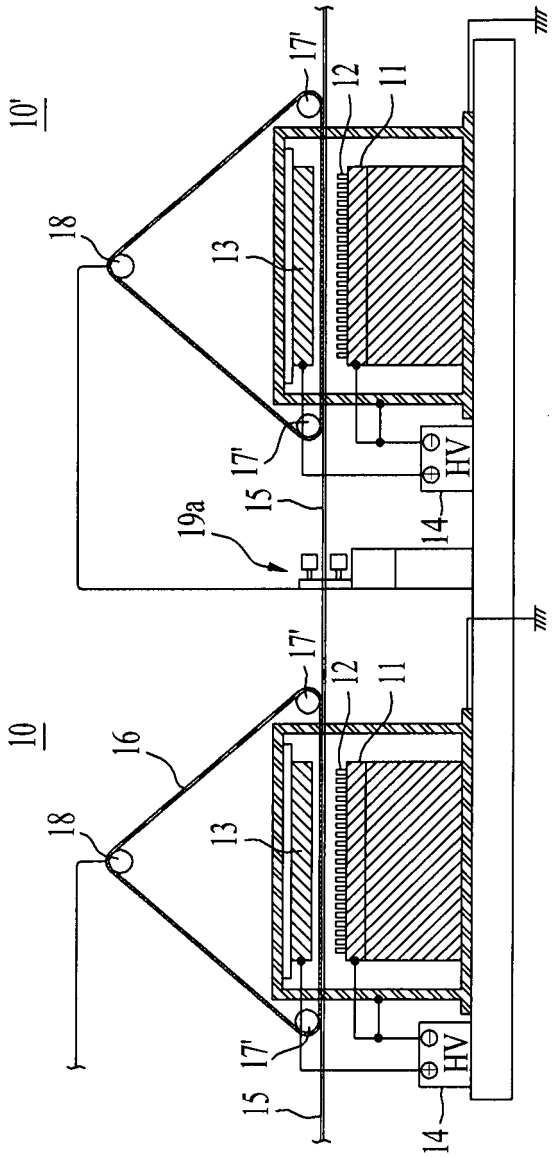


FIG.13

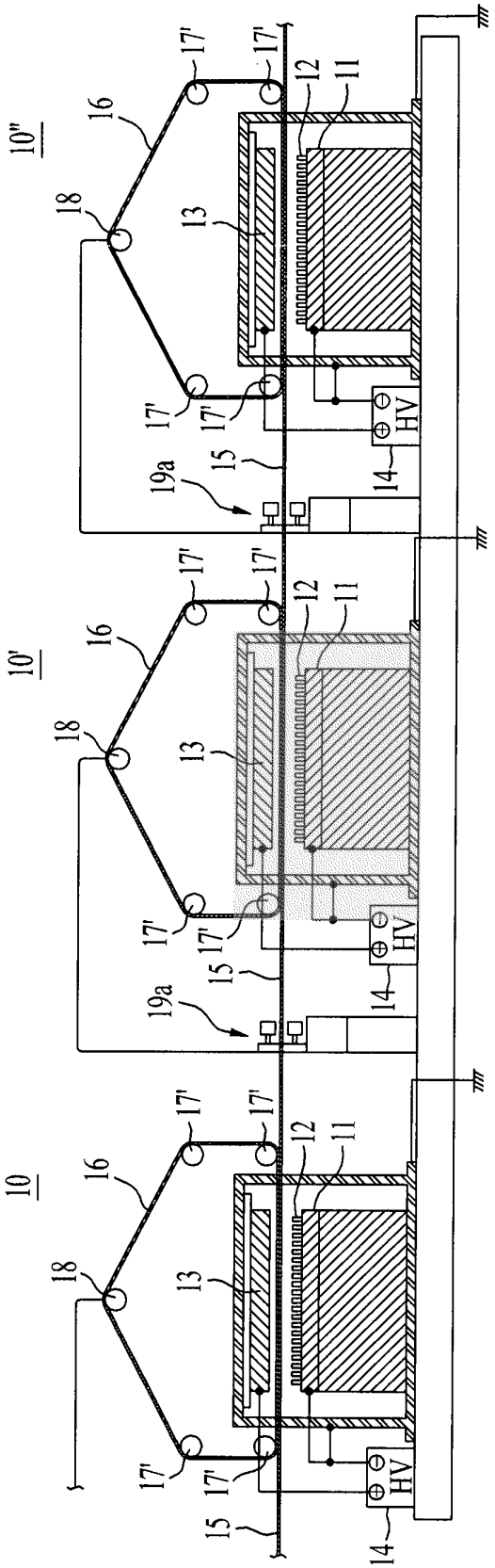


FIG.14

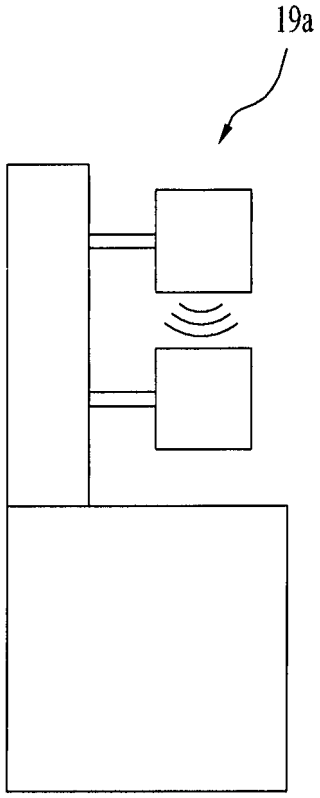


FIG.15

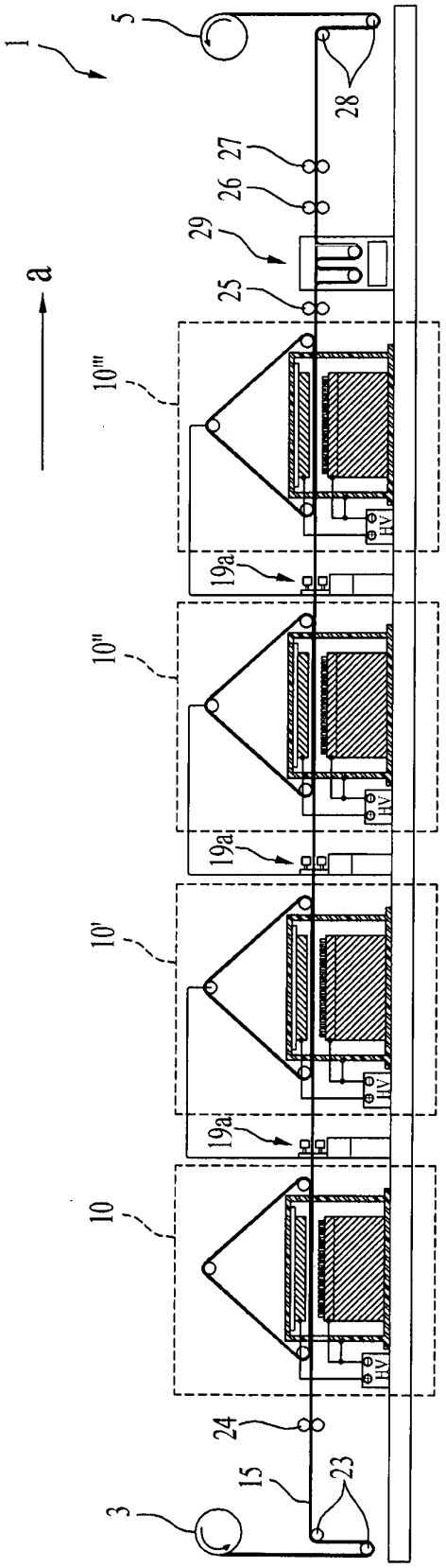


FIG.16

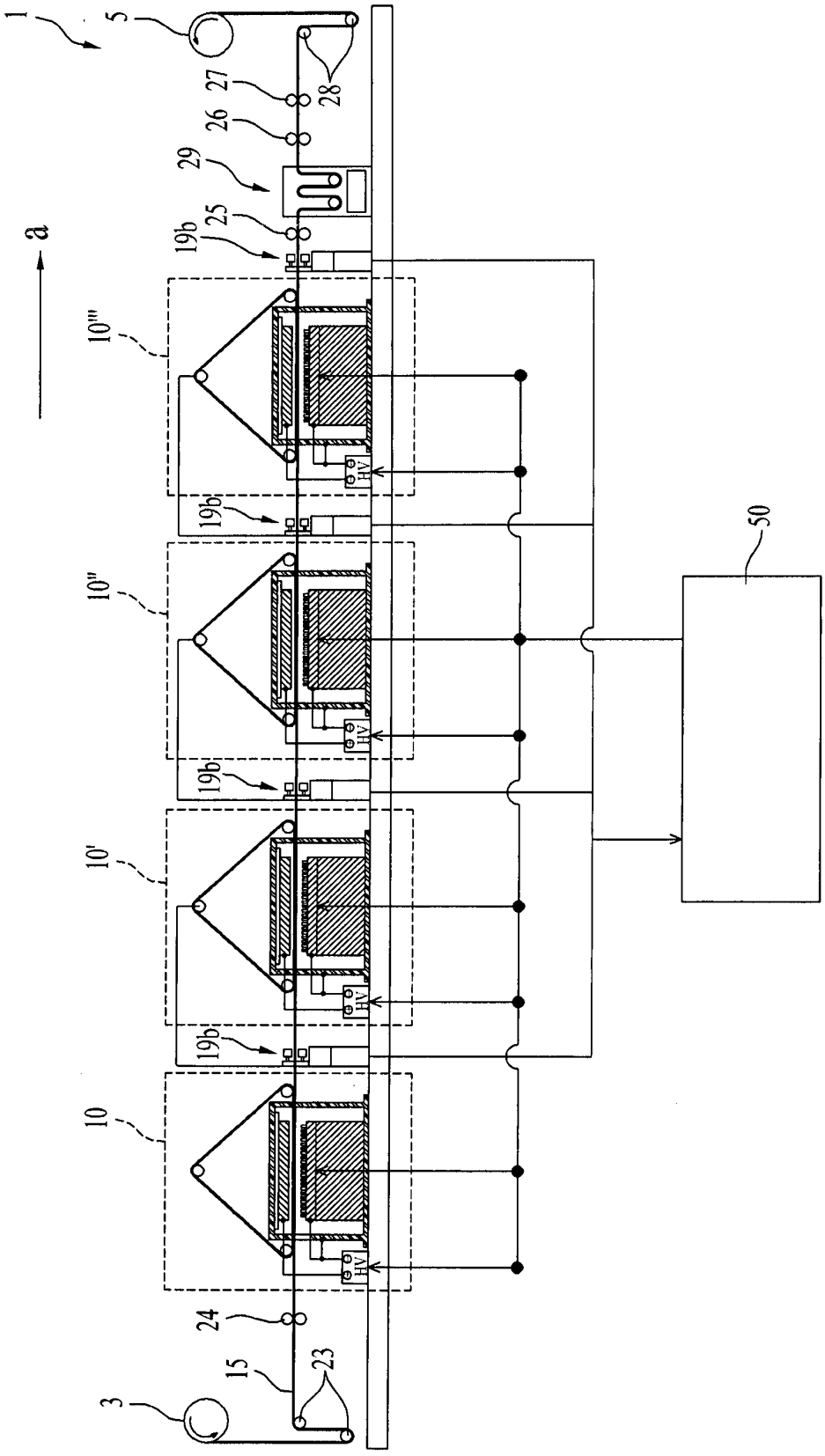


FIG.17

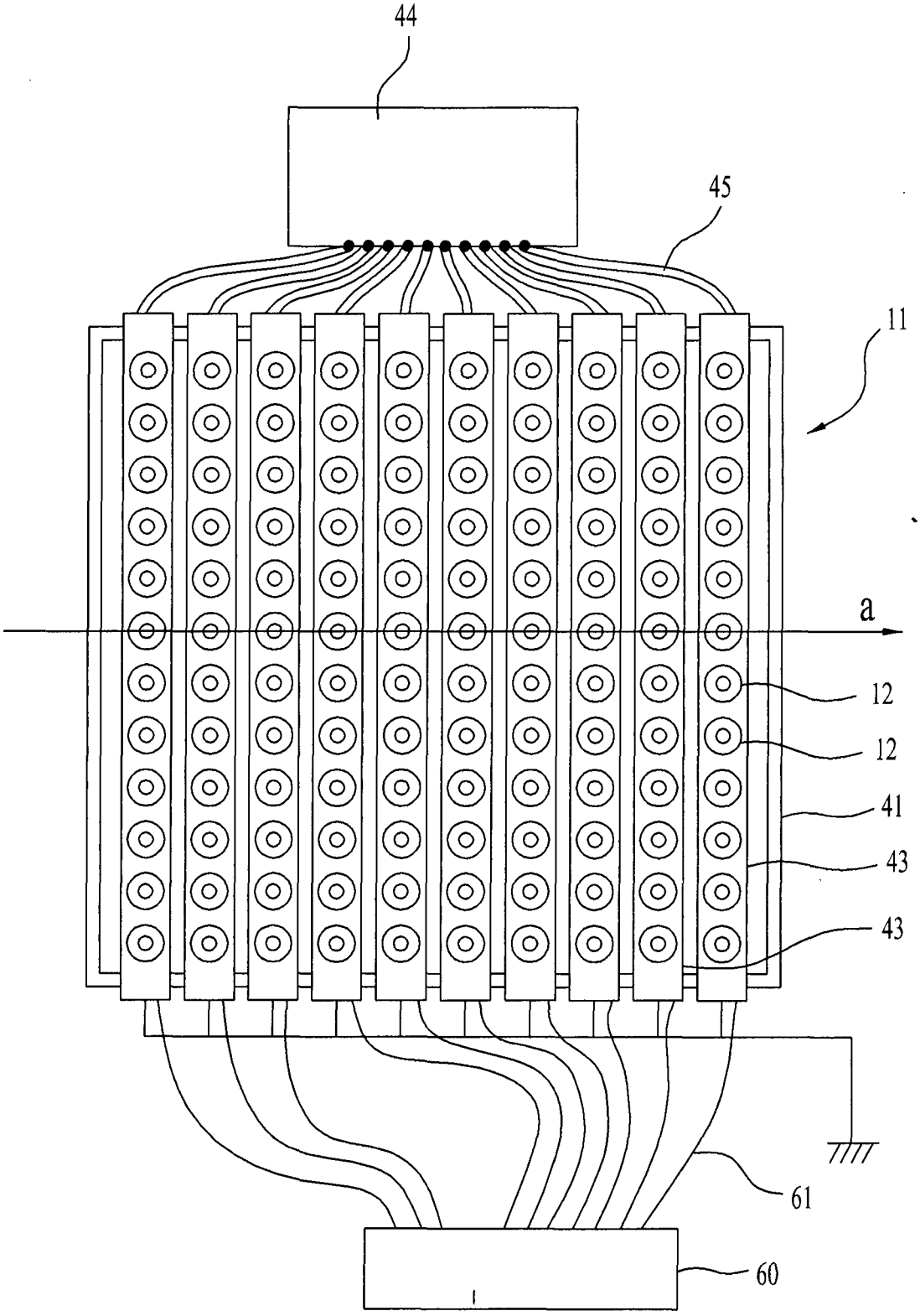
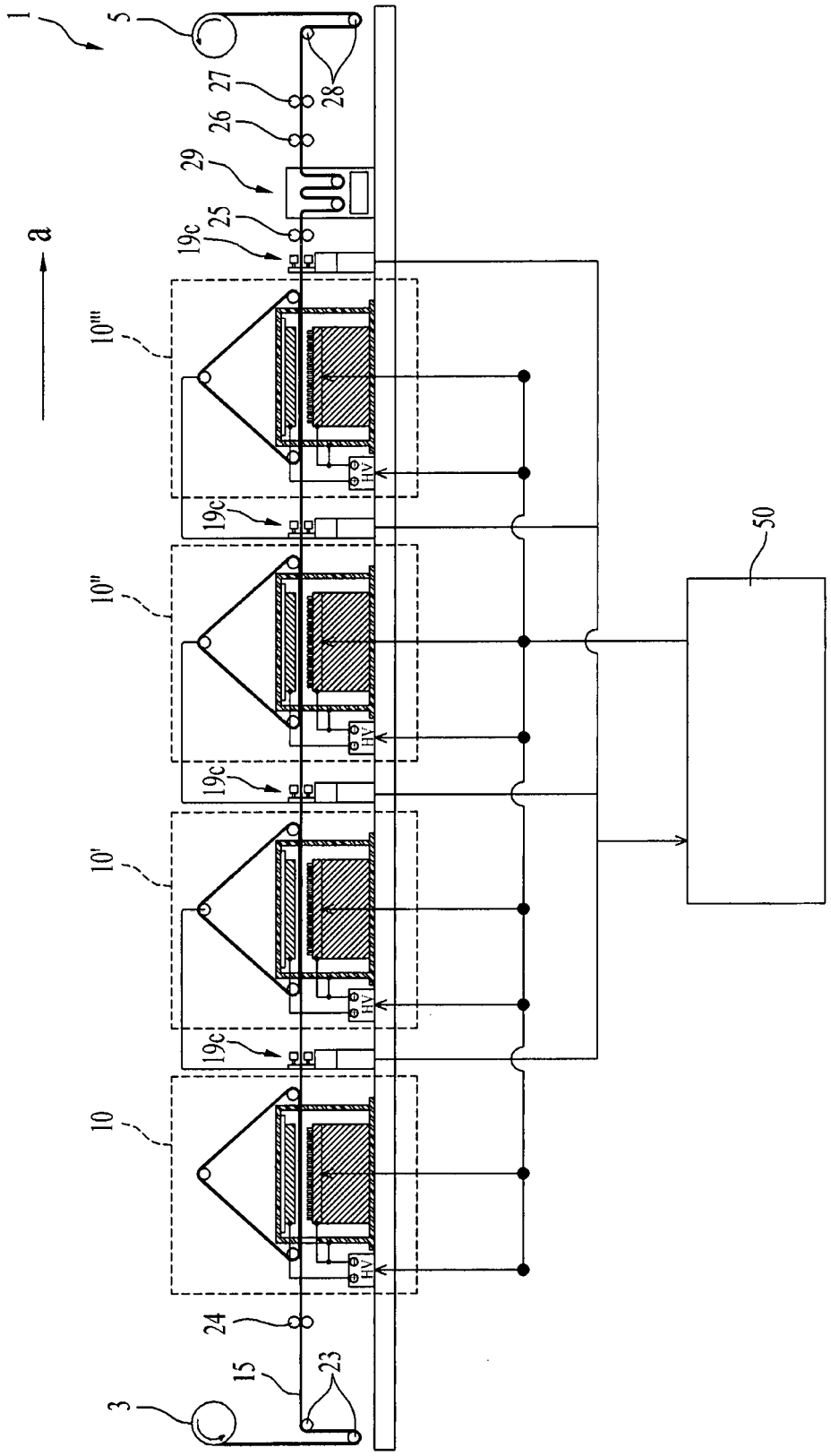


FIG.18



## INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2014/001583

A. CLASSIFICATION OF SUBJECT MATTER

*D01D 5/00(2006.01)i, D01D 4/00(2006.01)i, D01D 13/00(2006.01)i*

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)
D01D 5/00; B82Y 40/00; D04H 3/16; D04H 1/72; D01D 4/00; D01D 13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: D01D

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | KR 10-1226046 B1 (TOPTEC CO., LTD et al.) 24 January 2013<br>See abstract, paragraphs [0041]-[0097], figures 1 to 5 | 1-4,13-15 |
| Y | | 16-18 |
| A | | 5-12 |
| Y | KR 10-1040064 B1 (SHINSHU UNIVERSITY et al.) 09 June 2011<br>See abstract, paragraphs [0043]-[0097], figures 1 to 5 | 16-18 |
| A | | 1-15 |
| A | KR 10-1040063 B1 (SHINSHU UNIVERSITY et al.) 09 June 2011<br>See abstract, claims 1 to 19, figures 1 to 30 | 1-18 |
| A | KR 10-2012-0077998 A (HYOSUNG CORPORATION) 10 July 2012<br>See abstract, claims 1 to 5, figures 1 to 4 | 1-18 |

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 MAY 2014 (14.05.2014) | **15 MAY 2014 (15.05.2014)** |
| Name and mailing address of the ISA/KR<br>Korean Intellectual Property Office<br>Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea<br>Facsimile No. 82-42-472-7140 | Authorized officer<br><br>Telephone No. |

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2014/001583

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. The invention of group 1: claims 1 to 4 pertain to an electrospinning device comprising a case, a nozzle block, a collector, a voltage generating device, a mounting seat, an auxiliary belt, an auxiliary belt roller, and a mounting seat transfer speed control system,
2. The invention of group 2: claims 5 to 8 pertain to an electrospinning device comprising a case, a nozzle block, a collector, a voltage generating device, a mounting seat, an auxiliary belt, and an auxiliary belt roller having a low friction factor,
3. The invention of group 3: claims 9 to 12 pertain to an electrospinning device comprising a case, a nozzle block, a collector, a voltage generating device, a mounting seat, an auxiliary belt, an auxiliary belt roller, and a mounting seat sagging detection device,
4. The invention of group 4: claims 13 to 18 pertain to an electrospinning device comprising a case, a nozzle block, a collector, a voltage generating device, a mounting seat, an auxiliary belt, an auxiliary belt roller, and a permeability measurement device(or thickness measurement device).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
**PCT/KR2014/001583**

| Patent document cited in search report | Publication date | Patent family member | Publication date |
|---|---|---|---|
| KR 10-1226046 B1 | 24/01/2013 | JP 2012-164584 A | 30/08/2012 |
| KR 10-1040064 B1 | 09/06/2011 | JP 2012-122155 A | 28/06/2012 |
| | | WO 2012-077873 A1 | 14/06/2012 |
| KR 10-1040063 B1 | 09/06/2011 | CN 103370457 A | 23/10/2013 |
| | | EP 2650410 A1 | 16/10/2013 |
| | | JP 2012-122154 A | 28/06/2012 |
| | | US 2013-0273190 A1 | 17/10/2013 |
| | | WO 2012-077872 A1 | 14/06/2012 |
| KR 10-2012-0077998 A | 10/07/2012 | NONE | |

Form PCT/ISA/210 (patent family annex) (July 2009)

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- US 4044404 A **[0006]**
- JP 2011033229 A **[0018]**
- KR 20100123820 **[0019]**
- JP 2008274522 A **[0020]**