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

(11) EP 4 266 827 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.10.2023 Bulletin 2023/43

(21) Application number: **23167914.3**

(22) Date of filing: **14.04.2023**

(51) International Patent Classification (IPC):
H05B 3/42 *(2006.01)* ***H05B 1/02*** *(2006.01)*
H05B 3/06 *(2006.01)* ***D02J 13/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H05B 1/023; D02J 13/003; H05B 3/06; H05B 3/42;
H05B 2203/037

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **18.04.2022 JP 2022068060**

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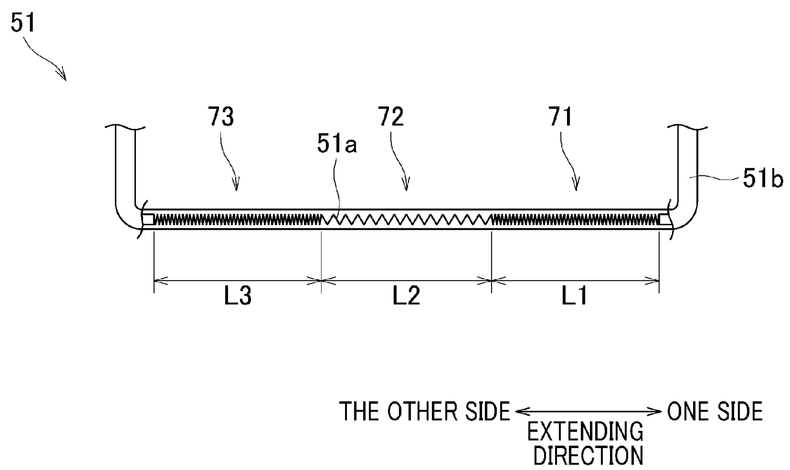
(54) HEATER

(57) An object of the present invention is to suppress the decrease in temperature of end portions of a heating unit in a yarn running direction and to further evenly heat a yarn running in the heating unit.

A heat source 51 is provided to extend in the yarn running direction, and configured to generate heat when an electric current is supplied to a resistive element 51a. The heat source 51 is configured to heat the heating unit provided with a yarn running space in which the yarn runs. The heat source 51 includes: an entrance-side heating part 71 and an exit-side heating part 73 which are configured to heat both end portions of the heating unit in the yarn running direction, respectively; and a center heating part 72 at which the watt density of the resistive element 51a is lower than that at each of the entrance-side heating part 71 and the exit-side heating part 73. In this regard, the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 are aligned in the yarn running direction.

FIG.7



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a heater configured to heat a yarn.

[0002] A known heater is configured to heat a yarn formed of synthetic fibers, in a processor configured to perform various processes such as yarn combining and false twisting. Patent Literature 1 (Japanese Laid-Open Patent Publication No. 2006-022411) discloses a yarn heater (heater) which is provided in a yarn combining machine configured to combine two yarns and which includes a heating body (heating unit) provided along a yarn running direction. The heating body is provided with a running groove along the yarn running direction. Inside the heating body, a sheathed heater (heat source) is provided along the yarn running direction. This heating body performs the transmission of heat generated by the sheathed heater, so that a yarn running in a space inside the running groove can be heated.

SUMMARY OF THE INVENTION

[0003] The above-described yarn heater is configured to turn on/off a current giving circuit configured to supply an electric current to the sheathed heater based on the temperature of the heating body, which is detected by a sensor. The heating body is configured to radiate the heat from its end portions in the yarn running direction, where an entrance and an exit are provided for the yarn running in the running groove. With this arrangement, the temperature of the end portions of the heating body in the yarn running direction is easily decreased as compared to that of the center of the heating body in the yarn running direction.

[0004] Therefore, when the current giving circuit is turned on/off to adjust the temperature of this center of the heating body to a temperature which is suitable for heating the yarn, the temperature of these end portions of the heating body is decreased to be equal to or less than the suitable temperature for heating the yarn. As a result, the yarn cannot be properly heated. Meanwhile, when the temperature of the end portions of the heating body is adjusted to the suitable temperature for heating the yarn, the center of the heating body is excessively heated. As a result, unnecessary power consumption occurs. In the heating body, when the temperature of the center is different from that of the end portions, the yarn is unevenly heated. As a result, the quality of the yarn may be deteriorated.

[0005] An object of the present invention is to provide a heater which is able to suppress the decrease in temperature of end portions of a heating unit in a yarn running direction and to further evenly heat a yarn running in the heating unit.

[0006] According to a first aspect of the invention, a heater includes: a heat source of a resistance-heating type, which extends in a yarn running direction and which is configured to generate heat when an electric current is supplied to a resistive element; a heating unit in which a yarn running space is provided and which is heated by the heat source, a yarn running in the yarn running space; a sensor configured to detect the temperature of the heating unit; and a controller programmed to switch, based on an output signal of the sensor, between a state in which an electric current is supplied to the resistive element and a state in which an electric current is not supplied to the resistive element. In this regard, the heat source includes: a first part configured to heat at least one of end portions of the heating unit on at least one side in the yarn running direction of the heating unit; and a second part at which the watt density of the resistive element is lower than the watt density of the resistive element at the first part, the first part and the second part being aligned in the yarn running direction.

[0007] According to this aspect of the present invention, even though the temperature of the at least one end portion of the heating unit in the yarn running direction is relatively easily decreased, the at least one end portion of the heating unit is heated by the first part of the heat source. In the heat source, an amount of heat generated at the first part at which the watt density of the resistive element is relatively high is larger than an amount of heat generated at the second part at which the watt density of the resistive element is relatively low. It is therefore possible to heat the at least one end portion of the heating unit in the yarn running direction with a relatively large amount of heat. As a result, the decrease in temperature of the at least one end portion of the heating unit on the one side in the yarn running direction is suppressed, and the yarn running in the heating unit is further evenly heated.

[0008] According to a second aspect of the invention, the heater is arranged so that the first part is configured to heat the both end portions of the heating unit in the yarn running direction.

[0009] According to this aspect of the present invention, even though the temperature of the both end portions of the heating unit in the yarn running direction is relatively easily decreased, these end portions of the heating unit are heated by the first part at which the watt density of the resistive element of the heat source is relatively high. It is therefore possible to suppress the decrease in temperature of the both end portions of the heating unit in the yarn running direction.

[0010] According to a third aspect of the invention, the heater is arranged so that the yarn running space is inclined so that one end portion of the yarn running space on one side in the yarn running direction is lower than the other end portion of the yarn running space on the other side in the yarn running direction, and the heat source includes the first part configured to heat the at least one end portion of the heating unit on the one side in the yarn running direction of the heating unit.

[0011] According to this aspect of the present inventiontion, because the yarn running space is inclined so that the one end portion of the yarn running space on the one side in the yarn running direction is lower than the other end portion of the yarn running space on the other side in the yarn running direction, air heated in the yarn running space is moved toward an upper end portion of the yarn running space, i.e., toward an end portion of the yarn running space on the other side in the yarn running direction of the yarn running space. Therefore, the temperature at the at least one end portion of the heating unit on the one side in the yarn running direction of the heating unit is relatively easily decreased. Even though the temperature at the at least one end portion of the heating unit on the one side in the yarn running direction of the heating unit is relatively easily decreased, this end portion of the heating unit is heated by the first part at which the watt density of the resistive element of the heat source is relatively high. It is therefore possible to reliably suppress the decrease in temperature of the at least one end portion of the heating unit on the one side in the yarn running direction.

[0012] According to a fourth aspect of the invention, the heater is arranged so that the heating unit includes a yarn contacted portion which extends in the yarn running direction and which has a yarn contacted surface with which the yarn running in the yarn running space makes contact.

[0013] In the present invention, the decrease in temperature of end portions of the yarn contacted surface in the yarn running direction is suppressed. It is therefore possible to stably heat the yarn by causing the yarn to make contact with the yarn contacted surface.

[0014] According to a fifth aspect of the invention, the heater is arranged so that the heating unit contains a metal material, and the watt density of the resistive element at each of the first part and the second part is equal to or less than 3.0 [W/cm^2].

[0015] According to this aspect of the present invention, the heating unit which is a heating target of the heat source contains the metal material, and the watt density of the resistive element is equal to or less than 3.0 [W/cm^2] at each of the first part and the second part. It is therefore possible to suppress the occurrence of a phase change and a chemical change at the heating unit. This contributes to a long life of the heat source.

[0016] According to a sixth aspect of the invention, the heater is arranged so that a difference in heat source capacity between the first part and the second part is equal to or more than 40 [W] and equal to or less than 45 [W] .

[0017] According to this aspect of the present invention, when the difference in heat source capacity between the first part and the second part is equal to or more than 40 [W] and equal to or less than 45 [W], temperature distribution of the yarn contacted surface of the heating unit is further equalized in the yarn running direction. It is therefore possible to reliably suppress the yarn from being unevenly heated, and thus production of high-quality yarns is enabled.

[0018] According to a seventh aspect of the invention, the heater is arranged so that the heat source is a sheathed heater in which the resistive element is surrounded by a pipe.

[0019] According to this aspect of the present invention, when the sheathed heater in which the resistive element is surrounded by the pipe is used as the heat source, the heat source is easily applied to the heater.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a profile of a false-twist texturing machine of an embodiment of the present invention.

FIG. 2 is a schematic diagram of the false-twist texturing machine, expanded along paths of yarns.

FIG. 3 shows a first heater.

FIG. 4 is a cross section taken along a line IV-IV in FIG. 3.

FIG. 5 is a cross section taken along a line V-V in FIG. 4.

FIG. 6 is a cross section taken along a line VI-VI in FIG. 4.

FIG. 7 shows a heat source.

FIG. 8 is a table showing conditions of a comparison test between Example 1, Example 2, and Comparative Example.

FIG. 9 is a graph showing temperature distribution of a yarn contacted surface in each of heat sources of Example 1, Example 2, and Comparative Example.

FIG. 10 is a graph showing power consumption of each of the heat sources of Example 1, Example 2, and Comparative Example.

FIG. 11 is a table showing conditions of Example 3.

FIG. 12 is a graph showing temperature distribution of a yarn contacted surface in a heat source of Example 3.

FIG. 13 is a cross section taken along a line in a direction orthogonal to a base longitudinal direction of a first heater of a modification.

FIG. 14 shows a heat source of a first heater of the modification.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The following will describe a false-twist texturing machine 1 of a preferred embodiment of the present invention, with reference to FIG. 1. Hereinafter, a vertical direction to the sheet of FIG. 1 is defined as a base longitudinal direction, and a left-right direction to the sheet is defined as a base width direction. A direction orthogonal to the base longitudinal direction and the base width direction is defined as an up-down direction (vertical direction) in which the gravity acts. In this regard, the base longitudinal direction and the base width direction are substantially in parallel to a horizontal direction.

(Overall Structure of False-Twist Texturing Machine 1)

[0022] The false-twist texturing machine 1 is able to perform false twisting of yarns Y (i.e., to false-twist the yarns Y) made of synthetic fibers such as nylon (polyamide fibers) and polyester. The false-twist texturing machine 1 includes a yarn supplying unit 2 for supplying the yarns Y, a processing unit 3 configured to false-twist the yarns Y supplied from the yarn supplying unit 2, and a winding unit 4 configured to wind the yarns Y processed by the processing unit 3 onto winding bobbins Bw. Components of the yarn supplying unit 2, the processing unit 3, and the winding unit 4 are aligned to form plural lines (see FIG. 2) in the base longitudinal direction. The base longitudinal direction is a direction orthogonal to a running plane (plane of FIG. 1) of the yarns Y. The running plane of the yarns Y is formed of the yarn paths extending from the yarn supplying unit 2 to the winding unit 4 through the processing unit 3.

[0023] The yarn supplying unit 2 includes a creel stand 5 retaining yarn supply packages Ps. The yarn supplying unit 2 is configured to supply the yarns Y to the processing unit 3. The processing unit 3 is configured to false-twist the yarns Y supplied from the yarn supply packages Ps. In the processing unit 3, the following members are placed in this order from the upstream side in a yarn running direction: each first feed roller 11; each twist-stopping guide 12; each first heater 13 (equivalent to a heater of the present invention); each cooler 14; each false-twisting device 15; each second feed roller 16; each interlacing device 17; each third feed roller 18; a second heater 19; and each fourth feed roller 20. The winding unit 4 includes winding devices 21. Each winding device 21 is configured to wind a yarn Y false-twisted by the processing unit 3 onto a winding bobbin Bw, so as to form a wound package Pw.

[0024] The false-twist texturing machine 1 includes a main base 8 and a winding base 9 which are spaced apart from each other in the base width direction. The main base 8 and the winding base 9 extend to be substantially identical in length in the base longitudinal direction. The main base 8 and the winding base 9 oppose each other in the base width direction. An upper part of the main base 8 is connected to an upper part of the winding base 9 by a supporting frame 10. Each device forming the processing unit 3 is mainly attached to the main base 8 or the supporting frame 10. Each device forming the winding unit 4 is mainly attached to the winding base 9. The main base 8, the winding base 9, and the supporting frame 10 form a working space A in which an operator performs an operation such as yarn threading to each device. The yarn paths are formed so that the yarns Y mainly run around the working space A.

[0025] The false-twist texturing machine 1 includes units termed spans each of which includes a pair of the main base 8 and the winding base 9 provided to oppose each other. In one span, processing units (which are also termed spindles) in which yarn paths are formed to pass the devices forming the processing unit 3 are aligned in the base longitudinal direction. With this arrangement, in one span, the yarns Y running while being aligned in the base longitudinal direction can be simultaneously false-twisted. In the false-twist texturing machine 1, the spans are placed in a left-right symmetrical manner to the sheet, with a center line C in the base width direction of the main base 8 being set as a symmetry axis. The main base 8 is shared between the left span and the right span.

(Processing Unit)

[0026] The following will describe the structure of the processing unit 3 with reference to FIG. 1 and FIG. 2. Each first feed roller 11 is configured to unwind a yarn Y from one yarn supply package Ps attached to the yarn supplying unit 2 and to send the yarn Y to one first heater 13. As shown in FIG. 2, each first feed roller 11 is configured to send, e.g., a single yarn Y to the first heater 13. Alternatively, each first feed roller 11 may be able to send plural adjacent yarns Y to the downstream side in the yarn running direction. Each twist-stopping guide 12 prevents twisting, which is applied to a yarn Y by one false-twisting device 15, from being propagated to the upstream side of each twist-stopping guide 12 in the yarn running direction.

[0027] Each first heater 13 is configured to heat yarns Y which are sent from some first feed rollers 11, to a predetermined processing temperature. As shown in FIG. 2, each first heater 13 is able to heat, e.g., two yarns Y. Each first heater 13 will be detailed later.

[0028] Each cooler 14 is configured to cool a yarn Y heated by one first heater 13. As shown in FIG. 2, each cooler 14 is configured to cool, e.g., a single yarn Y. Alternatively, each cooler 14 may be able to simultaneously cool plural yarns Y. Each false-twisting device 15 is provided downstream of one cooler 14 in the yarn running direction, and configured to twist a yarn Y. Each false-twisting device 15 is, e.g., a so-called disc-friction false-twisting device. However, the disclosure is not limited to this. Each second feed roller 16 is configured to send a yarn Y processed by one false-twisting device 15 to one interlacing device 17. The conveyance speed of conveying the yarn Y by each second feed roller 16 is higher than the conveyance speed of conveying the yarn Y by each first feed roller 11. The yarn Y is therefore drawn and false-twisted between the first feed roller 11 and the second feed roller 16.

[0029] Each interlacing device 17 is configured to interlace a yarn Y. Each interlacing device 17 has, e.g., a known interlace nozzle configured to interlace the yarn Y by means of an airflow.

[0030] Each third feed roller 18 is configured to send, to the second heater 19, a yarn Y running on the downstream side of one interlacing device 17 in the yarn running direction. As shown in FIG. 2, each third feed roller

18 is configured to send, e.g., a single yarn Y to the second heater 19. Alternatively, each third feed roller 18 may be able to send plural adjacent yarns Y to the downstream side in the yarn running direction. The conveyance speed of conveying the yarn Y by each third feed roller 18 is lower than the conveyance speed of conveying the yarn Y by each second feed roller 16. The yarn Y is therefore relaxed between the second feed roller 16 and the third feed roller 18.

[0031] The second heater 19 is configured to heat yarns Y sent from some third feed rollers 18. The second heater 19 extends along the vertical direction, and is provided for each of the spans. Each fourth feed roller 20 is configured to send a yarn Y heated by the second heater 19 to one winding device 21. As shown in FIG. 2, each fourth feed roller 20 is able to send, e.g., a single yarn Y to the winding device 21. Alternatively, each fourth feed roller 20 may be able to send plural adjacent yarns Y to the downstream side in the yarn running direction. The conveyance speed of conveying the yarn Y by each fourth feed roller 20 is lower than the conveyance speed of conveying the yarn Y by each third feed roller 18. The yarn Y is therefore relaxed between the third feed roller 18 and the fourth feed roller 20.

[0032] In the processing unit 3 arranged as described above, each yarn Y drawn between the first feed roller 11 and the second feed roller 16 is twisted by the false-twisting device 15. The twist formed by the false-twisting device 15 propagates to the twist-stopping guide 12, but does not propagate to the upstream side of the twist-stopping guide 12 in the yarn running direction. The yarn Y which is twisted and drawn is heated by the first heater 13 and thermally set. After that, the yarn Y is cooled by the cooler 14. The yarn Y is untwisted on the downstream side of the false-twisting device 15 in the yarn running direction. However, the yarn Y is maintained to be wavy in shape on account of the thermal setting described above (i.e., crimp contraction of the yarn Y is maintained).

[0033] After being false-twisted, the yarn Y is interlaced by the interlacing device 17 while being relaxed between the second feed roller 16 and the third feed roller 18. The yarn Y is then guided to the downstream side in the yarn running direction. Furthermore, the yarn Y is thermally processed by the second heater 19 while being relaxed between the third feed roller 18 and the fourth feed roller 20. Finally, the yarn Y sent from the fourth feed roller 20 is wound by the winding device 21.

(Winding Unit)

[0034] The following will describe the structure of the winding unit 4 with reference to FIG. 2. The winding unit 4 includes plural winding devices 21. Each winding device 21 is able to wind a yarn Y onto one winding bobbin Bw. The winding device 21 includes a fulcrum guide 41, a traverse unit 42, and a cradle 43. The fulcrum guide 41 is a guide functioning as a fulcrum when the yarn Y is traversed. The traverse unit 42 is able to traverse the yarn Y by means of a traverse guide 45. The cradle 43 is configured to rotatably support the winding bobbin Bw. A contact roller 46 is provided in the vicinity of the cradle 43. The contact roller 46 is configured to apply a contact pressure to a surface of one wound package Pw by making contact with the surface of the wound package Pw. In the winding unit 4 arranged as described above, the yarn Y sent from the fourth feed roller 20 described above is wound onto the winding bobbin Bw by each winding device 21 so as to form the wound package Pw.

(First Heater)

[0035] The following will detail each first heater 13 with reference to FIG. 3 to FIG. 7. As shown in FIG. 3, the first heater 13 extends in a predetermined extending direction orthogonal to the base longitudinal direction. In the present embodiment, the extending direction is in parallel to the base width direction.

[0036] The first heater 13 is configured to heat at least one running yarn Y. In the present embodiment, the first heater 13 is able to heat, e.g., two yarns Y (yarns Ya and Yb: see FIG. 4). One end portion on one side in the extending direction of the first heater 13 is provided with an entrance 13a into which yarns Y are sent from some first feed rollers 11. Meanwhile, the other end portion on the other side in the extending direction of the first heater 13 is provided with an exit 13b from which the heated yarns Y are sent out. In the present embodiment, the position of the entrance 13a is substantially identical with that of the exit 13b in the up-down direction.

[0037] As shown in FIG. 4 and FIG. 5, the first heater 13 includes: a heat source 51; a heating unit 52; a sensor 57 configured to detect the temperature of the heating unit 52; a current giving circuit 58; heat insulating materials 59; a box 60; and a controller 100. The first heater 13 is configured to simultaneously heat the yarns Ya and Yb by causing the running yarns Ya and Yb to make contact with the heating unit 52 heated by the heat source 51.

[0038] The heat source 51 is a sheathed heater, and includes a resistive element 51a which is a coiled Nichrome wire, etc. and a pipe 51b surrounding the resistive element 51a as shown in FIG. 7. The heat source 51 extends along the extending direction. In other words, the heat source 51 extends in the yarn running direction. The heat source 51 will be detailed later. As shown in FIG. 4 and FIG. 5, the heat source 51 is connected to the current giving circuit 58. The current giving circuit 58 is provided for supplying an electric current to the resistive element 51a of the heat source 51. The heat source 51 is configured to generate Joule heat in such a way that the current giving circuit 58 supplies an electric current to the resistive element 51a.

[0039] The current giving circuit 58 is electrically connected to the controller 100. The controller 100 is programmed to turn on/off the current giving circuit 58 based on an output signal of the sensor 57, so as to switch between a state in which an electric current is supplied to the resistive element 51a and a state in which an electric current is not supplied to the resistive element 51a. With this arrangement, the controller 100 is able to control the heating temperature of the first heater 13 (the temperature of a yarn contacted surface 56 described later). The controller 100 may be electrically connected not only to the first heater 13, but also to other devices forming the false-twist texturing machine 1.

[0040] The heating unit 52 is heated by the heat generated by the heat source 51. The heating unit 52 contains a metal material. As shown in FIG. 5, the heating unit 52 extends in the extending direction along the heat source 51. In other words, the heating unit 52 extends in the yarn running direction. The heating unit 52 includes, e.g., two heating members 53 (heating members 53a and 53b) and two yarn contacted portions 54 (yarn contacted portions 54a and 54b). The heating member 53a and the yarn contacted portion 54a are members for heating the yarn Ya. The heating member 53b and the yarn contacted portion 54b are members for heating the yarn Yb. (i) The members for heating the yarn Ya and (ii) the members for heating the yarn Yb are provided to oppose each other over the heat source 51 in, e.g., the base longitudinal direction.

[0041] The following will describe the members for heating the yarn Ya. The heating member 53a is made of a metal material such as yellow copper whose specific heat is high. The heating member 53a extends in the extending direction along the heat source 51. In other words, the heating member 53a extends in the yarn running direction. The heating member 53a is in contact with the heat source 51. For example, the heating member 53a is provided on one side of the heat source 51 in the base longitudinal direction (in a left part of the sheet of FIG. 4). The heating member 53a includes, e.g., one slit 55 (slit 55a) extending in the extending direction (yarn running direction). The slit 55a is reverse U-shaped in a cross section orthogonal to the extending direction. The slit 55a is open on the lower side in the up-down direction. In the slit 55a, one yarn contacted portion 54 (yarn contacted portion 54a) is housed.

[0042] The yarn contacted portion 54a is a long member made of, e.g., SUS. The yarn contacted portion 54a extends along the extending direction. In other words, the yarn contacted portion 54a extends in the yarn running direction. The yarn contacted portion 54a is fixed to the heating member 53a while being in contact with the heating member 53a. The temperature of the yarn contacted portion 54a is increased by the heat transmitted from the heat source 51 through the heating member 53a. The yarn contacted portion 54a has one yarn contacted surface 56 (yarn contacted surface 56a) for causing a yarn Y to make contact therewith. The yarn contacted surface 56a is oriented to the lower side in the up-down direction. As shown in FIG. 6, in a cross section orthogonal to the base longitudinal direction, the yarn contacted surface 56a is substantially U-shaped and curved to form a concave toward the lower side in the up-down direction. As shown in FIG. 4, when viewed in the extending direction, the yarn contacted surface 56a is reverse U-shaped and curved to form a convex toward the upper side in the up-down direction.

[0043] One yarn running space 50 (50a) in which the yarn Ya runs is provided below the yarn contacted surface 56a. The yarn running space 50a is surrounded by (i) wall surfaces defining the slit 55a of the heating member 53a and (ii) the yarn contacted surface 56a of the yarn contacted portion 54a. The yarn running space 50a is open on the lower side in the up-down direction. The yarn Ya which is sent into the first heater 13 through the entrance 13a runs in the yarn running space 50a while being in contact with the yarn contacted surface 56a.

[0044] The following will describe the members for heating the yarn Yb. For example, the heating member 53b is provided on the other side of the heat source 51 in the base longitudinal direction (in a right part of the sheet of FIG. 4). The heating member 53b is in contact with the heat source 51. The heating member 53b includes a slit 55b which is identical in shape with the slit 55a. In the slit 55b, the yarn contacted portion 54b structured in the same manner as the yarn contacted portion 54a is housed. The yarn contacted portion 54b has a yarn contacted surface 56b which is identical in shape with the yarn contacted surface 56a. A yarn running space 50b which is identical in shape with the yarn running space 50a is provided below the yarn contacted surface 56b. The details of these members will be omitted.

[0045] As shown in FIG. 4 and FIG. 5, the sensor 57 is provided in the vicinity of a central part of the heat source 51 in the extending direction. To be more specific, the sensor 57 is provided in a concave portion 52a formed at the heating member 53a as shown in FIG. 4. The concave portion 52a extends along the up-down direction, and is open to the upper surface of the heating member 53a. The sensor 57 is provided to be aligned with the heat source 51 in the base longitudinal direction. The concave portion 52a in which the sensor 57 is provided may be formed at the heating member 53b. The concave portion 52a may be open to the lower side of the heating member 53 in the up-down direction.

[0046] The heating unit 52 is housed in the box 60. The box 60 is a hollow member which is rectangular parallelepiped in shape and which is long in the extending direction. As shown in FIG. 4, an opening 61 is formed on a side wall of the box 60 on the lower side in the up-down direction. The opening 61 allows the slits 55 of two heating members 53 to communicate with the outside of the box 60. As shown in FIG. 5 and FIG. 6, openings 62 and 63 are respectively formed on both side walls of the box 60 in the extending direction. The openings 62 and 63 also allow the slits 55 of two heating members 53 to communicate with the outside of the box 60.

[0047] The heat insulating materials 59 are provided to fill gaps between the box 60 and the heating unit 52 housed in the box 60. The heat insulating materials 59 cover (i) both wall surfaces of the heating unit 52 in the base longitudinal direction and (ii) both wall surfaces of the heating unit 52 in the up-down direction. There is no heat insulating material 59 below the yarn running spaces 50. In addition to that, both wall surfaces of the heating unit 52 in the extending direction are not covered by the heat insulating materials 59 and are exposed to the outside air.

[0048] When the yarns Y properly run, (i) the positional relationship between the first heater 13 and the twist-stopping guide 12 and (ii) the positional relationship between the first heater 13 and the cooler 14 are appropriately arranged so that the yarns Y reliably make contact with the respective yarn contacted surfaces 56. The upward force is applied to the yarns Y running along the yarn contacted surfaces 56, so as to press the yarns Y onto the yarn contacted surfaces 56. This prevents the yarns Y from moving away from the yarn contacted surfaces 56.

[0049] In the first heater 13 arranged as described above, the running yarns Y make contact with the respective yarn contacted surfaces 56 so as to receive heat from the heating unit 52 through the yarn contacted surfaces 56. In this way, the yarns Y are heated. The temperature of each yarn Y is adjusted to an appropriate processing temperature in such a way that the type, brand (thickness), and running speed of the yarn Y and the heating temperature of the first heater 13 are properly set.

(HEAT SOURCE)

[0050] The following will detail the heat source 51 with reference to FIG. 7. A heating part of the heat source 51 is formed of three parts, i.e., an entrance-side heating part 71, a center heating part 72, and an exit-side heating part 73 (hereinafter, these parts may be simply referred to as the parts 71, 72, and 73). The entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 are aligned in this order from one side toward the other side in the extending direction. The entrance-side heating part 71 is configured to heat one end portion of the heating unit 52 on one side in the extending direction (yarn running direction). The center heating part 72 is configured to heat a central part of the heating unit 52 in the extending direction. The exit-side heating part 73 is configured to heat the other end portion of the heating unit 52 on the other side in the extending direction (yarn running direction).

[0051] The watt density of the resistive element 51a at the center heating part 72 is lower than that at each of the entrance-side heating part 71 and the exit-side heating part 73. The entrance-side heating part 71 and the exit-side heating part 73 are equivalent to a "first part" of the present invention. The center heating part 72 is equivalent to a "second part" of the present invention. In the present embodiment, the watt density of the resistive element 51a at the entrance-side heating part 71 is equal to that at the exit-side heating part 73. In the present embodiment, the watt density of the resistive element 51a at each of these parts 71, 72, and 73 is equal to or less than 3.0 [W/cm^2].

[0052] Hereinafter, a difference of heat source capacity (the capacity of the heat source) between (i) each of the entrance-side heating part 71 and the exit-side heating part 73 and (ii) the center heating part 72 will be simply referred to as a "difference of heat source capacity". In this regard, a difference of heat source capacity between (i) each of the entrance-side heating part 71 and the exit-side heating part 73 and (ii) the center heating part 72 is equivalent to a "difference of heat source capacity between the first part and the second part" of the present invention.

(Comparison Test)

[0053] The present inventor performed a comparison test between cases (Examples 1 and 2) in each of which, as in the present embodiment, the watt density of a resistive element of a heat source was not uniform and a case (Comparative Example) in which the watt density of a resistive element of a heat source was uniform.

[0054] In the extending direction of each heat source, the length of a part corresponding to the entrance-side heating part 71 is defined as the length L1, the length of a part corresponding to the center heating part 72 is defined as the length L2, and the length of a part corresponding to the exit-side heating part 73 is defined as the length L3. The lengths L1, L2, and L3 are equal to one another in the comparison test. The diameter of each heater (equivalent to the diameter of the pipe 51b) is substantially constant in the extending direction, and surface areas of the parts corresponding to the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 are equal to one another. A surface area of each of the parts corresponding to the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 is defined as a surface area S [cm^2]. The heat source capacity of the part corresponding to the entrance-side heating part 71 is defined as the heat source capacity W1 [W], the heat source capacity of the part corresponding to the center heating part 72 is defined as the heat source capacity W2 [W], and the heat source capacity of the part corresponding to the exit-side heating part 73 is defined as the heat source capacity W3 [W]. The watt density of the part corresponding to the entrance-side heating part 71 is defined as W1/S [W/cm^2], the watt density of the part corresponding to the center heating part 72 is defined as W2/S [W/cm^2], and the watt density of the part corresponding to the exit-side heating part 73 is defined as W3/S [W/cm^2]. In regard to the watt density, the magnitude relationship between these parts is $(W1/S)=(W3/S)>(W2/S)$.

[0055] FIG. 8 is a table showing conditions of the comparison test. As shown in the table of FIG. 8, (i) the heater diameter D (diameter of the heater: equivalent to the diameter of the pipe 51b) and (ii) the lengths L1, L2, and L3 of the parts corresponding to the parts 71, 72, and 73 are the same between Example 1, Example 2, and Comparative Example. To be more specific, the heater diameter D is 1.2 [cm]. Each of the lengths L1, L2, and L3 is 30 [cm]. That is, the heating length (L1+L2+L3) is 90 [cm]. The surface area S [cm^2] of each of the parts corresponding to the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 is approximately 113.1 [cm^2]. The heat source capacity of the entire heat source is 900 [W].

[0056] In regard to the heat source of Example 1, each of the heat source capacity W1 [W] of the part corresponding to the entrance-side heating part 71 and the heat source capacity W3 [W] of the part corresponding to the exit-side heating part 73 is 315 [W] as shown in the table of FIG. 8. The heat source capacity W2 [W] of the part corresponding to the center heating part 72 is 270 [W]. As described above, the surface area S [cm^2] of each of the parts corresponding to the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 is 113.1 [cm^2] . Therefore, each of the watt density (W1/S) of the part corresponding to the entrance-side heating part 71 and the watt density (W3/S) of the part corresponding to the exit-side heating part 73 is approximately 2.79 [W/cm^2]. The watt density (W2/S) of the part corresponding to the center heating part 72 is approximately 2.39 [W/cm^2]. That is, the watt density of each of the parts corresponding to the parts 71, 72, and 73 is equal to or less than 3.0 [W/cm^2] in Example 1. A difference of heat source capacity is 45 [W].

[0057] In regard to the heat source of Example 2, each of the heat source capacity W1 [W] of the part corresponding to the entrance-side heating part 71 and the heat source capacity W3 [W] of the part corresponding to the exit-side heating part 73 is 325 [W] as shown in the table of FIG. 8. The heat source capacity W2 [W] of the part corresponding to the center heating part 72 is 250 [W]. As described above, the surface area S [cm^2] of each of the parts corresponding to the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 is 113.1 [cm^2] . Therefore, each of the watt density (W1/S) of the part corresponding to the entrance-side heating part 71 and the watt density (W3/S) of the part corresponding to the exit-side heating part 73 is approximately 2.87 [W/cm^2]. The watt density (W2/S) of the part corresponding to the center heating part 72 is approximately 2.21 [W/cm^2]. That is, the watt density of each of the parts corresponding to the parts 71, 72, and 73 is equal to or less than 3.0 [W/cm^2] in Example 2. A difference of heat source capacity is 75 [W]. A difference of heat source capacity in the heat source of Example 2 is larger than that in the heat source of Example 1.

[0058] In regard to the heat source of Comparative Example, each of the heat source capacity W1 [W] of the part corresponding to the entrance-side heating part 71, the heat source capacity W2 [W] of the part corresponding to the center heating part 72, and the heat source capacity W3 [W] of the part corresponding to the exit-side heating part 73 is 300 [W] as shown in the table of FIG. 8.

[0059] FIG. 9 is a graph of temperature distribution of a yarn contacted surface in the extending direction of each of the heat sources of Example 1, Example 2, and Comparative Example when the set temperature is adjusted to 200 [°C] (when the temperature of a heating unit is detected by a sensor and controlled to be 200 [°C]). When Example 1, Example 2, and Comparative Example are compared to one another in the graph of FIG. 9, Comparative Example with the heat source in which the watt density of the resistive element is uniform has the largest degree of decrease in temperature of both end portions of the yarn contacted surface in the extending direction (yarn running direction). As compared to Example 1 in the graph, Example 2 with the heat source in which a difference of heat source capacity is large has a smaller degree of decrease in temperature of both end portions of the yarn contacted surface in the extending direction (yarn running direction).

[0060] In each of the heat sources of Comparative Example and Example 1, the temperature of the yarn contacted surface is the highest at the center of the yarn contacted surface in the extending direction and is decreased toward both end portions of the yarn contacted surface in the extending direction. Meanwhile, in the heat source of Example 2, the temperature of the yarn contacted surface is high at peak points provided on both sides of the center of the yarn contacted surface in the extending direction and is relatively low at a part between these two peak points. This is because of the size of a difference of heat source capacity. In the heat source of Example 1, a difference of heat source capacity is 45 [W]. In the heat source of Example 2, a difference of heat source capacity is 75 [W]. That is, in the heat source of Example 2, the temperature of the yarn contacted surface is high at the peak points and low between the peak points because a difference of heat source capacity is relatively high, i.e., because an amount of heat generated at the parts corresponding to the entrance-side heating part 71 and the exit-side heating part 73 is much larger than that at the part corresponding to the center heating part 72. In other words, the temperature of the yarn contacted surface in the heat source of Example 2 is high at the peak points and low between the peak points because both sides of the center of the yarn contacted surface in the extending direction are heated by the heat generated at the parts corresponding to the entrance-side heating part 71 and the exit-side heating part 73. As such, a difference of heat source capacity is preferably equal to or less than 45 [W] in order (i) to further equalize the temperature distribution of each yarn contacted surface in the extending direction and (ii) to reliably suppress the yarn from being unevenly heated. When a difference of heat source capacity is equal to or less than 45 [W], the difficulty in production of each heat source is reduced and a lot of heat sources are easily produced.

[0061] FIG. 10 is a graph showing power consumption of each of the heat sources of Example 1, Example 2, and comparative example when the set temperature in a loadless state (a state in which a yarn Y is not heated) is adjusted to 200 [°C]. When Examples 1 and 2 with the heat sources in each of which the heat source capacity of the resistive element is not uniform are compared to Comparative Example with the heat source in which the heat source capacity of the resistive element is uniform, power consumption is almost identical between them as shown in FIG. 10. To be more specific, the power consumption of the heat source of Example 1 is 104.7 [W] and slightly larger than that (103.3 [W]) of the heat source of Comparative Example. Meanwhile, the power consumption of the heat source of Example 2 is 103.1 [W] and slightly smaller than that (103.3 [W]) of the heat source of Comparative Example.

[0062] As described above, when Examples 1 and 2 and Comparative Example are compared to each other, each of Examples 1 and 2 has a smaller degree of decrease in temperature of both end portions of the yarn contacted surface in the extending direction (yarn running direction). Therefore, even when the set temperature in each of the heat sources of Examples 1 and 2 is lower than that in the heat source of Comparative Example, each of the heat sources of Examples 1 and 2 maintains the temperature of both end portions of the yarn contacted surface in the extending direction (yarn running direction) to be a temperature suitable for heating the yarn. As such, the set temperature in each of the heat sources of Examples 1 and 2 can be low. Therefore, the power consumption of each of the heat sources of Examples 1 and 2 is reduced as compared to that of the heat source of Comparative Example.

(Example 3)

[0063] In each of Examples 1 and 2 of the above-described comparison test, the lengths L1, L2, and L3 of the parts corresponding to the parts 71, 72, and 73 of the heat source are equal to one another. The present inventor also checked a case (Example 3) in which the lengths L1, L2, and L3 of the parts corresponding to the parts 71, 72, and 73 were different from one another.

[0064] FIG. 11 is a table showing conditions of Example 3. The table of FIG. 11 shows that the heater diameter D is 1 [cm]. The length L1 of a part corresponding to the entrance-side heating part 71 is 33 [cm], the length L2 of a part corresponding to the center heating part 72 is 29 [cm], and the length L3 of a part corresponding to the exit-side heating part 73 is 33 [cm]. That is, the heating length (L1+L2+L3) is 95 [cm]. The surface area of the part corresponding to the entrance-side heating part 71 is defined as the surface area S1 [cm^2], and the surface area of the part corresponding to the exit-side heating part 73 is defined as the surface area S3 [cm^2]. Each of the surface areas S1 and S3 is 103.7 [cm^2]. The surface area of the part corresponding to the center heating part 72 is defined as the surface area S2 [cm^2] . The surface area S2 is 91.1 [cm^2] .

[0065] The heat source capacity W1 [W] of the part corresponding to the entrance-side heating part 71 is 280 [W], the heat source capacity W2 [W] of the part corresponding to the center heating part 72 is 240 [W], and the heat source capacity W3 [W] of the part corresponding to the exit-side heating part 73 is 280 [W]. In Example 3, the heat source capacity of the entire heat source is 800 [W]. With these arrangements, each of the watt density (W1/S1) of the part corresponding to the entrance-side heating part 71 and the watt density (W3/S3) of the part corresponding to the exit-side heating part 73 is approximately 2.7 [W/cm^2]. The watt density (W2/S2) of the part corresponding to the center heating part 72 is approximately 2.6 [W/cm^2]. As such, the watt density of each of the parts corresponding to the parts 71, 72, and 73 is equal to or less than 3.0 [W/cm^2]. Furthermore, a difference of heat source capacity is 40 [W].

[0066] FIG. 12 is a graph of temperature distribution of a yarn contacted surface in the extending direction of the heat source of Example 3 when the set temperature is adjusted to 200 [°C] (when the temperature of a heating unit is detected by a sensor and controlled to be 200 [°C]). As compared to the heat source of Comparative Example shown in the graph of FIG. 9, the heat source of Example 3 shown in the graph of FIG. 12 has a sufficiently small degree of decrease in temperature of both end portions of the yarn contacted surface in the extending direction (yarn running direction). As compared to Examples 1 and 2 shown in the graph of FIG. 9, the temperature at the center of the yarn contacted surface in the extending direction (yarn running direction) is slightly small (by approximately 1 °C) in Example 3 shown in the graph of FIG. 12. This is because of the influence of individual differences between temperature sensors. According to the results of Examples 1 to 3, when (i) the watt density of the heating part of the heat source is equal to or less than 3.0 [W/cm^2] and (ii) a difference of heat source capacity is equal to or more than 40 [W] and equal to or less than 45 [W], the decrease in temperature of both end portions of the heating unit in the extending direction (yarn running direction) is sufficiently suppressed.

(Characteristics of Embodiment)

[0067] The first heater 13 of the present embodiment includes: the heat source 51 which extends in the yarn running direction and which is configured to generate heat when an electric current is supplied to the resistive element 51a; the heating unit 52 in which the yarn running spaces 50, in which yarns Y run, are provided and which is heated by the heat source 51; the sensor 57 configured to detect the temperature of the heating unit 52; and the controller 100 configured to switch, based on an output signal by the sensor 57, between a state in which an electric current is supplied to the resistive element 51a and a state in which an electric current is not supplied to the resistive element 51a. The heat source 51 has: the entrance-side heating part 71 and the exit-side heating part 73 which are configured to heat the end portions of the heating unit 52 in the yarn running direction; and the center heating part 72 at which the watt density of the resistive element 51a is lower than that at each of the entrance-side heating part 71 and the exit-side heating part 73. In this regard, the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 are aligned in the yarn running direction.

[0068] With this arrangement, even though the temperature of the end portions of the heating unit 52 in the yarn running direction is relatively easily decreased, these end portions are heated by the entrance-side heating part 71 and exit-side heating part 73 of the heat source 51. In the heat source 51, an amount of heat generated at each of the entrance-side heating part 71 and the exit-side heating part 73 at each of which the watt density of the resistive element 51a is relatively high is larger than an amount of heat generated at the center heating part 72 at which the watt density of the resistive element 51a is relatively low. It is therefore possible to heat the end portions of the heating unit 52 in the yarn running direction with a relatively large amount of heat. As a result, the decrease in temperature of the end portions of the heating unit 52 in the yarn running direction is suppressed, and the yarns Y running in the heating unit 52 are further evenly heated.

[0069] In the first heater 13 of the present embodiment, the heat source 51 has the entrance-side heating part 71 and the exit-side heating part 73 which are configured to heat the respective end portions of the heating unit 52 in the yarn running direction. With this arrangement, even though the temperature of both end portions of the heating unit 52 in the yarn running direction is relatively easily decreased, these end portions are heated by the entrance-side heating part 71 and the exit-side heating part 73 at each of which the watt density of the resistive element 51a of the heat source 51 is relatively high. It is therefore possible to suppress the decrease in temperature of both end portions of the heating unit 52 in the yarn running direction.

[0070] In the first heater 13 of the present embodiment, the heating unit 52 includes the yarn contacted portions 54 which extend in the yarn running direction and which have the respective yarn contacted surfaces 56 with which the yarns Y running in the yarn running spaces 50 make contact. With this arrangement, the decrease in temperature of both end portions of each yarn contacted surface 56 in the yarn running direction is suppressed. It is therefore possible to stably heat a yarn Y by causing the yarn Y to make contact with the yarn contacted surface 56.

[0071] In the first heater 13 of the present embodiment, the heating members 53 and the yarn contacted portions 54 form the heating unit 52 and are made of a metal material. In other words, the heating unit 52 contains a metal material. The watt density of the resistive element 51a at each of the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 is equal to or less than 3.0 [W/cm^2]. The watt density needs to be set in accordance with the type of a material of a heating target. In the present embodiment, the heating unit 52 which is a heating target of the heat source 51 contains a metal material. It is therefore possible to suppress the occurrence of a phase change and a chemical change at the heating unit 52, by controlling the watt density to be equal to or less than 3.0 [w/cm^2] . This contributes to a long life of the heat source 51.

[0072] A difference of heat source capacity between each of the entrance-side heating part 71 and exit-side heating part 73 and the center heating part 72 is preferably equal to or more than 40 [W] and equal to or less than 45 [W], in order (i) to further equalize the temperature distribution of each yarn contacted surface 56 of the heating unit 52 in the extending direction (yarn running direction) and (ii) to reliably suppress the yarns Y from being unevenly heated. However, a difference of heat source capacity may be less than 40 [W] or more than 45 [W] .

[0073] In the first heater 13 of the present embodiment, the heat source 51 is a sheathed heater in which the resistive element 51a is surrounded by the pipe 51b. When the sheathed heater in which the resistive element 51a is surrounded by the pipe 51b is used as the heat source 51, the heat source 51 is easily applied to the first heater 13.

[0074] The embodiment of the present invention is described hereinabove. However, the specific structure of the present invention shall not be interpreted as to be limited to the above described embodiment. The scope of the present invention is defined not by the above embodiment but by claims set forth below, and shall encompass the equivalents in the meaning of the claims and every modification within the scope of the claims.

[0075] In the embodiment above, the heating part of the heat source 51 is formed of three parts, i.e., the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73. However, the disclosure is not limited to this. The heating part of the heat source 51 may be suitably arranged as long as it is formed of at least two parts which are different from one another in watt density of the resistive element 51a. For example, (i) the watt density of the resistive element 51a at the center heating part 72 may be equal to that at the exit-side heating part 73 and (ii) the watt density of the resistive element 51a at each of the center heating part 72 and the exit-side heating part 73 may be lower than that at the entrance-side heating part 71. Alternatively, (i) the watt density of the resistive element 51a at the entrance-side heating part 71 may be equal to that at the center heating part 72 and (ii) the watt density of the resistive element 51a at each of the entrance-side heating part 71 and the center heating part 72 may be lower than that at the exit-side heating part 73.

[0076] FIG. 13 shows a first heater 113 of one modification of the embodiment above. In the first heater 113, each yarn running space 50 (50a) is inclined so that its one end portion on one side in the extending direction (yarn running direction) is lower than its the other end portion on the other side in the extending direction (yarn running direction). Among both end portions of the yarn running space 50a in the extending direction (yarn running direction), an end portion on the entrance 13a side is provided to be lower than an end portion on the exit 13b side as shown in FIG. 13. Among both end portions of the yarn running space 50a in the extending direction (yarn running direction), the end portion on the 13b side may be alternatively provided to be lower than the end portion on the entrance 13a side.

[0077] FIG. 14 shows a heat source 151 provided in the first heater 113. The heat source 151 is formed of two parts, i.e., a first part 171 configured to heat one end portion of the heating unit 52 on one side in the extending direction (yarn running direction) and a second part 172 at which the watt density of the resistive element 51a is lower than that at the first part 171. The first part 171 and the second part 172 are aligned in the extending direction (yarn running direction).

[0078] As described above, when the yarn running space 50 is inclined so that its one end portion on one side (its end portion on the entrance 13a side) in the yarn running direction is lower than its the other end portion on the other side (its end portion on the exit 13b side) in the yarn running direction, air heated in the yarn running space 50 is moved toward an upper end portion of the yarn running space 50, i.e., toward the other end portion of the yarn running space 50 on the other side in the yarn running direction. Therefore, the temperature at one end portion of the heating unit 52 on one side in the yarn running direction is relatively easily decreased. In the modification, even though the temperature at one end portion of the heating unit 52 on one side in the yarn running direction is relatively easily decreased, this end portion of the heating unit 52 is heated by the first part 171 at which the watt density of the resistive element 51a of the heat source 151 is relatively high. It is therefore possible to reliably suppress the decrease in temperature of one end portion of the heating unit 52 on one side in the yarn running direction.

[0079] In the embodiment above, the watt density of the resistive element 51a at the entrance-side heating part 71 is equal to that at the exit-side heating part 73. However, the disclosure is not limited to this. The watt density of the resistive element 51a at the entrance-side heating part 71 may be different from that at the exit-side heating part 73.

[0080] In the embodiment above, the watt density of the resistive element 51a at each of the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 is equal to or less than 3.0 [W/cm^2]. However, the disclosure is not limited to this. The watt density of the resistive element 51a at each of the entrance-side heating part 71, the center heating part 72, and the exit-side heating part 73 may be suitably arranged as long as the watt density of the resistive element 51a at the center heating part 72 is lower than that at each of the entrance-side heating part 71 and the exit-side heating part 73. In the modification of the embodiment above, the watt density of the resistive element 51a at each of the first part 171 and the second part 172 may be suitably arranged as long as the watt density of the resistive element 51a at the second part 172 is lower than that at the first part 171. The watt density of the resistive element 51a may be larger than 3.0 [W/cm^2] at one of or all of the parts 71, 72, and 73.

[0081] In the embodiment above, the heating members 53 and the yarn contacted portions 54 form the heating unit 52 and are made of a metal material. However, the disclosure is not limited to this. The heating unit 52 may be suitably arranged as long as it contains a metal material. For example, all of or a part of each heating member 53 may be made of a material different from a metal material. Examples of the material different from a metal material include a composite material including fibers such as carbon fibers. That is, examples of the material different from a metal material include a composite material of carbon fibers and graphite and a composite material of carbon fibers and resin.

[0082] In the first heater 13 of the embodiment above, the yarns Y are heated in a contact manner such that the running yarns Y are heated while being in contact with the yarn contacted surfaces 56 of the yarn contacted portions 54. However, the disclosure is not limited to this. In the heater of the present invention, a yarn may be heated in a contactless manner such that the yarn running in a yarn running space is heated by gas in the yarn running space heated by a heating unit.

[0083] In the embodiment above, the sheathed heater is used as the heat source 51. However, the disclosure is not limited to this. The heat source 51 may be suitably arranged as long as it is a heat source of a resistance-heating type, which is configured to generate heat when an electric current is supplied to the resistive element 51a.

[0084] In the embodiment above, the heater of the present invention is applied to the false-twist texturing machine 1 configured to false-twist the yarns Y. However, the disclosure is not limited to this. The heater of the present invention is applicable to a processor configured to perform, for yarns formed of synthetic fibers, various processes such as yarn combining in addition to false twisting.

Claims

1. A heater (13, 113) comprising: a heat source (51, 151) of a resistance-heating type, which extends in a yarn running direction and which is configured to

generate heat when an electric current is supplied to a resistive element (51a);

a heating unit (52) in which a yarn running space (50) is provided and which is heated by the heat source (51, 151), a yarn (Y) running in the yarn running space (50) ;
a sensor (57) configured to detect the temperature of the heating unit (52); and
a controller (100) programmed to switch, based on an output signal of the sensor (57), between a state in which an electric current is supplied to the resistive element (51a) and a state in which an electric current is not supplied to the resistive element (51a), and
the heat source (51, 151) including:

a first part (71, 73, 171) configured to heat at least one of end portions of the heating unit (52) on at least one side in the yarn running direction of the heating unit (52); and
a second part (72, 172) at which the watt density of the resistive element (51a) is lower than the watt density of the resistive element (51a) at the first part (71, 73, 171), the first part (71, 73, 171) and the second part (72, 172) being aligned in the yarn running direction.

2. The heater (13) according to claim 1, wherein, the first part (71, 73) is configured to heat the both end portions of the heating unit (52) in the yarn running direction.

3. The heater (113) according to claim 1, wherein, the yarn running space (50) is inclined so that one end portion of the yarn running space (50) on one side in the yarn running direction is lower than the other end portion of the yarn running space (50) on the other side in the yarn running direction, and
the heat source (151) includes the first part (171) configured to heat the at least one end portion of the heating unit (52) on the one side in the yarn running direction of the heating unit (52).

4. The heater (13, 113) according to any one of claims 1 to 3, wherein, the heating unit (52) includes a yarn contacted portion (54) which extends in the yarn running direction and which has a yarn contacted surface (56) with which the yarn (Y) running in the yarn running space (50) makes contact.

5. The heater (13, 113) according to claim 4, wherein, the heating unit (52) contains a metal material, and the watt density of the resistive element (51a) at each of the first part (71, 73, 171) and the second part (72, 172) is equal to or less than 3.0 [W/cm^2].

6. The heater (13, 113) according to claim 4 or 5, wherein, a difference in heat source capacity between the first part (71, 73, 171) and the second part (72, 172) is equal to or more than 40 [W] and equal to or less than 45 [W] .

7. The heater (13, 113) according to any one of claims 1 to 6, wherein, the heat source (51, 151) is a sheathed heater in which the resistive element (51a) is surrounded by a pipe (51b).

FIG.1

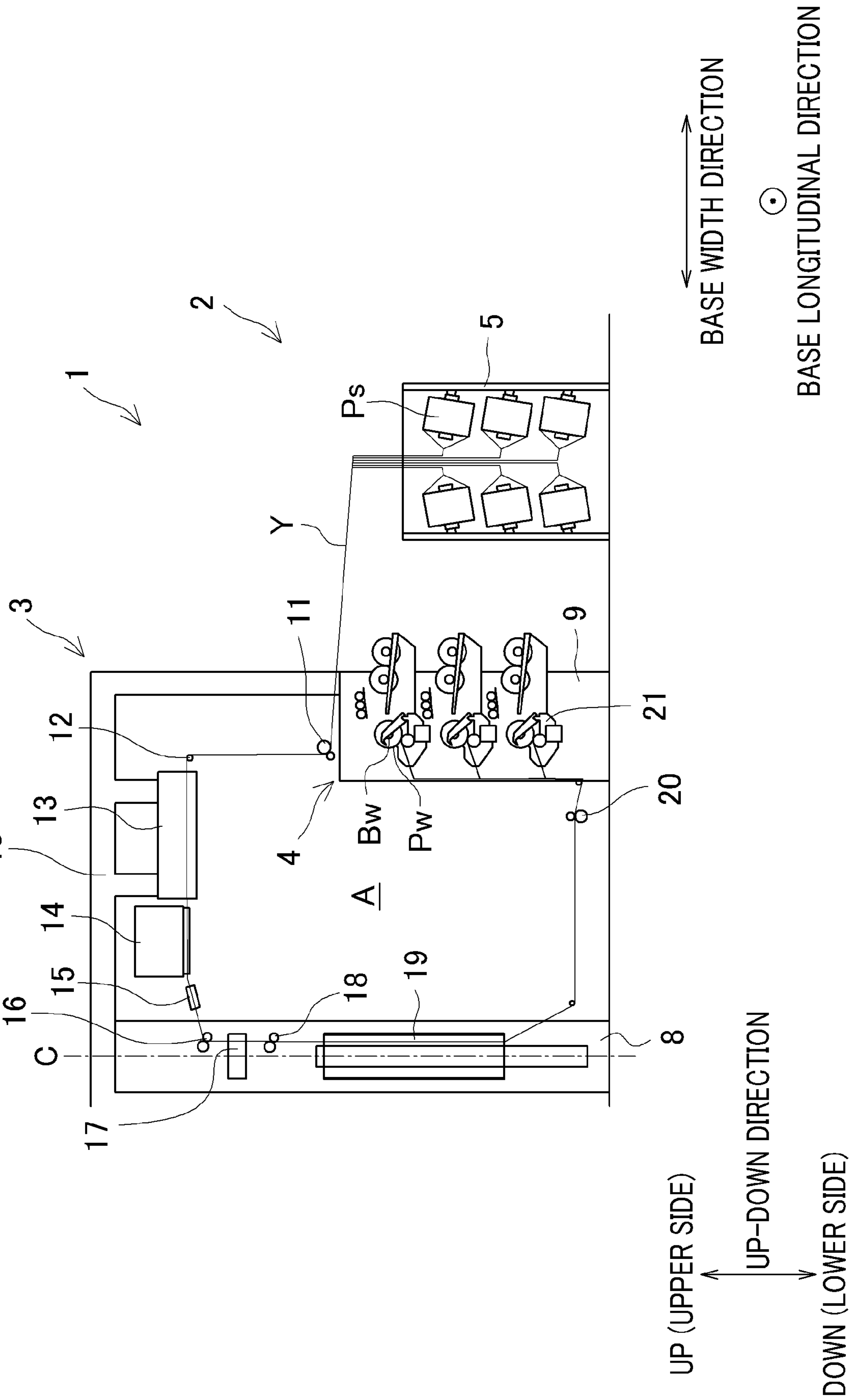
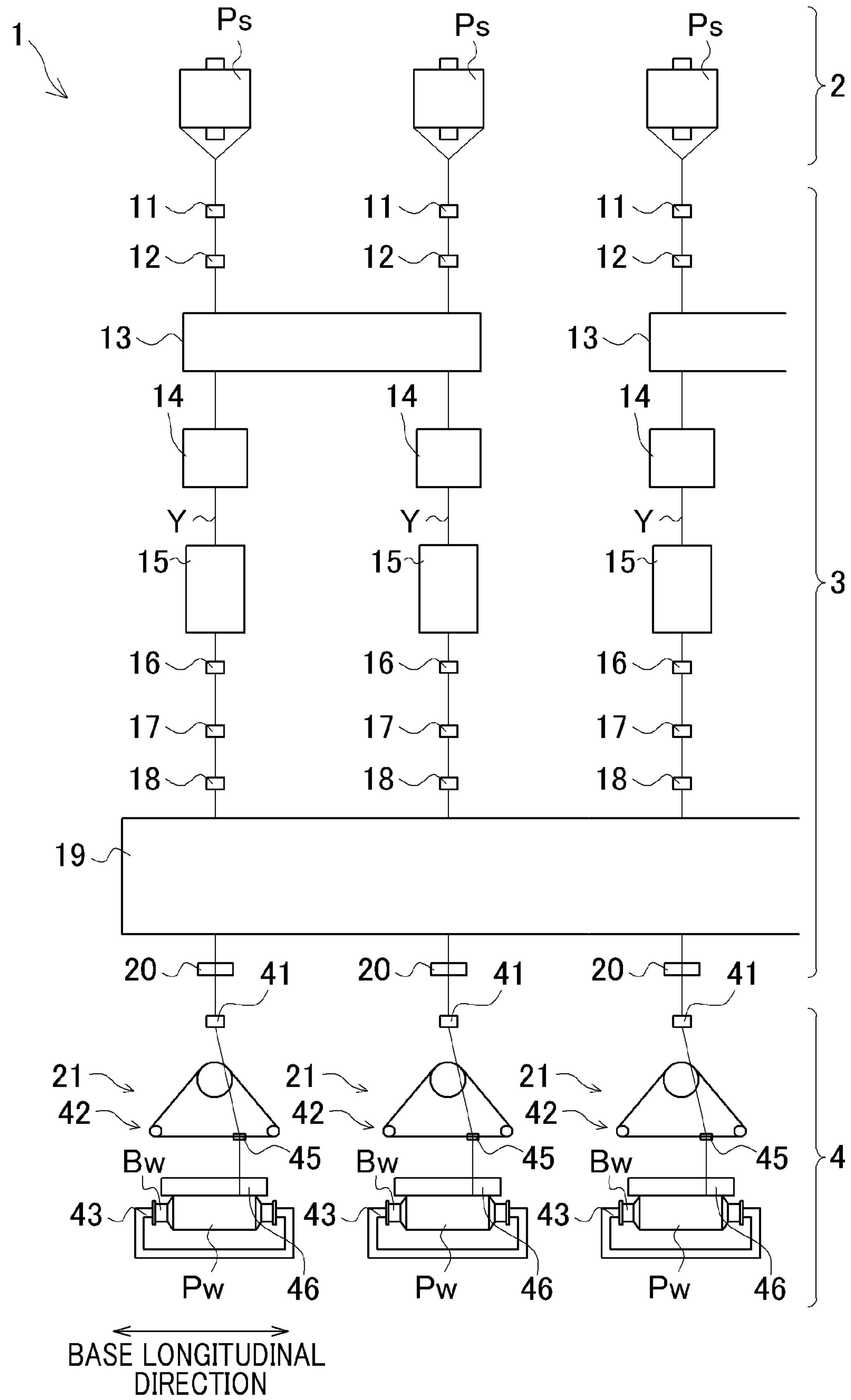

1
2
3
4
5
8
9
10
11
12
13
14
15
16
17
18
19
20
21
A
C
Y
Ps
Bw
Pw
BASE WIDTH DIRECTION
BASE LONGITUDINAL DIRECTION
UP (UPPER SIDE)
UP-DOWN DIRECTION
DOWN (LOWER SIDE)

FIG.2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11
12
13
14
Y
15
16
17
18
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21
42
45
Bw
43
Pw
46
3
4
BASE LONGITUDINAL DIRECTION

FIG.3

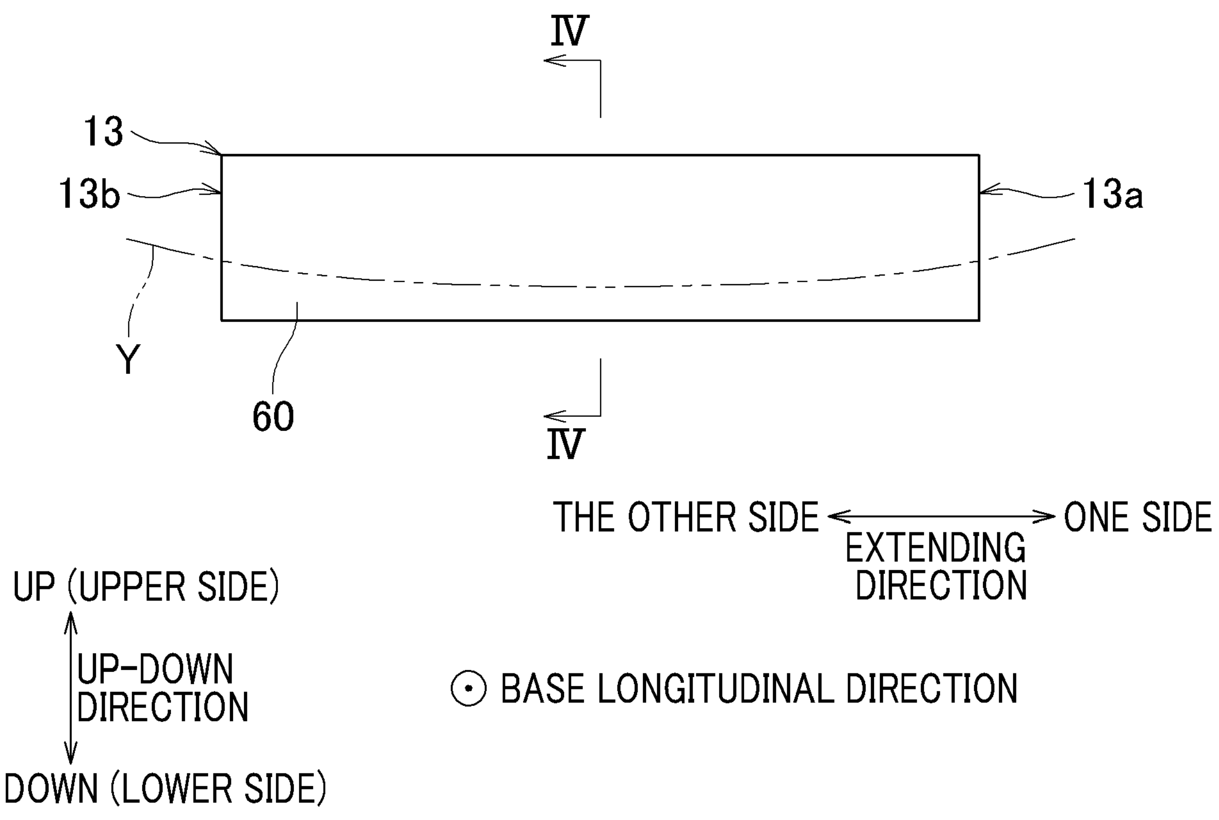
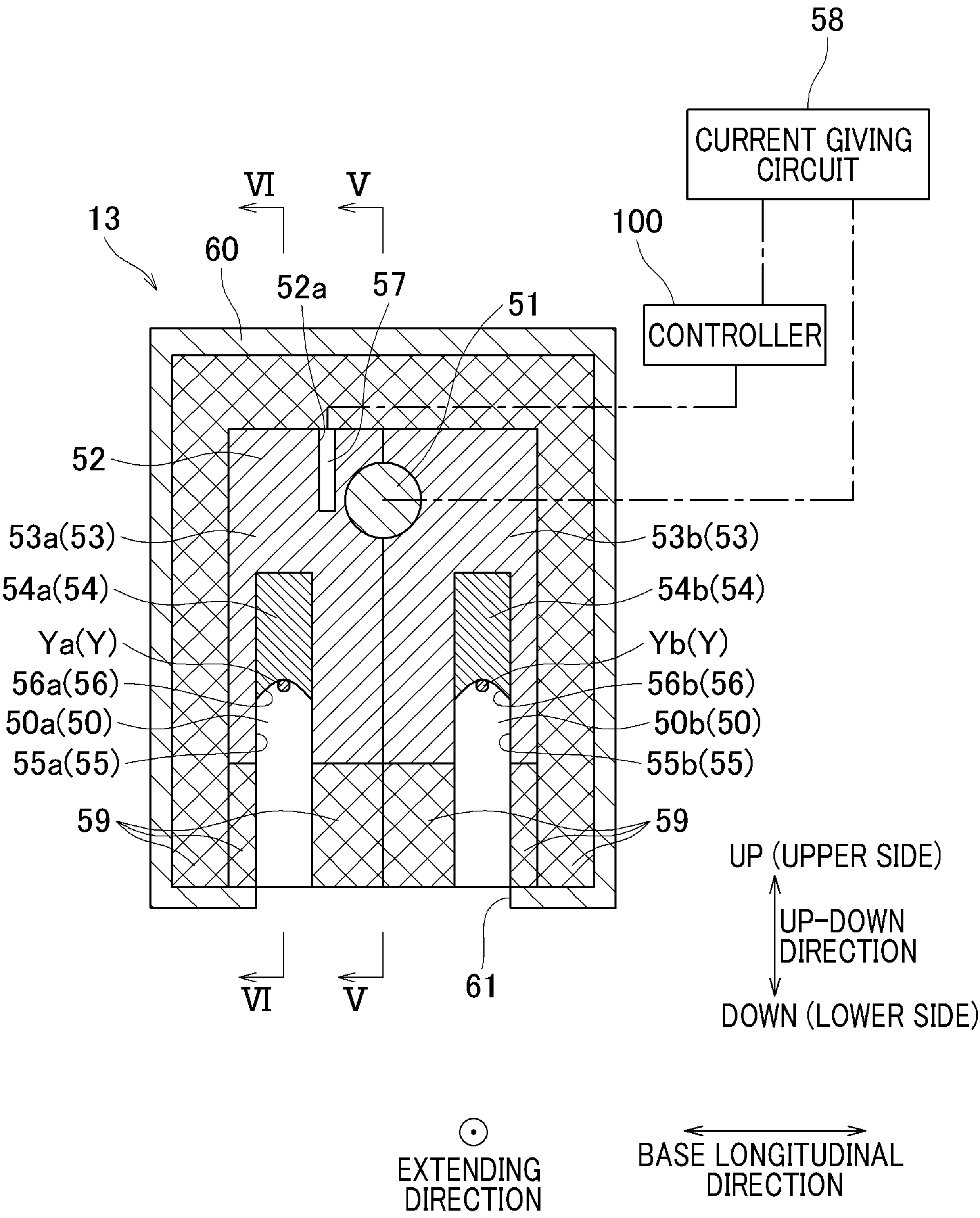
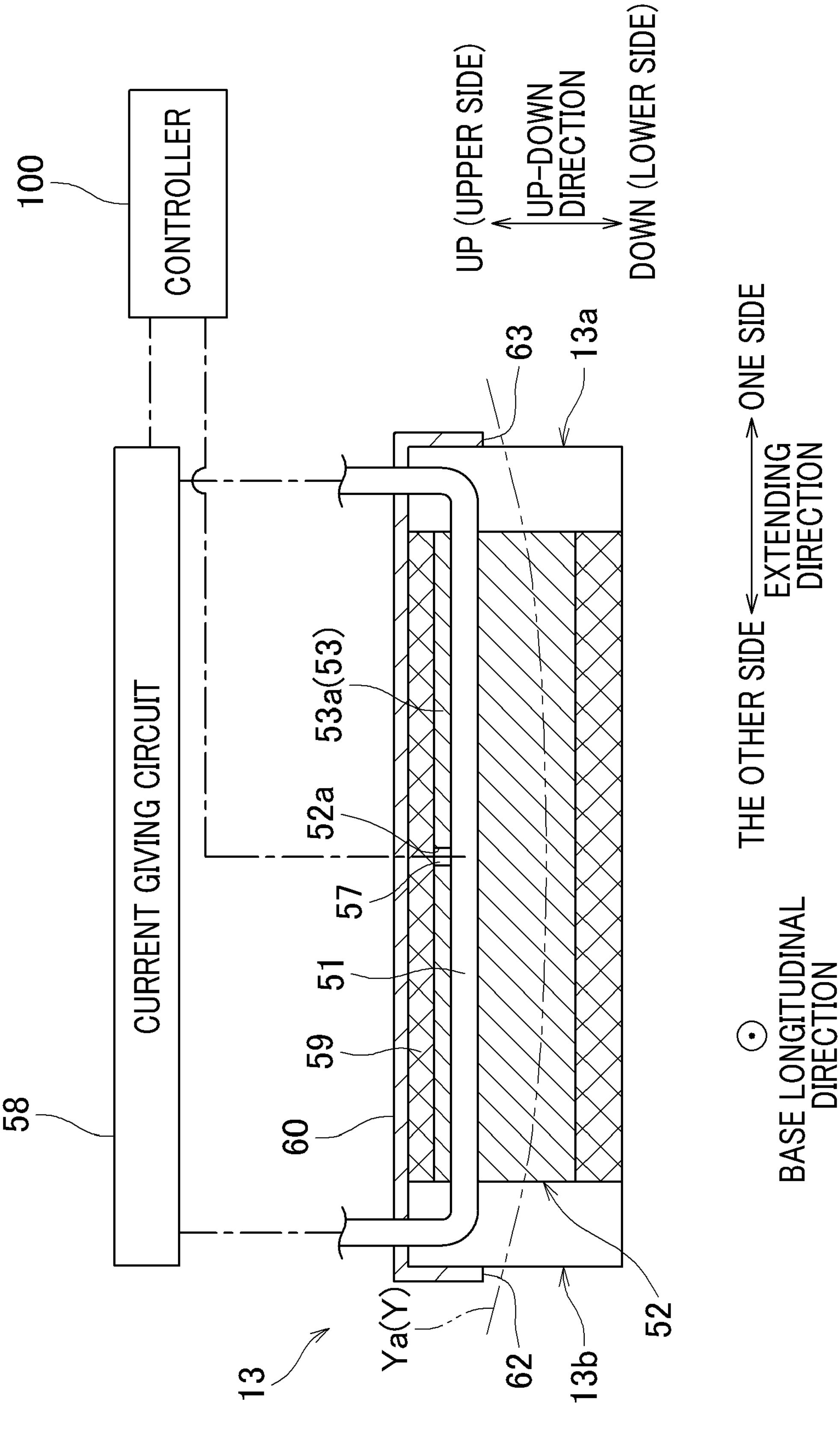

IV
13
13b
13a
Y
60
IV
THE OTHER SIDE
ONE SIDE
EXTENDING
DIRECTION
UP (UPPER SIDE)
UP-DOWN
DIRECTION
DOWN (LOWER SIDE)
BASE LONGITUDINAL DIRECTION

FIG.4



58
CURRENT GIVING CIRCUIT
100
CONTROLLER
13
60
VI
V
52a
57
51
52
53a(53)
53b(53)
54a(54)
54b(54)
Ya(Y)
Yb(Y)
56a(56)
56b(56)
50a(50)
50b(50)
55a(55)
55b(55)
59
59
61
VI
V
UP (UPPER SIDE)
UP-DOWN DIRECTION
DOWN (LOWER SIDE)
EXTENDING DIRECTION
BASE LONGITUDINAL DIRECTION

FIG.5


CONTROLLER
100
CURRENT GIVING CIRCUIT
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53a(53)
52a
57
51
59
60
63
13a
13
Ya(Y)
62
13b
52
UP (UPPER SIDE)
UP-DOWN DIRECTION
DOWN (LOWER SIDE)
ONE SIDE
EXTENDING DIRECTION
THE OTHER SIDE
BASE LONGITUDINAL DIRECTION

FIG.6

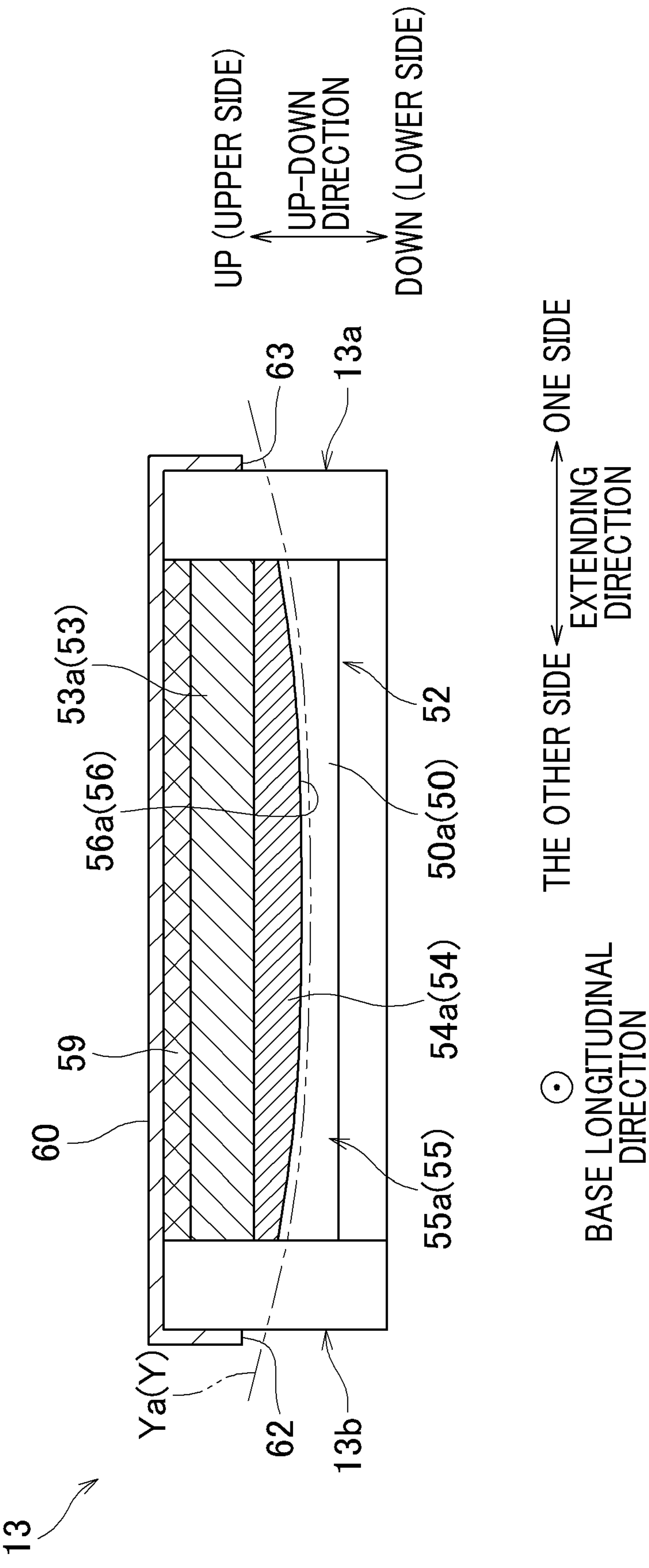

UP (UPPER SIDE)
UP-DOWN DIRECTION
DOWN (LOWER SIDE)
63
13a
ONE SIDE
EXTENDING DIRECTION
THE OTHER SIDE
53a(53)
56a(56)
52
50a(50)
59
54a(54)
60
55a(55)
BASE LONGITUDINAL DIRECTION
Ya(Y)
62
13b
13

FIG.7

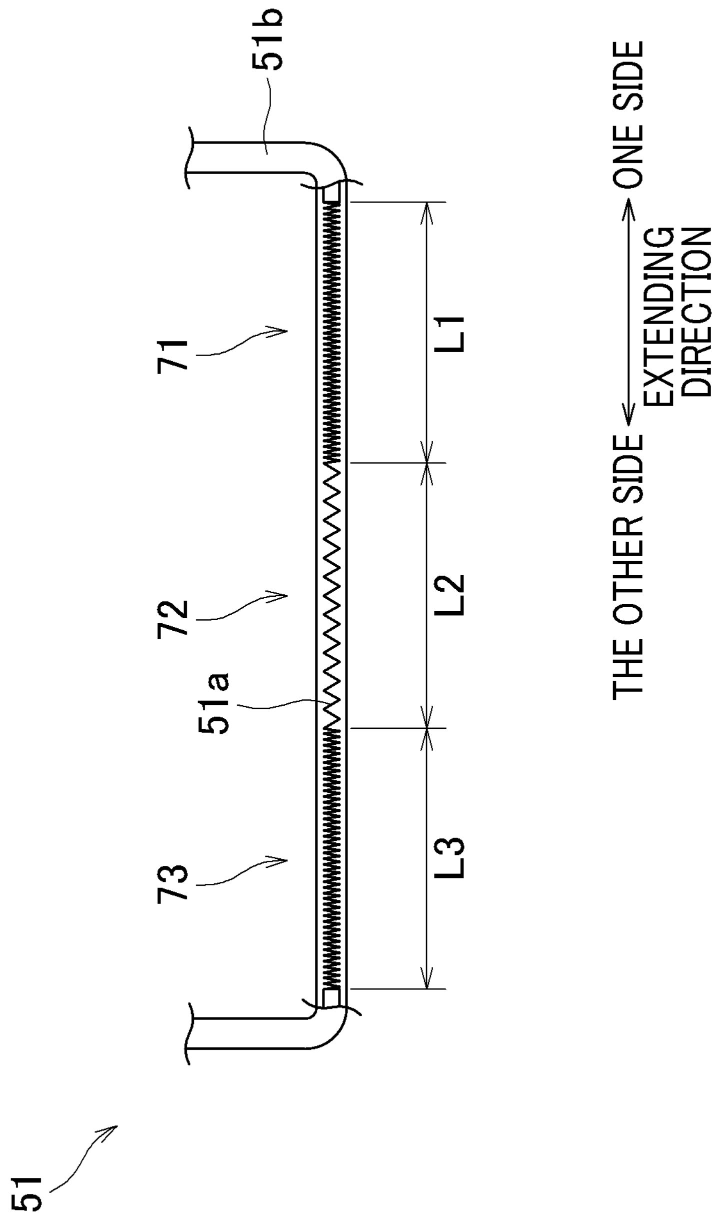

51b
71
72
51a
73
L1
L2
L3
51
ONE SIDE
EXTENDING DIRECTION
THE OTHER SIDE

FIG.8

	COMPARATIVE EXAMPLE	EXAMPLE1	EXAMPLE2
HEATER DIAMETER D	1.2cm		
LENGTH L1 OF ENTRANCE-SIDE HEATING PART	30cm		
LENGTH L2 OF CENTER HEATING PART	30cm		
LENGTH L3 OF EXIT-SIDE HEATING PART	30cm		
HEAT SOURCE CAPACITY W1 OF ENTRANCE-SIDE HEATING PART	300W	315W	325W
HEAT SOURCE CAPACITY W2 OF CENTER HEATING PART	300W	270W	250W
HEAT SOURCE CAPACITY W3 OF EXIT-SIDE HEATING PART	300W	315W	325W
WATT DENSITY OF ENTRANCE-SIDE HEATING PART	2.65W/cm^2	2.79W/cm^2	2.87W/cm^2
WATT DENSITY OF CENTER HEATING PART	2.65W/cm^2	2.39W/cm^2	2.21W/cm^2
WATT DENSITY OF EXIT-SIDE HEATING PART	2.65W/cm^2	2.79W/cm^2	2.87W/cm^2
DIFFERENCE OF HEAT SOURCE CAPACITY	0W	45W	75W

FIG.9

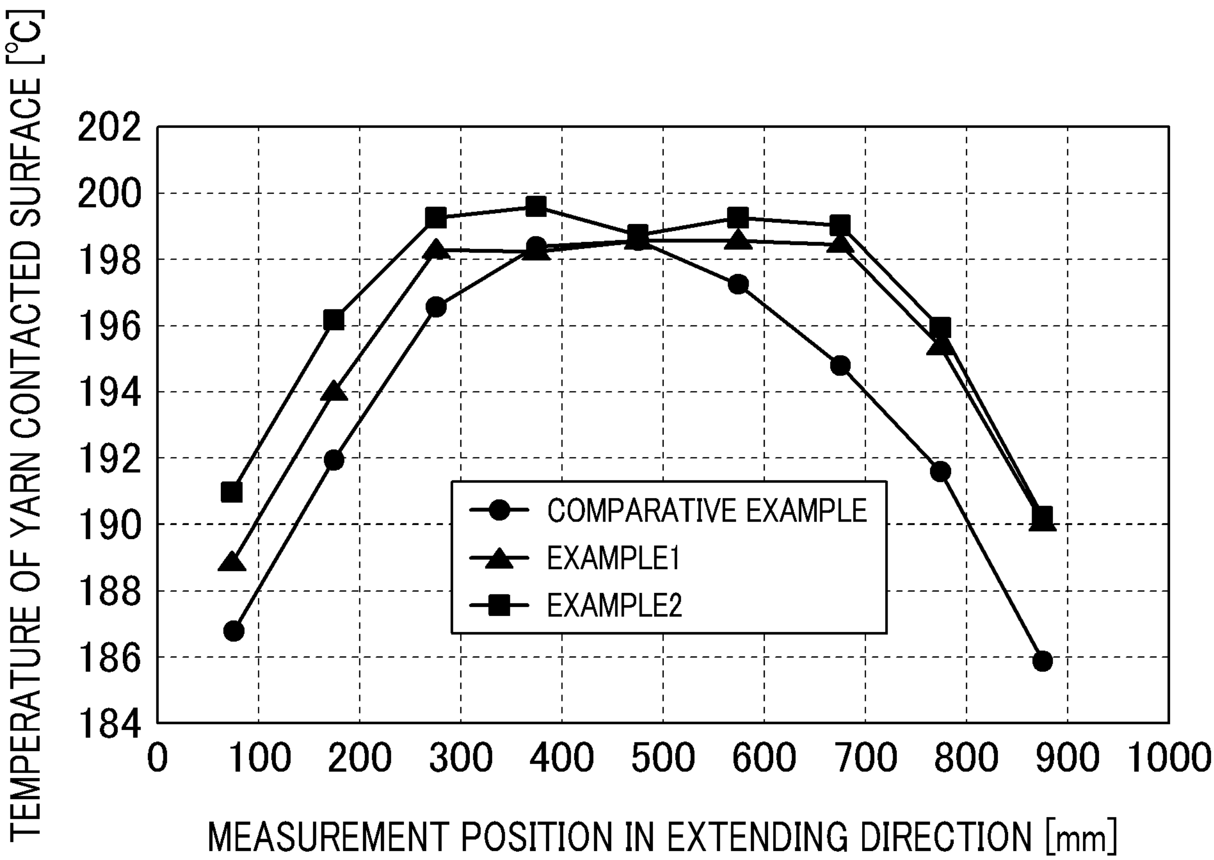

TEMPERATURE OF YARN CONTACTED SURFACE [°C]
202
200
198
196
194
192
190
188
186
184
0
100
200
300
400
500
600
700
800
900
1000
MEASUREMENT POSITION IN EXTENDING DIRECTION [mm]
COMPARATIVE EXAMPLE
EXAMPLE1
EXAMPLE2

FIG.10

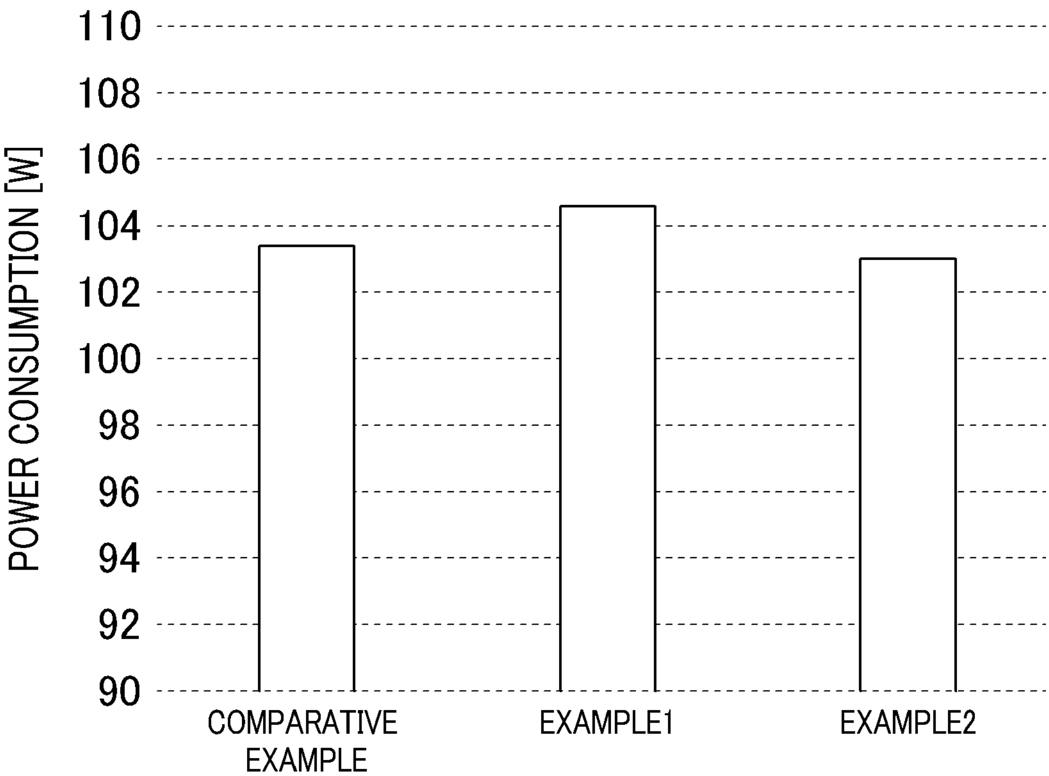

110
108
106
104
102
100
98
96
94
92
90
POWER CONSUMPTION [W]
COMPARATIVE EXAMPLE
EXAMPLE1
EXAMPLE2

FIG.11

	EXAMPLE3
HEATER DIAMETER D	1cm
LENGTH L1 OF ENTRANCE-SIDE HEATING PART	33cm
LENGTH L2 OF CENTER HEATING PART	29cm
LENGTH L3 OF EXIT-SIDE HEATING PART	33cm
HEAT SOURCE CAPACITY W1 OF ENTRANCE-SIDE HEATING PART	280W
HEAT SOURCE CAPACITY W2 OF CENTER HEATING PART	240W
HEAT SOURCE CAPACITY W3 OF EXIT-SIDE HEATING PART	280W
WATT DENSITY OF ENTRANCE-SIDE HEATING PART	2.7W/cm^2
WATT DENSITY OF CENTER HEATING PART	2.6W/cm^2
WATT DENSITY OF EXIT-SIDE HEATING PART	2.7W/cm^2
DIFFERENCE OF HEAT SOURCE CAPACITY	40W

FIG.12

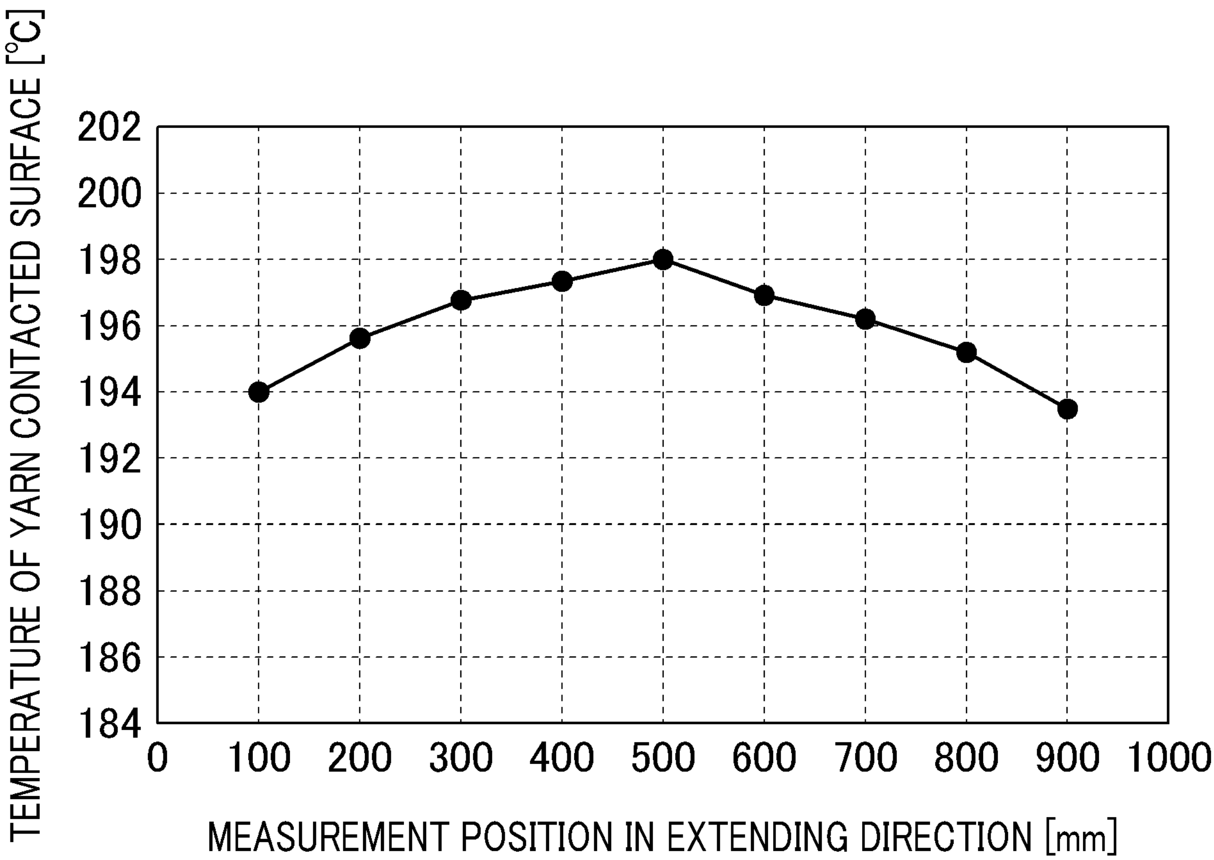

TEMPERATURE OF YARN CONTACTED SURFACE [°C]
202
200
198
196
194
192
190
188
186
184
0
100
200
300
400
500
600
700
800
900
1000
MEASUREMENT POSITION IN EXTENDING DIRECTION [mm]

FIG.13

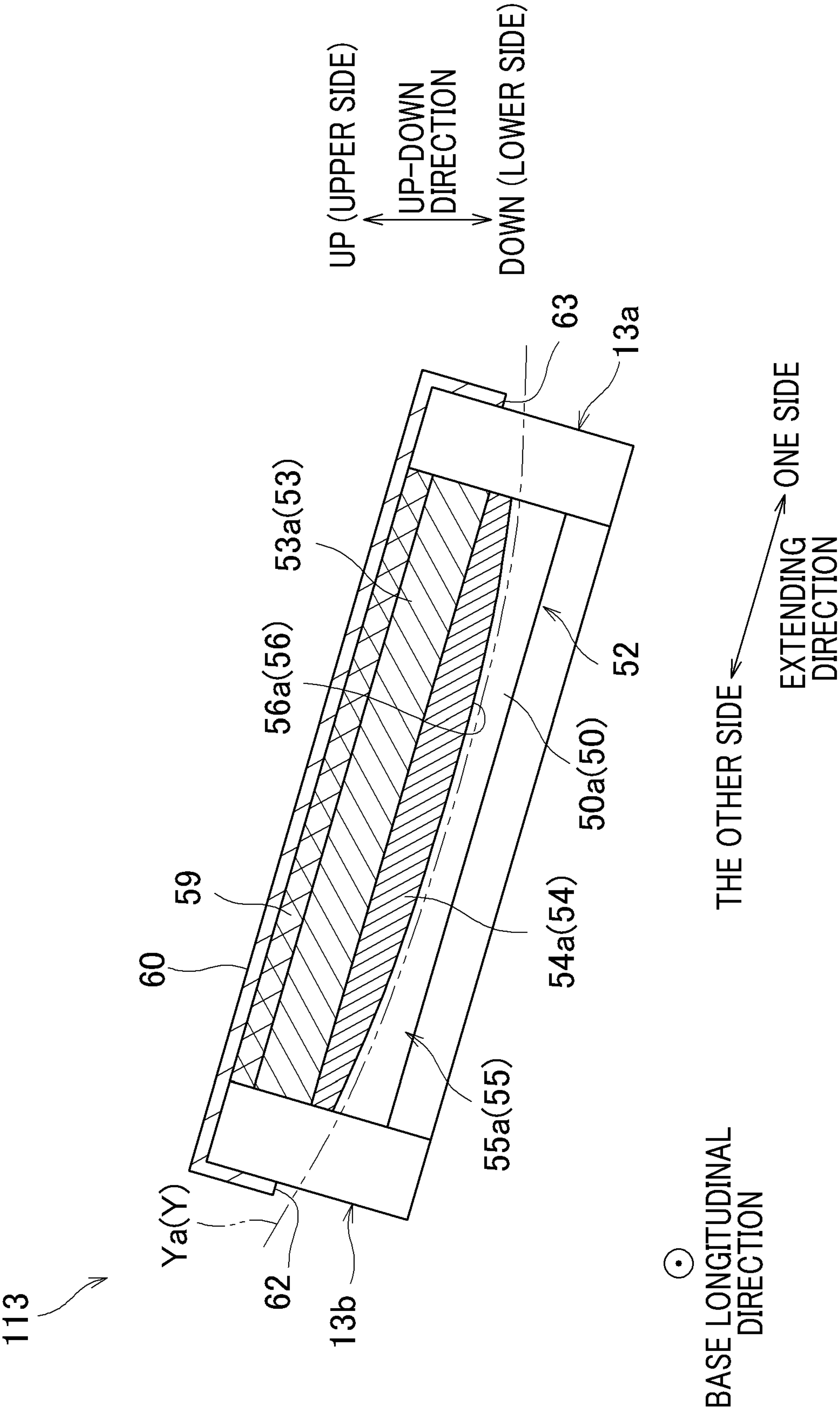
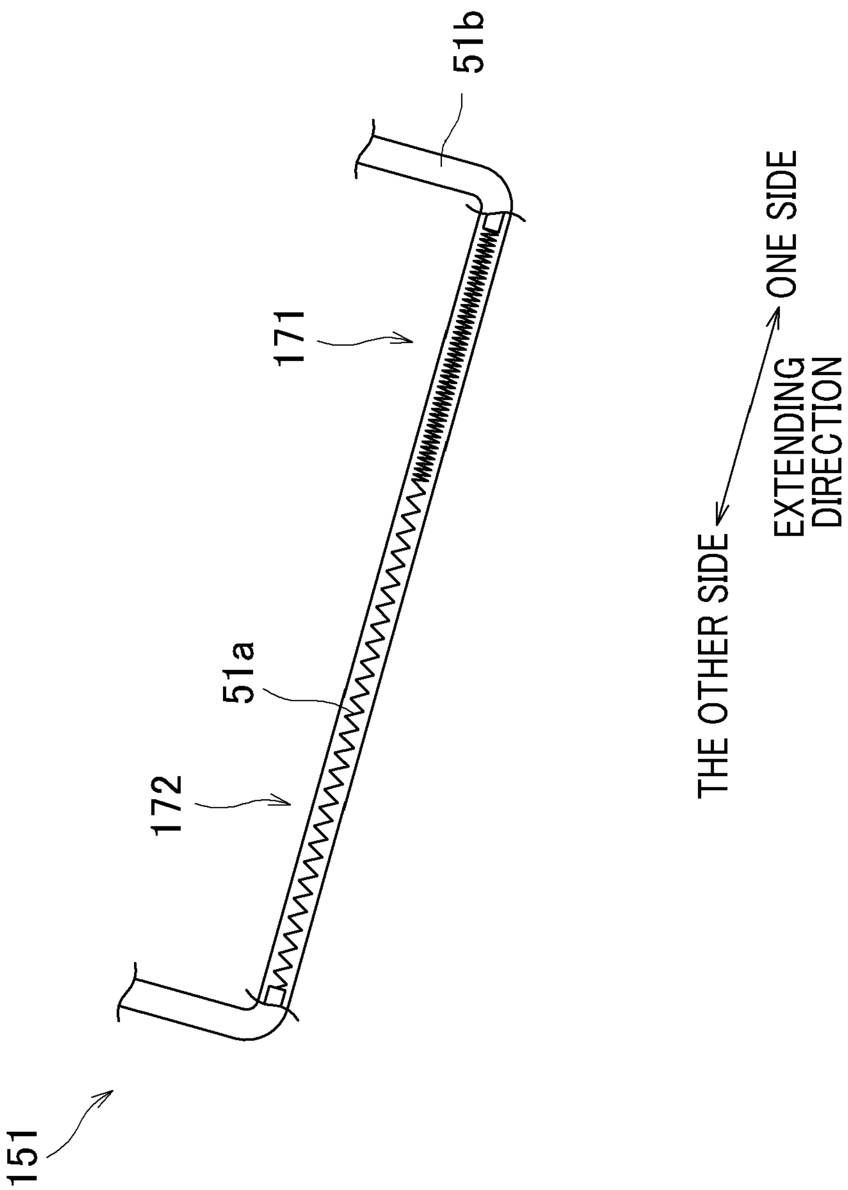

UP (UPPER SIDE)
UP-DOWN DIRECTION
DOWN (LOWER SIDE)
63
13a
53a(53)
56a(56)
52
50a(50)
59
60
54a(54)
55a(55)
Ya(Y)
62
13b
113
ONE SIDE
EXTENDING DIRECTION
THE OTHER SIDE
BASE LONGITUDINAL DIRECTION

FIG.14


51b
171
51a
172
151
ONE SIDE
THE OTHER SIDE
EXTENDING
DIRECTION

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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 7914

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X Y	JP H09 111561 A (MURATA MACHINERY LTD) 28 April 1997 (1997-04-28) * paragraph [0001] * * paragraph [0010] - paragraph [0011]; figures 1-2 * * paragraph [0013]; figure 1 * * paragraph [0016]; figure 1 * * paragraph [0017]; figures 7-8 * * paragraph [0019] * -----	1-3,7 4-6	INV. H05B3/42 H05B1/02 H05B3/06 D02J13/00
Y	CN 212 655 929 U (RUIAN JIARUN NEW MATERIAL TECH CO LTD) 5 March 2021 (2021-03-05) * paragraph [0001] * * paragraph [0012] - paragraph [0013]; figures 1-2 * -----	4-6	

TECHNICAL FIELDS SEARCHED (IPC)
H05B D02J

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	1 September 2023	Barzic, Florent

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01-09-2023

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