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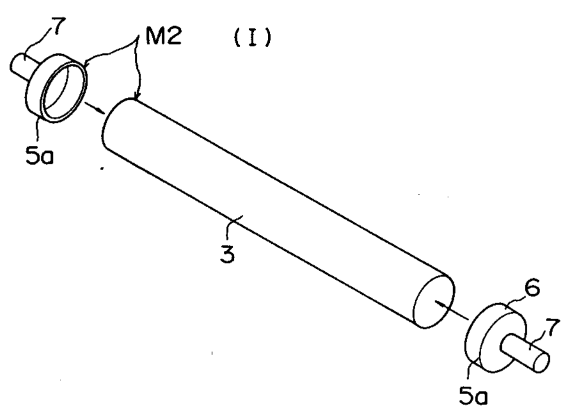
(54) **Magnet roll.**

(57) The substantially cylindrical plastic bonded magnet is provided with plural magnetic poles which are formed on the magnet by the focus orientation method in the presence of magnetic field. The maximum outer diameter of the magnet is below 30 mm, and flexural strength thereof is above 1200 kgf/cm^2. In addition, both end portions of the magnet in the longitudinal direction are formed by only one cutting processing. Both end proportions of the magnet are used as fitting portions in order to fit the magnet directly to the body of a developing unit. Said magnet roll comprises only a few parts and can be produced at low costs.

Fig. 6



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This invention relates to a magnet roll which is installed into a developing unit for use in devices using an electrophotograph such as copying machine, a printer, a facsimile, etc., and more particularly to a magnet roll which can be suitably used for a novel fabricating method having high producibility and can be produced in low cost by improving a fitting method of the magnet roll to the body of the developing unit.

A developing unit using an electrophotograph such as a copying machine, a facsimile, a printer, etc. is provided therein with a developing cylinder 103 as shown in Figs. 21(I) and (II). The developing cylinder 103 includes a metal sleeve 101, and a magnet roll 100 which comprises a solid-cylindrical or hollow-cylindrical magnet body 1 having shaft portions 2a and 2b at both ends thereof, and is supported through bearings 102 in the metal sleeve 101 so as to be rotatable relatively to the metal sleeve 101. The developing cylinder 103 is integrally fabricated with peripheral devices such as a photosensitive drum, a developing agent box, etc. to constitute the developing unit.

As the construction of the magnet roll 100 have been conventionally used the following constructions: a construction that plural longitudinal magnet fragments 1a, 1b, 1c and 1d are attached to one another so as to surround a metal shaft 2 as shown in Fig. 22, a construction that a hollow-cylindrical magnet 1' is disposed around a shaft 2 as shown in Fig. 23, a construction that the whole structure containing both shaft portions 2a and 2b is integrally formed of plastic bonded magnet material through a molding process as shown in Fig. 24, a construction that short shaft pins 2a' and 2b' for shaft portion are inserted into both end portions of a substantially solid-cylindrical magnet 1" as shown in Fig. 25, and so on.

The construction as shown in Fig. 22 is effectively used because extremely high magnetic field can be generated by selecting a suitable combination of magnets. However, in this construction, magnets whose number corresponds to a desired number of magnetic poles are required, and a process of attaching these magnets to one another is further required, so that a low-cost magnet roll is not necessarily achieved. On the other hand, the constructions as shown in Figs. 23 to 25 are obtained by a method that a shaft is inserted and fixed into a cylindrical sintered ferrite magnet or a cylindrical plastic bonded magnet obtained through an injection molding or an extrusion molding, or a method that the shaft and the plastic bonded magnet material are subjected to an insertion-molding to be integrally formed with each other, and thus these constructions are superior in producibility to the construction as shown in Fig. 22. Particularly the extrusion molding is most widely propagated because it provides an uniform magnetic property (surface magnetic flux density) over its longitudinal direction and has highest producibility.

However, there is a common problem among the magnet rolls having the constructions as shown in Figs. 22 to 25 which are presently frequently used. That is, in all of the constructions as described above, the hollow-cylindrical or solid-cylindrical magnet body is freely rotatably mounted through the bearings 102 in the metal sleeve 101 as shown in Fig. 21, and thus the shaft portion 2a and 2b are indispensably required at the both end portions of the magnet body as described above. Therefore, a fabrication process for fitting the shaft portions to the magnet body is newly required. For example, as described above, the insertion of the shaft 1' into the hollow portion of the hollow-cylindrical magnet body is required for the magnet roll as shown in Fig. 23, the insert-molding of the short shaft pins 2a' and 2b' is required for the magnet roll 100 as shown in Fig. 25, and further the integral molding of the magnet body with the shaft portions 2a and 2b is required for the magnet roll as shown in Fig. 24.

Particularly when a metal shaft or a short shaft pin is used for a magnet roll, they are required to be subjected to a precision processing, so that the cost of these elements obstructs the production of a low-cost magnet roll. On the other hand, when the whole structure of a magnet roll containing both shaft portions is integrally formed of plastic bonded magnet material, there is required no cost for the metal shaft, and the number of parts can be reduced. However, this magnet roll requires a complicated metal mold, and the injection molding therefor is high in cost. In addition, since the shaft portions of this magnet roll are also formed of plastic bonded magnet material filled with a large amount of ferrite powder, there is a possibility that the bearing portion is abrasive. Therefore, this type of magnet roll has a problem in durability.

In addition to the problems as described above, the conventional magnet roll has a problem in fabrication procedure. That is, the conventional magnet roll 100 is installed into the metal sleeve 101 to constitute the developing cylinder 103, and then the developing cylinder 103 is installed into the developing unit. Considering the flow of the fabrication process, a working of installing the magnet roll 100 into the metal sleeve 101 to constitute the developing cylinder 103 is carried out completely separately from a fabrication process of the developing unit. This is a vain working in the fabrication process, and obstructs the improvement in producibility. As a fabrication procedure to be most reasonably considered may be recommended, not a process that similarly in the conventional process, the magnet roll 100 is beforehand installed into the metal sleeve 101 in a separate process, but a process that the magnet roll 100 itself is directly fed as a part into the fabrication process of the developing unit together with other parts, and then the magnet roll 100 and the other parts are fabricated in a serial process. However, the conventional magnet roll 100 has not been suitable for the reasonable fabrication process as described above.

This invention has been implemented to solve the above problem of the conventional technique, and has an object to provide a magnet roll which can be produced in low cost and suitable for a novel and reasonable fabrication process method.

In order to solve the above problem, the inventor of this invention has a technical idea that no shaft is used for the magnet and the shaft portion itself is eliminated from the magnet roll. Therefore, in order to solve a new problem which would occur if the shaft and the shaft portion are eliminated from the magnet roll, the shape, dimension and material of the magnet roll is deliberately considered to implement this invention, and the following three aspects to solve the above problem have been proposed.

A common feature among the following first, second and third aspects of this invention resides in that a substantially cylindrical plastic bonded magnet which is particularly limited and improved in outer diameter dimension, mechanical strength and end surface shape is used.

The substantially cylindrical plastic bonded magnet as described above is provided with plural magnetic poles which are formed on the magnet by the focus orientation method in the presence of magnetic field. The substantially-cylindricalplastic bonded magnet is so designed that the maximum outer diameter of the magnet when it is rotated is set to a value below 30 mm, and flexural strength thereof is set to a value above 1200 kgf/cm^2. In addition, both end portions of the magnet in the longitudinal direction are formed by only a cutting processing.

According to the magnet roll of the first aspect of this invention is characterized in that the substantially-cylindrical plastic bonded magnet as described above is used, and each of both end portions of the magnet is used as a fitting portion through which the magnet is directly fitted to the body of a developing unit.

The most important point to produce a magnet roll in low cost is to reduce the number of parts. Accordingly, according to this invention, the magnet roll is constructed by one substantially-cylindrical plastic bonded magnet which is magnetized with plural magnetic poles on the surface thereof. However, the plastic boned magnet has a problem that it provides lower surface magnetic flux density than a sintered magnet. Therefore, in this invention, in order to sufficiently intensify a generated magnetic field for practical use, each magnetic pole on the surface of the magnet is formed by the focus orientation in the presence of magnetic field. The focus-oriented magnetic pole is formed by the focus orientation in a molding process. The focus orientation is defined as an orienting method of applying a magnetic field to melted plastic bonded magnet material to locus the axis of easy magnetization of magnetic powder in the plastic bonded magnet material in the magnetic field direction, and for example, a method of disposing external magnetic poles (N-magnetic pole and S-magnetic pole in Fig. 26) for generating the applied magnetic field for the focus orientation at predetermined positions so as to be confronted to the outer peripheral surface of the melted cylindrical plastic bonded magnet as shown in Fig. 26 to focus the axis of easy magnetization of the magnetic powder in the plastic bonded magnet material in the magnetic field as indicated by an arrow in Fig. 26. As described above, the plastic bonded magnet material is melted with heat and molded while magnetic field is applied from an external to positions corresponding to magnetic poles to be formed, and then cooling and solidifying the melted plastic bonded magnet material to form the focus-oriented plastic bonded magnet.

The length of the substantially-cylindrical plastic bonded magnet is preferably longer than a length required for development by 20 mm or more, and the cut surface at the both ends of the magnet preferably has a shape (a cut shape having directionality) obtained by cutting each of both ends of the plastic bonded magnet in a direction intersecting to the radial direction of the magnet at an angle (hereinafter referred to as oblique shape). In addition, it is favorable in manufacturing process that the substantially-cylindrical plastic bonded magnet is so designed that the outer diameter thereof is uniform over its longitudinal length.

The magnet roll thus formed, not being beforehand installed into a metal sleeve, but is directly fed as a part into a developing unit fabricating process together with other parts. Thereafter, both ends of the magnet roll are directly positioned to a fixture of the developing unit side in such a manner as to be fixed or rotatable, so that it is fabricated simultaneously with the fabrication of the developing unit. The magnet roll of this invention has no shaft, but its flexural strength is set above 1200 kgf/cm^2, so that it has sufficient mechanical strength against its dead weight. In addition, no use of a shaft in the magnet roll enables the plastic bonded magnet material to be filled into the central portion of the magnet roll in the radial direction. In a conventional thick magnet roll having large diameter, the magnetic force (magnetic flux density) of the magnet material located at the central portion of the magnet roll in the radial direction hardly reaches the surface of the magnet roll, so that the magnet material at the central portion of the magnet roll is vainly used. However, in the magnet roll of this invention, the maximum outer diameter of the substantially-cylindrical plastic bonded magnet when it is rotated (the maximum outer diameter at the rotation time is hereinafter referred to as "rotational diameter") is set below 30 mm, so that the magnetic force (magnetic flux density) of the magnet material at the central portion of the magnet roll in the radial direction also contributes the intensification of the surface magnetic flux density on the magnet roll, and thus the magnet material at the central portion of the magnet roll in the radial direction is also effectively used.

In the magnet roll according to the first aspect of this invention, both end portions of the substantially-cylindrical plastic bonded magnet serve as direct fitting portions to the developing unit body side. However, the substantially-cylindrical plastic bonded magnet can be also installed into the developing unit by fitting a low-price support member manufactured in a separate process to both ends of the substantially-cylindrical plastic bonded magnet. This is the feature of the second aspect of this invention. That is, the magnet roll of the second aspect of this invention is characterized in that a support jig (or supporter) for supporting both ends of the substantially-cylindrical plastic bonded magnet in the developing unit is directly secured to the cut end surfaces at both ends of the substantially-cylindrical plastic bonded magnet as described in the first aspect of this invention. The support jig may be formed of metal, but it is preferably formed of synthetic resin which is low in price. Various shapes and methods are considerable as the shape of the support jig and the method of fitting the support jig to the end portion of the substantially-cylindrical plastic bonded magnet, respectively. For example, it may be adopted that a support jig having a cup-shaped engaging portion is used and the cup-shaped engaging portion of the support jig is fixedly engaged with the end portion of the magnet.

Further, it is preferable that both end portions of the substantially-cylindrical plastic bonded magnet is so designed as to have a cut surface having the oblique shape (a cut shape having directionality), and the portion of the support jig which is to be confronted to the cut surface is so designed as to be substantially coincident with the shape of the cut surface.

Like the magnet roll of the first aspect of this invention, the magnet roll of the second aspect of this invention, not being beforehand installed into a metal sleeve, is directly fed as a part into a developing unit fabricating process together with other parts. The substantially-cylindrical plastic bonded magnet and the support jig disposed at the both ends thereof may be beforehand fabricated, or may be fabricated in the developing unit fabricating process. Thereafter, the magnet roll is positioned to a predetermined position in the developing unit through the support jig located at the both ends of the magnet roll in such a manner as to be fixed or rotatable, so that it is fabricated into the developing unit together with the other parts in the fabrication process of the developing unit.

When the support jig having the cup-shaped engaging portion is used, the positioning and fixing operations of the substantially-cylindrical plastic bonded magnet are simultaneously carried out by engaging the cup-shaped engaging portion with the end portion of the substantially-cylindrical plastic bonded magnet. Of course, adhesive agent may be wholly or partly filled at the coupling portion between the support jig and the substantially-cylindrical plastic bonded magnet.

When the both ends of the substantially-cylindrical plastic bonded magnet are formed so as to have an oblique shape (a cut shape having directionality) and the portion of the support jig which is confronted to be the cut surface is so designed as to be substantially coincident with the cut surface shape, the positioning operation for the substantially-cylindrical plastic bonded magnet can be easily performed, and a driving force can be easily transmitted to the substantially-cylindrical plastic bonded magnet.

Next, a magnet roll according to a third aspect of this invention will be described. In the magnet roll of the second aspect of this invention, the support jig through which the substantially-cylindrical plastic bonded magnet is installed into the developing unit is secured to the both ends of the substantially-cylindrical plastic bonded magnet, and the support jig is fitted to the developing device body side. In the magnet roll of the third aspect of this invention, the support jig is not secured to the both ends of the substantially-cylindrical plastic bonded magnet. That is, the magnet roll of the third aspect of this invention is characterized in that a support member for fixing the magnet roll is beforehand fixed to the developing unit body side, and then the substantially-cylindrical plastic bonded magnet is horizontally suspensively secured to a predetermined position in the developing device body through the support member (the magnet is fixedly suspended or bridged to the predetermined position while it is horizontally laid down).

The support member may be formed of metal, however, it is preferably formed of synthetic resin which is low in price. Various shapes and various fitting methods are considered as the shape of the support member and the method of fitting the support member to the magnet roll, respectively. For example, it may be adopted that the support member is formed of a substantially L-shaped member having a needle-shaped pin projected from a position thereof which is confronted to the end surface of the magnet roll, and the needle-shaped pin is stuck into the end surface of the magnet roll to horizontally suspensively fix the magnet roll to the support member.

Like the magnet rolls of the first and second aspects of this invention, the magnet roll of the third aspect of this invention, not beforehand installed into the metal sleeve, is also fed as a part into the developing unit fabricating process together with the other parts. Thereafter, the magnet roll is installed into the developing unit through the external support member directly fixed to the developing unit side in the developing unit fabricating process.

Preferred Embodiments according to this invention will be hereunder described with reference to the accompanying drawings.

Fig. 1 is a perspective view of the construction of a magnet roll of the first aspect according to this invention;

Fig. 2 is a perspective view of the construction of a magnet roll of the second aspect according to this invention;

Fig. 3 is a perspective view of the construction of a magnet roll of the third aspect according to this invention;

Fig. 4 is a partial cross-sectional front view of the magnet roll of the first aspect which is installed into a developing unit;

Figs.5(I) and (II) are diagrams showing the construction of the cut end surface of a substantially-cylindrical plastic bonded magnet;

Fig. 6(I) is an perspective view of an embodiment of the magnet roll of the second aspect of this invention, and Fig. 6(II) is a partial cross-sectional front view of the embodiment;

Figs. 7(I) and (II) are perspective views of an embodiment of a support jig used for the magnet roll of the second aspect according to this invention;

Fig. 8 is a front view of another embodiment of the magnet roll of the second aspect of this invention, where (I) shows a state before fabrication, and (II) shows a state after the fabrication;

Fig. 9 is a front view of another embodiment of the magnet roll of the second aspect of this invention, where (I) shows a state before the fabrication, and (II) shows a state after the fabrication;

Figs. 10(I) and (II) are partial cross-sectional views of an example of a fitting of the support jig to the cut end surface of the substantially-cylindrical plastic bonded magnet in the second aspect of this invention;

Figs. 11(I) and (II) are partial cross-sectional views of another example of a fitting of the support jig to the cut end surface of the substantially-cylindrical plastic bonded magnet in the second aspect of this invention;

Fig. 12 is a partial cross-sectional front view of an example of the installation of the magnet roll of the second aspect of this invention into the developing unit;

Fig. 13 is a partial cross-sectional front view of an example of the installation of the magnet roll of the second aspect of this invention into the developing unit;

Fig. 14 shows an embodiment of the magnet roll of the third aspect of this invention, where (I) is a perspective view of the magnet roll, and (II) is a front view of the magnet roll;

Fig. 15 is a front view showing a state where the magnet roll of the third aspect of this invention is surrounded by a sleeve;

Fig. 16 is a diagram showing an example of a procedure of fixing the magnet roll of the third aspect of this invention to the developing device body side through a support member;

Fig. 17 is a front view of a main part of another embodiment of the magnet roll of the third aspect of this invention;

Fig. 18(I) is a perspective view of another embodiment of the support member used to fix the magnet roll of the third aspect of this invention, Fig. 18(II) is an explanatory diagram of a procedure of fixing the support member to the magnet roll, and Fig. 18(III) is a front view showing a state where the magnet roll is horizontally suspensively fixed using the support member;

Figs. 19(I) and (II) are partial cross-sectional front views of another embodiment of the magnet roll according to the third aspect of this invention;

Fig. 20(I) is a perspective view of another embodiment of the support member used to fix the magnet roll according to the third aspect of this invention, Fig. 20(II) is a front view showing a state where the magnet roll is horizontally suspensively fixed using the support member, and Fig. 20(III) is a side view of the state of Fig. 20-(II);

Fig. 21 shows a state where a conventional magnet roll is disposed in the metal sleeve, where (I) is a longitudinal-sectional view, and (II) is a transverse-sectional view;

Fig. 22 is a perspective view of an embodiment of the conventional magnet roll;

Fig. 23 is a cross-sectional view of an embodiment of the conventional magnet roll;

Fig. 24 is a cross-sectional view of an embodiment of the conventional magnet roll;

Fig. 25 is a cross-sectional view of an embodiment of the conventional magnet roll; and

Fig. 26 is an explanatory diagram of magnetic poles which are formed by a focus-orienting method in the presence of magnetic field.

Fig. 1 is a perspective view of an embodiment of the magnet roll according to the first aspect of this invention, Fig 2 is a perspective view of an embodiment of the magnet roll according to the second aspect of this invention, and Fig. 3 is a perspective view of an embodiment of the magnet roll according to the third aspect of this invention. Each of the magnet rolls according to the first to third aspects of this invention is commonly characterized in that a substantially-cylindrical plastic bonded magnet having no shaft is used.

The magnet roll (M1) of the first aspect of this invention comprises only a substantially-cylindrical plastic bonded magnet 3. The magnet roll (M2) of the second aspect of this invention comprises a substantially-cylindrical plastic bonded magnet 3 and support jigs 5 disposed at both end portions thereof. In the magnet roll (M3) of the third aspect of this invention, the both end surfaces or the outer peripheral surfaces of the both end portions of the substantially-cylindrical plastic bonded magnet 3 are directly secured to a support member 12 fixed to a member (Z) of the developing unit body side to directly suspensively fix the substantially-cylindrical plastic bonded magnet 3 to a predetermined position in the developing unit.

The magnet rolls of the first to third aspect of this invention will be hereunder described in this order.

The magnet roll of the first aspect of this invention is wholly formed of plastic bonded magnet with no metal shaft. The term "substantially-cylindrical shape" used in this application is not limited to a mere cylindrical shape, but covers a substantially cylindrical shape having grooves or projections on the surface thereof insofar as an enveloping surface thereof becomes a cylindrical surface. In addition, the substantially-cylindrical plastic bonded magnet 3 is so designed that the maximum rotational outer diameter thereof when it is rotated is set below 30 mm. If the maximum rotational outer diameter, that is, the rotational diameter exceeds 30 mm, there would occur a magnetic portion which is magnetically vainly used (i.e., does not contribute to the surface magnetic flux density) (hereinafter referred to as "non-active part", and this obstructs the object of this invention that a low-price magnet roll is provided. For example, when the diameter of the magnet is 35 mm, no difference occurs in magnetic flux density to be measured near the surface of the magnet (hereinafter referred to as surface magnetic flux density) between two cases where the magnet is designed in a solid-cylindrical shape and where the magnet is designed in a hollow-cylindrical shape having a through hole of 5 mm diameter at the center portion. Therefore, a region from the center of the plastic bonded magnet to a position away from the center at 5 mm (that is, 5 mm diameter portion) is judged not to substantially contribute to the surface magnetic flux density, and thus the plastic bonded magnet material at this portion is wholly vainly used.

The inventor has experimentally found that the substantially-cylindrical focus-oriented plastic bonded magnet in which the non-active part is almost absent is the one whose rotational diameter is not more than 30 mm.

According to this invention, by eliminating the metal shaft serving as a main supporting part, the total cost of the magnet roll is reduced by a cost required for the metal shaft. The elimination of the shaft enables the magnet material to be filled into the eliminated portion, so that high surface magnetic flux density can be obtained by a magnet roll having smaller diameter.

However, at the same time, another function of the shaft, that is, a function of keeping the linear shape of the magnet roll is also lost. That is, the shaft is indispensable for the bearing structure, and in addition it has a function of keeping the dead-weight flexural strength of a slender structure such as a magnet roll. Therefore, in this invention, a dead-weight flexural strength against the dead weight of the substantially-cylindrical plastic bonded magnet itself is required due to the elimination of the shaft. In order to solve this problem, it is insufficient to use an soft plastic bonded magnet using soft rubber or soft resin as base material. According to the inventor's consideration, if a shaftless substantially-cylindrical plastic bonded magnet is provided with a sufficient mechanical strength against the dead weight, material providing flexural strength above at least 1200 kgf/cm^2 would be required. In view of this point, a hard plastic bonded magnet providing flexural strength above 1200 kgf/cm^2 is used as raw material of the substantially-cylindrical plastic bonded magnet of this invention. If the flexural strength is less than 1200 kgf/cm^2, there would occur a case where the magnet roll is sagged in its fabrication process or at its use time in accordance with the size of the rotational diameter of the magnet. However, if the flexural strength is above 1200 kgf/cm^2, there would occur no sagging of the magnet roll, and the linear shape of the magnet roll can be kept.

The magnet roll of this invention is also characterized in that both end portions of the substantially-cylindrical plastic bonded magnet 3 is formed by only the cutting processing. That is, the end surface portions of the substantially-cylindrical plastic bonded magnet obtained by a thermoplastic molding is subjected to a cutting processing which is an extremely simple processing to thereby forming each of the both end surfaces of the magnet with a fitting portion to be directly secured to the developing unit. This processing is very simple, and conducted with a low-price equipment for a short time. As the thermoplastic molding may be used a general method such as an extrusion molding, an injection molding, a compression molding or the like.

The extrusion molding is most preferably used to form a substantially-cylindrical plastic bonded magnet 3 because it can easily form a continuous longitudinal product. For example, if a cylindrical magnet is continuously molded at a constant speed while it is cut at a predetermined interval using a cutting machine which is moved in synchronism with a molding speed, a desired substantially-cylindrical plastic bonded magnet 3 could be easily obtained using a simple equipment without an additive process. The substantially-cylindricalplastic bonded magnet 3 can be obtained by the injection molding. In this case, a molded product is taken out from a metal mold for the injection molding, and then an end portion thereof is subjected to a cutting process. However, this method requires an additive process, and thus the extrusion molding is more preferable as the molding method of the substantially-cylindrical plastic bonded magnet 3 because it can produce a continuous longitudinal product.

A mixture obtained by dispersing ferrite powder into a hard thermoplastic resin is most preferable as the plastic bonded magnet used in this invention. As the hard thermoplastic resin is preferably used polyamide, filamentary polyester, polyphenylene sulfide, polyphenylene oxide or denatured materials of the above materials, or widely-used engineering plastic. As the ferrite powder is used anisotropic barium ferrite powder, or strontium ferrite powder. The ferrite content in the plastic bonded magnet is suitably determined in consideration of the magnetic property (surface magnetic flux density) and dynami strength to be required, and it is ordinarily set to 50 to 70 volume %.

The length of the cylindrical magnet used in this invention is preferably longer than a length required for development by 20 mm or more. In this invention, in order to produce magnet for a magnet roll in low cost, the magnet is designed in a very simple shape. The design of the magnet for the magnet roll having such a simple shape is made to intend the one-stroke fabrication of the magnet roll into the developing unit in all fabrication processes by improving a fitting jig of the developing unit side. Accordingly, the length of the cylindrical magnet constituting the magnet roll of this invention is designed so as to be slightly longer than the magnet length required for the development, and the magnet roll is secured to the developing unit through fitting jigs 4 of the developing unit using surplus end portions at both ends of the magnet roll as shown in Fig. 4 in such a manner as to be fixed in the developing unit or freely rotatable relative to the sleeve (S). In the prior art where a magnet roll is beforehand installed into a sleeve and then it is provided as a developing cylinder, the length of the magnet roll is also designed so as to be longer than the length required for the development by about 10 to 20 mm. However, the length of the magnet roll of this invention is preferably designed so as to be further longer than the development length by 20 mm or more because a surplus length for the fitting of the magnet roll to the developing unit is required for the magnet roll. However, if the magnet roll can be supported at both ends thereof, the surplus length of the magnet roll may be below 20 mm.

As described above, both ends of the magnet roll (M1) of this invention are formed by only the cutting processing. The simplest structure of the end surface is a structure which is obtained by vertically and flatly cutting the magnet roll as shown in Fig. 1. However, another structure may be adopted insofar as it is formed by only the cutting processing. For example, in some designs of the developing unit, the magnetic poles a the surface of the magnet are required to be disposed in a desired direction, and a prescribed magnetic pole is required to be disposed in a predetermined position. In this case, as shown in Figs. 5(I) and 5-(II), an angular positioning operation is easily performed using an obliquely-cut end surface structure. Such a cut surface can be formed by plural cutting machines having different fitting angles for cutting blades. In some shapes of the end surface of the magnet roll, the end surface portion having such an oblique shape may be used not only to perform the positioning of the magnet, but also to transit a driving force to the magnet roll when the magnet roll is rotated.

The magnet roll (M1) of the first aspect of this invention thus constructed is directly fed as a part to the fabrication process of the developing unit while not being beforehand installed into the metal sleeve, and it is fabricated with other parts at a stroke in the fabrication process of the developing unit. The fabrication process is a novel one which has not been hitherto attempted. The magnet roll of this invention is matched to this novel fabrication process.

The magnet roll of this invention has not shaft, but has sufficient mechanical strength to the extent that it can be used as a magnet roll. In addition, the rotational diameter thereof is set to such a value that the magnet material at the center portion of the magnet roll is effectively used (contribute to the surface magnetic flux density), so that the loss of the raw material is prevented. Further, the both end portions serving as fitting portions to be directly secured to the developing unit body side are formed by only the cutting processing, so that a processing cost is remarkably reduced. As described above, this invention can provide a magnet roll which has a sufficient performance to the extent that it is applicable to a developing unit using an electrophotographic technique and which is very low in price.

An embodiment of the magnet roll of the second aspect of this invention will be next described. As shown in Fig. 2, the magnet roll (M2) of the second aspect of this invention comprises a substantially-cylindrical plastic bonded magnet 3 and support jigs 5 disposed at both end portions thereof. The construction of the substantially-cylindrical plastic bonded magnet 3 is identical to that of the first aspect of this invention.

In the magnet roll (M2) of the second aspect of this invention, both end portions of a substantially-cylindrical plastic bonded magnet 3 obtained by the thermoplastic molding is subjected to a simple processing, that is, a cutting processing, and then support jigs 5 which are produced in a separate process are disposed at the cut end portions, whereby the installation of the magnet roll (M2) into the developing unit can be performed.

Any member may be used as the support jig 5 insofar as it can be secured to both end portions of the substantially-cylindrical plastic bonded magnet 3 and can support the substantially-cylindrical plastic bonded magnet 3 so as to be fixed or rotatable in the developing unit. For example, a support jig 5a as shown in Figs. 6(I) and (II) may be adopted. The support jig 5a has at one side thereof a cup-shaped engaging portion 6 which is engageably disposed around the end portion of the substantially-cylindrical plastic bonded magnet 3 and a support shaft 7 at the other side thereof. The positioning and fixing of the substantially-cylindrical plastic bonded magnet 3 to the developing unit can be performed by only engagedly disposing the cap-shaped engaging portion 6 around the end portion of the substantially-cylindrical plastic bonded magnet 3. An adhesive agent may be provided at a coupling portion between the substantially-cylindrical plastic bonded magnet 3 and the cup-shaped engaging portion 6. The adhesive agent may be coated wholly or partially at the coupling portion. In addition, the support jig 5a may be formed of metal, however, it is preferably formed of synthetic resin in view of low cost. When the support jig 5a is formed of metal, it is preferably non-magnetic to avoid an influence on the magnetic property of the substantially-cylindrical plastic bonded magnet 3.

The support shaft 7 may be designed in a round bar shape, and it may be supported by a bearing of the developing unit side to rotatably support the magnet roll (M2) in the developing unit. Alternatively, the support shaft may be designed in a polygonal prismatic shape like support shafts 7a and 7b as shown in Figs. 7(I) and (II) to fixedly support the magnet roll (M2).

When the support jig having the cup-shaped engaging portion 6 is used, the substantially-cylindrical plastic bonded magnet 3 is required to be provided with a surplus portion around which the cup-shaped engaging portion 6 is engagedly disposed. As described above, the length of the substantially-cylindricalplastic bonded magnet 3 is set to be longer than the length required for the development by 20 mm or more. In the magnet roll of the second aspect of this invention, this surplus length portion is used as a portion to which the support jig is secured.

Figs. 8(I) and (II) show a case where a support jig 5b having a flat contact surface 8 (having no cup-shaped engaging portion) is fixed to the end surface of the substantially-cylindrical plastic bonded magnet 3 through adhesive agent. Figs. 9(I) and (II) show a case where a needle-shaped member 9 is provided to a support jig 5c so as to be projected from the flat surface thereof which is confronted to the end surface of the substantially-cylindrical plastic bonded magnet, and the tip side of the needle-shaped member 9 is stuck into the end surface of the substantially-cylindrical plastic bonded magnet 3 to thereby fix the support jig 5c to the substantially-cylindrical plastic bonded magnet 3. In the above embodiments where the support jig has no cup-shaped engaging portion, the length of the surplus portion which is formed in the substantially-cylindrical plastic bonded magnet 3 may be shorter than 20 mm.

As described above, the both ends of the substantially-cylindrical plastic bonded magnet 3 is formed by only the cutting processing. As an example of the end surface structure which is obtained by only the cutting processing may be used not only the end surface structure of normal flat plane which is the simplest end surface structure, but also the end surface structure having the oblique cut shape (cut shape having directionality) as shown in Fig.5 which is described for the magnet roll (M1) of the first aspect of this invention. In this case, if the support jig is designed so as to have the shape corresponding to the obliquely-cut end surface structure of the magnet roll like support jigs 5d to 5g as shown in Figs. 10 and 11, the end surface portion having the oblique shape is used not only as a mere positioning member for the magnet roll, but also means for transmitting a driving force to the magnet roll when the magnet roll is rotated.

The magnet roll (M2) thus constructed is rotatably supported through the support jig 5a by a bearing 10 of the developing side in a state where it is inserted in a sleeve (S) as shown in Fig. 12, or fixed through the support jig 5a to the developing unit side member 11 as shown in Fig. 13. The insertion of the magnet roll (M2) into the sleeve (S) is carried out simultaneously with the fabrication of the other parts in the fabrication process of the developing unit.

As described above, the magnet roll of the second aspect of this invention is so constructed that a support jig which can be easily produced is disposed at the both end portions of the substantially-cylindrical plastic bonded magnet which can be also easily produced, and thus the magnet roll is produced in low cost using no expensive metal shaft. Therefore, according to this invention, a magnet roll having a smaller diameter and a desired magnetic property (a desired amount of surface magnetic flux density) can be produced in remarkably low cost. In addition, the magnet roll (M2) of the second aspect of this invention has the following same effect as the magnet roll (M1) of the first aspect of this invention. That is, the magnet roll (M2) can be fed as a part into the fabrication process of the developing unit together with the other parts while it is not beforehand installed into the metal sleeve (S), and then fabricated with the other parts at a stroke in the fabrication process of the developing unit.

When the support jig having the cup-shaped engaging portion is used, the positioning and fixing operations of the substantially-cylindrical plastic bonded magnet can be simultaneously performed only by engaging the cup-shaped engaging portion as described above with the end portion of the substantially-cylindrical plastic bonded magnet. Further, when the both ends of the substantially-cylindrical plastic bonded magnet is obliquely cut and a portion of the support jig which is confronted to the cut surface of the magnet is designed so as to be substantially coincident with the cut surface in shape, the positioning operation of the substantially-cylindrical plastic bonded magnet is easily performed and the transmission of the driving force to the substantially-cylindrical plastic bonded magnet can be also easily performed.

An embodiment of the magnet roll according to the third aspect of this invention will be next described. As shown in Fig. 3, in the magnet roll (M3) of the third aspect of this invention, the substantially-cylindrical plastic bonded magnet 3 is horizontally suspensively fixed at both end portions thereof to a predetermined position in the developing unit through a support member 12 which is directly secured to the member (Z) of the developing unit body side. Each of the magnet rolls as described in the first and second aspects of this invention is a part which is handled separately from the developing unit body. On the other hand, in the magnet roll of the third aspect of this invention, the substantially-cylindrical plastic bonded magnet 3 is horizontally suspensively fixed to the member (Z) of the developing unit body side through the support member 12 which is directly secured to the member (Z) of the developing unit body side.

Fig. 3 shows the concept of the magnet roll of the third aspect of this invention and the fixing method thereof, and the sleeve (S) and the peripheral equipments are eliminated from the figure to simplify the description. The construction of the substantially-cylindrical plastic bonded magnet 3 is identical to those of the magnet rolls of the first and second aspects of this invention. The magnet roll of the third aspect of this invention is characterized in that the substantially-cylindrical plastic bonded magnet 3 is horizontally suspensively secured to a predetermined position in the developing unit through the support member 3 which is directly fixed to the developing unit body side member (Z).

More specifically, the both end portions of the substantially-cylindrical plastic bonded magnet 3 which is formed by only the simple processing, that is, the cutting processing is positioned to the support members 12 which are directly fixed to the developing unit body side member (Z), thereby enabling the installation of the substantially-cylindrical plastic bonded magnet 3 to the predetermined position in the developing unit in a state where the magnet 3 is horizontally suspensively secured.

Any member may be used as the support member 12 insofar as it can be fixed to the developing unit body side member (Z) and horizontally suspensively support the substantially-cylindrical plastic bonded magnet 3. For example, a substantially L-shaped support member 12a as shown in Figs. 14(I) and (II) may be used. The fixation of the substantially L-shaped support member 12a to the substantially-cylindrical plastic bonded magnet 3 may be performed by a suitable method such as adhesion, engagement or the like. In addition, the contact surface of the support member with the substantially-cylindrical plastic bonded magnet 3 may be subjected to a surface roughening processing to support the substantially-cylindrical plastic bonded magnet through friction between the roughened surface of the support member 12 and the substantially-cylindrical plastic bonded magnet 3. Further, the fixation of the support member 12a to the developing unit body side member (Z) is also performed through any method such as screw fixing, engagement, adhesion or the like. The support member 12a may be formed of metal, however, it is preferably formed of synthetic resin because it is lower in cost. When the support member 12a is formed of metal, it is required to be non-magnetic in order to avoid the affection on the magnetic property (surface magnetic flux density) of the substantially-cylindrical plastic bonded magnet 3.

Fig. 15 shows the substantially-cylindrical plastic bonded magnet 3 which is horizontally fixedly suspended between the support members 12a, and a portion as indicated by a two-dotted chain line represents the sleeve (S).The sleeve (S) is rotatably supported by a mechanism (not shown) with keeping a non-contact state with the substantially-cylindrical plastic bonded magnet 3. The sleeve (S) is not illustrated in the following description, however, it is assumed to be disposed around the substantially-cylindrical plastic bonded magnet 3 which is fixed to the developing unit body side member (Z) through the support member. A procedure of horizontally suspensively securing the substantially-cylindrical plastic bonded magnet 3 to the support members 12a which are directly fixed to the developing unit body side member (Z) includes a work of fixing the support members 12a to the developing unit body side member (Z) and a work of horizontally suspensively securing the substantially-cylindrical plastic bonded magnet 3 between the support members 12a. The priority of the both works is suitably determined in accordance with concrete fixing means.

Fig. 17 shows another embodiment of the support member. In this embodiment, a projection fragment 13 is formed on the erection wall of the substantially L-shaped member, and the lower ide of each end portion of the substantially-cylindrical plastic bonded magnet 3 is supported by the projection fragment 13. With this construction, the positioning and fixing operations of the substantially-cylindrical plastic bonded magnet 3 can be more easily performed.

Fig. 18 shows the construction of a support member 12c in which plural needle-shaped pins 14 are projected from the erection wall of the substantially L-shaped member. The needle-shaped pins 14 are stuck into a part of the end surface of the substantially-cylindrical plastic bonded magnet 3 to easily perform the suspensive fixation of the substantially-cylindrical plastic bonded magnet 3.

Like the first and second aspects of this invention, the both ends of the substantially-cylindrical plastic bonded magnet 3 can be formed by only the cutting processing, and the shapes of the end surfaces as described in the first and second aspects of this invention can be also adopted. For example, for the substantially-cylindrical plastic bonded magnet having the end surface portion having directionality in shape as shown in Fig. 5, if the support members 12d and 12e having the shape corresponding to the end surface structure of the substantially-cylindrical plastic bonded magnet as shown in Figs. 19(I) and (II) are used, plural magnetic poles which are formed on the outer peripheral surface of the substantially-cylindrical plastic bonded magnet 3 are positioned to predetermined corresponding positions respectively, and the fixation of the magnet can be stabilized.

In the above embodiment, since the horizontally suspensive fixation of the substantially-cylindrical plastic bonded magnet 3 is performed by directly fixing the support member to the end surface of the substantially-cylindrical plastic bonded magnet 3, there occurs a case where the magnet property (surface magnetic flux density) at the end portion of the magnet roll (M) is disturbed. In such a case, it is preferable that like the first and second aspects of this invention, the length of the magnet roll (M) is set to be longer than the length required for the development by 20 mm or more to provide a surplus length portion for support member fixation. However, the surplus length portion may be set to be below 20 mm if the magnet roll (M) can be supported at both ends thereof and no disturbance occurs in the magnetic property (surface magnetic flux density).

In the above embodiment, the support member is fixed to the end surface of the substantially-cylindrical plastic bonded magnet 3 to horizontally suspensively fix the substantially-cylindrical plastic bonded magnet 3. However, the support member may be disposed at a portion other than the end surface insofar as it is adjacent to each of both end portions. For example, as shown in Fig. 20, a support member 12f may be designed so as to have an erected wall having an arcuate engaging support portion 15 for supporting the outer peripheral surface of the substantially-cylindrical plastic bonded magnet 3, and a needle-pin 16 projected from the inner surface of the erected wall. When the support member 12f is used, the substantially-cylindrical plastic bonded magnet 3 can be fixed to the developing unit by pushing from the upper side the substantially-cylindrical plastic bonded magnet 3 against the support member 12f which is beforehand fixed to the developing unit body side member (Z), and thus the work can be easily performed.

As described above, in the magnet roll of the third aspect of this invention, the both ends of the substantially-cylindrical plastic bonded magnet which can be easily produced is horizontally suspensively secured to a predetermined position in the developing unit by directing securing the both end surfaces or the outer peripheral surfaces of the both end portions of the substantially-cylindrical plastic bonded magnet to the support members which are fixed to the developing unit body side member, so that the same effect as the first and second aspects of this invention can be obtained. That is, since no expensive metal shaft is required, the reduction of the producing cost can be performed. In addition, since the magnet roll is fed as a part into the fabrication process of the developing unit while it is not beforehand installed into the metal sleeve, and then it is fabricated with the other parts at a stroke in the fabrication process of the developing unit, the working efficiency of the fabrication of the developing unit can be improved. The magnet roll has sufficient mechanical strength to the extent that it can be used as a magnet roll although it has no shaft, and the rotational diameter of the magnet roll is set to such a value that the magnet material at the center portion of the magnet can contribute to the surface magnetic flux density of the magnet roll, so that the loss of the raw material can be prevented. Both end portions of the substantially-cylindrical plastic bonded magnet are formed by only the cutting processing, so that the processing cost is also very low.

Claims

1. A magnet roll comprising:
a substantially-cylindrical plastic bonded magnet having on the surface thereof plural magnetic poles formed by a focus-orienting method in the presence of magnetic field, said substantially-cylindrical plastic bonded magnet having the maximum outer diameter below 30 mm when said magnet is rotated, and the flexural strength above 1200 kgf/cm^2, wherein both end portions of said magnet in a longitudinal direction thereof are formed by only a cutting processing, and serve as a fixing portion to be directly fixed to a developing unit body.

2. The magnet roll as claimed in claim 1, wherein the length of said substantially-cylindrical plastic bonded magnet is set to be longer than the length required for development by 20 mm or more.

3. The magnet roll as claimed in claim 1 or 2, wherein both ends of said substantially-cylindrical plastic bonded magnet is designed so as to have an oblique cut surface (a cut surface having an asymmetrical shape with respect to a rotation center).

4. The magnet roll as claimed in claim 1, 2 or 3, wherein the outer diameter of said substantially-cylindrical plastic bonded magnet is uniform over the longitudinal direction thereof.

5. A magnet roll comprising:
a substantially-cylindrical plastic bonded magnet having on the surface thereof plural magnetic poles formed by a focus-orienting method in the presence of magnetic field; and
a support jig for securing said substantially-cylindrical plastic bonded magnet to a developing unit body, said substantially-cylindrical plastic bonded magnet having the maximum outer diameter below 30 mm when said magnet is rotated, and the flexural strength above 1200 kgf/cm^2, wherein both end portions of said magnet in a longitudinal direction thereof are formed by only a cutting processing, and said support jig is directly secured to the cut end surface of said substantially-cylindrical plastic bonded magnet.

6. The magnet roll as claimed in claim 5, wherein said support jig is formed of synthetic resin.

7. The magnet roll as claimed in claim 5 or 6, wherein said support jig has a cup-shaped engaging portion which is closely engagedly disposed around the end portion of said substantially-cylindrical plastic bonded magnet.

8. The magnet roll as claimed in claim 5, 6 or 7, wherein the cut surface at the both ends of said substantially-cylindrical plastic bonded magnet are obliquely cut, and a portion of said support jig which is confronted to each of the cut surfaces is designed so as to be substantially coincident with the shape of the cut surface.

9. A magnet roll comprising:
a substantially-cylindrical plastic bonded magnet having on the surface thereof plural magnetic poles formed by a focus-orienting method in the presence of magnetic field; and
a support member secured to a developing unit body, said substantially-cylindrical plastic bonded magnet having the maximum outer diameter below 30 mm when said magnet is rotated, and the flexural strength above 1200 kgf/cm^2, wherein both end portions of said magnet in a longitudinal direction thereof are formed by only a cutting processing, and wherein the both end surfaces or the outer peripheral surfaces of the both end portions of said substantially-cylindrical plastic bonded

magnet are directly secured to said support member which is fixed to said developing unit body to thereby directly horizontally suspensively fix said substantially-cylindrical plastic bonded magnet to a predetermined position in said developing unit.

10. The magnet roll as claimed in claim 9, wherein said support member is formed of synthetic resin.

11. The magnet roll as claimed in claim 9 or 10, wherein said support member includes substantially L-shaped support members each having a needle-shaped pin projected from the inner surface thereof, said substantially L-shaped support members being disposed at predetermined positions in said developing unit so as to be confronted to each other at an predetermined interval, and said substantially-cylindrical plastic bonded magnet is positioned between said substantially L-shaped support members and said needle-shaped pin is stuck into the end surface of said substantially-cylindrical plastic bonded magnet to thereby directly horizontally suspensively fix said substantially-cylindrical plastic bonded magnet to the predetermined position in said developing unit.

Fig. 1

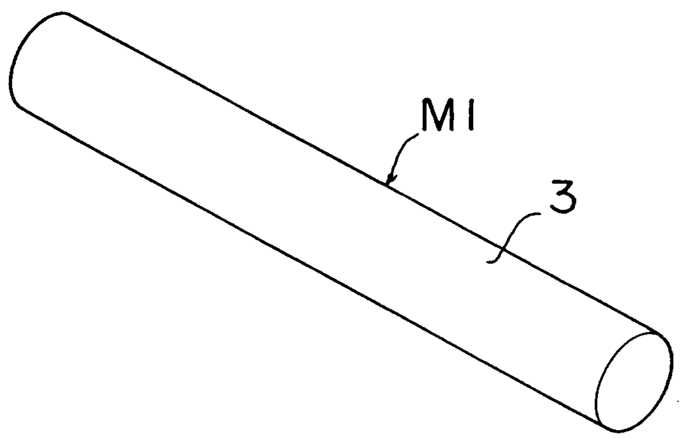


Fig. 2

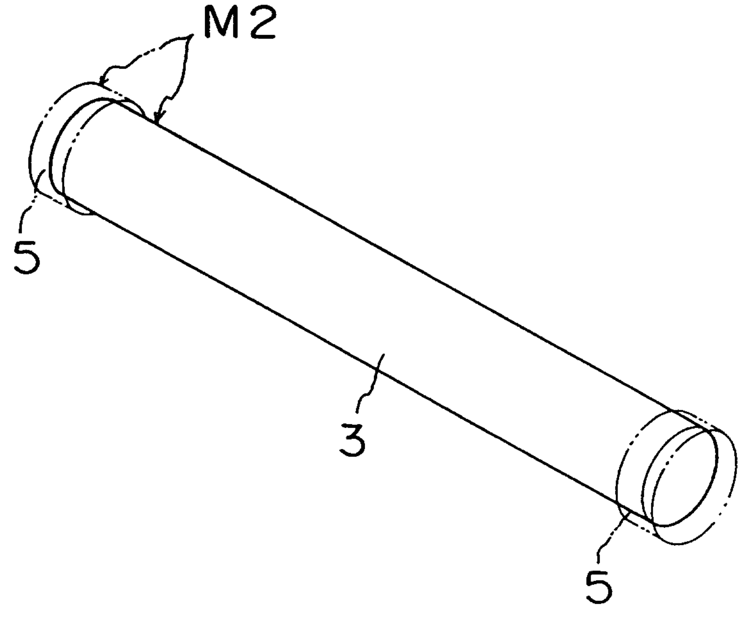


Fig. 3

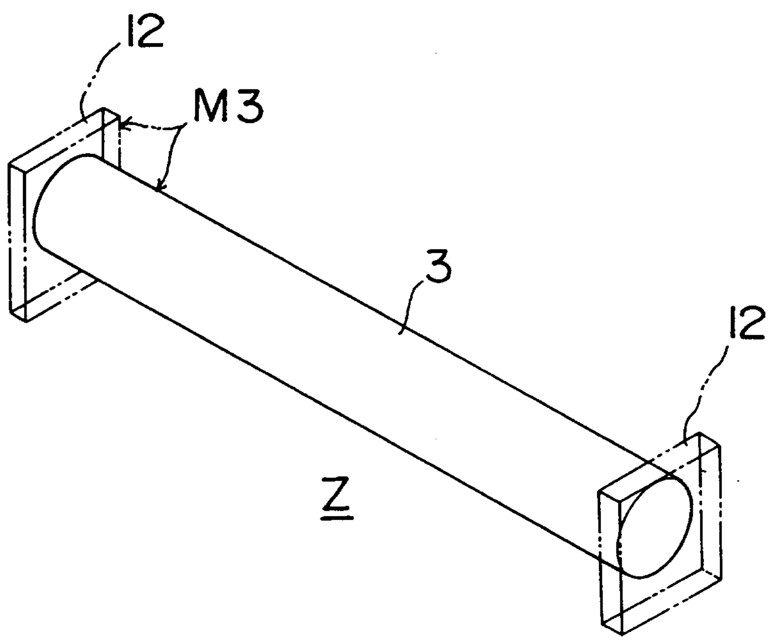


Fig. 4

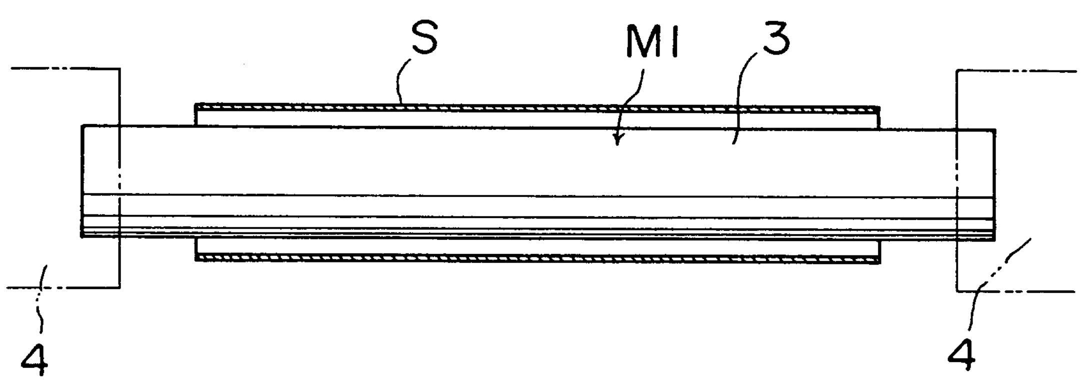
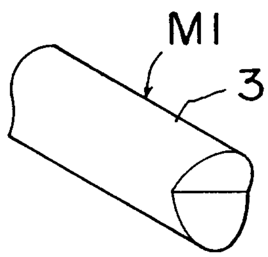


Fig. 5

(I)



(II)

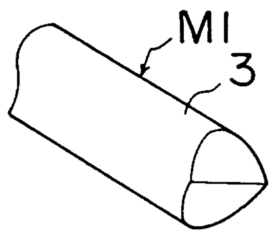
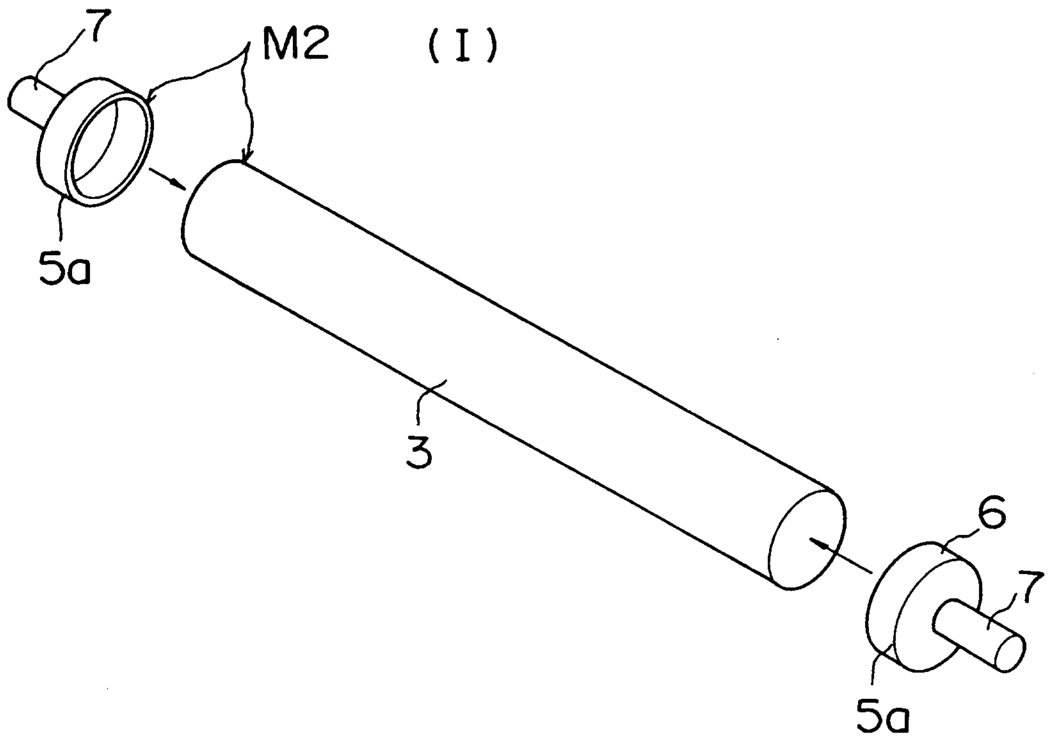


Fig. 6

(I)



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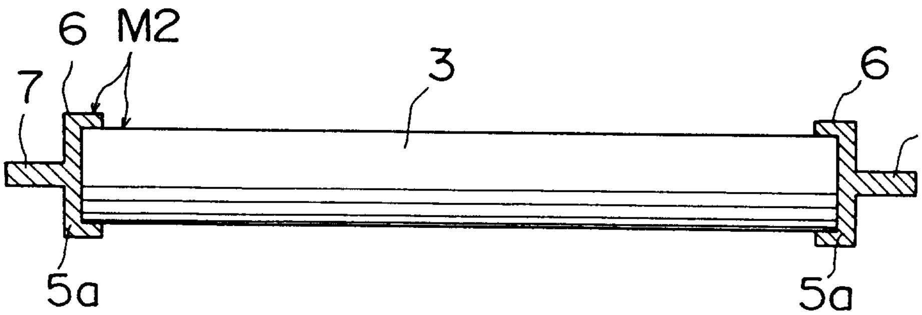


Fig. 7

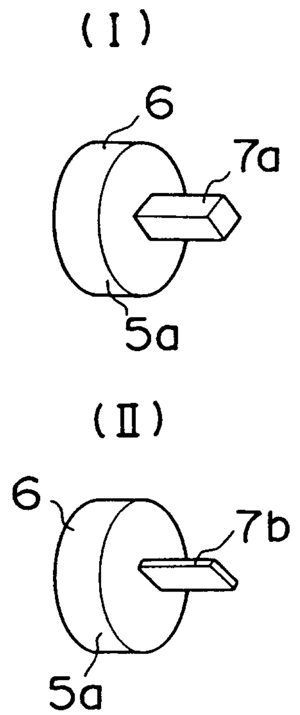


Fig. 8

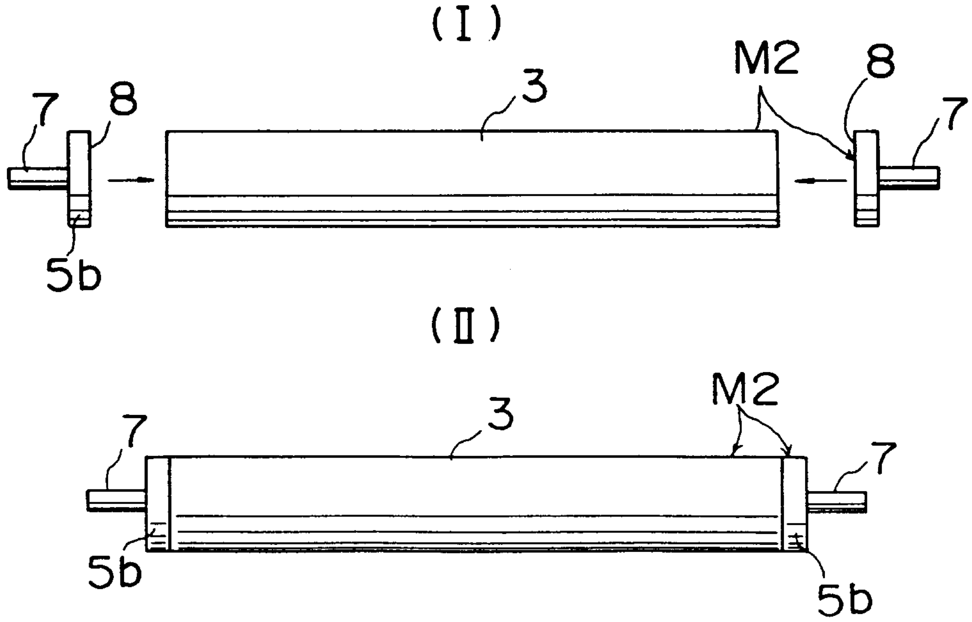
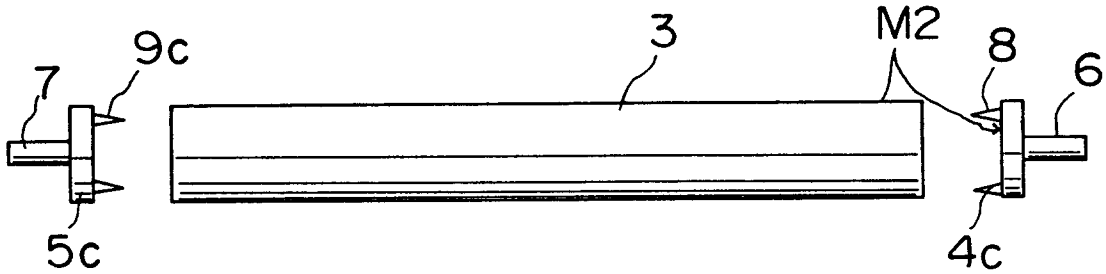


Fig. 9

(I)



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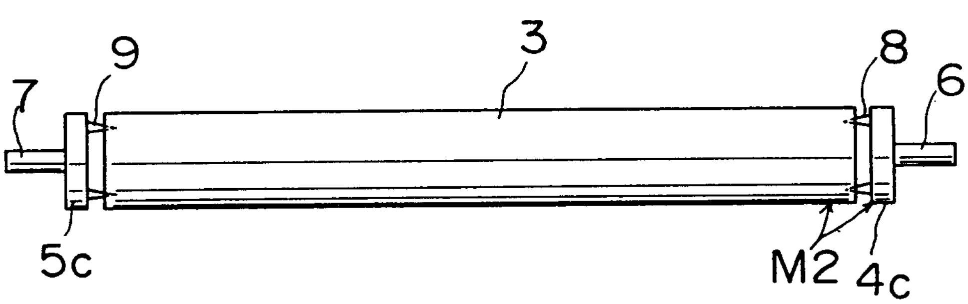
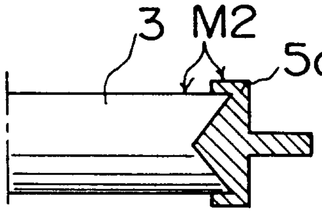


Fig. 10

(I)



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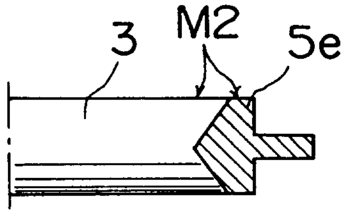
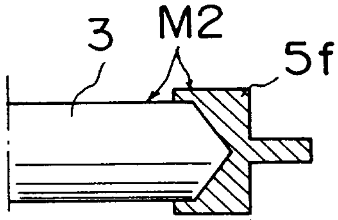


Fig. 11

(I)



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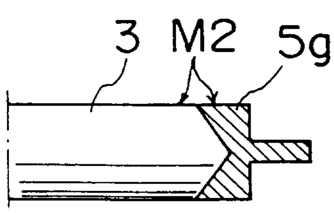


Fig. 12

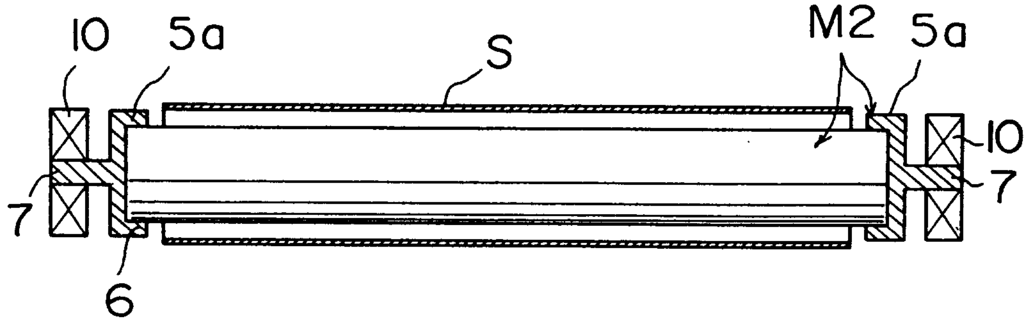


Fig. 13

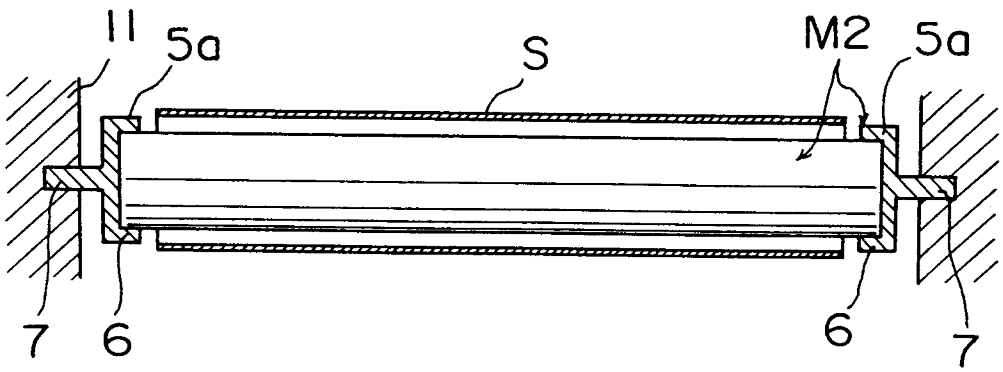
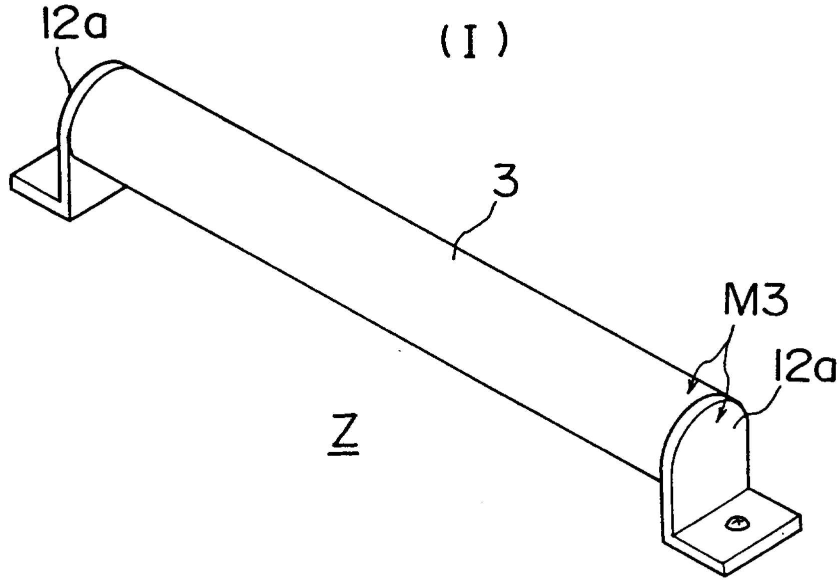


Fig. 14

(I)



(II)

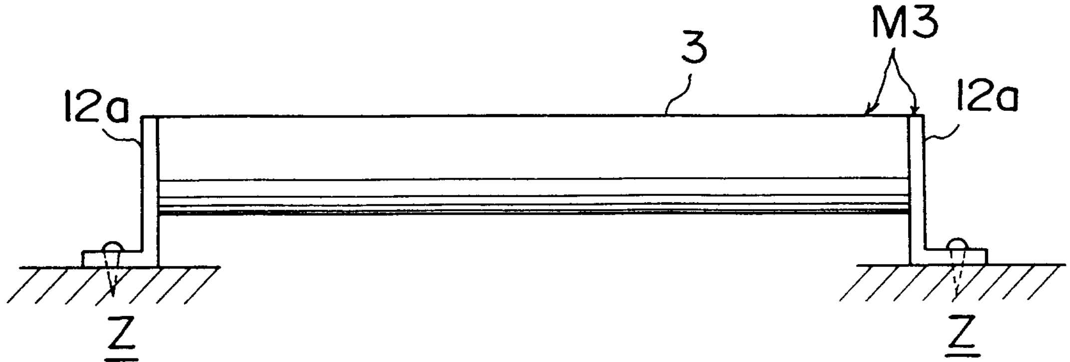


Fig. 15

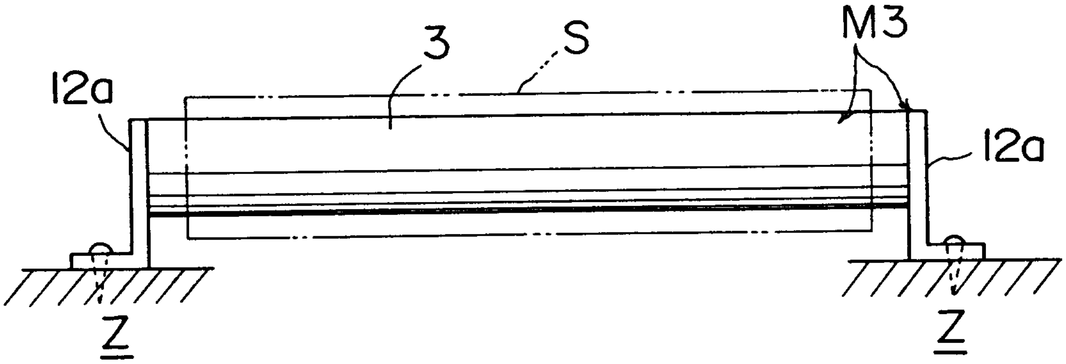


Fig. 16

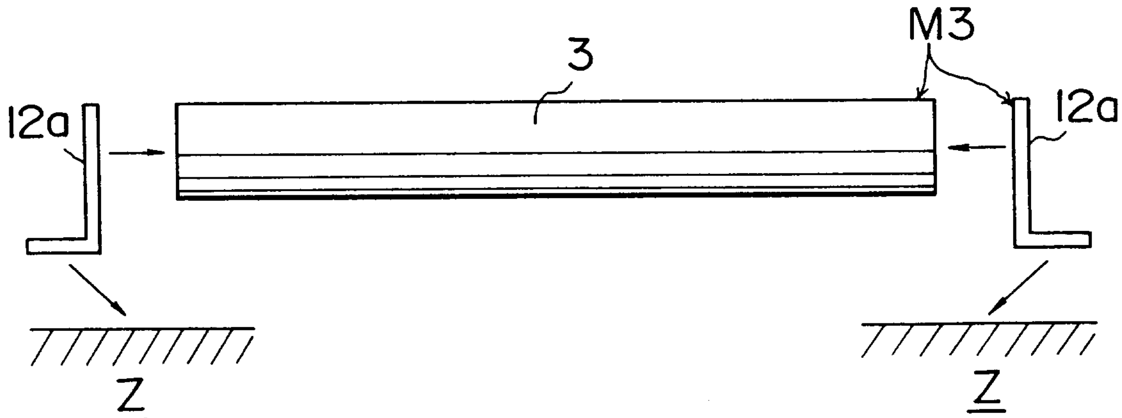


Fig. 17

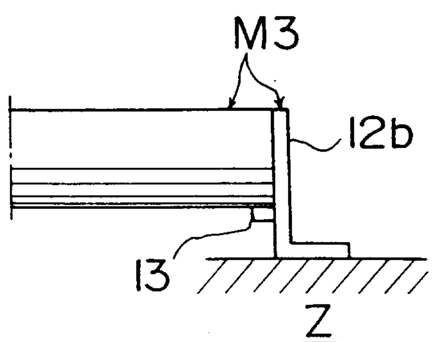
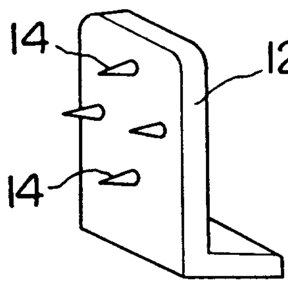
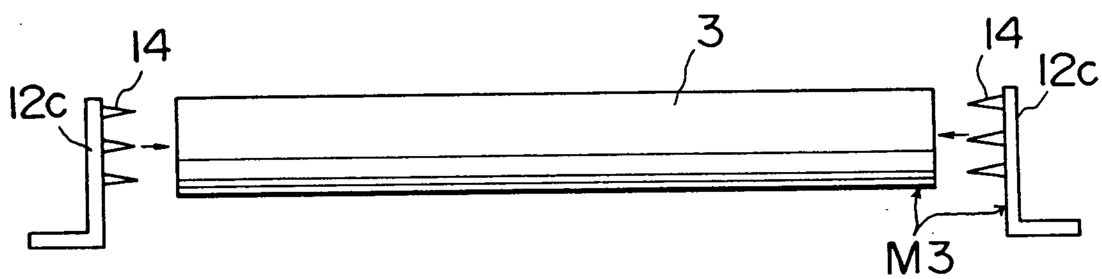


Fig. 18

(I)



(II)



(III)

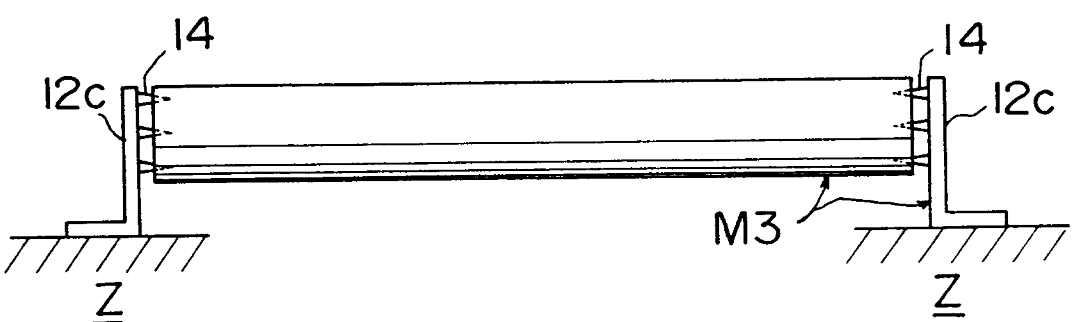
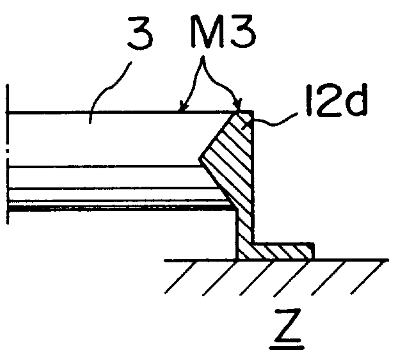


Fig. 19

(I)



(II)

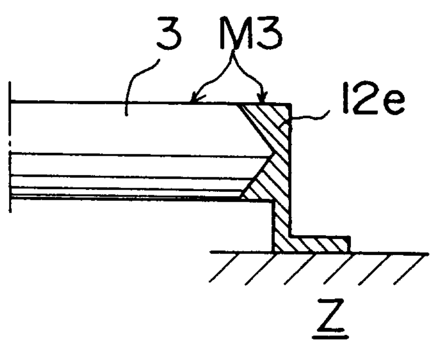


Fig. 20

(I)

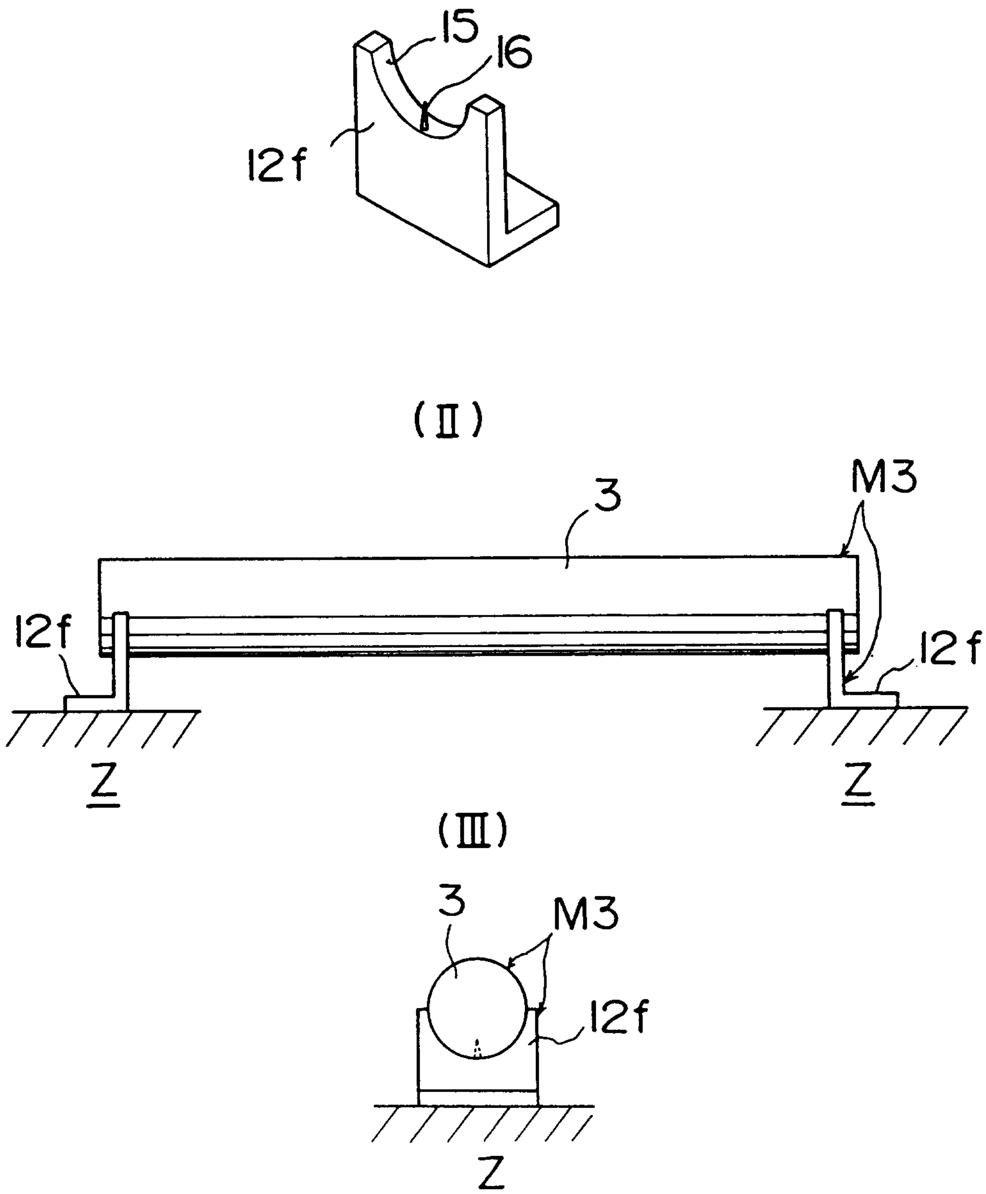
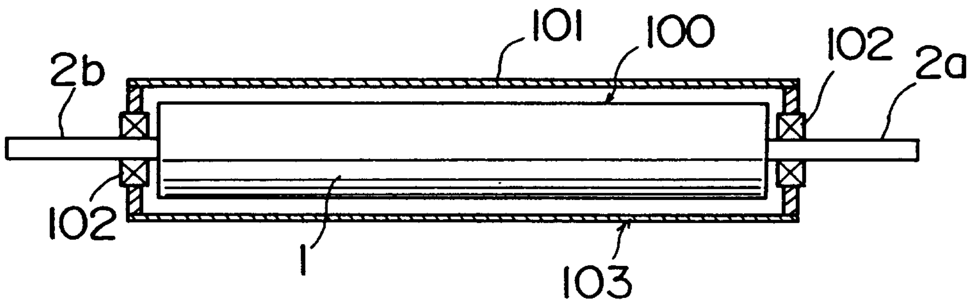


Fig. 21

(I)



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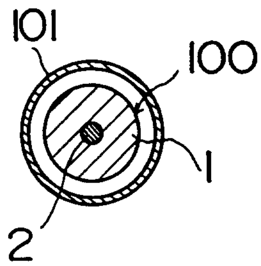

Fig. 22

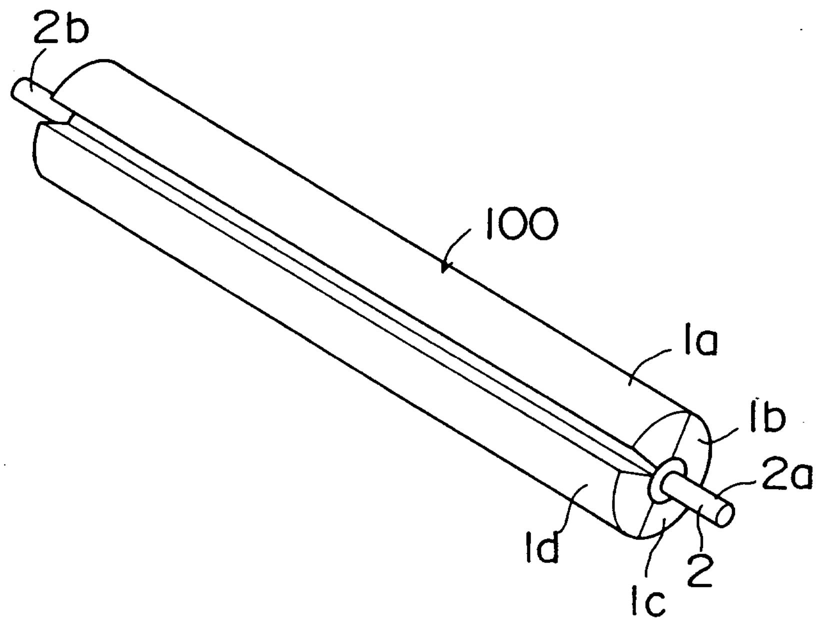

Fig. 23

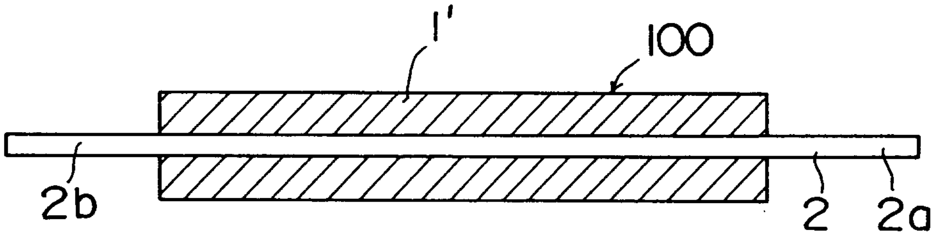

Fig. 24

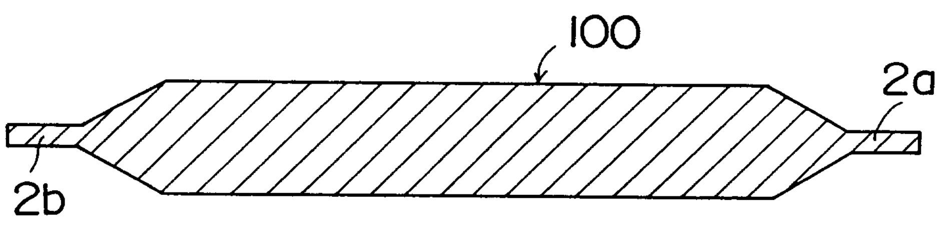

Fig. 25

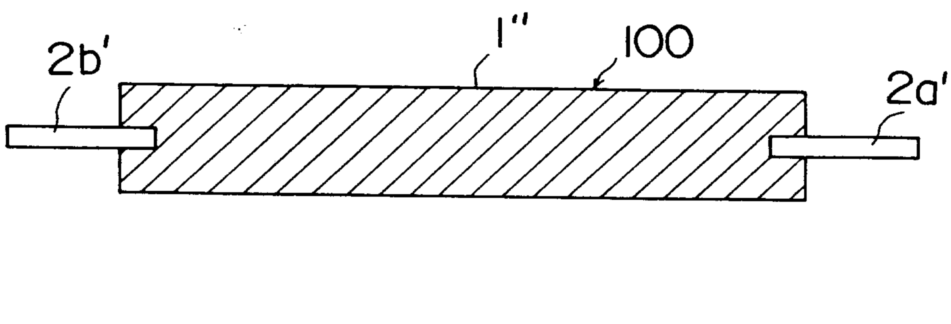

Fig. 26