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(54) **Method and apparatus for heat treating a heat-shrinkable tape-like object.**

(57) A tape-like object such as a fastener tape the shrinkage curve of which is known traverses a plurality of rollers disposed within a heating unit. In order for the tape to travel through the heating unit in a substantially tension-free state or under a prescribed tension, a suitable feed speed based upon the shrinkage curve is obtained. The rollers are driven by drive means, responsive to commands from control means, in accordance with the feed speed in such a manner that each roller rotates at a speed different from the other rollers, or in such a manner that groups of the rollers each rotate at a speed which is different for each group.

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METHOD AND APPARATUS FOR HEAT TREATING A HEAT-SHRINKABLE TAPE-LIKE OBJECT

This invention relates to a heat treatment method and apparatus for stabilizing the dimensions of a tape-like object consisting of a heat-shrinkable material prior to submitting the object to a dyeing process. The object, e.g., a fastener tape or a fastener chain having elements consisting of a formed monofilament secured to a fastener tape, is dimensionally stabilized by applying heat thereto before dyeing in order to shrink the object in advance, and further by stretching the object after the heat-shrinkage step if so desired.

A tape-like object made of a heat-shrinkable material often requires to be preshrunk by a heat treatment in order to obtain dimensional and structural stability. This is particularly true of a slide fastener tape or of a fastener chain having elements consisting of a formed plastic monofilament secured to a tape, in which the tape or chain requires the removal of residual strain or deformation in a weaving and knitting process, bead forming process and sewing process. Since the tape-like object is subsequently subjected to heat in a dyeing process, it also requires to be heat-shrunk prior to dyeing in order to be provided with dimensional stability.

More specifically, if a fastener tape were submitted to dyeing without first being heat-treated, the tape would wrinkle, twist and bend due to unregulated, rapid shrinkage. Since this would make it impossible to obtain a configuration having a prescribed bias, the pitch or spacing between elements on a fastener chain using the fastener tape would become irregular. Moreover, since the uniform flow of a dye solution would be impeded by shrinkage of the tape-like object wound around a dyeing beam, uneven dyeing would occur. Accordingly, heat-shrinkage prior to dyeing is necessary as long as the tape-like object exhibits a heat shrinking

property. This is true not only for heat-shrinkable synthetic resin fibers like polyester, which are commonly used as the tape material, but also when mixed fabrics are used. It is also important to effect the heat shrinkage without causing the tape-like object to slacken or entangle, and of upmost importance is how to perform the heat shrinkage to the maximum required degree when the amount of shrinkage prescribed is great.

The tape-like object of the type described above is subjected to heat treatment by being wound around a plurality of rollers and heated while fed by the rollers. However, the relation between the amount of shrinkage and heating time is non-linear, with the degree of shrinkage being great at the beginning of heating and gradually diminishing with the passage of time. If the rollers are merely driven at the same speed, therefore, the tape-like object will sustain a large tensile force at the initial stage of the heat treatment. There is need of an apparatus for preventing this phenomenon by applying a heat treatment to shrink the tape-like object sufficiently without the object sustaining substantially any tensile force along its entire length, or under a condition where only a small, constant tensile force is received, while at the same time avoiding slackening or entanglement of the object. An example of such an apparatus is disclosed in the specification of Japanese Patent Publication No. 42-8751, published on April 21, 1967. The apparatus includes a heating unit having a plurality of drive rollers for sensing the tension of the tape-like object, which is fed by rollers. The drive rollers are adapted to drive the tape-like object in such a manner that the tension is held below a certain value at all times.

With the above-described conventional apparatus, however, a number of disadvantages are encountered. Specifically, the final length of the tape-like object following heat treatment is not regulated in any active manner, and local differences in heat shrinkage translate directly into a deformation in overall shape. Also, since the tension of the tape-like object is sensed as the object is being

treated and the speed at which the object is driven is controlled in accordance with the tension sensed, only a single tape-like object can be wound around the rollers at one time. The result is poor processing efficiency. Where the tape-like object is made of a polyester material, moreover, heat setting is carried out by cooling following the heat treatment. However, a method and apparatus capable of dealing with this effectively are not available.

An object of the present invention is to provide a heat treatment method and apparatus devoid of the foregoing defects encountered in the prior art.

Another object of the present invention is to submit a tape-like object to a sufficient degree of shrinkage necessary for delivery to a dyeing process.

Still another object of the present invention is to perform a heat treatment in a correct and stable manner, and to cope rapidly with any change in degree of shrinkage.

Yet another object of the present invention is to subject a number of tape-like objects to heat treatment at one time in an efficient manner.

A further object of the present invention is to provide a heat treatment method and apparatus particularly suited to treatment of a tape-like object made of a polyester material.

According to the present invention, the foregoing objects are attained by providing a heat treatment method having the following characterizing features, as well as an apparatus for practicing the method. The method includes obtaining, from a shrinkage curve of the tape-like object that is to undergo heating, a feed speed for the tape-like object that is necessary to maintain the tape-like object substantially free of tension, or at an approximately fixed tension, over the entire travelling distance of the tape-like object, which travelling distance is regulated by a plurality of rollers, and driving the rollers in accordance with the feed speed in such a manner that each roller rotates at a speed different from the other rollers, or in

such a manner that groups of the rollers each rotate at a speed which is different for each group.

The apparatus includes a plurality of drive units for driving a plurality of rollers provided in a heating unit. The drive units are so adapted that each drives one of the rollers individually or a single group of the rollers. The apparatus also includes control means for controlling the drive units in such a manner that the rollers are rotated at a speed decided by a shrinkage curve of the tape-like object in order to maintain the tape-like object substantially free of tension, or at an approximately fixed tension, over the entire travelling distance of the tape-like object regulated by the rollers.

In another aspect of the invention, a tape-like object is first heat-shrunk by a predetermined amount in a substantially untensioned state or under a prescribed tension, after which the object is heat-set by being cooled while stretched. To this end, the apparatus is provided with a heating and cooling units. Each of the heating and cooling units includes a plurality of rollers driven independently or in independent groups. Means are provided for adjusting the feed speed of each roller or roller group.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

Fig. 1 is a side view, with portions shown in section, illustrating the overall construction of a heat treatment apparatus according to the present invention;

Fig. 2 is a schematic view illustrating a group of rollers in a heating unit included in the apparatus of Fig. 1;

Fig. 3 is a top view of the apparatus shown in Fig. 1;

Fig. 4 is a graph of shrinkage curves pertaining to three different tape-like objects; and

Fig. 5 is a simplified circuit diagram showing the

connections between roller drive units and a control apparatus.

Reference will first be had to Fig. 1 to describe the overall construction of a heat treatment apparatus according to the present invention. The apparatus includes a heating unit 1, a supply unit 3 for feeding a tape-like object 2 into the heating unit 1, and a discharge unit 4 for extracting the tape-like object 2 from the heating unit 1. The heating unit 1 has a casing 5 for establishing an atmosphere of high-temperature air therein, and a plurality of rollers 6 around which the tape-like object 2 is wound to be fed thereby. Provided inside the casing 5 is a heater 7. Air drawn into the casing 5 from an air intake 8 thereof is fed into the heater where the air is heated before being fed into a duct 11 by a blower 9. The duct 11 is arranged in such a manner that the tape-like object 2 wound around the rollers 6 is supplied with the heated air in a uniform manner. Air which has heated the tape-like object 2 after being injected toward the rollers through nozzles Na and has accumulated in the casing is charged from discharge ports 10 and 12. Though air is used for heating the tape-like object in the illustrated embodiment, any suitable fluid can be employed in a similar manner.

As shown in Fig. 2, the rollers 6 are divided into first, second, third and fourth groups 13, 14, 15 and 16, respectively. Each roller 6 is provided with a sprocket, which is not shown. As illustrated in Fig. 3, the four groups of rollers 13, 14, 15 and 16 are arranged to be actively rotated by respective drive units 17, 18, 19 and 20. By a combination of the roller sprockets in one group with the drive chain 21, 22, 23 or 24 corresponding to that group, the rollers within the group may be rotatively driven at the same speed by a single drive unit. The rollers 6 thus serves as drive rollers.

Shrinkage curves exhibited by three different tape-like objects having a heat shrinking property are depicted in Fig. 4. It will be appreciated that while degree of

shrinkage differs depending upon the material, the rate of shrinkage is high at the start of heating and diminishes with time for all three of the materials. In order to effect shrinkage under conditions in which the tape-like object is substantially free of tension or in which a regular tension is applied thereto over the entirety of the object length within the heating unit, it is required that the degree of reduction in rotation speed of rollers 6 in the second group 14 with respect to the rollers 6 in the first group 13 is great, and, similarly, that the degree of reduction in rotation speed of one group with respect to the immediately preceding group decreases as it goes downwardly to the third and the fourth groups, with the reduction in speed from one group to the next being a function of the shrinkage curve of the tape-like object undergoing treatment. It is also required that the reduction in rotational speed of the rollers 6 in the first group 13 with respect to a feed roller 25 in the supply unit 3, which roller 25 decides the speed at which the tape-like object 2 is fed prior to the heat treatment, is the greatest. To satisfy these requirements, a drive unit 26 for driving the feed roller 25, and the drive units 17, 18, 19, 20 for the rollers 6 in the corresponding groups 13, 14, 15, 16 are adapted so as to drive the feed roller 25 and the corresponding roller groups at speeds which differ from one another.

As shown in Fig. 5, the drive units 17, 18, 19, 20 and 26 are electrically connected to a common control apparatus 27, which is adapted to supply each drive unit with a command signal designating the speed at which the drive unit is to rotate the roller or rollers driven thereby. Data giving the proper roller speed calculated in advance from the shrinkage curve of the tape-like object to undergo treatment is fed into the control apparatus 27 through an input medium such as a punched card. In response, the control apparatus 27 produces command signals commensurate with the data and applies the signals to the proper drive units. In another possible alternative, the control apparatus can be provided with an internal microcomputer programmed to

compute roller speed automatically and to apply the resulting command signals to the drive units. With this expedient, therefore, one need only enter data indicative of the measured degree of shrinkage of the tape-like object.

The supply unit 3 includes the above-mentioned feed roller 25, a guide roller 31, a pressure roller 32 and a guide roller 34. The tape-like object 2 is passed over the guide roller 31, travels under pressure between the feed roller 25 and pressure roller 32 and then traverses the tension roller 33 and guide roller 34 before being fed into the heating unit 1. The tension roller 33 is mounted on one end of a lever 36 which is pivotal about a support shaft 35, the end of which opposite the tension roller 33 is provided with a weight 37 capable of being displaced relative to the support shaft by an adjustment screw 38. Regulating the position of the weight 37 by the adjustment screw 38 enables the tape-like object 2 to be subjected to a tension preselected in accordance with the material consituting the object. The heat treatment conditions may thus be fixed to uniformalize shrinkage.

The discharge unit 4 includes a cooling device 41 and a discharge section 42. The cooling device has feed rollers 43, 44, the former also serving as a discharge roller, upper guide rollers 45, 46, 47, 48, 49, and lower guide rollers 51, 52. A housing 53 defines a cooling compartment 54 around the tape-like object 2, which travels between the upper and lower guide rollers. Air for cooling the tape-like object 2 is drawn in from an air inlet 55 through nozzles Nb by a suction device, not shown, and exits, after cooling the object, via a discharge port 56. Drive units 57, 58 for driving feed rollers 43, 44, respectively, receive command signals from the control apparatus 27. In accordance with these command signals, the drive unit rotates the feed roller 44 at a speed lower than that of the feed roller 25 but slightly higher than that of the feed or discharge roller 43. The tape-like object 2 is thus cooled and heat-set while being elongated by the action of the rollers 43, 44. The feed roller 43 is rotated slower than

the rollers 6 in the fourth group 16, with the actual rotational speed depending upon the shrinkage curve of the tape-like object 2.

Lengthening the tape-like object in this manner while cooling is in progress stretches the satisfactorily shrunk object to endow it with a prescribed shrinkage factor. The cooling process also heat-sets the object so that the shrinkage factor provided will be retained thereby. This makes it possible to reliably supply a subsequent dyeing process with a tape-like object that meets all the shrinkage requirements demanded of a fastener tape or fastener chain that is to be submitted to dyeing.

The discharge section 42 of the discharge unit 4 has a guide roller 59 and diverting rollers 61, 62, 63, 64, for guiding a plurality of the tape-like objects 2 into respective receptacles.

In the illustrated embodiment, the rollers 6 of the heating unit 1 are divided into a plurality of groups each of which is driven by a single, corresponding drive unit. Alternatively, however, a drive unit can be provided for each one of the rollers 6 so that each roller can be driven at a rotational speed different from the others. While such an arrangement will raise overall cost owing to the greater number of drive units, it will permit the tape-like object 2 to be fed at a speed which is much closer to that required by the shrinkage curve of the object. It is also permissible in the cooling device 41 to actively rotate the guide rollers 45, 46 at the same speed as the feed roller 43, and the guide rollers 48, 49 at the same speed as the feed roller 44.

The advantages of the present invention are numerous. Specifically, since the tape-like object is heated while it is being fed at a rate which conforms to the shrinkage curve thereof, the heat treatment can be performed under a condition in which the overall length of the object internally of the heating unit is substantially free of tension or is constantly tensioned to a prescribed degree. Further, since the rate at which the tape-like object is fed is regulated

actively by rollers which are driven rotatively, control of the final amount of shrinkage is performed in reliable fashion and undesirable deformation of the object does not occur even if there are local variations in shrinkage characteristic. The invention also raises processing efficiency by enabling a plurality of tape-like objects to be processed simultaneously.

Furthermore, by providing the cooling unit which operates in tandem with the heating unit, the tape-like object, which has been subjected to sufficient shrinkage by the preceding heat treatment, can be cooled and heat-set while being stretched. The amount of shrinkage required can therefore be controlled in a reliable manner. The method of the invention, inclusive of foregoing cooling step, is particularly advantageous when applied to a polyester-based tape-like object.

Claims:

1. A heat treatment method for heating a heat-shrinkable tape-like object while the object successively traverses a plurality of rollers around which the object is wound, comprising the steps of:

obtaining, from a shrinkage curve of the tape-like object that is to undergo heating, a feed speed for the tape-like object that is necessary to maintain the tape-like object substantially free of tension, or at an approximately fixed tension, over the entire travelling distance of the tape-like object regulated by the plurality of rollers; and

driving said plurality of rollers in accordance with the feed speed in such a manner that each roller rotates at a speed different from the other rollers, or in such a manner that groups of said plurality of rollers each rotate at a speed which is different for each group.

2. The heat treatment method according to Claim 1, further comprising a step of feeding the tape-like object into said plurality of rollers upon first applying a regulated tension to said tape-like object.

3. An apparatus for heat treating a tape-like object, comprising:

a heating unit having a casing for establishing therein an environment consisting of a high-temperature fluid, and a plurality of rollers provided inside the casing for feeding a tape-like object wound therearound;

a supply unit for feeding the tape-like object into said heating unit;

a discharge unit for receiving the tape-like object from said heating unit;

a plurality of drive units for driving the plurality of rollers, said drive units being adapted in such a manner that each drives one of said rollers individually or a single group of said rollers; and

control means for controlling said plurality of drive units in such a manner that the rollers are rotated at a speed decided by a shrinkage curve of the tape-like object in order to maintain the tape-like object substantially free

of tension, or under an approximately fixed tension, over the entire travelling distance of the tape-like object regulated by the rollers.

4. The apparatus according to Claim 3, wherein said supply unit includes means for applying a prescribed tension to the tape-like object before it is fed into said heating unit.

5. The apparatus according to Claim 3, wherein said rollers are divided into four groups, a group which is closest to said discharge unit having a greater number of the rollers than a group closest to said supply unit.

6. A method of heat treating a heat-shrinkable tape-like object comprising the steps of:

first subjecting the heat-shrinkable tape-like object, which is fed while substantially free of tension or while maintained at an approximately fixed tension, to a predetermined amount of shrinkage in an atmosphere consisting of a high-temperature fluid; and

then heat setting the tape-like object while said tape-like object successively traverses a cooling atmosphere and is stretched within said cooling atmosphere.

7. A heat treatment method for heating a heat-shrinkable tape-like object while the object successively traverses a plurality of rollers around which the object is wound, comprising the steps of:

first feeding the tape-like object at a fixed speed into an atmosphere consisting of a high-temperature fluid;

heat shrinking the tape-like object while feed speed of said tape-like object within the high-temperature fluid atmosphere is reduced below said fixed speed, and while said feed speed is progressively reduced as said tape-like object passes through said high-temperature fluid atmosphere from a supply end to a discharge end thereof; and

subsequently heat setting the tape-like object while it is stretched by being discharged from said high-temperature fluid atmosphere into a cooling atmosphere, said tape-like object being fed through said cooling atmosphere at a speed lower than said fixed speed but higher than a speed at

which the tape-like object is discharged from said high-temperature fluid atmosphere.

8. An apparatus for heat treating a tape-like object, comprising:

a heat unit having a casing for establishing therein an environment consisting of a high-temperature fluid, and a plurality of first drive rollers provided inside the casing for feeding a tape-like object wound therearound;

a feed roller for feeding the tape-like object into said heating unit;

a cooling unit having a discharge roller for feeding the tape-like object from said heating unit into a cooling atmosphere, a housing for confining the cooling atmosphere which cools the tape-like object fed in by the discharge roller, and second drive rollers provided inside the housing for feeding the tape-like object wound therearound; and

control means for rotating said feed roller, said first drive rollers, said second drive rollers and said discharge roller in such a manner that said feed roller rotates slower than each of said first drive rollers, said first drive rollers rotate at a progressively lower speed from a supply end to a discharge end of said heating unit, said discharge roller rotates slower than each of said first drive rollers, and said second drive rollers rotate slower than said feed roller but faster than said discharge roller.

Fig. 1

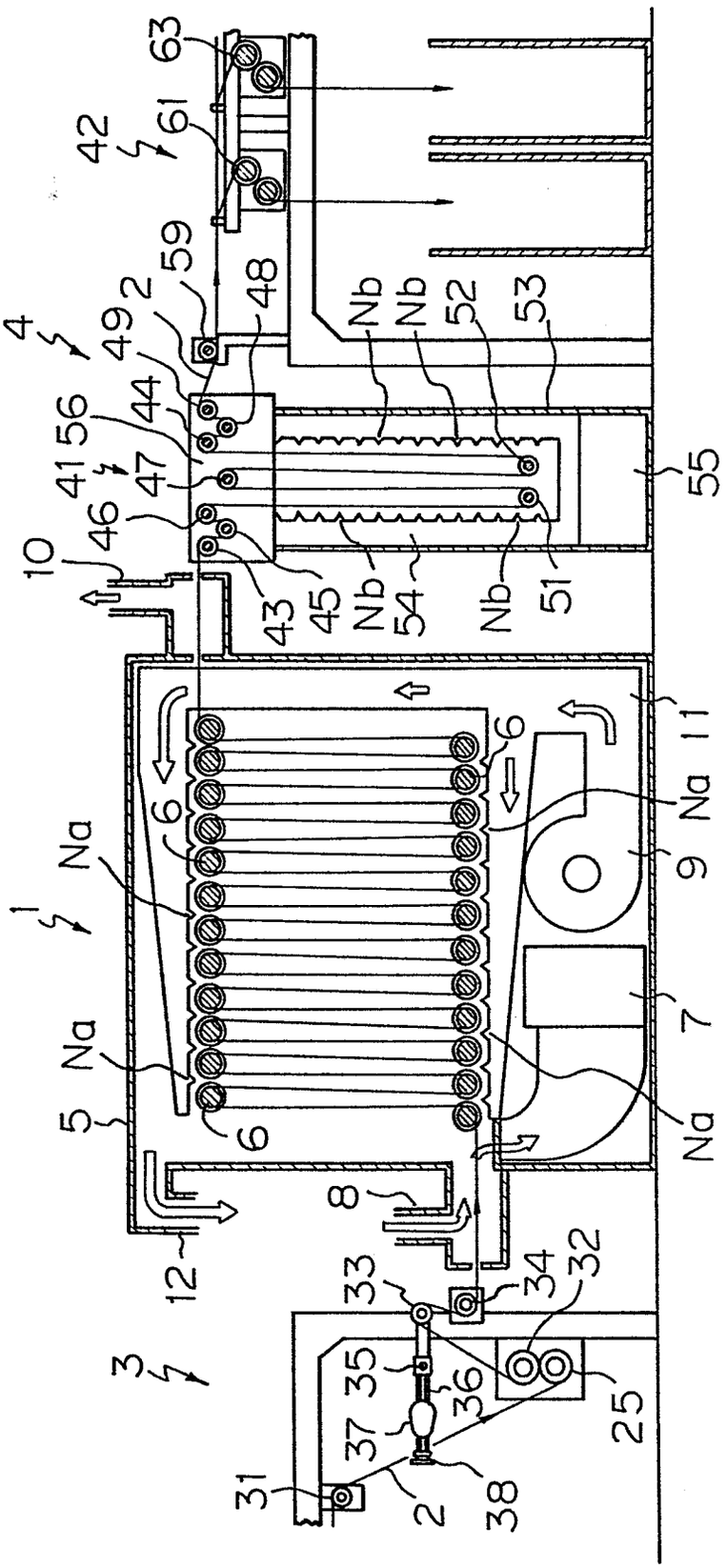
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Fig. 2

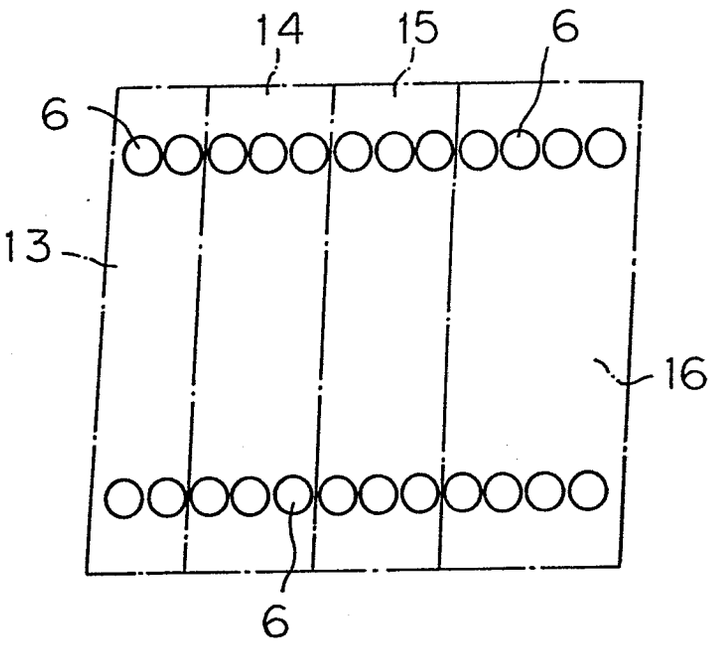

Fig. 4

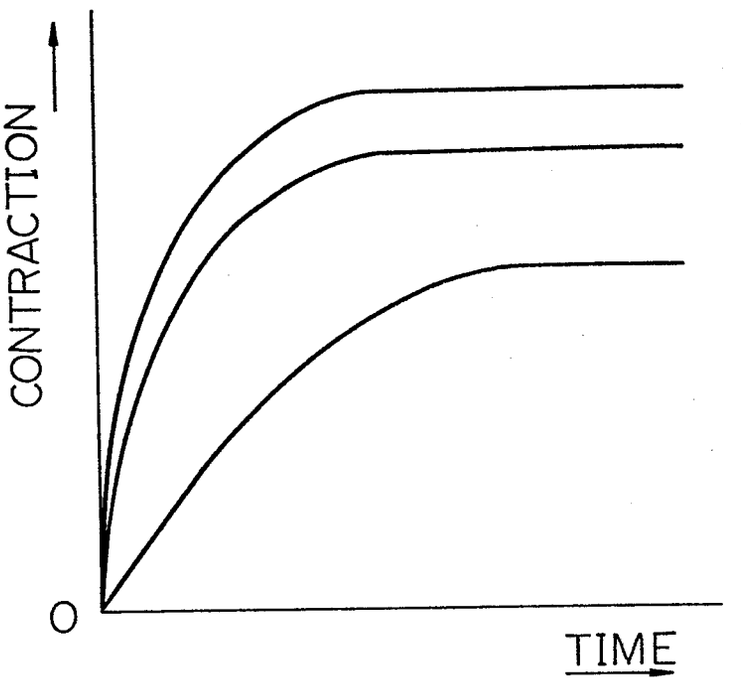

Fig. 3

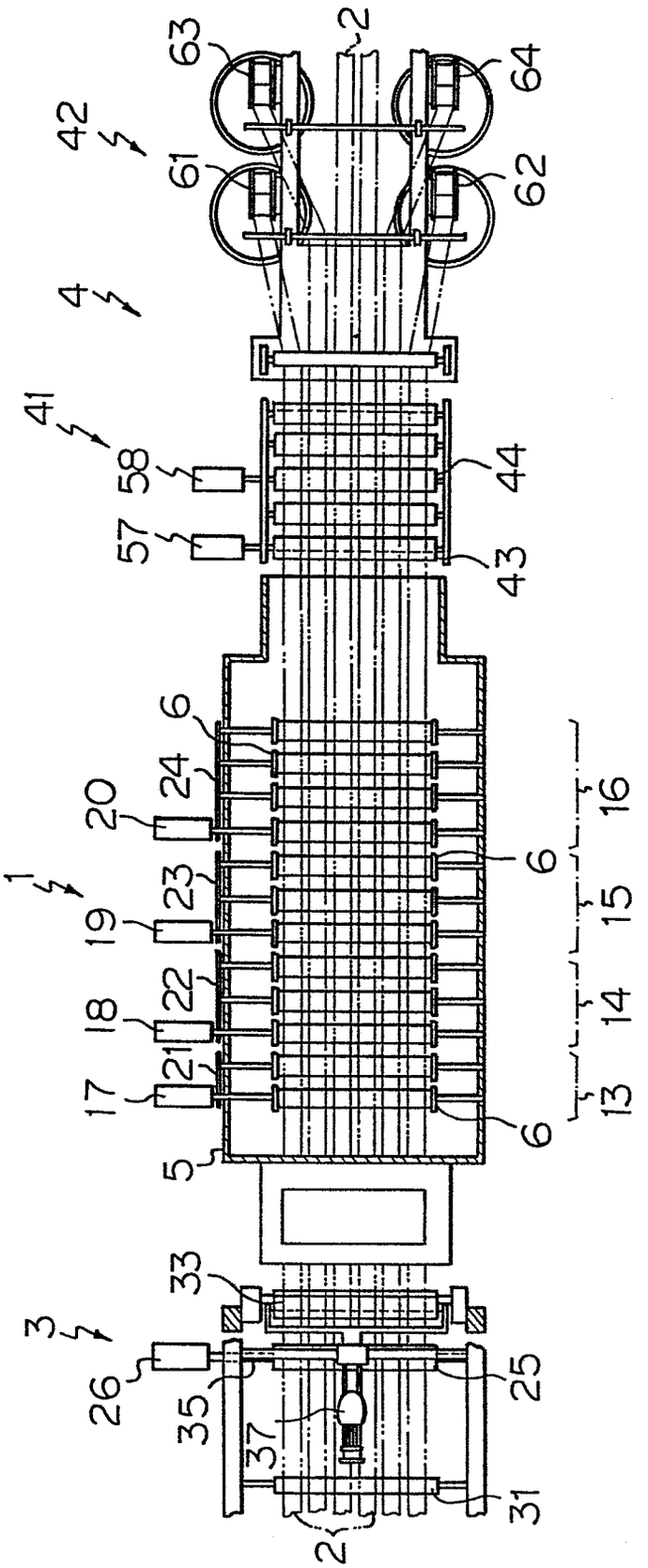
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Fig. 5