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(54) **Rubber roller, and paper sheet take-out apparatus including the rubber roller**

(57) A take-out roller (4) which rotates and contacts a paper sheet (P) supplied to a take-out position has an outer layer (42) to contact the paper sheet (P) and an inner layer (44) provided inside the outer layer. The outer layer (42) is made of relatively hard rubber material with a sufficient coefficient of kinetic friction. The inner layer (44) is made of relatively soft non-foamed rubber material deformable by a relatively weak force. When the take-out roller (4) contacts the paper sheet (P) supplied to the take-out position in the inclined state, the inner layer (44) is largely deformed, and the outer surface of the outer layer (42) stably contacts the surface of the paper sheet (P).

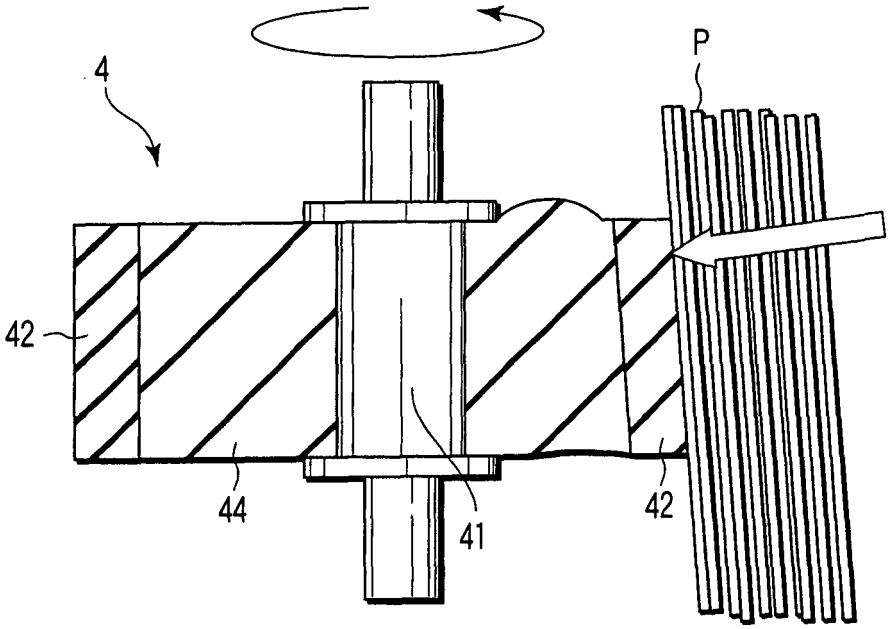

FIG. 6

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Description

[0001] The present invention relates to a rubber roller to contact and rotates with a paper sheet, and a paper sheet take-out device including the rubber roller.

[0002] As a conventional paper sheet take-out apparatus, there is a known apparatus, which takes out a stack of paper sheets one by one, and feeds the paper sheets to a processor in a later state.

[0003] This take-out apparatus has a stacker to house paper sheets stacked upright, a take-out roller pressed to contact a paper sheet at one end of the stacking direction of the paper sheets housed in the stacker, and a separation unit which separates paper sheets doubly taken out by receiving and passing the taken-out paper sheets through a nip (e.g., Jpn. Pat. Appln. KOKAI Publication No. 2003-341860).

[0004] The take-out roller rotates and contacts a paper sheet at one end of the stacking direction, and takes out the paper sheet by the frictional force generated between the peripheral surface and the paper sheet surface. At this time, if the paper sheet at one end of the stacking direction is inclined when contacting the take-out roller, the take-out roller rotates by contacting the paper sheet at the edge, and insufficient frictional force is applied to the paper sheet. If the rotation of the take-out roller is continued with the edge contacting the paper sheet, the take-out roller will be unevenly worn, the edge of the roller will become round, and the contact area of the take-out roller to an upright paper sheet will become smaller.

[0005] When the frictional force of the take-out roller to a paper sheet is insufficient, a paper sheet cannot be normally taken out. If the contact pressure of the take-out roller to a paper sheet is increased with time, the possibility of multiply feeding two or more overlapped paper sheets is increased.

[0006] It is an object of the invention to provide a rubber roller to stably generate a sufficient frictional force regardless of the state of a paper sheet to contact, and a paper sheet take-out apparatus including the rubber roller.

[0007] In order to achieve the above object, a rubber roller according to an embodiment of the invention rotates by contacting a paper sheet, has an outer layer made of rubber material of JIS-A with a hardness over 35 Ha and below 90 Ha, and an inner layer provided inside the outer layer and made of non-foamed rubber material of JIS-A with a hardness over 5 Ha and below 25 Ha.

[0008] According to the rubber roller of the invention, the hardness of the outer layer is set to over JIS-A 35 Ha and below 90 Ha to ensure a sufficient wear proof, and the inner layer hardness is set soft over JIS-A 5 Ha and below 25 Ha. Therefore, the rubber roller is configured to make contact with a paper sheet stably and sufficiently widely by deforming the inner surface according to the state (e.g., inclination) of a paper sheet to make contact with the outer surface, and a sufficient friction force is applied to the paper sheet surface irrespectively of the state of the paper sheet. This eliminates the necessity of a mechanism to move the rubber roller according to the changes in the state of the paper sheet, simplifies the structure of the apparatus, reduces the manufacturing cost of the apparatus, and reduces the size of the apparatus. Moreover, the periphery of the roller stably contacts a paper sheet, and the edge of the outer layer does not contact a paper sheet and is not unevenly worn, and a decrease in the frictional force with time is prevented.

[0009] Further, a rubber roller according to an embodiment of the invention has a substantially cylindrical roller body which is made of rubber material, has an outer surface to contact a paper sheet, and a remover which is made soft by partially removing the roller body, to make the outer surface sufficiently contact a paper sheet by deforming the roller body to meet the state of a paper sheet to contact.

[0010] According to the rubber roller of the invention, since a remover made by removing a part of the roller body is provided, the roller body is made soft in an area of the remover, the roller body is easily deformed to meet the state (e.g., inclination) of the paper sheet contacting the outer surface, and the outer surface of the roller contacts the paper sheet stably and sufficiently widely.

[0011] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a top plane view showing the structure of a paper sheet take-out apparatus according to an embodiment of the invention;

FIG. 2 is a front view of the take-out apparatus of FIG. 1, viewed from the upstream side of a direction of taking out paper sheets;

FIG. 3 is a side view of the take-out apparatus of FIG. 1, viewed from one end of a direction of stacking paper sheets;

FIG. 4 is a view showing a paper sheet inclined to a take-out roller, and wear of the take-out roller;

FIG. 5 is a view showing a paper sheet inclined to a backup plate, and wear of the take-out roller;

FIG. 6 is a sectional view showing a take-out roller according to a first embodiment of the invention;

FIG. 7 is a partially enlarged sectional view for explaining a barrier layer of the take-out roller of FIG. 6;

FIG. 8 is a graph for explaining the characteristics of an outer layer of the take-out roller of FIG. 6;

FIG. 9 is a graph for explaining the characteristics of an inner layer of the take-out roller of FIG. 6;

FIG. 10 is s sectional view showing a take-out roller according to a second embodiment of the invention;

FIG. 11 is a sectional view showing a modification of the take-out roller of FIG. 10;

FIG. 12 is a view showing the state that a paper sheet is separated by a rubber roller according to a third embodiment of the invention;

FIG. 13 is a view showing the state that a paper sheet is fed out by rotating the rubber roller of FIG. 12 in

the forward direction;

FIG. 14 is a view showing a first modification of the rubber roller of FIG. 12; and

FIG. 15 is a view showing a second modification of the rubber roller of FIG. 12.

[0012] Embodiments of the invention will be explained in detail hereinafter with reference to the accompanying drawings.

[0013] FIG. 1 is a top plane view showing the structure of a paper sheet take-out apparatus 1 (hereinafter simply called a take-out apparatus) according to an embodiment of the invention. FIG. 2 a front view of the take-out apparatus 1 of FIG. 1, viewed from the upstream side of a direction of taking out paper sheets P. FIG. 3 is a side view of the take-out apparatus 1 viewed from a direction of stacking paper sheets P.

[0014] As shown in FIG. 1, the take-out apparatus 1 has a stacker 2 which houses the paper sheets P such as mail stacked upright, a take-out roller 4 (a rubber roller) which contacts and rotates with the paper sheet P1 supplied to a take-out position at one end of a stacking direction (the left end in the drawing), and takes out the paper sheet P1 in the substantially horizontal direction substantially orthogonal to the stacking direction (in the direction of the arrow T in the drawing), a floor belt 6 which is extended movably along the paper sheets P stacking direction in the state contacting the lower end sides of all paper sheets P housed in the stacker 2, a backup plate 8 which is provided movably in the stacking direction in the state facing closely to the upper end of the paper sheet P2 at the other end of the stacking direction (at the right end in the drawing) remote from the floor belt 6, and a separation unit 10 (a separation mechanism) which separates the paper sheets P taken out by the take-out roller 24 one by one, and feed the paper sheet to a processor in a later state.

[0015] As shown in FIG. 2, the take-out roller 4 has a lower roller 4L to contact the paper sheet P1 at one end of the stacking direction in the area close to the lower end, and an upper roller 4U to contact the paper sheet P1 in the area close to the upper end. The lower roller 4L and upper roller 4U are provided rotatably along the predetermined direction about a rotation axis 5 (refer to FIG. 1) extended in a substantially vertical direction, that is, the direction of taking out the paper sheet P1 (in the direction of the arrow T in FIG. 1) .

[0016] The rotation axis 5 of the rollers 4L and 4U is pivotally fixed to the distal ends of arms 11L and 11U. The proximal ends of the arms 11L and 11U are pivotally fixed to a not-shown casing of the take-out apparatus 1. Therefore, when the arms 11L and 11U are driven by motors 14L and 14U (refer to FIG. 3) described later, the rollers 4L and 4U contact and separate from the paper sheet P1 at one end of the stacking direction.

[0017] At the proximal ends of the arms 11L and 11U, sensors 12L and 12U are provided to detect the positions of the rollers 4L and 4U contacting the paper sheet P1, or the positions XL and XU of the rollers 4L and 4U along the stacking direction rotationally contacting the paper sheet P1 at one end of the stacking direction, by detecting the rotational angles of the arm 11.

[0018] At the proximal ends of the arms 11L and 11U, motors 14L and 14U are provided to swing the arms 11L and 11U through link mechanisms 13L and 13U (refer to FIG. 3) are connected. The arms 11L/11U, link mechanisms 13L/13U and motors 14L/14U move the rollers 4L and 4U in the direction of stacking the paper sheet P.

[0019] As shown in FIG. 3, sensors 15L and 15U are provided at the middle of the link mechanisms 13L and 13U to detect the pressures of FL and FU of the rollers 4L and 4U contacting the paper sheet P1. The sensor 15L detects the contact pressure FL of the lower roller 4L to the paper sheet P1, and the sensor 15U detects the contact pressure FU of the upper roller 4U to the paper sheet P1. Namely, the rollers 4L and 4U are brought into contact with the paper sheet P1 at a desired contact pressure, by driving the motors 14L and 14U by monitoring the outputs of the sensors 15L and 15U.

[0020] At the proximal end of the arms 11L and 11U, two pulleys 16 and 17 are provided as one unit rotatably and coaxially with the rotational axis of the arm 11. An endless belt 18 wound on a pulley 4a provided on the rotation axis 5 of the rollers 4L/4U is wound on the pulley 16. An endless belt 20 wound on a pulley 19a provided on the rotation axis of the motor 19 to simultaneously rotate the rollers 4L and 4L is provided on the other pulley 17. Therefore, the lower roller 4L and upper roller 4U are rotated in a predetermined direction at a desired speed by driving the motor 19.

[0021] The floor belt 6 has two endless belts extended over along the paper sheet P stacking direction in the front and rear sides of the apparatus. A motor 22 for driving the floor belt 6 in the forward and rearward directions along the stacking direction is provided on the rotation axis 6a of the roller (not shown) on which the belts are wound.

[0022] The backup plate 8 is provided slidably with respect to a rail 24 extended in the stacking direction, at a position close to the upper end of the paper sheet stack, in the rear side of the stacker 2 and remote from the floor belt 6. The backup plate 8 is provided at a position opposite to the upper end of the paper sheet P2 housed upright in the stacker 2 at the other end of the stacking direction. The backup plate 8 is moved in the stacking direction along the rail 24, by a motor 26 connected through a not-shown driving mechanism.

[0023] The floor belt 6 driven by the motor 22 and the backup plate 8 driven by the motor 26 functions as a supply mechanism of the invention, which cooperates and moves the paper sheets stacker in the stacker 2 in the stacking direction, and supplies the paper sheet P1 at one end of the stacking direction to the take-out position.

[0024] In the take-out apparatus 1, as the take-out roller 4 takes out the stacked paper sheet to the conveying

path sequentially from the paper sheet P1 stacked at one end of the stacking direction, the floor belt 6 is driven whenever the paper sheet P is taken out, and the backup plate 8 is moved. In other words, the floor belt 6 and backup plate 8 are driven, so that the paper sheet P1 at one end of the stacking direction is always supplied to the take-out position.

[0025] As shown in FIG. 1, the separation unit 10 has a feed roller 32 provided at a position rotationally contacting one side (the left side in FIG. 1) of the paper sheet P taken out in the direction of the arrow T by the take-out roller 4, and a separation roller 34 (rubber roller) provided opposite to the feed roller 32 with a predetermined gap through the paper sheet conveying path. The separation unit 10 has a motor 36 to rotate the feed roller 32 in the paper sheet feeding direction (forward), and a motor 38 to impart a reverse torque to the separation roller 34.

[0026] An endless belt 33 is extended over a pulley 36a provided on the rotation axis of a motor 36 and a pulley 32a provided on the rotation axis of the feed roller 32. An endless belt 35 is extended over a pulley 38a provided on the rotation axis of a motor 38 and a pulley 34a provided on the rotation axis of a separation roller 34. Therefore, the feed roller is rotated forward by the motor 36, and a reverse separation torque is imparted to the separation roller 34 by the motor 38.

[0027] The take-out apparatus 1 has a control unit 40, which monitors the outputs of the sensors 12L, 12U, 15L and 15U, and controls the driving of the motors 14L, 14U, 19, 22, 26, 36, and 38. The control unit 40 controls the motors 14L and 14U, and adjusts the contact pressures FL and FU of the upper and lower rollers 4U and 4L to optimum values, based on the detection results of the sensors 15L and 15U. The control unit 40 controls the motors 22 and 26, moves the floor belt 6 and/or backup plate 8, and adjusts the contact pressures FL and FU of the upper roller 4U and/or lower roller 4L to optimum values.

[0028] As the take-out apparatus 1 collectively inputs and processes several kinds of paper sheets P such as mail with different size and thickness, after several numbers of paper sheets P are stacked and set in the stacker 2, the paper sheet P1 stacked at one end of the stacking direction is rarely supplied in a state upright to the outer surface of the take-out roller 4.

[0029] Therefore, as shown in FIG. 2, for example, if the paper sheets P set in the stacker are supplied to the take-out position in the state that the upper end side remote from the floor belt 6 is inclined to the roller 4, the upper roller 4U contacts the area close to the upper end of the paper sheet P1 stacked at one end of the stacking direction, but the lower roller 4L does not contact the paper sheet P. If the paper sheet P is continuously taken out in this state, the corner of the upper roller 4U contacting the paper sheet P is partially worn. The inclination angle of the paper sheet P with a different size is not constant, and the corner of the upper roller is rounded as shown in FIG. 4 when the wear advances.

[0030] When the wear of the upper roller 4U advances to the state shown in FIG. 4, for example, the upper roller 4U contacts the paper sheet P substantially at a point, and the frictional force between the upper roller 4U and the surface of the paper sheet P becomes very small. In this time, the roller 4L does not contact the paper sheet P, the frictional force of two take-out rollers 4 to the paper sheet P becomes very small.

[0031] Contrarily, if the paper sheet P set in the stacker 2 is supplied to the take-out position in the state inclined to the backup plate 8, only the lower roller 4L contacts the paper sheet P1, and the upper roller 4U does not contact the paper sheet. If the paper sheet P is continuously taken out in this state, the corner of the lower roller 4L is worn and rounded as shown in FIG. 5. Namely, as the lower roller 4L contacts the paper sheet P at a point and the upper roller 4U does not contact the paper sheet P, the frictional force of two take-out rollers 4 to the paper sheet P becomes very small.

[0032] The frictional force decrease caused by the partial wear of the take-out roller 4 gradually advances from the initial state of the roller, and the frictional force is gradually decreased from immediately after the start of using the roller. To prevent the decrease of the frictional force, it is considerable to gradually increase the contact pressure of the take-out roller 4 to the paper sheet P. However, if the contact pressure of the take-out roller 4 is increased, there arises another problem of mis-feeding of several paper sheets P. The partial wear of the take-out roller 4 reduces the life of the roller in a very short time.

[0033] Therefore, in an embodiment of the invention, even if the paper sheet P is supplied to the take-out position in the inclined state, the take-out roller 4 follows the inclination of the paper sheet P and changes the form, and the outer surface of the take-out roller 4 is brought into contact with the surface of the paper sheet P in a sufficient area, without increasing the contact pressure to the paper sheet P. Hereinafter, an explanation will be given on the take-out roller 4 according to a first embodiment of the invention with reference to FIG. 6.

[0034] As shown in FIG. 6, the take-out roller 4 has an outer layer 42 made of relatively hard rubber having a sufficient coefficient of kinetic friction to the surface of the paper sheet P to contact and being sufficiently wear-proof, and an inner layer 44 provided inside the outer layer 42 and made of relatively soft rubber deformable by a weak force. Concretely, the take-out roller 4 of this embodiment is formed by bonding the inner layer 44 to the outer surface of a core member 41, and bonding the outer layer 42 to the outer surface of the inner layer 44 through a barrier layer 46 shown partially enlarged in FIG. 7.

[0035] In particular, the outer layer 42 of the take-out roller 4 is made of natural rubber, EPDM rubber or urethane rubber of JISK 6253 type A (JIS-A) having the coefficient of kinetic friction 1.0-1.5 to the surface of copy paper or envelope to contact, and the hardness of 35-90

Ha.

[0036] FIG.8 is a graph showing the relation between the hardness of the rubber of the outer layer 42 and the coefficient of kinetic friction to an envelope. As measuring conditions, the pressing load of the take-out roller 4 is 100 g, and the relative sliding speed of the roller surface to an envelope is 1 m/s. It is seen from the graph that as the rubber roller hardness increases, the coefficient of kinetic friction decreases.

[0037] If the hardness of the outer layer 42 is lower than 35 Ha, the wear proof of the rubber roller is largely decreased and the life of the roller is reduced. Contrarily, if the hardness of the outer layer 42 is higher than 90 Ha, the coefficient of kinetic friction of the rubber roller is rapidly decreased to be lower than the coefficient of static friction between envelopes (approximately 0.4 Ha), and an envelope cannot be taken out. Namely, by setting the hardness of the outer layer 42 to over 35 Ha and below 90 Ha, the wearproof characteristic sufficient to take out the paper sheet P can be ensured, and the coefficient of kinetic friction necessary to take out an envelope can be ensured.

[0038] The inner layer 44 is made of rubber material of JIS-A with the hardness of 5-25 Ha, such as butyl rubber or EPDM rubber. By making the inner layer 44 of the take-out roller 4 of relatively soft rubber, the take-out roller 4 can be easily deformed to follow the state of the paper sheet P contacting the outer surface of the outer layer 42 of the take-out roller 4, and the outer surface of the outer layer 42 contacts the surface of the paper sheet P stably in a relatively wide area.

[0039] FIG. 9 is a graph showing the relationship between the coefficient of kinetic friction and the hardness of the inner layer 44 of the take-out roller 4 whose outer layer 42 is made of EPDM rubber with the hardness of 60 Ha, by taking the inclination angle of the paper sheet P to the take-out roller 4 as a parameter. It is seen from the graph that when the hardness of the inner layer 44 is set to over 5 Ha and below 25 Ha, a sufficiently large coefficient of kinetic friction can be obtained at each inclination angle.

[0040] Namely, if the hardness of the inner layer 44 is lower than 5 Ha, the rubber strength becomes insufficient, the rotation force of the axis is not transmitted to the rubber roller, and the roller is broken. Contrarily, if the hardness of the inner layer 44 is higher than 5 Ha, the rubber roller is insufficiently deformed at each inclination angle of an envelope, the coefficient of kinetic friction is not sufficiently increased, and the roller is partially worn. In other words, by setting the hardness of the inner layer 44 to over 5 Ha and below 25 Ha, the outer surface of the outer layer 42 stably contacts the paper sheet P inclined at various angles, and a sufficiently large frictional force can be applied to the paper sheet.

[0041] The inner layer 44 bonded to the outer surface of the metal bar 41 may be made of other elastic materials such as a sponge and gel, but a stress may be generated in the clearance to the core member 41 by the rotation of roller, and the rubber roller may be broken.

Therefore, it is necessary to use a non-foamed rubber for the inner layer 44.

[0042] The barrier layer 46 shown partially enlarged in FIG. 7 is provided to prevent transfer of a plasticizer between the inner layer 44 and outer layer 42. The barrier layer is made of material whose index of solubility (SP value) of a transfer component is largely different from the SP values of the plasticizer of the inner layer 44 and outer layer 42. Namely, when different kinds of rubber contact for a relatively long time, it is known that a plasticizer is mainly transferred between the different kinds of rubber.

Such a transfer of component occurs easily when the index of solubility of a transfer component is closer to that of a rubber.

[0043] Concretely, in the take-out roller 4 of this embodiment, a plasticizer such as dioctyl adipate (DOA) and diethyl phthalate (DEP) is transferred from the relatively soft inner layer 44 to the outer layer 42, and the outer layer 42 may be denatured. The SP value of a plasticizer of the inner layer 44, such as dioctyl adipate (DOA) and diethyl phthalate (DEP), is a relatively high value, for example, 8.7 or 10. Therefore, the barrier layer 46 is desirably made of resin such as ethylene resin terafluoride (PTFE, SP value 7.3), polyethylene (PE, SP value 7.9) and polypropylene (PP, SP value 7.9).

[0044] In this embodiment, the barrier layer 46 is made of rubber having an index of solubility lower than at least that of the component transferred from the inner layer 44 to the outer layer 42 and that of the component transferred from the outer layer 42 to the inner layer. This prevents denaturation of the inner layer 44 or outer layer 42 caused by the transfer of plasticizer, and prevents degradation of the characteristics of the take-out roller 4.

[0045] As described above, according to this embodiment, by the denaturing the inner layer 44 of the take-out roller 4, the outer surface of the outer layer 42 stably contacts the surface of the paper sheet P as shown in FIG. 6, and a sufficient frictional force can be acted on the paper sheet. This stabilizes the taking out of paper sheet P, and extends the life of the worn take-out roller 4. Particularly, this eliminates the necessity of increasing the contact pressure of the take-out roller 4 to the paper P in order to compensate the decrease of the frictional force caused by the wearing, and substantially eliminates the problem of feeding two or more paper sheets at a time.

[0046] FIG. 10 is a sectional view of the take-out roller 50 according to a second embodiment of the invention. The take-out roller 50 has a relatively hard outer layer 52 made of the same rubber as the outer layer 42 of the take-out roller 4 of the first embodiment, and has an inner layer 54 made of rubber at least softer then the outer layer 52, inside the outer layer. As in the take-out roller 4 of the first embodiment, a barrier layer (not shown) is provided between the outer layer 52 and inner layer 54, to prevent transfer of components such as a plasticizer. In this embodiment, the hardness of the inner layer 54 is

not strictly limited.

[0047] The take-out roller 50 of this embodiment is characterized by a circular groove 56 (remover) formed in the inner layer. Namely, the circular groove 56 concentric with the rotational axis is formed by partially eliminating both end-faces in the axial direction of the inner layer 54 softer than the outer layer 52. When the outer surface of the outer layer 52 contacts the paper sheet P is supplied to the take-out position in a state being inclined, the groove 56 functions to positively deform the inner layer 54 at the position of the groove 56, and to bring the outer surface of the outer layer 52 into contact with the surface of the paper sheet P stably and in a relatively wide area. The depth and width of the groove 56 determine the softness of the inner layer 54, and can be set to the values to achieve desired softness. The shape of the groove 56 is not limited to circular, and can be optionally changed according to the desired softness of the inner layer 54.

[0048] However, in the take-out roller 50 of this embodiment, when the outer surface of the outer layer 52 contacts the surface of the inclined paper sheet P, the deforming stress is concentrated on the position of the groove 56 of the inner layer 54, and the inner layer 54 may be broken at the position of the groove 56. Thus, as shown in FIG. 10, the cross section of the groove 56 is desirably wide at the bottom, and desirably curved like an arc. By forming the cross section of the bottom of the groove like an arc, the concentrated stress can be dispersed, and the breakage of the inner layer 54 in the groove 56 can be prevented.

[0049] To increase the fatigue strength of the inner layer 54 where the groove 56 is formed, the inner layer 54 may be made of rubber material with much carbon black added to natural rubber. This can increase the fatigue strength of the inner layer 54 and prevent the breakage of the inner layer, even if the groove 56 is formed in the inner layer. If the outer layer 52 is made of rubber material with carbon black added, a black mark may be formed on the surface of the paper sheet P when touched by the take-out roller 50. However, it is no problem to add carbon black to the rubber material of the inner layer 54, which does not come in contact with the paper sheet P.

[0050] FIG. 11 shows a modification of the take-out roller 50. This take-out roller 50' has the same structure as the take-out roller 50 of the second embodiment, except that the outer layer and inner layer are made of the same rubber material. When the outer layer and inner layer are made of the same material, the rubber material is selected by giving priority to the hardness of the outer layer and the coefficient of kinetic friction of the outer surface of the roller to the paper sheet P. Therefore, it is necessary to make the depth and width of the groove 56 relatively large to deform the roller following the state of the paper sheet P. Concretely, this embodiment uses rubber material of JIS-A with the hardness of 35-90 Ha.

[0051] FIG. 11 shows the state that one groove 56 is formed at the end-face of the axial direction of the roller. It is permitted to form a plurality of grooves substantially concentrically at each end-face. In any case, by setting the depth, width, shape and number of the groove 56 to appropriate values, the softness of the roller capable of following the state of the paper sheet P can be achieved. As in this modification, by forming the roller by using one kind of rubber material, the above-mentioned barrier layer becomes unnecessary. When manufacturing the take-out rollers 50 and 50' of this embodiment, especially when forming the groove 56, molding is possible without any problem. This is advantageous in the reliability and cost efficiency.

[0052] As described above, in the second embodiment, like the take-out roller 4 of the first embodiment, when the outer surface of the take-out roller 50 contacts the surface the paper sheet P supplied to the take-out position in the inclined state, the inner layer 54 is deformed at the position of the groove 56 and the outer surface of the outer layer 52 contacts the surface of the paper sheet P stably in a sufficiently wide area.

[0053] Next, an explanation will be given on a rubber roller 60 according to a third embodiment of the invention with reference to FIG. 12 to FIG. 15. The rubber roller 60 of this embodiment can be used as the take-our roller 4 to take out the paper sheet P supplied to the take-out position in the direction of the surface crossing the stacking direction, and can also be used as the separation roller 34 of the separation unit 10 which separates the paper sheets P taken out in the stacked state into each single sheet.

[0054] As shown in FIG. 12 and FIG. 13, the rubber roller 60 has basically the same structure as the take-out roller 4 of the first embodiment, except the slits 66 (remover) cut through the inner layer 64 in the axial direction. Particularly, an outer layer 62 of the rubber roller 60 is made of the same rubber material as the outer layer 42 of the take-out roller 4 of the first embodiment. However, the hardness of the inner layer 64 may be at least softer than the outer layer 62, and may not be the same material as the inner layer 44 of the take-out roller 4 of the first embodiment. The same layer (not shown) as the above-mentioned barrier layer 46 is provided between the inner layer 62 and outer layer 64, when necessary.

[0055] The slits 66 are formed symmetrically with respect to the rotation axis of the rubber roller 60, and extended and arranged spirally in the direction crossing the radial direction, so that the adjacent slits 66 are at least partially overlapped in the radial direction of the roller. As a result, a relatively thin cylindrical wall 64a contacting the outer layer 62 is formed in the inner layer 64 of the rubber roller 60, and relatively thin walls 64b with substantially the even thickness are formed between the adjacent slits 66. In other words, the walls 64b are extended radially and spirally in the direction crossing the radial direction from the rotation axis of the roller to the wall 64a.

[0056] As described above, by forming thin walls 64a and 64b in the inner layer 64, the inner layer 64 is easily deformed elastically. In particular, by forming the elon-

gated slits shaped as shown in the drawing, the walls 64a and 64b extending along substantially the periphery of the rubber roller (in the direction crossing the radial direction) can be formed, and the hardness of the rubber roller 60 along the radial direction can be made soft. Namely, a substantially bending stress, not an compression stress to press the rubber roller 60 in the radial direction, acts on the walls 64a and 64b shaped as shown in the drawing, and the roller is easily deformed elastically against the load in the radial direction. The quantity and size of the slits 66 are selectable according to a desired hardness of the inner layer 64, and not limited to those shown in the drawing.

[0057] When this rubber roller 60 is used as a take-out roller, the inner layer 64 is elastically deformed by a relatively weak force as in the first and second embodiments, and the outer layer 62 of the rubber roller 60 can stably contact the paper sheet P supplied to the take-out position in the inclined state, and a sufficient frictional force is applied to the paper sheet P.

[0058] When the rubber roller 60 is used as the separation roller 34 of the separation unit 10, if the paper sheet P is inserted into the nip between the feed roller 32 and separation roller 34, the inner layer 64 is elastically deformed and absorbs the shock of the insertion. Compared with a case that the rubber roller 60 is pressed to the feed roller 32 by using a pinch, the rubber roller 60 does not jump up in the direction of separating from the feed roller 32, and the outer surface of the outer layer 62 can stably contact the surface of the paper sheet P passing through the nip.

[0059] Contrarily, when using a mechanism that presses the separation roller 34 (e.g., a solid rubber roller) of the separation unit 10 to the feed roller 32 by using a spring, if the paper sheet P is inserted into the nip between the feed roller 32 and separation roller 34, the separation roller 34 jumps up in the direction of separating from the roller 32 and bounces several times. At this time, the separation roller 34 does not momentarily contact the paper sheet P passing through the nip. Namely, when stacked several paper sheets P are inserted into the nip, while the separation roller 34 is bouncing, the separation roller 34 does not impart a reverse separation torque to the second and following paper sheets, and these paper sheets are fed together with the first paper sheet, causing a double-feed.

[0060] Contrarily, when the rubber roller 60 of this embodiment is used as a separation roller, a mechanism to press the rubber roller 60 to the feed roller by a pinch becomes unnecessary, and even if stacked several paper sheets P are inserted into the nip, the inner layer 64 is deformed and absorbs the shock of the insertion, as described above, the periphery of the outer layer 62 stably contacts the second and following paper sheets P, and a reverse separation torque is stably imparted to the second and following paper sheets P. Namely, by using the rubber roller 60 of this embodiment, the probability of doubly feeding the paper sheet P can be drastically decreased.

[0061] In particular, by setting in an appropriate direction, the rubber roller 60 of this embodiment can be used as a separation roller, and increases the paper sheet P feeding performance and the paper sheet P separation performance. Concretely, the roller 60 is provided in the take-out apparatus 1 at the position to rotate in the direction of the arrow e (the position shown in FIGS. 12 and 13) when the paper sheet P is fed in the direction indicated by the arrow in FIG. 13 (in the left-hand direction).

[0062] Namely, by providing the rubber roller 60 in this position, when the roller rotates in the direction of the arrow e and the paper sheet P runs in the direction of the arrow, a frictional force f of the paper sheet P acts on the outer surface of the outer layer 62, as shown in FIG. 13. At this time, a resultant force h of the frictional force f and a reaction force g of the paper sheet P to the pressing force of the rubber roller 60 acts on the inner layer 64 of the rubber roller 60, as shown in the drawing. Namely, in this state, the resultant force h acts as a bending stress on the walls 64a and 64b of the inner layer 64, and the inner layer 64 is largely deformed by a relatively small force. Therefore, the shock of the insertion of the paper sheet P is absorbed, and the surface of the outer layer 62 contacts the paper sheet P stably in a sufficiently wide area.

[0063] Further, as shown in FIG. 12, when separating a second paper sheet P2 taken out together with a first paper sheet P1, the rubber roller 60 rotates as a separation roller in the direction of the arrow a (in the reverse direction) to impart a separation torque. In this time, the rubber roller 60 applies a frictional force b to the second paper sheet P2, and the resultant force d of the friction force and the reaction force c to the pressing force of the rubber roller 60 acts on the inner layer 64 as shown in the drawing. Namely, in this state, the resultant force d acts on the wall 64b of the inner layer 64 along the direction of the length, a compression stress acts on the wall 64b, and the degree of the deformation of the inner layer 64 is decreased. In other words, when imparting a separation torque to the paper sheet P by using the rubber roller 60 incorporated in the position mentioned above, the deformation amount of the rubber roller 60 is small, and a sufficiently large separation torque can be imparted to the paper sheet P.

[0064] As described hereinbefore, according to the embodiment, particularly when the rubber roller 60 is used as a separation roller, the shock of the insertion of the paper sheet P can be effectively absorbed, the rubber roller 60 can stably contact the paper sheet P, the probability of doubly feeding a paper sheet can be decreased, a sufficiently large separation torque can be imparted to the paper sheet P supplied in the stacked state, and the separation function can be increased. These effects can be realized by providing the rubber roller 60 in an appropriate direction. In other words, if the rubber roller 60 is reversely attached, large effects cannot be expected.

[0065] Further, by adopting the rubber roller of this em-

bodiment as a separation roller, a pinch-press mechanism by a spring becomes unnecessary, the rubber roller 60 can be fixedly placed to the feed roller 32, the apparatus structure is simplified, the apparatus is made compact, and the manufacturing cost of the apparatus is decreased.

[0066] FIG. 14 shows a first modification of the rubber roller 60 according to the third embodiment. A rubber roller 70 according to the first modification has the same structure as the rubber roller 60 of the third embodiment, except that the inner layer and outer layer are made of the same rubber material as one unit.

[0067] The rubber roller 70 provides the same functions and effects as those of the rubber roller 60. In the rubber roller 70, it is necessary to set the coefficient of kinetic friction of the outer surface to contact the paper sheet P to an appropriate value, if a rubber material with a relatively large coefficient of kinetic friction is selected, the roller becomes difficult to deform compared with the rubber roller 60. Therefore, it is necessary to adjust the thickness of the wall by adjusting the size of the slit 72 in order to obtain a desired deformation rate.

[0068] FIG. 15 shows a rubber roller 80 according to a second modification. The rubber roller 80 according to the second modification has basically the same structure as the rubber roller 60, and has many auxiliary holes 88 to even the deformation of the inner layer, in addition to slits 86. The shape, quantity, position and size of the slit provided in the inner layer can be optionally changed as long as they can apply a desired deformation ratio to the rubber roller.

[0069] For example, the take-out rollers 4, 50 and 50' of the first and second embodiment may be adopted as the separation roller 34 of the separation unit 10. Namely, the rubber roller of the invention has the characteristic structure deformable according to the state of the paper sheet P. Therefore, the rubber roller can effectively absorb the shock of the insertion of a paper sheet, even if it is used as a separation roller.

[0070] In the embodiments described hereinbefore, the rubber roller is composed of two layers, outer and inner layers, but the number of layers is not limited to two. A rubber roller having three or more layers including an outer layer is allowed. In this case, a barrier layer may be provided among the layers if necessary.

Claims

1. A rubber roller to rotate and contact a paper sheet **characterized by** comprising:

   an outer layer (42, 52, 62) made of rubber material of JIS-A with the hardness over 35 Ha and below 90 Ha; and
   an inner layer (44, 54, 64) provided inside the outer layer, and made of non-foamed rubber material of JIS-A with the hardness over 5 Ha and below 25 Ha.

2. The rubber roller according to claim 1, **characterized in that** the coefficient of kinetic friction of the outer surface of the outer layer (42) is 1.0-1.5.

3. The rubber roller according to claim 1, **characterized by** further comprising a barrier layer (46) which is provided between the inner layer (44) and outer layer (42), and prevents transfer of transfer components such as a plasticizer between the inner layer and outer layer.

4. The rubber roller according to claim 3, **characterized in that** the barrier layer (46) is made of rubber material having the index of solubility lower than the indexes of solubility of components transferred from the inner layer (44) to the outer layer (42) and from the outer layer (42) to the inner layer (44).

5. The rubber roller according to claim 3, **characterized in that** the barrier layer (46) is made of resin such as ethylene resin terafluoride (PTFE), polyethylene (PE) and polypropylene (PP).

6. A rubber roller **characterized by** comprising:

   a substantially cylindrical roller body which is made of rubber material, has an outer surface to contact a paper sheet; and
   a remover (56, 66, 88) which is made soft by partially removing the roller body, to make the outer surface sufficiently contact a paper sheet by deforming the roller body to meet the state of a paper sheet to contact.

7. The rubber roller according to claim 6, **characterized in that** the coefficient of kinetic friction of the outer surface is 1.0-1.5.

8. The rubber roller according to claim 6, **characterized in that** the rubber material is JIS-A with the hardness over 35 Ha and below 90 Ha.

9. The rubber roller according to claim 6, **characterized in that** the remover includes a circular groove (56) formed by making the thickness of the roller body partially thin in the axial direction.

10. The rubber roller according to claim 6, **characterized in that** the remover includes slits (66, 68) symmetrical with respect to an axis, penetrating through the roller body in the axial direction.

11. The rubber roller according to claim 10, **characterized in that** the slits (66) are extended and arranged spirally in the direction crossing the radial direction, so that the adjacent slits (66) are at least partially

overlapped in the radial direction of the roller, and the adjacent slits are parted by a wall (64b) extending in the direction crossing the radial direction and having substantially even thickness.

12. The rubber roller according to claim 6, **characterized in that** the roller body has an outer layer (52, 62) which is mode of rubber material of JIS-A having the outer surface and having the hardness over 35 Ha and below 90 Ha, and an inner layer (54, 64) provided inside the outer layer and made of non-foamed rubber material softer than the outer layer, and
the remover (56, 66, 68) is formed by partially removing the rubber material of the inner layer.

13. The rubber roller according to claim 12, **characterized in that** the remover includes a circular groove (56) formed by making the thickness of the inner layer (54) partially thin in the axial direction.

14. The rubber roller according to claim 12, **characterized in that** the remover includes slits (66, 88) symmetrical with respect to an axis, penetrating through the inner layer (64) in the axial direction.

15. The rubber roller according to claim 14, **characterized in that** the slits (66) are extended and arranged spirally in the direction crossing the radial direction, so that the adjacent slits (66) are at least partially overlapped in the radial direction of the roller, and the adjacent slits are parted by a wall (64b) extending in the direction crossing the radial direction and having substantially even thickness.

16. The rubber roller according to claim 12, **characterized by** further comprising a barrier layer which is provided between the inner layer and outer layer, and prevents transfer of transfer components such as a plasticizer between the inner layer (54, 64) and the outer layer (52, 62).

17. A paper sheet take-out apparatus **characterized by** comprising:

a supply mechanism (6, 8) which moves paper sheets stacked upright in a stacking direction, takes out the paper sheets sequentially from a paper sheet at one end of the stacking direction, and supplies the paper sheet to the take-out position; and
a rubber roller (4) which rotates and contacts the paper sheet supplied to the take-out position, and takes out the paper sheet in the direction crossing the stacking direction, wherein
the rubber roller has an outer layer (42, 52, 62) made of rubber material of JIS-A with the hardness over 35 Ha and below 90 Ha; and
an inner layer (44, 54, 64) provided inside the outer layer, and made of non-foamed rubber material of JIS-A with the hardness over 5 Ha and below 25 Ha.

18. The paper sheet take-out apparatus according to claim 17, **characterized in that** the coefficient of kinetic friction of the outer surface of the outer layer (42) is 1.0-1.5.

19. The paper sheet take-out apparatus according to claim 17, **characterized by** further comprising a barrier layer (46) which is provided between the inner layer (44) and outer layer (42), and prevents transfer of transfer components such as a plasticizer between the inner layer and outer layer.

20. The paper sheet take-out apparatus according to claim 19, **characterized in that** the barrier layer (46) is made of rubber material having the index of solubility lower than the indexes of solubility of components transferred from the inner layer to the outer layer and from the outer layer to the inner layer.

21. The paper sheet take-out apparatus according to claim 19, **characterized in that** the barrier layer (46) is made of resin such as ethylene resin terafluoride (PTFE), polyethylene (PE) and polypropylene (PP).

22. A paper sheet take-out apparatus **characterized by** comprising:

a supply mechanism (6, 8) which moves paper sheets stacked upright in a stacking direction, takes out the paper sheets sequentially from a paper sheet at one end of the stacking direction, and supplies the paper sheet to the take-out position;
a take-out roller (4) which rotates and contacts the paper sheet supplied to the take-out position, and takes out the paper sheet in the direction crossing the stacking direction; and
a separation mechanism having a feed roller (32) which contacts a paper sheet taken out from the take-out position by the take-out roller, and rotates in the take-out direction, and a rubber roller (34) which rotates following the feed roller by holding the taken-out paper sheet between the feed roller, and separates second and following paper sheets doubly taken out, by giving a reverse torque to the second and following paper sheets, wherein
the rubber roller has an outer layer (42, 52, 62) made of rubber material of JIS-A with the hardness over 35 Ha and below 90 Ha; and
an inner layer (44, 54, 64) provided inside the outer layer, and made of non-foamed rubber material of JIS-A with the hardness over 5 Ha and

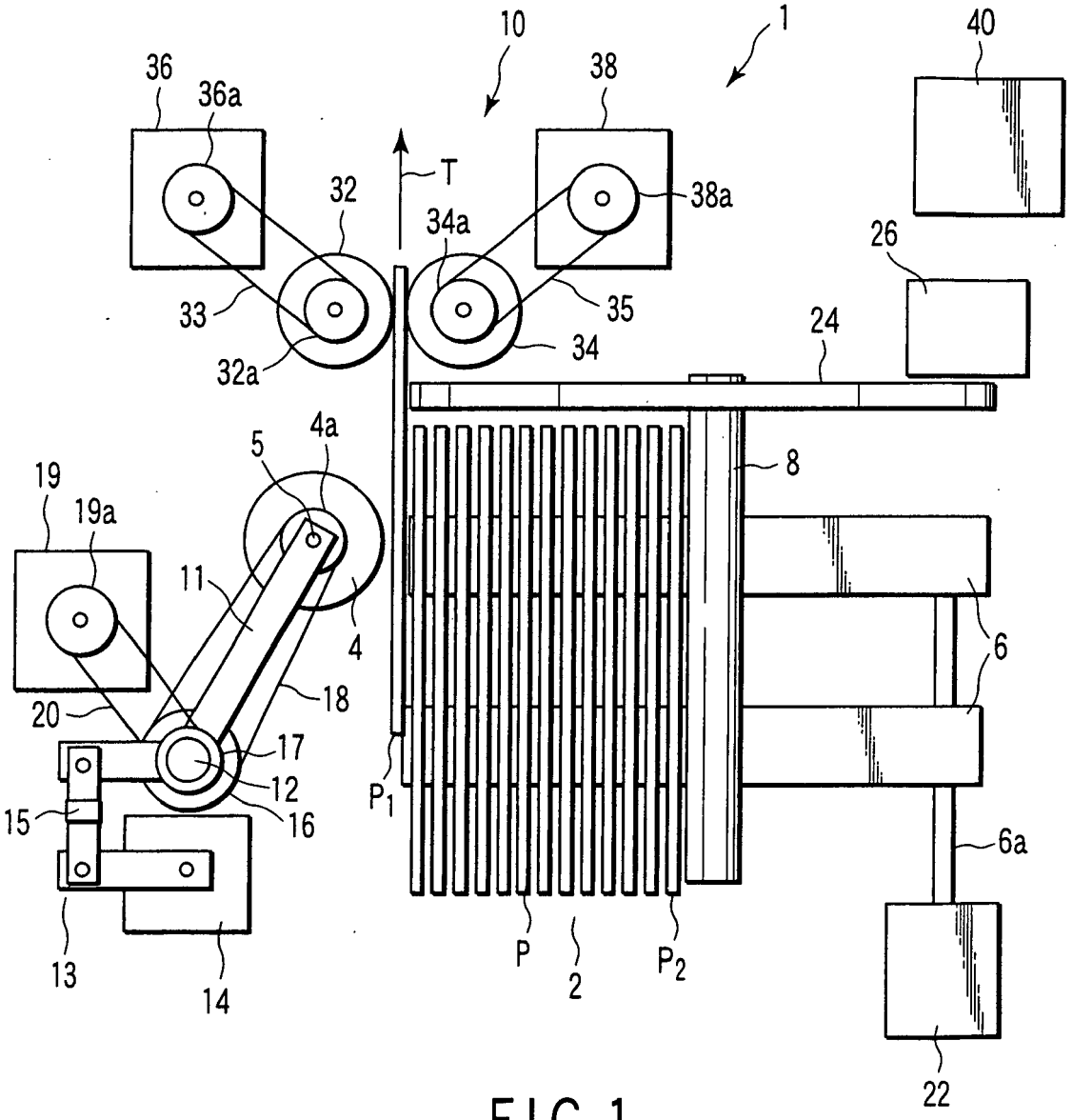
below 25 Ha.

23. The paper sheet take-out apparatus according to claim 22, **characterized in that** the coefficient of kinetic friction of the outer surface of the outer layer (42) is 1.0-1.5.

24. The paper sheet take-out apparatus according to claim 22, **characterized by** further comprising a barrier layer (46) which is provided between the inner layer (44) and outer layer (42), and prevents transfer of transfer components such as a plasticizer between the inner layer (44) and outer layer (42).

25. The paper sheet take-out apparatus according to claim 24, **characterized in that** the barrier layer (46) is made of rubber material having the index of solubility lower than the indexes of solubility of components transferred from the inner layer (44) to the outer layer (42) and from the outer layer (42) to the inner layer (44).

26. The paper sheet take-out apparatus according to claim 24, **characterized in that** the barrier layer (46) is made of resin such as ethylene resin terafluoride (PTFE), polyethylene (PE) and polypropylene (PP).


10
1
40
36
36a
38
T
32
38a
34a
26
33
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24
32a
34
5
4a
8
19
19a
11
6
4
18
20
17
12
16
15
6a
P_1
P
2
P_2
13
14
22

FIG. 1

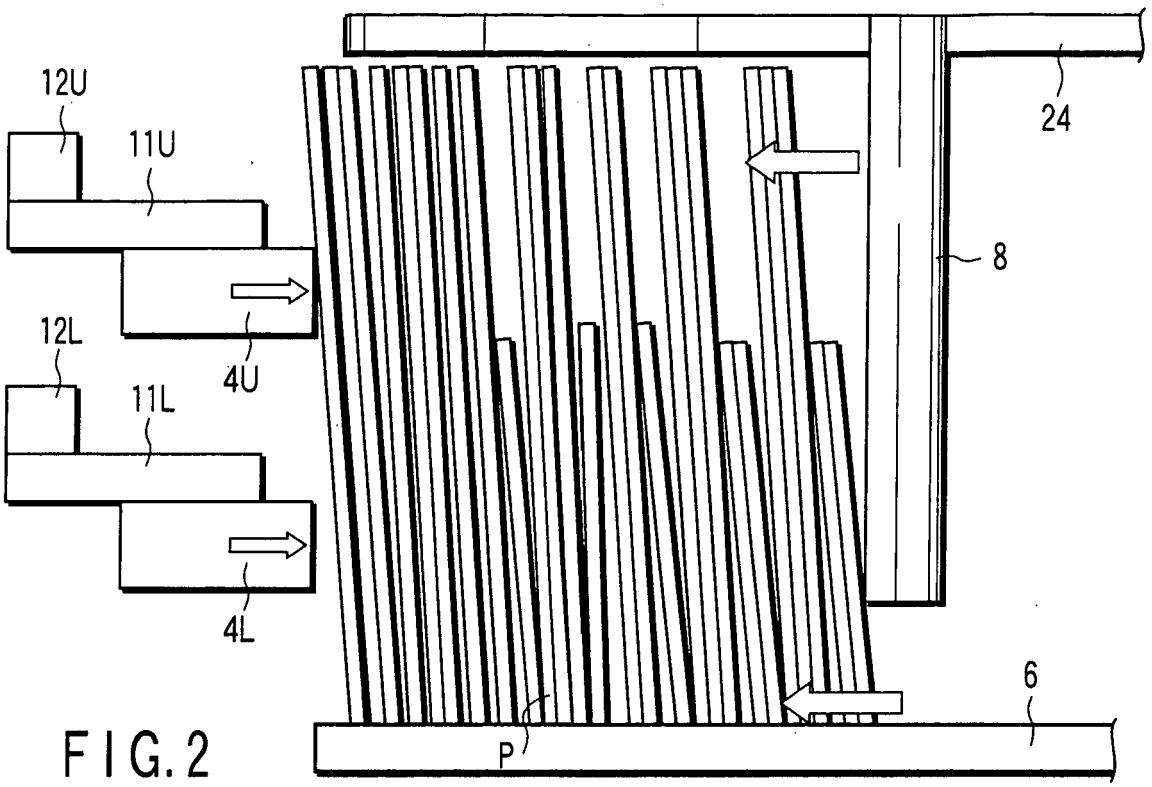
12U
11U
24
8
12L
4U
11L
4L
6
P

FIG. 2

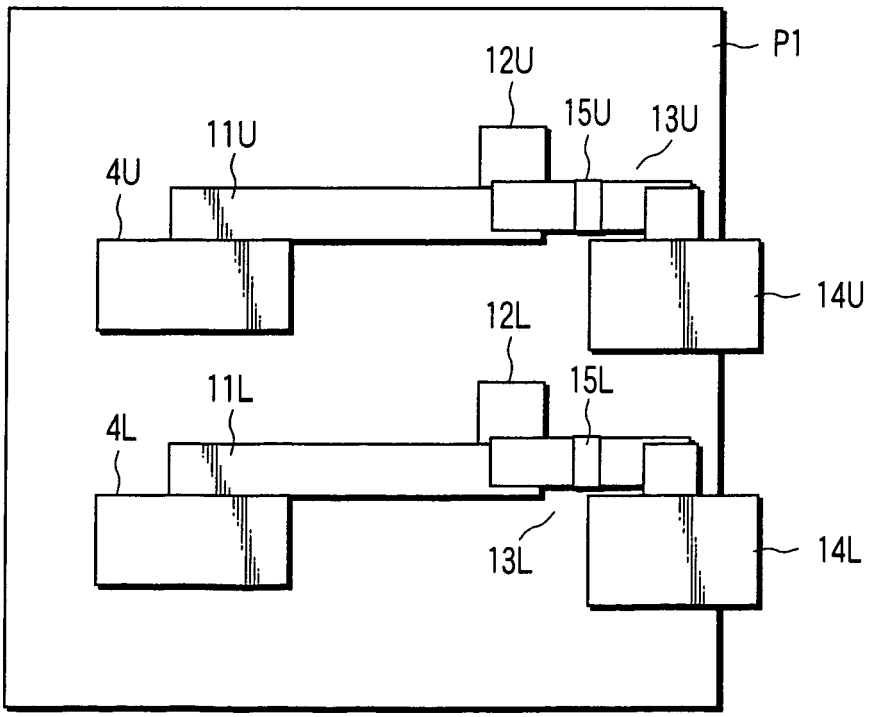
P1
12U
15U
13U
11U
4U
14U
12L
11L
15L
4L
13L
14L

FIG. 3

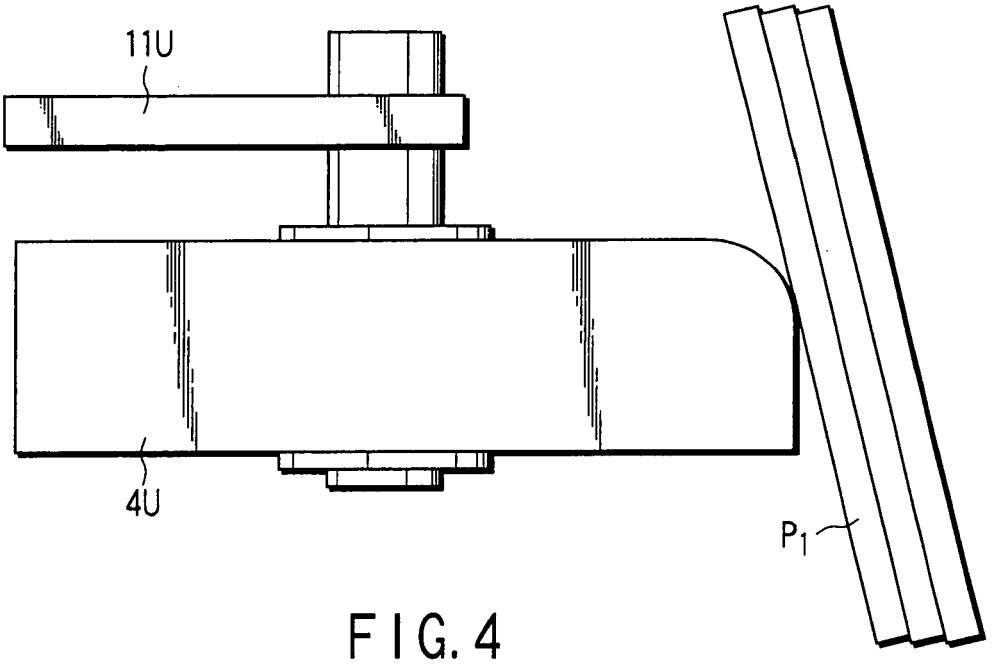

FIG. 4

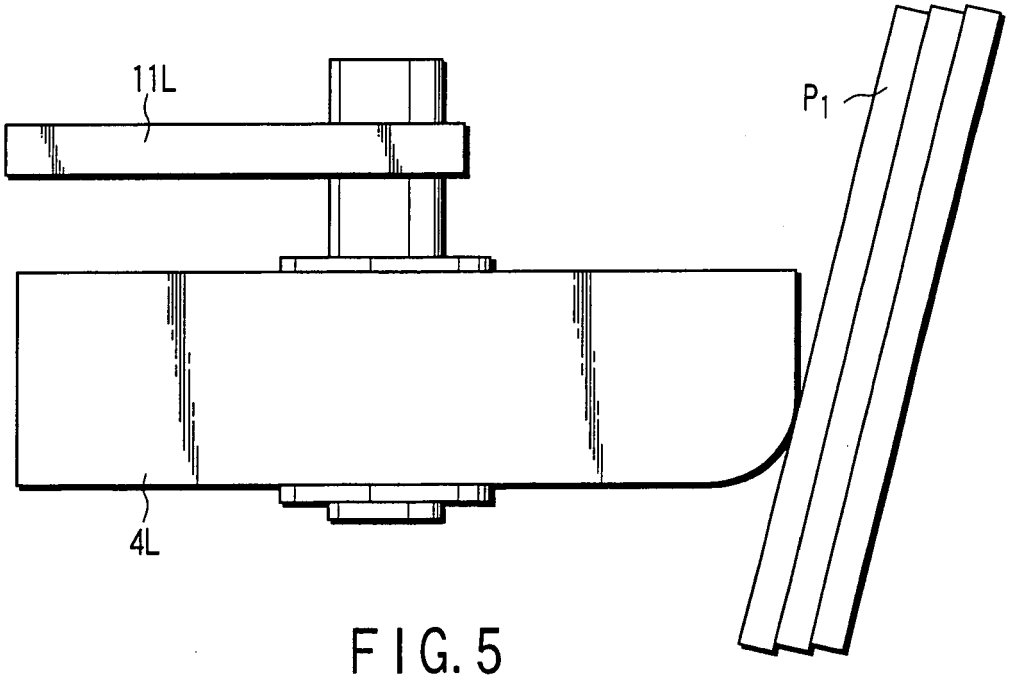

FIG. 5

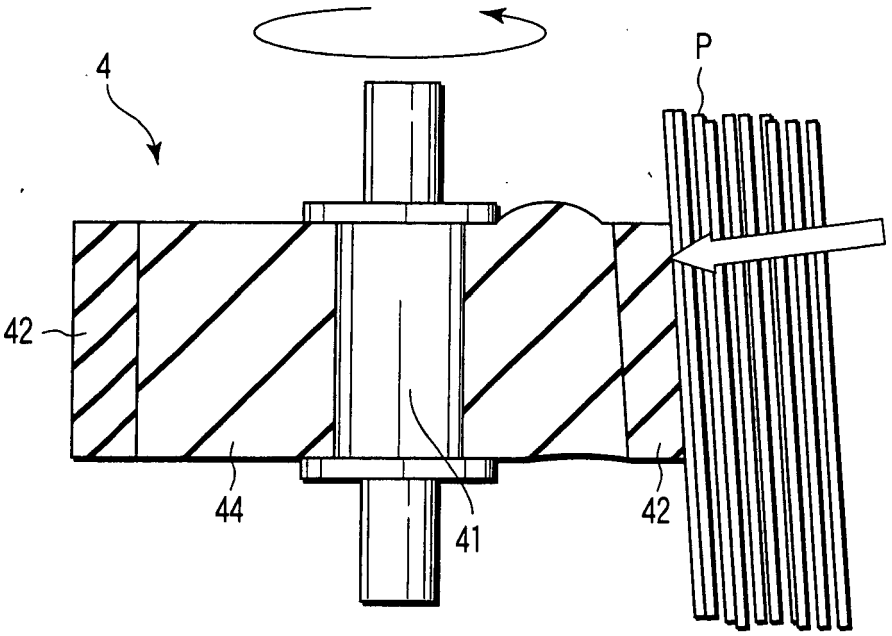

FIG. 6

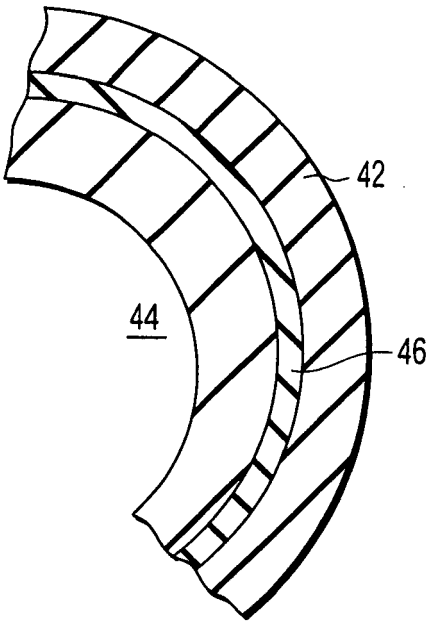

FIG. 7

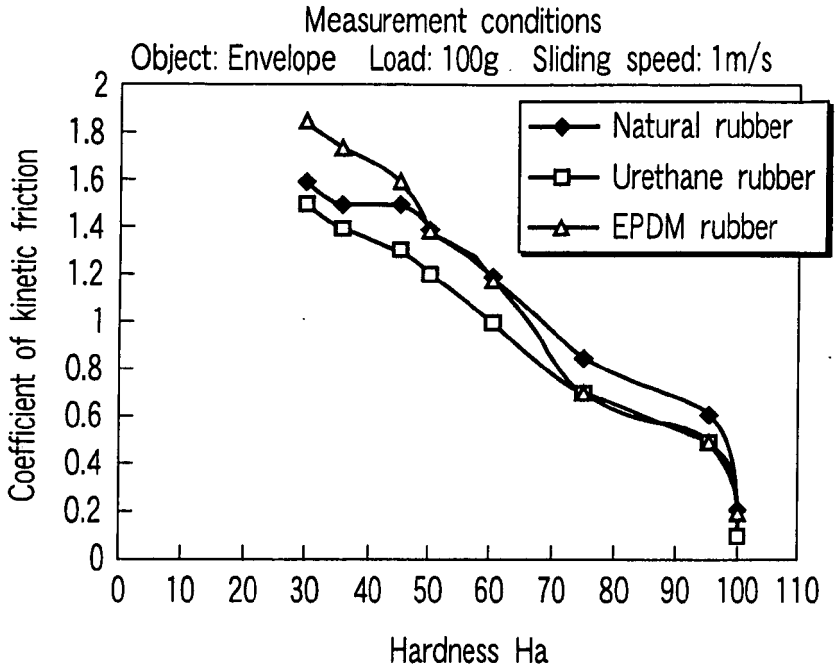
Measurement conditions
Object: Envelope Load: 100g Sliding speed: 1m/s
Coefficient of kinetic friction
Hardness Ha
Natural rubber
Urethane rubber
EPDM rubber
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0 10 20 30 40 50 60 70 80 90 100 110

FIG. 8

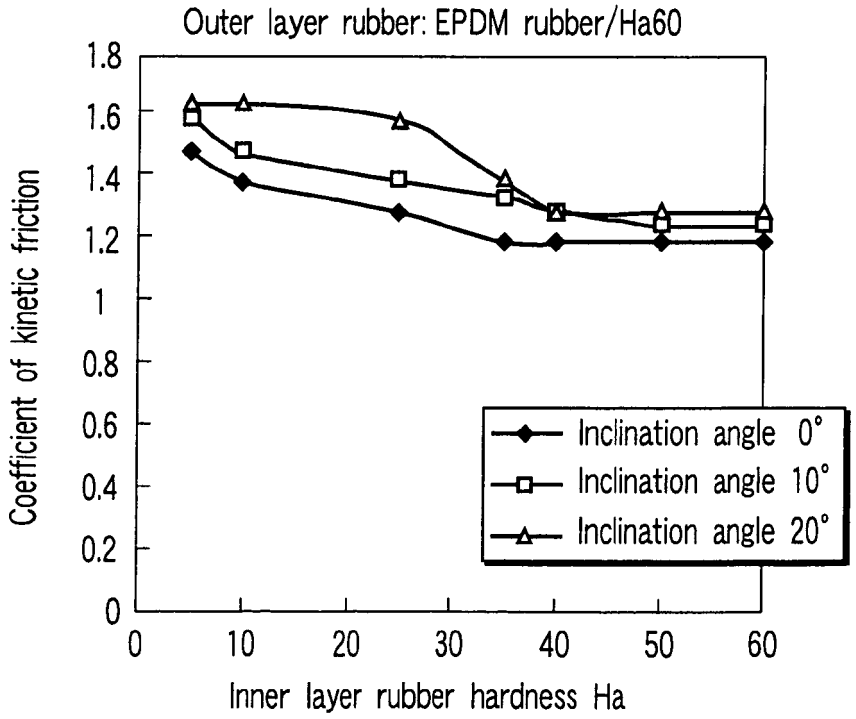
Outer layer rubber: EPDM rubber/Ha60
Coefficient of kinetic friction
Inner layer rubber hardness Ha
Inclination angle 0°
Inclination angle 10°
Inclination angle 20°
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0 10 20 30 40 50 60

FIG. 9

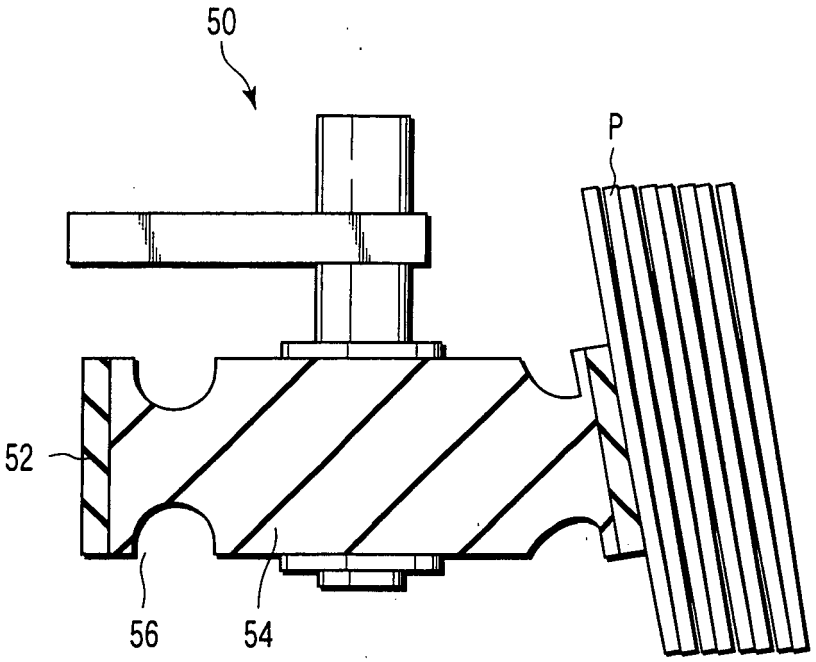

FIG. 10

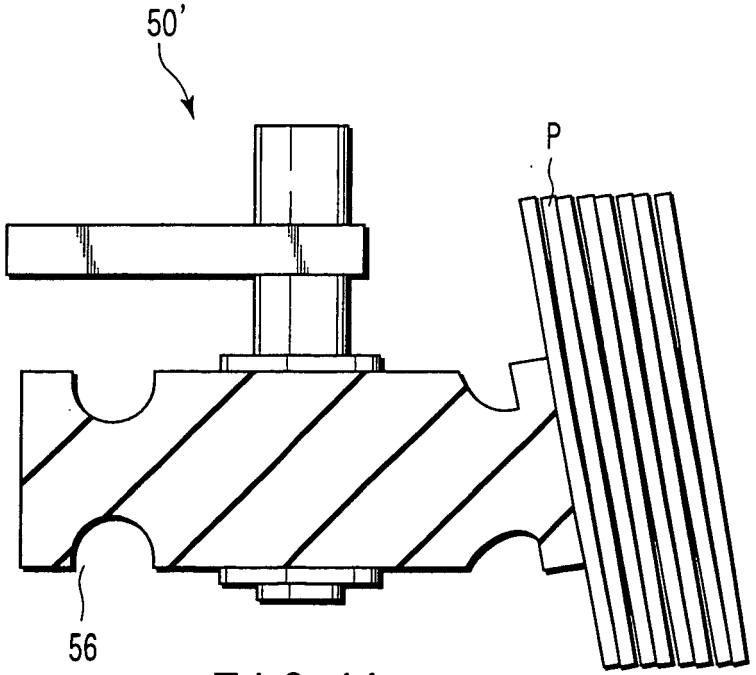

FIG. 11

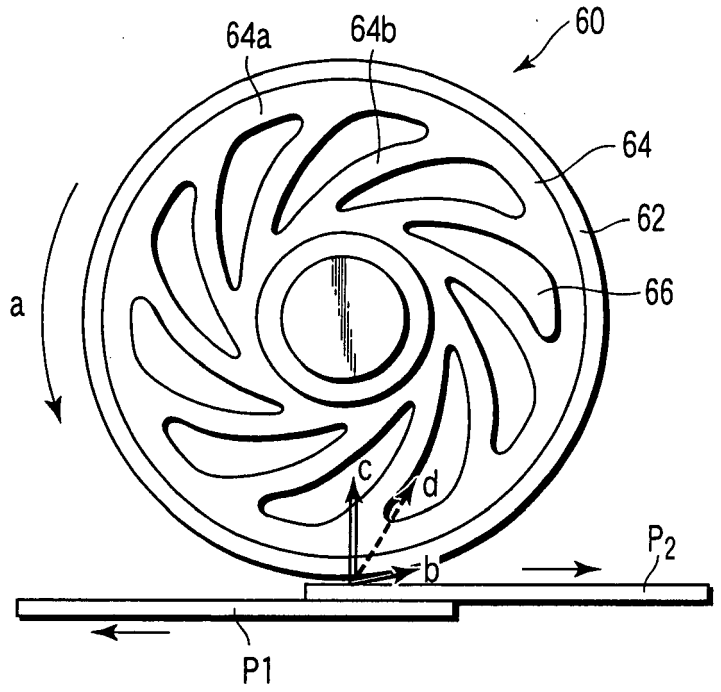

FIG. 12

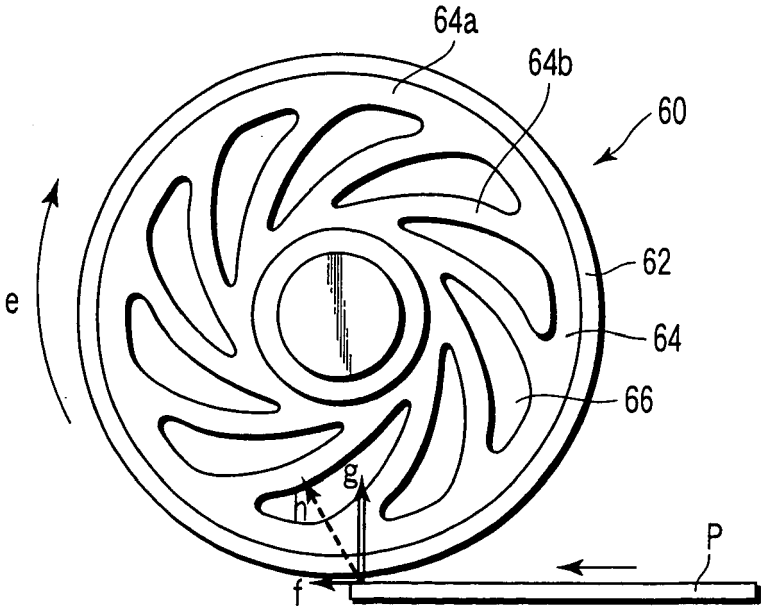

FIG. 13

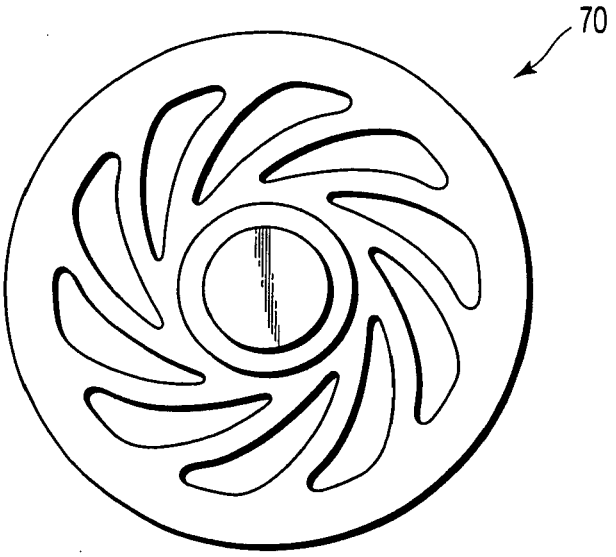

FIG. 14

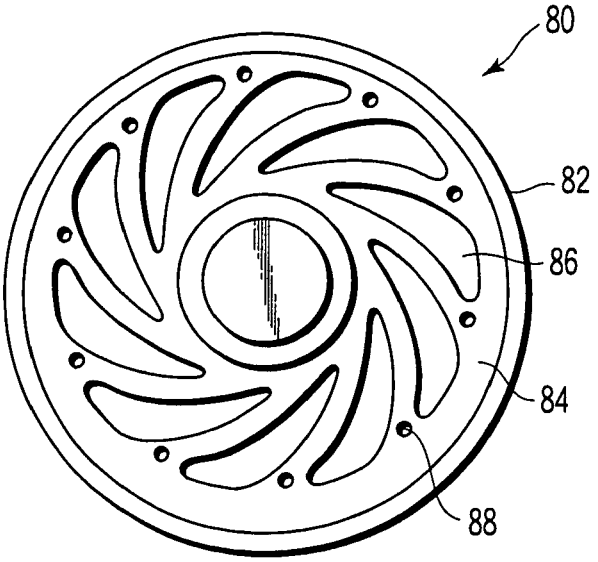

FIG. 15

REFERENCES CITED IN THE DESCRIPTION

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- JP 2003341860 A **[0003]**