

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



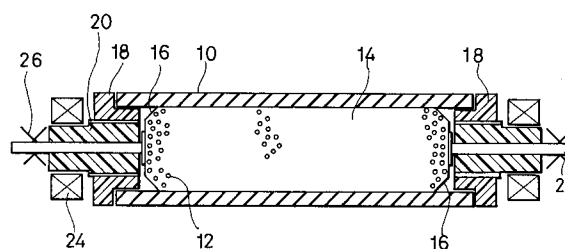
(11) Publication number:

0 505 731 A2

(12)

EUROPEAN PATENT APPLICATION(21) Application number: **92102871.8**(51) Int. Cl.⁵: **H05B 3/00**(22) Date of filing: **20.02.92**(30) Priority: **08.03.91 JP 68917/91**(43) Date of publication of application:
30.09.92 Bulletin 92/40(84) Designated Contracting States:
DE FR GB(71) Applicant: **SOMAR CORPORATION**
11-2, Ginza 4-chome Chuo-ku
Tokyo 104(JP)(72) Inventor: **Tachibana, Masao**
3-1, Sengendainishi
Koshigaya-shi, Saitama 343(JP)
Inventor: **Moriguchi, Kazutomo**
8-29-29, Aoygi-cho
Souka-shi, Saitama 340(JP)(74) Representative: **Patentanwälte Grünecker,**
Kinkeldey, Stockmair & Partner
Maximilianstrasse 58
W-8000 München 22(DE)(54) **Heat-roll and process for manufacturing the same.**

(57) A heat roll is produced by packing electrically conductive particles (12), consisting essentially of spherical particles of glassy carbon, into a roll cylinder (10) made of aluminum nitride, plugging up both end portions of the roll cylinder (10) with electrode support members (20), and compressing the conductive particles (12) by electrodes (16) to hold the particles (12) in a compressed condition. The degree of compression of the conductive particles (12) is controlled by regulating the screwing (or tightening) amount of the electrode support member (20) into a seal member (18), thereby adjusting the electric resistance of a heating member composed of the conductive particles (12). Electric power is supplied to lead shafts (22) through brushes (26), thereby causing heat generation throughout the conductive particles (12).

FIG. 1

This invention relates to a heat roll and a process for manufacturing the same, and more particularly to a heat roll having a high speed of temperature rise upon energization and suitable for application to small printers, laminators, erasing of magnetic records, sublimation of dyes, heating of resins, and so on, and a process for manufacturing the same.

As a heat roll for use in small printers, laminators, erasing of magnetic records, sublimation of dyes, softening of resins, heating of sheet materials, etc., there have been known, for example, a heat roll which has a heating member comprising a nichrome or tungsten wire and disposed in a roll cylinder, and a heat roll in which an electrically conductive pattern formed of metal foil is provided on or embedded in a roll cylinder of ceramic or the like.

However, a heating member composed of a nichrome or tungsten wire or an electrically conductive pattern has the problem that disconnection (or breaking of wire) is liable to occur and a uniform temperature distribution is not easily obtainable.

Especially when a small heat roll is manufactured using the heating member as described above, therefore, complicated manufacturing steps are required with the inevitable result of raised cost, since there are severe requirements as to the design of resistance wire for realizing a uniform temperature distribution or as to the accuracy in mounting the heating member.

Furthermore, a heat roll comprising such a heating member as above has the problem that the circuit therein is apt to be broken, leading to a shorter service life. In addition, this type of heat roll has a low speed of temperature rise, thereby needing a long time for starting operation, and its low heat capacity causes difficulty in achieving a stable heat treatment, at a constant temperature, of a material to be treated.

A heater (heat roll) improved in temperature rise speed has been proposed in Japanese Patent Application Laid-Open (KOKAI) No. 2-213079 (1990).

This heater comprises a heating member composed of silicon nitride (Si_3N_4) or silicon carbide (SiC) and an electrically conductive ceramic material, disposed on the surface of a core portion, electrodes for supplying electric power to the heating member, and an infrared radiating layer formed on the heating member, whereby the heat generated at the heating member is transmitted directly to the infrared radiating layer and radiated rapidly therefrom to the exterior.

Although the heater disclosed in the aforementioned patent application shows an improved speed of temperature rise, it requires a complicated pro-

cess for manufacture and, due to its low heat capacity, cannot always provide a stable heat treatment.

This invention has been made in order to solve the aforementioned problems involved in the prior art.

It is accordingly an object of this invention to provide a heat roll which has a high speed of temperature rise, is able to provide a stable heat treatment of a material to be treated, is easy to manufacture because of its simple construction, and which has high reliability with no possibility of failure arising from disconnection or the like.

In order to attain the above object, this invention provides a heat roll comprising a roll cylinder being electrically insulating at least on the inner surface thereof, a heating member composed essentially of electrically conductive particles packed in the roll cylinder, and electrodes for supplying electric power to the conductive particles.

The heat roll according to this invention may further comprise pressing means for compressing the electrically conductive particles packed in the roll cylinder.

Thus, according to this invention, the electrically conductive particles which are, for example, substantially spherical in shape are packed in the roll cylinder so that specific resistance of each conductive particle and points of contact between the conductive particles provide electric resistance. This construction ensures that a heating member consisting essentially of a three-dimensional resistor is formed in close contact with the inner surface of the roll cylinder.

According to this invention, therefore, it is possible, by forming the roll cylinder of a highly heat-conductive material, to heat the surface of the roll cylinder rapidly to a predetermined temperature.

Also, since heat is generated evenly throughout the conductive particles packed in the roll cylinder, it is possible to heat the entire surface of the roll cylinder to a uniform temperature. In addition, the heat roll of this invention has a high heat capacity, which ensures a heat treatment at a stable temperature of the material to be treated.

Furthermore, the heat roll according to this invention has a simple construction, which permits a small overall size and easy manufacture of the roll. The construction eliminates the possibility of failure arising from disconnection, and enables the heat roll to have an enhanced reliability.

The preferred embodiments will be described with reference to the drawings, wherein like elements have been denoted throughout the figures with like reference numerals, and wherein:

Fig. 1 is a schematic sectional view of a heat roll according to one embodiment of this invention;

Fig. 2 is an enlarged sectional view of a modi-

fication of a roll cylinder; and

Fig. 3 is a graph showing the operation of the heat roll according to the embodiment of this invention.

Some preferred embodiments of this invention will now be explained more in detail with reference to the drawings.

Fig. 1 is a schematic sectional view of a heat roll according to one embodiment of this invention, along a plane passing through the center of the roll.

The heat roll of this embodiment comprises a roll cylinder 10 having a cylindrical tubular form, a heating member 14 composed essentially of electrically conductive particles 12 packed in the roll cylinder 10, and electrodes 16 disposed symmetrically, at the left and the right in the figure, for supplying electric power to the conductive particles 12. The electrodes 16 are each formed of an electrically conductive material in the form of a circular disk with a peripheral portion bent to the side of the conductive particles 12.

In each end of the roll cylinder 10 is fitted a seal member 18 formed of an electrically insulating, low-heat-conductivity material, with an electrode support member 20 screwed in the seal member 18.

Each of the electrodes 16 is attached to an inner end portion of the electrode support member 20, and a lead shaft 22 connected to the electrode 16 at one end thereof and led out to the exterior at the other end is inserted and embedded in a central portion of the electrode support member 20.

The electrode support members 20 have the function of a rotating shaft. In use of the heat roll, the electrode support members 20 are fitted in bearings 24 so that the heat roll is supported rotatably, and the lead shaft 22 are each connected to a power supply through a brush 26.

Further, it is possible to compress the electrically conductive particles 12 with the electrodes 16, by screwing the electrode support member 20 into the seal member 18. The degree of compression on the conductive particles 12 is adjustable by regulating the screwing (or tightening) amount of the electrode support member 20 into the seal member 18. That is, the electrodes 16 and the electrode support members 20 constitute a pressing means for compressing the electrically conductive particles 12.

The heat roll according to this embodiment will now be described more in detail. The roll cylinder 10 is formed of a material which has electrically insulating nature and which preferably has a high thermal conductivity, for rapid transfer of heat from the heating member 14 to the outer surface of the roll cylinder 10. For example, a highly heat-conductive ceramic such as aluminum nitride can be suit-

ably used for the roll cylinder 10.

It is sufficient for the roll cylinder 10 to be electrically insulating at least on the inner surface thereof. Therefore, as shown in an enlarged sectional view in Figure 2, the roll cylinder 10 may be a metal cylinder 10A coated with an insulating film 10B on the inner surface thereof.

The substantially spherical, electrically conductive particles 12 constituting the heating member 14 are spherical or substantially spherical in shape. With such shape, the conductive particles 12 are capable of high-density packing in the roll cylinder 10, ensuring that the points of contact between the particles 12, which points provide electric resistance, are distributed evenly on a three-dimensional basis. It is thus possible to form a heating element such that heat generation takes place evenly throughout the heating element.

The electrically conductive particles 12 may be formed of any of electrically conductive materials which are able to constitute the heating member 14 when packed in the roll cylinder 10. For instance, carbon such as glassy carbon, metals and electrically conductive ceramics such as silicon carbide can be used as a material for the conductive particles 12.

The electrically conductive particles 12 should be resistant to oxidation, from the viewpoint of durability. In this respect, spherical glassy carbon consisting of pure carbon, free of ash, is particularly preferable as a material for the conductive particles 12.

The diameter of the electrically conductive particles 12 can vary depending on the size of the heat roll, namely, the size of the roll cylinder 10, properties of the material constituting the particles 12, and so on. It is generally preferable, however, that the particle diameter be not more than 1/10 times the inside diameter of the roll cylinder 10. Where the inside diameter of the roll cylinder 10 is 10 cm, for instance, the particle diameter is preferably 1 cm or less.

As a material for forming the seal members 18, materials which have heat-resistant and electrically insulating properties can be used without any special limitations.

For prevention of the lowering in the temperature of the roll cylinder 10 due to heat transfer, however, it is preferable that the material for the seal members 18 have a low thermal conductivity, with a difference of the order of 10^2 between the thermal conductivity of the material and the thermal conductivity of the roll cylinder 10. Because the seal member 18 are to be provided with thread grooves for constituting bolt holes, in addition, the material for the seal members 18 desirably has machinability, toughness and the like.

The materials usable for the seal members

include, for example, heat-resistant resins such as polybenzimidazole (PBI), polyphenylene sulfide (PPS), polyethersulfones (PES), polyetheretherketones (PEEK), polyetherketones (PEK), polyetherimides (PEI), polyimides (PI), etc., of which particularly preferred is polybenzimidazole (PBI) in view of the good heat resistance and low heat conductivity thereof.

Fitting the seal members 18 into the end portions of the roll cylinder 10 to make connection may be carried out by heat shrink fitting, snap-fitting, adhesion by use of a ceramic-based heat-resistant adhesive, or the like.

The electrode support members 20 are formed of a heat-resistant, electrically insulating material. For instance, the electrode support members 20 may be formed of the same material as that for the seal members 18.

Each of the electrode support members 20 is provided at its outer peripheral portion with a thread groove for engagement with the thread groove (bolt hole) formed in the seal member 18, said thread groove constituting a nut. By putting the thread grooves of the electrode support members 20 into engagement with the thread grooves of the seal members 18 in a fastening manner, it is possible to maintain the electrically conductive particles 12 of the heating member 14 in a predetermined shape and to compress the conductive particles 12.

The electrode 16 attached to the inner end portion of the electrode support member 20 has a circular disklike shape on the side for contact with the electrically conductive particles 12, with a peripheral portion of the disklike shape being bent to the side of the conductive particles 12. The circumferential edge of the disklike portion of the electrode 16 is placed in contact with the inner surface of the roll cylinder 10, over the whole circumference thereof, in such a degree of tightness as to leave no clearance through which the conductive particles 12 could leak. With this construction, a large area of contact is ensured between the electrode 16 and the conductive particles 12, thereby achieving a high energization efficiency. In addition, it is possible to control the degree of compression of the conductive particles 12 more securely, and to enhance sealing performance.

The above construction of the seal members 18 and the electrode support members 20 ensures that the electrode support members 20 with the electrodes 16 attached thereto can be attached to the roll cylinder 10 and the regulation of the compression degree of the electrically conductive particles 12 in the heating member 14 by use of the electrode support members 20 provides the function of a pressing means for controlling the electric resistance of the heating member 14. That is to

say, when the compression degree of the conductive particles 12 is increased by the pressing means, the closeness degree of mutual contact of the particles 12 is enhanced, leading to a lower electric resistance. When the compression degree is decreased, on the other hand, the closeness degree of mutual contact is lowered, resulting in a higher electric resistance. It is thus possible to control the electric resistance of the heating member 14, as desired.

Compression of the electrically conductive particles 12 to a suitable degree by the electrode support members 20 imposes restraints upon movement of the conductive particles 12, which have fluidity. Therefore, the movement of the conductive particles 12 can be prevented even when the heat roll is rotated, so that a stable resistance value is obtainable constantly.

Furthermore, although energization of the conductive particles 12 causes thermal expansion of air inside the roll cylinder 10, the expanded air is permitted to leak to the exterior through the engagement portions (clearance between the thread grooves in mesh) of the seal member 18 and the electrode support member 20, so that the expanded air exerts no stress on the roll cylinder 10.

Each of the electrode support member 20 comprises a screw portion consisting of the thread groove described above and a shank portion having a smooth surface. The shank portions of the electrode support members 20 are supported by bearings 24 having a bearing mechanism such as a slidable bush, whereby the heat roll composed of an integral assembly of the roll cylinder 10, the heating member 14 consisting essentially of the electrically conductive particles 12, the seal members 18, the electrodes 16 and the electrode support members 20 can be rotated.

The heat roll according to this embodiment as above can be assembled by setting the electrode support member 20, fitted with the seal member 18 and the electrode 16, in place on one side of the roll cylinder 10, packing a predetermined amount of the electrically conductive particles 12 into the roll cylinder 10 via its end portion on the other side, then setting the seal member 18 and the electrode support member 20 in the end portion, and screwing in the electrode support member 20 for tightening until a predetermined resistance is attained between the electrodes. In this manner, the heat roll can be manufactured extremely easily.

Now, this embodiment is described more in detail with reference to a specific example.

The heat roll shown in Fig. 1 was formed by use of the following materials.

The roll cylinder 10 was formed of aluminum nitride to have an outside diameter of 20 mm, an inside diameter of 16 mm and a length of 50 mm.

The aluminum nitride had a thermal conductivity of 100 W/m·K, a volume resistivity of 1.8×10^{13} ohm·cm, a bending strength of 294 N/mm², and a coefficient of thermal expansion of $4.4 \times 10^{-6}/^{\circ}\text{C}$.

As the electrically conductive particles 12, glassy carbon in the form of fine spherical particles with 25 micro meter average diameter was used. The glassy carbon had an electric resistivity of 40×10^{-4} ohm·cm, a thermal conductivity of 4.2 W/m·K, and a coefficient of thermal expansion of $2.2 \times 10^{-6}/^{\circ}\text{C}$.

The seal members 18 and the electrode support members 20 were formed by machining polybenzimidazole (PBI), which had a coefficient of thermal expansion of $23 \times 10^{-6}/^{\circ}\text{C}$, a thermal conductivity of 0.41 W/m·K, and a volume resistivity of 8×10^{14} ohm·cm.

To each of the electrode support members 20 was fitted a lead shaft 22 having a diameter of 1 mm, and an electrode 16 consisting of a dish-shaped aluminum foil having a thickness of 60 micro meter and an outside diameter approximately equal to the inside diameter of the roll cylinder 10 was attached to one end of the lead shaft 22.

The electrode support member 20 was fitted to one end of the roll cylinder 10, and 8.5 g of the glassy carbon was packed into the roll cylinder 10 via the other end. Then, the other end portion was plugged up with the electrode support member 20, thereby forming the heat roll.

The heat roll thus produced had a resistance adjustable to any desired value in the range from 2.5 to 600 ohm by regulating the degree of tightening of the electrode support member 20. The heat roll was energized at a DC voltage of 24 V, to examine heat generation characteristics. The results are shown in Fig. 3.

As is seen from Fig. 3, the heat roll showed an extremely high speed of rise in the surface temperature. When the heat roll was energized at a low DC voltage of 24 V by setting the resistance of the heating member 14 at 50 ohm and 100 ohm, it was possible to maintain the surface temperature of the roll cylinder 10 at 100 °C and 211 °C, respectively. When the energization was carried out by setting the resistance of the heating member 14 at 300 ohm and 6 ohm, it was possible to maintain the surface temperature of the roll cylinder 10 at 77 °C and 55 °C, respectively.

According to the above embodiment, the points of contact between the spherical particles of glassy carbon packed in the roll cylinder 10 provide electric resistance, thereby forming a three-dimensional resistor, so that a heating member 14 is obtainable in close contact with the inner surface of the highly heat-conductive roll cylinder 10.

Therefore, it is possible to rapidly heat the surface of the roll cylinder 10 to a predetermined

temperature. In addition, the heat generation throughout the glassy carbon packed in the roll cylinder 10, namely, the generation of heat evenly throughout the heating member 14 makes it possible to heat the entire surface of the roll cylinder 10 to a uniform temperature.

Because the roll cylinder 10 and the seal members 18 have respective thermal conductivities of 100 W/m·K and 0.41 W/m·K, with the difference therebetween being of the order of 10^2 or more, dissipation of heat from the roll cylinder 10 to the seal member 18 is prevented. This ensures a more higher uniformity of the surface temperature of the roll cylinder 10.

Besides, the heating member 14 has a high heat capacity, since heat generation takes place throughout the glassy carbon constituting the heating member 14. Therefore, a heat treatment of a material to be treated such as paper, plastic film, etc. can be carried out stably at a constant temperature, without any lowering in the surface temperature of the roll cylinder 10.

In addition, the heat roll can be formed in a simple construction, which is free of the possibility of disconnection occurring in the heating member 14 and enables the heat roll to have a remarkably elongated life.

Furthermore, the heat roll has the advantages that it can be made smaller, in size and weight, and that the low heat conductivity of the electrode support members 20 enables compact mounting in machine elements.

Although this invention has been described in detail with reference to the embodiment hereinabove, it should be understood that the invention is not limited to or by the above embodiment.

For instance, although the electrodes and the electrode support members in the above embodiment have been described as functioning also as a pressing means, the pressing means may be provided separately from those members.

Besides, the heat roll of this invention is not limited to the small type described in the above embodiment.

Claims

1. A heat roll comprising;
 - a roll cylinder (10) being electrically insulating at least on the inner surface thereof;
 - a heating member (14) composed essentially of electrically conductive particles (12) packed in the roll cylinder (10); and
 - electrodes (16) for supplying electric power to the conductive particles (12).
2. The heat roll as set forth in claim 1 wherein

said conductive particles (12) are substantially spherical in shape.

3. The heat roll as set forth in claim 2 wherein said conductive particles (12) are consisting of spherical glassy carbon. 5
4. The heat roll as set forth in claim 1 wherein diameter of each said conductive particle (12) is not more than 1/10 times inside diameter of said roll cylinder (10). 10
5. The heat roll as set forth in claim 1 wherein said roll cylinder (10) is formed of a material which has electrically insulating nature and which has a high thermal conductivity. 15
6. The heat roll as set forth in claim 1 wherein said roll cylinder (10) is a metal cylinder (10A) coated with an insulating film (10B) on the inner surface thereof. 20
7. The heat roll as set forth in claim 1 wherein said electrodes (16) are each formed of an electrically conductive material in the form of a circular disk with a peripheral portion bent to the side of the conductive particles, and with circumferential edge of the circular disk placed in contact with the inner surface of the roll cylinder (10), over the whole circumference thereof, in such a degree of tightness as to leave no clearance through which the conductive particles (12) could leak. 25 30
8. The heat roll as set forth in claim 1 wherein in each end of said roll cylinder (10) is fitted a seal member (18) formed of an electrically insulating, low-heat-conductivity material, with an electrode support member (20) screwed in said seal member (18). 35 40
9. The heat roll as set forth in claim 8 wherein thermal conductivity of said seal member (18) is less than 1/100 times that of said roll cylinder (10). 45
10. The heat roll as set forth in claim 8 wherein said seal member (18) is made of polybenzimidazole (PBI). 50
11. The heat roll as set forth in claim 8 wherein each of said electrodes (16) is attached to an inner end portion of said electrode support member (20), and a lead shaft (22) connected to the electrode (16) at one end thereof and led out to the exterior at the other end is inserted and embedded in a central portion of said electrode 55

support member (20).

12. The heat roll as set forth in claim 8 wherein both of said electrode support members (20) have the function of a rotating shaft, and in use of the heat roll, said electrode support members (20) are fitted in bearings (24) so that the heat roll is supported rotatably.
13. The heat roll as set forth in claim 1 further comprising pressing means for compressing said electrically conductive particles (12) packed in said roll cylinder (10).
14. The heat roll as set forth in claim 13 wherein said pressing means comprises said electrodes (16) each having a circular disklike shape with a peripheral portion bent to the side of said conductive particles (12), and electrode support members (20) screwed in seal members (18) which are fitted to both ends of said roll cylinder (10), whereby degree of compression on said conductive particles (12) is adjustable by regulating the screwing amount of said electrode support member (20) into said seal member (18).
15. The heat roll as set forth in claim 1 wherein expanded air inside said roll cylinder (10) due to thermal expansion caused by energization of said conductive particles (12), is permitted to leak to the exterior.
16. A process for manufacturing a heat roll comprising the step of; setting an electrode support member (20), fitted with a seal member (18) and an electrode (16), in place on one side of a roll cylinder (10), packing a predetermined amount of electrically conductive particles (12) into said roll cylinder (10) via its end portion on the other side, then setting another seal member (18) and another electrode support member (20) in the end portion, and screwing in said electrode support member (20) for tightening until a predetermined resistance is attained between the electrodes (16).

FIG. 1

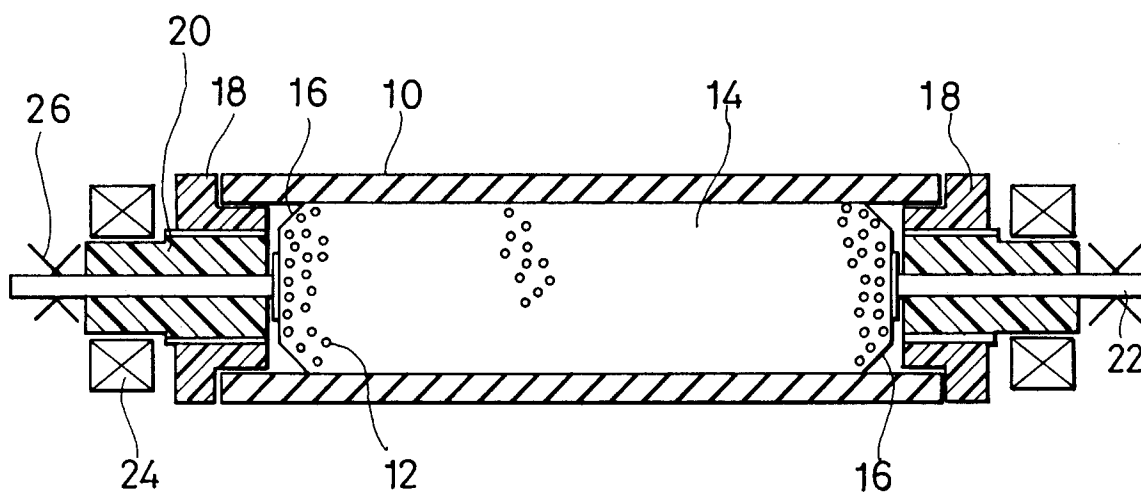


FIG. 2

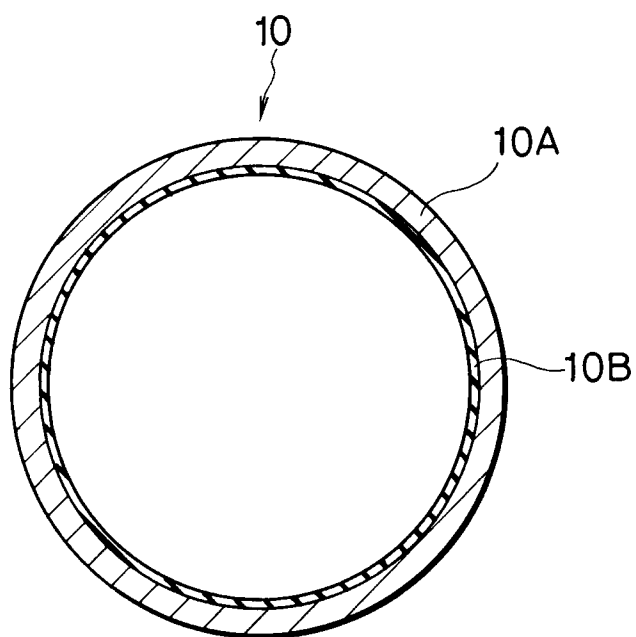


FIG. 3

