

TITLE OF THE INVENTION

Pinch Roller Apparatus, Pinch Roller and Plain Bearing for Pinch Roller

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a pinch roller apparatus for feeding a magnetic tape with the magnetic tape pinched between the pinch roller apparatus and a capstan that is forced to rotate in a tape recorder, a VTR or the like, as well as to a pinch roller and a plain bearing for the pinch roller in the pinch roller apparatus.

Description of the Background Art

Fig. 10 shows an example of a conventional pinch roller apparatus. As shown in the figure, the pinch roller apparatus 1 includes a roller shaft 2, and a roller body 7 mounted around the roller shaft 2 with a plain bearing 3 interposed.

Roller shaft 2 is held by an arm 9, and has a small diameter portion on the tip end side, and a large diameter portion on the side of the arm 9. At the tip end of the small diameter portion of roller shaft 2, a cap member 6 is attached. The plain bearing 3 is placed on a stepped portion between the small diameter portion and the large diameter portion of roller shaft 2, with a resin washer 8 interposed.

The roller body 7 has an elastic body 13 formed of a synthetic rubber or the like, and a metal sleeve 4 mounted on an inner peripheral surface of the elastic body 13. Sleeve 4 has an engaging portion 4a to be engaged with plain bearing 3. Plain bearing 3 is fitted inside the sleeve 4. A stop member for preventing slipping out of plain bearing 3 is attached on the inside of sleeve 4.

In the conventional pinch roller apparatus 1, cap member 6 and stop member 5 for preventing slipping are incorporated between roller shaft 2 and roller body 7. Therefore, substantial gap D1 between roller shaft 2 and roller body 7 becomes smaller, limiting the angle of inclination of roller body 7 with respect to roller shaft 2. This leads to a concern over decreased self-alignment function of roller body 7.

The self-alignment function refers to the function of adjusting parallelism between the core of capstan 10 and the axis of rotation of roller body 7 by the play in the direction of inclination of the roller body 7 with respect to the roller shaft 2, so that the core of capstan 10 is made parallel to the axis of rotation of roller body 7.

Further, if the space between the roller shaft 2 and the roller body 7 is small, it becomes difficult to increase thickness of the cap member 6. Accordingly, the force necessary to pull out the cap member 6 from roller body 7 decreases, and hence it becomes more likely that the cap member 6 is undesirably slipped out from the roller body 7.

The above-described problems will be more serious as the pinch roller apparatus 1 is reduced in size.

The present invention was made to solve the above-described problems. An object of the present invention is to increase a substantial space between the roller shaft and the roller body of a pinch roller apparatus.

SUMMARY OF THE INVENTION

The pinch roller apparatus in accordance with the present invention includes a roller shaft, a cylindrical plain bearing, and a roller body. The roller body is mounted around the roller shaft with the plain bearing interposed, and has a metal sleeve and a cylindrical elastic body fixed on an outer peripheral surface of the sleeve. The plain bearing includes an inner peripheral portion and an outer peripheral portion formed of a material different from that of the inner peripheral portion, and is fixed in the sleeve.

In the present invention, the pinch roller refers to portions of the pinch roller apparatus other than the roller shaft. The pinch roller in accordance with the present invention includes the plain bearing having the above-described structure and the roller body.

By appropriately selecting the material of the outer peripheral portion of the plain bearing, it becomes possible to press-fit the plain bearing in the metal sleeve. Accordingly, the stop member for preventing slipping and the engaging portion shown in Fig. 10 can be omitted, enabling increase of the substantial space between the roller shaft and the roller body. As a

result, the self-alignment function of the roller body can be improved. If a cap member is to be attached at the tip end of the roller shaft, it is possible to increase the thickness of the cap member, effectively preventing slipping of the cap member out from the roller shaft. Further, by appropriately
5 selecting the material of the inner peripheral portion of the plain bearing, friction coefficient between the outer peripheral surface of the roller shaft and the plain bearing can be decreased.

The inner peripheral portion is preferably implemented by a member (for example, resin) having slidability over the roller shaft, and the
10 outer peripheral portion is implemented by a member (for example, metal, ceramics, or a filled synthetic resin) that holds the inner peripheral portion and can be fixed on the sleeve. The above-described effects can be attained thereby.

The roller shaft has a small diameter portion on one end, and a large
15 diameter portion on the other end. On a stepped portion between the small diameter portion and the large diameter portion, the plain bearing is placed. Preferably, only the inner peripheral portion is in sliding-contact with the stepped portion. Here, by appropriately selecting the material of the inner peripheral portion, friction coefficient between the stepped portion and the
20 inner peripheral portion can be decreased.

Further, as the inner peripheral portion only is in sliding-contact with the stepped portion, variation in the amount of wear along the radial direction of the plain bearing can be reduced as compared when both inner and outer peripheral portions slide over the stepped portion.

25 A resin washer may be inserted between the stepped portion and the plain bearing.

In that case, it becomes possible to bring the inner peripheral portion into sliding-contact with the resin washer, and the amount of wear of the inner peripheral portion can be reduced than when the inner peripheral
30 portion is in sliding-contact with the stepped portion.

The outer diameter of an end surface along the axial direction of the inner peripheral portion of the plain bearing positioned on the side of the large diameter portion of the roller shaft should preferably be the same or

larger than the diameter of the large diameter portion of that portion on which the plain bearing is placed.

5 In this case also, it becomes possible to bring only the inner peripheral portion of the plain bearing into sliding-contact with the surface of the stepped portion of the roller shaft, and the friction coefficient between the surface of the stepped portion and the plain bearing can be decreased. Further, as the inner peripheral portion only is in sliding-contact with the stepped portion, variation of the amount of wear along the radial direction of the plain bearing can be reduced as compared with when both inner and
10 outer peripheral portions are in sliding-contact with the stepped portion.

When the resin washer is inserted between the stepped portion and the plain bearing, the outer diameter on an end surface along the axial direction of the inner peripheral portion positioned on the side of large diameter portion is, preferably, the same or larger than the outer diameter
15 of the washer.

Accordingly, it becomes possible to bring the inner peripheral portion into sliding-contact with the resin washer, and the amount of wear of the inner peripheral portion can be reduced than when the inner peripheral portion is in sliding-contact with the stepped portion.

20 Preferably, the thickness at an end surface in the axial direction of the inner peripheral portion positioned on the side of the large diameter portion is larger than the thickness of a central portion along the axial direction of the inner peripheral portion, and the thickness at an end surface along the axial direction of the outer peripheral portion positioned on the
25 side of the large diameter portion is smaller than the thickness of the central portion along the axial direction of the outer peripheral portion.

By increasing the thickness of the inner peripheral portion at the end surface along the axial direction in this manner, it becomes possible to bring the inner peripheral portion only into sliding-contact with the roller
30 shaft or the washer, attaining the above described effects. By increasing the thickness of the central portion along the axial direction of the outer peripheral portion, it is possible to increase press-fitting strength of the plain bearing.

Preferably, the thickness at the end surface along the axial direction of the inner peripheral portion positioned on the side of the large diameter portion is larger than the thickness at the end surface along the axial direction of the outer peripheral portion positioned on the side of the large diameter portion.

In this case also, it is possible to increase the thickness of the inner peripheral portion at the end surface along the axial direction of the plain bearing, and hence it is possible to bring the inner peripheral portion only into sliding-contact with the roller shaft or the washer.

The plain bearing may be constituted of the inner peripheral portion and the outer peripheral portion. In that case, the thickness at the end surface along the axial direction of the inner portion positioned on the side of the large diameter portion is preferably at least 40% and at most 100% of the thickness at the end surface along the axial direction of the plain bearing, and the thickness at the central portion along the axial direction of the inner peripheral portion is preferably at least 3% and at most 80% of the thickness at the central portion along the axial direction of the plain bearing.

The inventor of the present invention has found that the ratio of the inner peripheral portion of the plain bearing within the above described range enables provision of a plain bearing having particular characteristics required for the pinch roller apparatus. More specifically, it has been found that a plain bearing enabling decrease in friction coefficient with the roller shaft and increase in the press-fitting strength into the sleeve can be obtained.

The plain bearing may have such a shape in that the inner peripheral portion protrudes along the axial direction at the end surface along the axial direction. In that case, only the inner peripheral portion can be brought into sliding-contact with the stepped portion or the washer, even when the outer diameter at the end surface along the axial direction of the inner peripheral portion is smaller than the diameter of the large diameter portion or the outer diameter of the washer.

When the inner peripheral portion is formed of a resin and the outer peripheral portion is formed of a metal, the plain bearing can be formed by

insert molding. The outer peripheral portion has a surface portion preferably formed of a sintered metal and extending inward in the radial direction of the outer peripheral portion. Preferably, the inner peripheral portion extends on the surface portion.

5 By adopting insert molding, the plain bearing can be formed with high precision at a low cost. At this time, as the outer peripheral portion is formed of a sintered metal, it is possible to pour the resin into the voids at the surface of the outer peripheral portion. Therefore, by the anchoring effect, the inner peripheral portion and the outer peripheral portion can be
10 joined without using any adhesive. As the adhesive can be omitted, the manufacturing cost can be reduced. Further, as the outer peripheral portion has such a surface portion as described above, peeling of the inner peripheral portion resulting from shrinkage of the inner peripheral portion at the time of curing can effectively be suppressed. Further, junction
15 strength between the inner peripheral portion and the outer peripheral portion in the radial direction of the plain bearing can also be improved.

Preferably, the inner peripheral portion has an engaging portion extending along the axial direction of the inner peripheral portion and engages with the outer peripheral portion in the radial direction of the inner
20 peripheral portion.

This further improves junction strength between the inner peripheral portion and the outer peripheral portion in the radial direction of the plain bearing.

25 When the outer peripheral portion is formed of a sintered metal, metal powder for forming the outer peripheral portion should preferably have the grain diameter that can pass through a sieve whose opening is in the range of 60 meshes to 300 meshes (the maximum grain diameter is at least about 50 μm and at most about 250 μm).

30 Thus, the surface of the outer peripheral portion can be made rough, while maintaining shape retention at the time of forming or molding the outer peripheral portion. As the surface of the outer peripheral portion is made rough, junction strength between the inner and outer peripheral portions can be improved.

When the inner peripheral portion is formed of resin, preferably, the inner peripheral portion is formed of at least one material selected from the group comprising fluoropolymer, polyamide, polyacetal, polyethylene and polyethersulfone.

5 By using the above-described materials for the inner peripheral portion, not only the lubricating properties but also durability of the plain bearing can be improved. Preferably, the outer peripheral portion is formed of at least one material selected from the group consisting of metal, ceramics and filled synthetic resin.

10 Preferably, a tapered portion is provided on the outer peripheral surface near an end portion along the axial direction of the outer peripheral portion.

By providing the tapered portion on the outer peripheral surface of the outer peripheral portion, the operation of press-fitting the plain bearing is facilitated.

15 Further, it is preferable to form a recessed portion extending in the axial direction on the outer peripheral surface of the outer peripheral portion.

This ensures press-fit fixing of the plain bearing in the sleeve and, in addition, suppresses deformation of the sleeve when the plain bearing is press-fit.

20 The plain bearing for the pinch roller in accordance with the present invention includes an inner peripheral portion and an outer peripheral portion formed of a material different from that of the inner peripheral portion, and has a cylindrical shape. According to an aspect, the thickness of the inner peripheral portion at least at one end surface along the axial direction is larger than the thickness at the central portion along the axial direction of the inner peripheral portion, and the thickness of the outer peripheral portion of the aforementioned end surface is smaller than the thickness at the central portion along the axial direction of the outer peripheral portion.

30 According to another aspect, the thickness of the inner peripheral portion at least at one end surface along the axial direction is larger than the

thickness of the outer peripheral portion at the end surface.

By the adoption of the plain bearing as described above, it becomes possible to press-fit the plain bearing in a metal sleeve, as described above, and substantial space between the roller shaft and the roller body can be increased. Further, as the thickness of the inner peripheral portion at least at one end surface along the axial direction of the plain bearing is made large, friction coefficient between the roller shaft and the plain bearing can be decreased.

According to a still further aspect, the plain bearing for the pinch roller has an inner peripheral portion protruded over the outer peripheral portion along the axial direction, at an end surface along the axial direction of the plain bearing.

Accordingly, only the inner peripheral portion can be brought into sliding-contact with the roller shaft, whereby friction coefficient therebetween can be decreased.

According to a still further aspect, the plain bearing for the pinch roller has a recessed portion extending along the axial direction, on the outer peripheral surface of the outer peripheral portion.

Accordingly, it becomes possible to surely press-fit and fix the plain bearing in the sleeve, and deformation of the sleeve when the plain bearing is press-fit can be suppressed.

According to a still further aspect, the pinch roller apparatus includes a roller shaft, a cylindrical plain bearing, and a roller body mounted around the roller shaft with the plain bearing interposed, and having a sleeve and a cylindrical elastic body fixed on the outer peripheral surface of the sleeve. The plain bearing includes an inner peripheral portion formed of resin and an outer peripheral portion formed of a filled synthetic resin, and is fixed in the sleeve.

According to a still further aspect, the pinch roller includes a roller body having a metal sleeve and a cylindrical elastic body fixed on an outer peripheral surface of the sleeve, and a cylindrical plain bearing. The plain bearing includes an inner peripheral portion formed of resin and an outer peripheral portion formed of a filled synthetic resin, and is fixed in the

sleeve.

According to a still further aspect, the plain bearing for the pinch roller includes an internal peripheral portion formed of resin and an outer peripheral portion formed of a filled synthetic resin, and has a cylindrical shape.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross sectional view of the pinch roller apparatus in accordance with the present invention.

Fig. 2 is a cross sectional view of the plain bearing in accordance with the present invention.

Fig. 3 is an enlarged cross sectional view of the area 11 shown in Fig. 2.

Figs. 4 to 7 are cross sectional views of the first to fourth modifications of the plain bearing in accordance with the present invention.

Fig. 8 is a plan view of the plain bearing in accordance with the present invention.

Fig. 9 is a cross sectional view showing the pinch roller in accordance with the present invention.

Fig. 10 is a cross sectional view of a conventional pinch roller apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, embodiments of the present invention will be described with reference to Figs. 1 to 9. Fig. 1 is a cross sectional view showing the pinch roller apparatus 1 in accordance with one embodiment of the present invention, and Fig. 9 is a cross sectional view showing the pinch roller 14 of Fig. 1.

As can be seen from Fig. 1, pinch roller apparatus 1 includes a roller shaft 2, a cylindrical plain bearing 3, a cap member 6, a roller body 7 and a washer 8.

The roller shaft 2 is held by an arm 9, and has a small diameter portion at a tip end side and a large diameter portion on the side of the arm 9. At a stepped portion 2a between the small diameter portion and the large diameter portion, plain-bearing 3 is placed. Cap member 6 is attached at the tip end of the small diameter portion. The cap member is formed, for example, of a synthetic resin, and attached to the tip end of the small diameter portion by close fit.

Roller body 7 is mounted around the roller shaft 2 with plain bearing 3 interposed. Roller body 7 has a metal sleeve 4 and a cylindrical elastic body 13 formed of a synthetic rubber or the like, fixed on an outer peripheral surface of sleeve 4.

Plain bearing 3 has an inner peripheral portion and an outer peripheral portion of a material different from that of the inner peripheral portion, and fixed in the sleeve 4. The inner peripheral portion is implemented by a member having slidability over roller shaft 2, and the outer peripheral portion is implemented by a member that holds the inner peripheral portion and can be fixed on sleeve 4. The material of the inner peripheral portion may be resin or the like, and the material of the outer peripheral portion may be ceramics, filled synthetic resin (for example, glass fiber filled polyacetal) or the like.

In the example shown in Fig. 1, plain bearing 3 includes an annular resin portion 3a positioned on the inner peripheral side, and an annular metal portion 3b positioned on an outer peripheral side. The inner peripheral surface of plain bearing 3 is formed of a resin portion 3a, and the outer peripheral portion of plain bearing 3 is formed of a metal portion 3b. It should be noted, however, that at least part of the outer peripheral surface of plain bearing 3 might be formed by the metal portion 3b.

As at least a part of the outer peripheral surface of plain bearing 3 is formed by the metal portion 3b, it becomes possible to press-fit and fix the plain bearing 3 in a metal sleeve 4, which will be described later, as shown in Fig. 9. Accordingly, the stop member 5 for preventing slipping out and an engaging portion 4a protruding inward from the inner peripheral surface from the sleeve 4, shown in Fig. 10, can be omitted. Thus, substantial

space between the roller shaft 2 and the roller body 7 can be increased.

Further, as the stop member 5 becomes unnecessary, the cost can be reduced, and as the step of press-fitting the stop member 5 becomes unnecessary, the manufacturing steps can be simplified.

5 For example, in a pinch roller apparatus for a compact camera, the gap D2 shown in Fig. 1 must be at least 0.17 mm. When the present invention is applied to the pinch roller apparatus, the gap D2 of 0.35 mm could be ensured. This means that the angular range in which roller body 7 can be inclined is enlarged, and hence self-alignment function of the roller
10 body 7 can be improved.

As the substantial space between the roller shaft 2 and the roller body 7 is increased, it becomes possible to increase the thickness of the cap member 6 attached at the tip end of roller shaft 2. Therefore, a large force becomes necessary to pull out the cap member 6, and hence slipping out of
15 the cap member 6 from the roller shaft 2 can effectively be prevented.

When the inner peripheral surface of plain bearing 3 is formed by a resin portion 3a, it becomes possible to bring the resin portion 3a only to sliding-contact with the outer peripheral surface of roller shaft 2. Thus, friction coefficient between the outer peripheral surface of roller shaft 2 and
20 plain bearing 3 can be decreased.

Washer 8 is formed of resin, and inserted between the plain bearing 3 and the stepped portion 2a of roller shaft 2. Therefore, direct sliding-contact between plain bearing 3 and stepped portion 2a can be prevented, whereby the amount of wear of plain bearing can be reduced.

25 In the pinch roller apparatus 1 having the above described structure, arm 9 is driven so that roller body 7 together with roller shaft 2 are moved toward a capstan 10, and a tape is pinched between the roller body 7 and capstan 10. At this time, as the substantial space between roller shaft 2 and roller body 7 has been increased as described above, the self alignment
30 function of roller body 7 can be improved, so that the roller body 7 can better follow the capstan 10. This ensures running stability of the tape.

The structure of plain bearing 3 in accordance with the present invention will be described in detail with reference to Figs. 2 to 8.

Fig. 2 shows an example of the plain bearing 3 in accordance with the present invention. As can be seen in this figure, resin portion 3a and metal portion 3b are joined without using any adhesive therebetween. As the adhesive is omitted, the manufacturing cost can be reduced. The plain bearing 3 of this type can be formed by insert molding.

When plain bearing 3 is to be formed by insert molding, it is preferred that the surface of metal portion 3b is made rough, so that the resin flows into recessed portions on the surface of metal portion 3b at the time of molding, and resin portion 3a and the metal portion 3b can be joined tightly by the anchoring effect. By forming plain bearing 3 by insert molding, the plain bearing 3 can be formed with high precision at a low cost.

As shown in Fig. 2, metal portion 3b has a protruded portion 3b3 protruded inward in the radial direction of metal portion 3b, and a waist (recessed portion) 3b4 near a root of the protruding portion 3b3. The protruding portion 3b3 has a surface portion 3b2 extending inward in the radial direction of metal portion 3b. On the surface portion 3b2, a protruding portion 3a1 of the resin portion 3a extends. The protruding portion 3a1 protrudes outward in the radial direction of resin portion 3a, from the outer peripheral surface of resin portion 3a.

By the provision of the surface portion 3b2 as described above, it becomes possible to effectively suppress peeling of the resin portion 3a resulting from shrinkage of resin portion 3a at the time of curing and, in addition, it becomes possible to improve junction strength between the resin portion 3a and metal portion 3b in the radial direction of the plain bearing 3.

Further, as metal portion 3b is provided with a waist 3b4, it is possible to pour the resin into the waist 3b4. Accordingly, it becomes possible to form an engaging portion 3a2 extending in the axial direction of plain bearing 3 and engaging with the metal portion 3b in the radial direction of plain bearing 3. By the provision of engaging portion 3a2, stronger fixing of resin portion 3a and metal portion 3b in the radial direction of plain bearing 3 becomes possible.

The material of metal portion 3b may be a copper based sintered material or a copper alloy such as brass.

When plain bearing 3 is to be formed by insert molding, it is preferred that the metal portion 3b is formed of a sintered material. This makes it possible to pour the resin into the voids 30 on the surface of metal portion 3b as shown in Fig. 3, enabling strong joint between metal portion 3a and metal portion 3b. Fig. 3 is an enlarged cross section of the area 11 of Fig. 2.

When metal portion 3b is formed of a sintered material, the metal powder for forming metal portion 3b should preferably have the grain diameter that can pass through a sieve whose opening is in the range of 60 meshes to 300 meshes (the maximum grain diameter should be at least about 50 μm and at most about 250 μm). More preferably, the metal powder has the grain diameter that can pass through a sieve of 100 meshes. Thus, the surface of metal portion 3b can be made rough, while maintaining shape retention when the metal portion 3b is molded.

The resin portion 3a is formed of at least one material selected from the group including fluoropolymer, polyamide, polyacetal, polyethylene and polyethersulfone. When such a material is used for the resin portion 3a, not only the lubricating properties but also durability of plain bearing can be improved.

As shown in Fig. 2, an outer diameter d_2 at an end surface along the axial direction of resin portion 3a at the portion where plain bearing 3 is positioned is, preferably, the same as or larger than the diameter d_1 of the larger diameter portion of roller shaft 2. Thus, it becomes possible to bring only the resin portion 3a of plain bearing 3 into sliding-contact with the surface of stepped portion 2a of roller shaft 2. Therefore, as compared with the sliding-contact of both the resin portion 3a and metal portion 3b with the stepped portion 2a, friction coefficient between roller shaft 2 and plain bearing 3 can be reduced. Further, as the resin portion 3a only can be brought into sliding-contact with the stepped portion 2a, variation in the amount of wear in the radial direction of plain bearing 3 can also be reduced.

In the example shown in Fig. 2, a resin washer 8 is inserted between stepped portion 2a and plain bearing 3. Here, the outer diameter t_2 at the end surface along the axial direction of resin portion 3a positioned on the

side of large diameter portion is selected to be the same or larger than the outer diameter $d1$ of washer 8.

Thus, it becomes possible to bring the resin portion 3a into sliding-contact with the resin washer 8, and the amount of wear of resin portion 3a can be reduced than when the resin portion 3a is in direct sliding-contact with the stepped portion 2a.

Further, the thickness $t1$ at the end surface along the axial direction of resin portion 3a positioned on the side of the large diameter portion of roller shaft 2 is larger than the thickness $t2$ at the central portion along the axial direction of resin portion 3a, and the thickness $t3$ at the end surface along the axial direction of metal portion 3b positioned on the side of the large diameter portion is smaller than the thickness $t4$ at the central portion along the axial direction of metal portion 3b.

As the thickness $t1$ is increased as described above, it becomes possible to bring the resin portion 3a only into sliding-contact with the stepped portion 2a of roller shaft 2 or with the washer 8, and the above described effect can be attained. Further, as the thickness $t4$ at the central portion along the axial direction of metal portion 3b is increased, press-fitting strength of plain bearing 3 can be increased.

Further, the thickness $t1$ at the end surface along the axial direction of resin portion 3a positioned on the side of the large diameter portion of roller shaft 2 is made larger than the thickness $t3$ at the end surface along the axial direction of metal portion 3b positioned on the side of the large diameter portion, and the thickness $t2$ at the central portion along the axial direction of resin portion 3a is made smaller than the thickness $t4$ at the central portion along the axial direction of metal portion 3b.

More specifically, the thickness $t1$ at the end surface along the axial direction of resin portion 3a positioned on the side of the large diameter portion is set to be at least 40% and at most 100% (more preferably, at least 50% and at most 90%) of the thickness $t5$ at the end surface along the axial direction of plain bearing 3, and the thickness $t2$ at the central portion along the axial direction of resin portion 3a is set to be at least 3% and at most 80% (more preferably, at least 10% and at most 50%) of the thickness $t6$ at the

central portion along the axial direction of plain bearing 3, and the remaining part is occupied by the metal portion 3b. In this manner, the plain bearing 3 having superior characteristics as described above can be obtained.

5 The specific examples of the thicknesses t_1 to t_6 and outer diameters t_1 and t_2 are as follows. By way of example, the thickness t_1 is 0.87 mm, t_2 is 0.35 mm, t_3 is 0.3 mm, t_4 is 0.9 mm, t_5 is 1.17 mm, and t_6 is 1.25 mm. Further, by way of example, the outer diameter (diameter) d_1 is 2.4 mm and the outer diameter d_2 is 3.3 mm.

10 As shown in Fig. 2, a tapered portion 3b1 is provided on an outer peripheral surface near the end portion along the axial direction of metal portion 3b. The tapered portion 3b1 is inclined such that the diameter of plain bearing 3 is reduced toward the end surface along the axial direction of plain bearing 3. As the tapered portion 3b1 is provided on the outer
15 peripheral surface of metal portion 3b, press-fitting operation of plain bearing 3 into the sleeve 4 is facilitated.

 Modifications of plain bearing 3 will be described with reference to Figs. 4 to 7. Figs. 4 to 7 are cross sectional views representing modifications of the plain bearing 3.

20 The end surface along the axial direction of plain bearing 3 may be formed only by the resin portion 3a, as shown in Fig. 4. In this case, long surface portion 3b2 of metal portion 3b is ensured, whereby peeling of resin portion 3a can effectively be prevented.

 The plain bearing 3 having such a structure as shown in Fig. 4 may
25 be formed by insert molding. Forming in accordance with the following method, however, is also possible. Namely, the metal portion 3b is dipped in a melt resin so that the resin adheres on the surface of metal portion 3b, the resin is cured, and the resin on the outer peripheral surface of metal portion 3b is removed, whereby the plain bearing 3 is formed.

30 Alternatively, only the outer diameter d_2 of resin portion 3a at one end surface along the axial direction of plain bearing 3 may be increased, as shown in Fig. 5. In this case also, the surface portion 3b2 of metal portion 3b is ensured, and therefore the plain bearing 3 can be formed by insert

molding. Further, as the ratio of metal portion 3b can be increased, press-fitting strength of plain bearing 3 can be improved.

Further, the resin portion 3a may be protruded along the axial direction of plain bearing 3, at the end surface along the axial direction of plain bearing 3, as shown in Fig. 6. This makes it possible to bring the resin portion 3a only into sliding-contact with the stepped portion 2a of roller shaft 2.

Further, the resin portion 3a and the metal portion 3b may be adhered by an adhesive 12, as shown in Fig. 7. In this case also, by setting the outer diameter d2 of resin portion 3a to be the same or larger than the diameter d1 of the large diameter portion of roller shaft 2, for example, it is possible to bring the resin portion 3a only into sliding-contact with the stepped portion 2a of roller shaft 2 or the washer 8. It is also possible to interpose a layer other than the adhesive 12, between the resin portion 3a and the metal portion 3b.

The two-dimensional shape of plain bearing 3 will be described with reference to Fig. 8. As can be seen from Fig. 8, a plurality of grooves 15 are formed on an outer peripheral surface of metal portion 3b. The grooves 15 extend along the axial direction of plain bearing 3.

When plain bearing 3 is press-fit into sleeve 4, the sleeve 4 and/or metal portion 3b may possibly be deformed. By providing the grooves 15 on the outer peripheral surface of metal portion 3b, it becomes possible to receive part of the sleeve 4 (deformed portion) or part of the metal portion 3b (deformed portion) within the groove 15, when plain bearing 3 is press-fit. Thus, the plain bearing 3 can surely be fixed in sleeve 4 and, in addition, deformation of sleeve 4 after the press-fit of plain bearing 3 (for example, bulging in the radial direction) can be suppressed.

Though grooves 15 shown in Fig. 8 have been described as an example of recessed portions for receiving the deformed portion of sleeve 4 or deformed portion of metal portion 3b after the press-fit of plain bearing 3, recessed portion of an arbitrary shaped other than the grooves 15 may be provided on the outer peripheral surface of metal portion 3b.

Further, when the press-fit margin when the external member is

press-fit is adjusted to about 18 μm , deformation of the external member at the time of press-fit can be prevented, even without the provision of grooves 15. Further, if the press-fit margin is about 18 μm , slipping out of the external member can also be prevented.

5 Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

WHAT IS CLAIMED IS:

1. A pinch roller apparatus, comprising:
a roller shaft (2);
a cylindrical plain bearing (3); and
a roller body (7) mounted around said roller shaft (2) with said plain
5 bearing (3) interposed, and including a metal sleeve (4) and a cylindrical
elastic body (13) fixed on an outer peripheral surface of said sleeve (4);
wherein

said plain bearing (3) includes an inner peripheral portion (3a) and
an outer peripheral portion (3b) of a material different from that of the inner
10 peripheral portion (3a), and is fixed in said sleeve (4).

2. The pinch roller apparatus according to claim 1, wherein said
inner peripheral portion (3a) is implemented by a member having a
slidability over said roller shaft (2); and
said outer peripheral portion (3b) is implemented by a member that
5 holds said inner peripheral portion (3a) and can be fixed on said sleeve (4).

3. The pinch roller apparatus according to claim 1, wherein
said roller shaft (2) has a small diameter portion on one end and a
large diameter portion on the other end;
said plain bearing (3) is placed on a stepped portion (2a) between
5 said small diameter portion and said large diameter portion; and
said inner peripheral portion (3a) only is brought into sliding-contact
with said stepped portion (2a).

4. The pinch roller apparatus according to claim 1, wherein
said roller shaft has a small diameter portion on one end and a large
diameter portion on the other end;
said plain bearing (3) is placed on a stepped portion (2a) between
5 said small diameter portion and said large diameter portion with a resin
washer (8) interposed; and

said inner peripheral portion (3a) only is brought into sliding-contact with said washer (8).

5 5. The pinch roller apparatus according to claim 3, wherein an outer diameter (d2) at an end surface along the axial direction of said inner peripheral portion (3a) positioned on the side of said large diameter portion is equal to or larger than the diameter (d1) of said large diameter portion at that portion where said plain bearing (3) is placed.

6. The pinch roller apparatus according to claim 4, wherein the outer diameter (d2) at an end surface along the axial direction of said inner peripheral portion (3a) positioned on the side of said large diameter portion is equal to or larger than the diameter (d1) of said washer (8).

5 7. The pinch roller apparatus according to claim 5, wherein thickness (t1) at an end surface along the axial direction of said inner peripheral portion (3a) positioned on the side of said large diameter portion is larger than the thickness (t2) at a central portion along the axial direction of said inner peripheral portion (3a); and

thickness (t3) at an end surface along the axial direction of said outer peripheral portion (3b) positioned on the side of said large diameter portion is smaller than the thickness (t4) at the central portion along the axial direction of said outer peripheral portion (3b).

5 8. The pinch roller apparatus according to claim 6, wherein thickness (t1) at an end surface along the axial direction of said inner peripheral portion (3a) positioned on the side of said large diameter portion is larger than the thickness (t2) at a central portion along the axial direction of said inner peripheral portion (3a); and

thickness (t3) at an end surface along the axial direction of said outer peripheral portion (3b) positioned on the side of said large diameter portion is smaller than the thickness (t4) at the central portion along the axial direction of said outer peripheral portion (3b).

9. The pinch roller apparatus according to claim 5, wherein
 thickness (t1) at an end surface along the axial direction of said
 inner peripheral portion (3a) positioned on the side of said large diameter
 portion is larger than the thickness (t3) at an end surface along the axial
 direction of said outer peripheral portion (3b) positioned on the side of said
 large diameter portion.

10. The pinch roller apparatus according to claim 6, wherein
 thickness (t1) at an end surface along the axial direction of said
 inner peripheral portion (3a) positioned on the side of said large diameter
 portion is larger than the thickness (t3) at an end surface along the axial
 direction of said outer peripheral portion (3b) positioned on the side of said
 large diameter portion.

11. The pinch roller apparatus according to claim 7, wherein
 said plain bearing (3) is constituted of said inner peripheral portion
 (3a) and said outer peripheral portion (3b);

the thickness (t1) at an end surface along the axial direction of said
 inner peripheral portion (3a) positioned on the side of said large diameter
 portion is at least 40% and at most 100% of the thickness (t5) at an end
 surface along the axial direction of said plain bearing (3); and

the thickness (t2) at the central portion along the axial direction of
 said inner peripheral portion (3a) is at least 3% and at most 80% of the
 thickness (t6) at the central portion along the axial direction of said plain
 bearing (3).

12. The pinch roller apparatus according to claim 8, wherein
 said plain bearing (3) is constituted of said inner peripheral portion
 (3a) and said outer peripheral portion (3b);

the thickness (t1) at an end surface along the axial direction of said
 inner peripheral portion (3a) positioned on the side of said large diameter
 portion is at least 40% and at most 100% of the thickness (t5) at an end
 surface along the axial direction of said plain bearing (3); and

the thickness (t2) at the central portion along the axial direction of said inner peripheral portion (3a) is at least 3% and at most 80% of the thickness (t6) at the central portion along the axial direction of said plain bearing (3).

13. The pinch roller apparatus according to claim 3, wherein said inner peripheral portion (3a) protrudes along said axial direction, at an end surface along the axial direction of said plain bearing (3).

14. The pinch roller apparatus according to claim 4, wherein said inner peripheral portion (3a) protrudes along said axial direction, at an end surface along the axial direction of said plain bearing (3).

15. The pinch roller apparatus according to claim 1, wherein said inner peripheral portion (3a) is formed of resin, said outer peripheral portion (3b) is formed of a sintered metal and has a surface portion (3b2) extending inward in the radial direction of said outer peripheral portion (3b);
said plain bearing (3) is formed by insert molding; and
said inner peripheral portion (3a) extends on said surface portion (3b2).

16. The pinch roller apparatus according to claim 15, wherein said inner peripheral portion (3a) has an engaging portion (3a2) extending along the axial direction of the inner peripheral portion (3a) and engages with said outer peripheral portion (3b) in the radial direction of said inner peripheral portion (3a).

17. The pinch roller apparatus according to claim 1, wherein said outer peripheral portion (3b) is formed of a sintered metal, and metal powder for forming said outer peripheral portion (3b) has a grain

5 diameter that can pass through a sieve selected from the range of 60 meshes to 300 meshes.

18. The pinch roller apparatus according to claim 1, wherein
said inner peripheral portion (3a) is formed of resin; and
said inner peripheral portion (3a) is formed of at least one material selected
from the group including fluoropolymer, polyamide, polyacetal, polyethylene
5 and polyethersulfone.

19. The pinch roller apparatus according to claim 1, wherein
said outer peripheral portion is formed of at least one material
selected from the group including metal, ceramics and filled synthetic resin.

20. The pinch roller apparatus according to claim 1, wherein
a tapered portion (3b1) is provided on an outer peripheral surface
near an end portion along the axial direction of said outer peripheral portion
(3b).

21. The pinch roller apparatus according to claim 1, wherein
a recessed portion (15) extending along the axial direction is formed
on an outer peripheral surface of said outer peripheral portion (3b).

22. A pinch roller, comprising:
a roller body (7) having a metal sleeve (4) and a cylindrical elastic
body (13) fixed on an outer peripheral surface of said sleeve (4); and
a cylindrical plain bearing (3),
5 said plain bearing (3) including an inner peripheral portion (3a) and
an outer peripheral portion (3b) of a material different from that of said
inner peripheral portion (3a) and being fixed in said sleeve (4).

23. A plain bearing for a pinch roller, including an inner peripheral
portion (3a) and an outer peripheral portion (3b) of a material different from
the material of said inner peripheral portion (3a); wherein

5 thickness (t1) of said inner peripheral portion (3a) at least at one end surface along the axial direction is larger than the thickness (t2) at the central portion along the axial direction of said inner peripheral portion (3a); and

10 thickness (t3) of said outer peripheral portion (3b) at said end surface is smaller than the thickness (t4) at the central portion along the axial direction of said outer peripheral portion (3b).

24. A plain bearing for a pinch roller, including an inner peripheral portion (3a) and an outer peripheral portion (3b) of a material different from that of the inner peripheral portion (3a); wherein

5 thickness (t1) of said inner peripheral portion (3a) at least at one end surface along the axial direction is larger than thickness (t3) of said outer peripheral portion (3b) at said end surface.

25. A plain bearing for a pinch roller, including an inner peripheral portion (3a) and an outer peripheral portion (3b) of a material different from that of said inner peripheral portion (3a); wherein

5 said inner peripheral portion (3a) protrudes along said axial direction over said outer peripheral portion (3b) at an end surface along the axial direction of said plain bearing (3).

26. A plain bearing for a pinch roller including an inner peripheral portion (3a) and an outer peripheral portion (3b) of a material different from that of the inner peripheral portion (3a); wherein

5 a recessed portion (15) extending in the axial direction is formed on an outer peripheral surface of said outer peripheral portion (3b).

27. A pinch roller apparatus, comprising:

a roller shaft (2);

a cylindrical plain bearing (3); and

5 a roller body (7) mounted around said roller shaft (2) with said plain bearing (3) interposed, and having a metal sleeve (4) and a cylindrical

elastic body (13) fixed on an outer peripheral surface of said sleeve (4);
wherein

10 said plain bearing (3) includes an inner peripheral portion (3a)
formed of resin and an outer peripheral portion (3b) formed of a filled
synthetic resin, and fixed in said sleeve.

28. A pinch roller comprising:

 a roller body (7) having a metal sleeve (4) and a cylindrical elastic
body (13) fixed on an outer peripheral surface of said sleeve (4); and
 a cylindrical plain bearing (3); wherein

5 said plain bearing includes an inner peripheral portion (3a) formed
of resin and an outer peripheral portion (3b) formed of filled synthetic resin,
and fixed in said sleeve (4).

29. A plain bearing for a pinch roller, comprising an inner
peripheral portion (3a) formed of resin and an outer peripheral portion (3b)
formed of a filled synthetic resin, and having a cylindrical shape.