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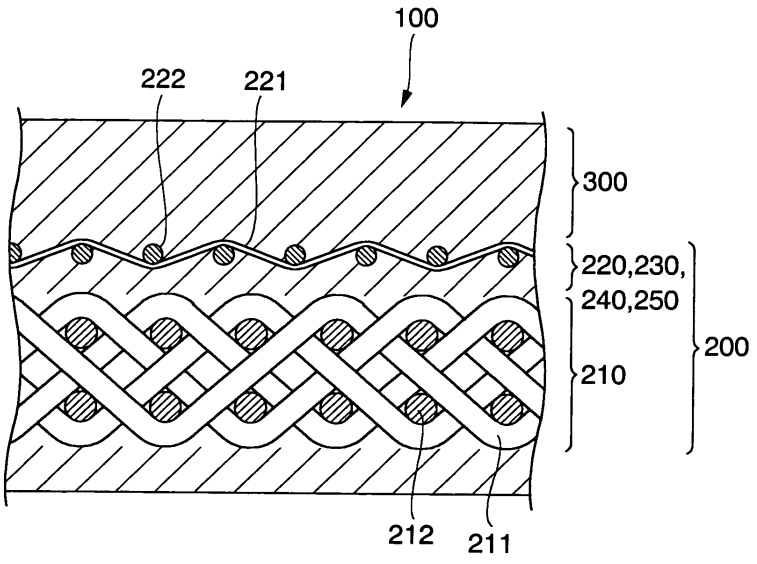
(54) **PAPERMAKING FELT**

(57) A felt (100) for papermaking comprises two or more bases of one type or different types and batt fibers including core-in-sheath composite fibers and integrally intertwined with one surface or both surfaces of the bases by needling. At least one of the bases is formed of twisted yarns comprising soft-twisted warp yarns or weft yarns including core-in-sheath composite fibers. The felt has a good water squeezing ability, an excellent wet paper web smoothing ability, a good compression rate, a good recovery ratio, and a good ability to sustaining the recovery ratio upon pressurization, and, in particular, an excellent fiber removal resisting ability. The felt is thus suitable for use in a high-speed papermaking machine.

FIG.2



EP 2 042 653 A1

Description

Technical field:

[0001] The present invention relates to a felt for papermaking (hereinafter referred to as "felt") for use in a papermaking machine, and more particularly to a felt for papermaking which is to be pressurized in the pressing zone of the papermaking machine for squeezing water out of a wet paper web.

Background art:

[0002] The pressing zone of a papermaking process employs a felt for squeezing water out of a wet paper web. Specifically, a papermaking machine for removing water from the wet paper web has three zones, i.e., a forming zone, a pressing zone and a drying zone, for removing water from the wet paper web during the papermaking process. In each of the zones, water is continuously removed from the wet paper web. Each of the zones employs a papermaking tool having a dehydrating capability.

[0003] Fig. 5 is a schematic view of a press apparatus.

[0004] As shown in Fig. 5, the press apparatus comprises a pair of pressing rolls Pa, Pa and a pair of felts 11a, 11a for sandwiching a wet paper web Wa therebetween. When the pressing rolls Pa, Pa, which make up a pressurizing mechanism, pressurized felts 11a, 11a and the wet paper web Wa, water is squeezed out of the wet paper web Wa and is absorbed by the felts 11a, 11a.

[0005] The water absorbed by the felts 11a, 11a is drawn and discharged by respective suction boxes FSB. The water which has not been absorbed by the felts is discharged as splashes SP in a direction tangential to the lower pressing roll Pa at the outlet of the press.

[0006] Each of the felts has a plurality of basic functions which need to be performed. These functions include a water squeezing function to squeeze water out of the wet paper web, a smoothing function to increase the smoothness of the wet paper web, and a wet paper web feeding function to feed the wet paper web. The felt has to have all these functions in balance.

[0007] Of these felt functions, the function to squeeze water out of the wet paper web (water squeezing function) is performed as follows: While the wet paper web and the felts are traveling through between the pressing rolls, the wet paper web and the felts are compressed in the thicknesswise direction under pressure. The water squeezed out of the wet paper web is transferred to the felts.

[0008] The water transferred to the felts is discharged from the reverse sides of the felt under pressure, or is drawn by the suction boxes of the papermaking machine and is discharged out of the felt system. Therefore, it is important for the felts to have water permeability and also a function to be recovered from the compressed state when the felts are depressurized (an ability to be compressed and recovered and an ability to sustain such an ability to be compressed and recovered).

[0009] As the felts pass across the suction boxes, the felts are worn by friction and some of their fibers tend to pull out. Consequently, it is critical for the felts to sustain the above functions, including a function to resist fiber removal, from an initial phase of their use.

[0010] The felts for papermaking should also have an important function (smoothing function) to be compressed into a smooth surface under pressure for making the wet paper web smooth.

[0011] Japanese laid-open patent publication No. 08-302584, for example, discloses a felt with such a function which has a core-in-sheath structure made of a bicomponent material. Specifically, the bicomponent material includes a sheath material having a low melting point and a core material having a high melting point, which makes up yarns of a base fabric and fibers of a batt layer. When the felt is set with heat, the sheath material is softened to form a matrix in the batt fiber layer for thereby enhancing the dehydrating and water discharging performance of the felt and increasing the resistance to being compressed.

[0012] Fig. 1 is a cross-sectional view of a general felt for papermaking according to the background art. The structure of the general felt will be described below with reference to Fig. 1.

[0013] A felt 10 for papermaking is of an endless structure comprising a base 20, in the form of a woven fabric or the like, and a batt fiber layer 30 integrally intertwined with the base 20 by needle punching.

[0014] The base 20 is constructed to impart mechanical strength to the felt 10. In Fig. 1, the base 20 comprises a woven fabric formed of warp yarns (MD yarns) 22 and weft yarns (CD yarns) 21.

[0015] In recent years, felts for papermaking have been used in more and more severe conditions as the operating speed of papermaking machines becomes higher and the pressure used in the pressing zone becomes greater for increased paper productivity. In other words, recent trends in the papermaking technology are toward higher-speed papermaking machines for increased productivity.

[0016] In the pressing zone, more and more rolls or shoe presses are capable of higher pressurization. Therefore,

the felt in the pressing zone tends to be flattened under high pressure, lowering its water permeability and its ability to be compressed and recovered.

[0017] As the papermaking machine has a higher operating speed, the batt fibers of the felt tend to be severely worn by friction and removed. As a result, various troubles including irregular paper qualities and printability shortfalls are liable to occur.

[0018] Basic performance requirements for felts include a sustained water squeezing ability, a sustained smoothing ability and a sustained fiber removal resisting ability. Particularly, latest high-speed papermaking machines are required to have a high sustainability level for the water squeezing ability, the smoothing ability and the fiber removal resisting ability.

[0019] Various structures have heretofore been proposed as means for satisfying the above requirements. For example, it has been proposed to increase the proportion of the base to keep the felt permeable to water. A method of increasing the proportion of the base is disclosed in Japanese laid-open patent publication No. 2003-13385. According to the proposed method, a plurality of endless woven fabrics such as of a hollow weave (or endless woven fabrics produced by joining the ends of woven fabrics having an ended structure) are superposed. After batt fibers are stacked on them, they are integrally intertwined by needling.

[0020] Japanese laid-open patent publication No. 08-302584 reveals a felt including a batt layer made of a bicomponent material. The felt is heated to soften a material of low melting point included in the bicomponent material, causing it to enter the cross section of the batt fibers and the base. Thereafter, the bicomponent material is hardened to form a matrix, which reinforces the base to exhibit compression resistance.

Patent document 1: Japanese laid-open patent publication No. 08-302584

Patent document 2: Japanese laid-open patent publication No. 2003-13385

[0021] However, the felts disclosed in Japanese laid-open patent publication No. 08-302584 and Japanese laid-open patent publication No. 2003-13385 are problematic in that they are susceptible to a compressive fatigue when repeatedly compressed by a press apparatus.

[0022] Furthermore, since the felt disclosed in Japanese laid-open patent publication No. 08-302584 is less compressive under pressure, its smoothing ability and water squeezing ability are poor.

[0023] The present invention has been made in view of the above problems. It is an object of the present invention to provide a felt for papermaking which has a good water squeezing ability, an excellent wet paper web smoothly ability, an excellent fiber removal resisting ability, an excellent durability, and which particularly has an excellent fiber removal resisting ability suitable for use in a high-speed papermaking machine.

Disclosure of the invention:

[0024] As a result of a study of the structure of a felt for achieving the above object, a felt according to the present invention comprises two or more stacked bases (a first base and a second base). At least one of the bases is formed of soft-twisted warp yarns or weft yarns including core-in-sheath composite fibers.

[0025] The yarns tend to become flat easily. Interstices between the yarns are closed by a melted low-melting-point component of batt fibers including core-in-sheath composite fibers and a melted low-melting-point component of the yarns. It has been found that the felt thus constructed can achieve the above object.

[0026] The "interstices between the yarns" signify interstices between the rows of warp yarns or weft yarns (interstices between the yarn and yarn) and interstices in the yarns (interstices between strands of the twisted yarns).

[0027] Specifically, in the felt for papermaking according to the present invention, batt fibers including core-in-sheath composite fibers are stacked on one or both surfaces of two or more bases of one type or different types, and integrally intertwined therewith by needling.

[0028] At least one of the bases is formed of soft-twisted warp yarns (MD yarns) or weft yarns (CD yarns) including core-in-sheath composite fibers.

[0029] Preferably, in the felt for papermaking according to the present invention, the base is formed of warp yarns and weft yarns and has an ended structure. The base is wound a plurality of times into a stacked base. The soft-twisted warp yarns (MD yarns) or weft yarns (CD yarns) including the core-in-sheath composite fibers of the stacked base are flat. Interstices between the yarns are closed by a melted low-melting-point component of the batt fibers including the core-in-sheath composite fibers and a melted low-melting-point component of the yarns.

[0030] Preferably, the base comprises a multiple-ply woven fabric woven as at least a double-ply weave. The soft-twisted warp yarns or weft yarns including the core-in-sheath composite fibers of the multiple-ply woven fabric are flat. Interstices between the yarns are closed by a melted low-melting-point component of the batt fibers including the core-in-sheath composite fibers and a melted low-melting-point component of the yarns.

[0031] According to the present invention, either the warp yarns or the weft yarns of the base comprise yarns (preferably,

soft-twisted yarns) including the core-in-sheath composite fibers and are twisted of filaments having a fineness ranging from 50 to 400 dtex.

[0032] Furthermore, the base according to the present invention has its yarns made flat because it is formed of yarns having certain fineness. Use of soft-twisted yarns is more effective to make themselves flatter. The soft-twisted yarns have 30 through 100 final twists per meter, with the ratio of the number of preliminary twists/the number of final twists being in the range from 1.2 to 1.4.

[0033] Since the twisted yarns are soft-twisted yarns, the twisted yarns are easily made flat in the base, and hence have a function to increase the smoothing ability of the base.

[0034] If the number of preliminary twists (and/or final twists) of the twisted yarns falls out of the range of 30 through 100 twists per meter, then the twisted wires become hard-twisted yarns, and are less liable to become flat in the base.

[0035] If the ratio of (the number of preliminary twists)/(the number of final twists) falls in the range from 1.2 to 1.4, then the twisted yarns easily become flat in the base, and are stable soft-twisted yarns free of kinks and loose strands. If the ratio of (the number of preliminary twists)/(the number of final twists) falls out of the range from 1.2 to 1.4, then the twisted yarns become crooked in the base, and are not uniformly flat.

[0036] The soft-twisted yarns (twisted yarns) according to the present invention comprise bundles of filaments including core-in-sheath composite fibers. The proportion of filaments in the core-in-sheath composite fibers should preferably be in the range from 25 % to 75 % with respect to the total number of filaments of the twisted yarns.

[0037] The first reason for the above proportion is that if the proportion of filaments in the core-in-sheath composite fibers is smaller than 25 %, then they are not well secured to the batt fibers including the core-in-sheath composite fibers when melted, and have a poor function to keep the twisted yarns flat.

[0038] The second reason for the above proportion is that if the proportion of filaments in the core-in-sheath composite fibers exceeds 75 %, then the yarns become too flat, and are too strongly secured to the batt fibers including the core-in-sheath composite fibers when melted, making the water squeezing ability of the felt poor.

[0039] The soft-twisted yarns according to the present invention may be spun yarns comprising staple yarns having a fineness ranging from 6 to 50 dtex, which include core-in-sheath composite fibers.

[0040] The felt according to the present invention has an excellent wet paper web smoothing ability and an excellent fiber removal resisting ability because the soft-twisted yarns of the base are flat with the interstices between the yarns being closed. To make the yarns of the base easier to become flat, the felt includes the base formed of warp yarns and weft yarns and having an ended structure.

[0041] The base is wound a plurality of times so as to be stacked into the stacked base. Since the soft-twisted yarns in the upper layer are arranged so as to be embedded in the interstices between the twisted yarns in the lower layer, the layers of the stacked base are dense.

[0042] The batt fibers including the core-in-sheath composite fibers are integrally intertwined with the stacked base by needling. The low-melting-point component of the batt fibers including the core-in-sheath composite fibers and the low-melting-point component of the yarns are melted with heat, easily closing the interstices between the yarns of the stacked base.

[0043] The soft-twisted yarns are made flat and the interstices therebetween are easily closed according to another embodiment. According to the other embodiment, the base comprises a multiple-ply woven fabric woven as at least a double-ply weave. Soft-twisted yarns of the multiple-ply woven fabric are flat.

[0044] As with the stacked base of the ended structure, when the low-melting-point component of the batt fibers including the core-in-sheath composite fibers and the low-melting-point component of the yarns are melted, the interstices between the soft-twisted yarns of the multiple-ply woven fabric are easily closed.

[0045] It is effective for the number of intertwined points between the warp yarns (MD yarns) and the weft yarns (CD yarns) of the base to be smaller in order to make the yarns easy to become flat when the yarns make up the base and also to make the interstices between the soft-twisted yarns easy to be closed.

[0046] To this end, solvent-soluble filaments (particularly water-soluble filaments) are used as the warp yarns (MD yarns) and the weft yarns (CD yarns) of the base, and woven into a woven fabric. Then, batt fibers are implanted on the woven fabric by needle punching. Thereafter, strands of the woven fabric are dissolved away to make the interstices between the yarns easier to be closed.

[0047] Although the solvent-soluble filaments may be made of polyvinyl alcohol, acrylic resin, or polyester, they should preferably be made of water-soluble polyvinyl alcohol in particular.

[0048] Except for the water-soluble polyvinyl alcohol, the twisted yarns and the strands of the base are made of nylon or polyester. Particularly, nylon yarns are preferable as they are of excellent strength and durability.

[0049] In the felt according to the present invention, the batt fibers including the core-in-sheath composite fibers are integrally intertwined with one or both surfaces of the base. According to the present invention, therefore, the low-melting-point component of the core-in-sheath composite fibers in the batt fibers and the low-melting-point component of the yarns of the base including the core-in-sheath composite fibers can be secured to each other when melted with heat. As a consequence, the bonding strength between the base and the batt fibers is increased, so that the felt has excellent

fiber removal resistance.

[0050] Particularly, the batt fibers including the core-in-sheath composite fibers are preferably used in the batt layer on the front side (the wet paper web side) of the base.

[0051] The content percentage of the core-in-sheath composite fibers in the batt layer on the front side of the base should preferably in the range from 25 % to 75 %. The first reason for the content percentage is that if the content percentage of the core-in-sheath composite fibers is smaller than 25 %, then the bonding strength between the base and the batt fibers is weak, resulting in poor fiber removal resistance. The second reason is that if the content percentage of the core-in-sheath composite fibers exceeds 75 %, then the ability of the batt fiber layer to be compressed and recovered is lowered, and the felt is of a poor water squeezing ability.

[0052] The batt layer on the front side of the base may be of a multilayer structure, and the content percentage of the core-in-sheath composite fibers may be higher stepwise from the front side of the base toward the wet paper web.

[0053] The nylon of the core component of the core-in-sheath composite fibers should preferably be nylon 6, nylon 66, nylon 46, nylon 610 or nylon 612. Specifically, nylon produced by polycondensation of nylon salt, such as polymerization of ε-caprolactam (nylon 6), polycondensation of hexamethylenediamine adipate (nylon 66), polycondensation of 1,4-diaminobutane adipate (nylon 46), polycondensation of hexamethylenediamine sebacate (nylon 610), or polycondensation of hexamethylenediamine dodecanedionate (nylon 612), is preferable. Particularly, aliphatic nylon having a melting point of 200°C or higher as measured by a DSC (differential scanning calorimeter) is recited.

[0054] The nylon of the sheath component of the core-in-sheath composite fibers should preferably be nylon whose melting point is lower than the core component. The nylon may be binary copolymer nylon or ternary copolymer nylon.

[0055] The binary copolymer nylon may be nylon 6/12, nylon 6/610, nylon 66/6, nylon 66/12, nylon 66/610, or the like. The ternary copolymer nylon may be nylon 6/66/12, nylon 6/66/610, or the like.

[0056] It is known that these copolymer nylons have melting points variable depending on the composition (the weight % of a copolymer component). The copolymer nylons which can be used in the present invention are limited to those having a melting point up to 180°C.

[0057] Preferably, at least one of the stacked bases of the felt for papermaking comprises soft-twisted yarns including core-in-sheath composite fibers. When the yarns make up the base, the yarns become flat, and the low-melting-point component of the batt fibers including the core-in-sheath composite fibers and the low-melting-point component of the yarns are melted to close interstices between the yarns. As a result, the felt for papermaking has an excellent water squeezing ability, an excellent wet paper web smoothing ability, and an excellent fiber removal resisting ability.

[0058] According to the present invention thus arranged, there is provided a felt having an excellent ability to be compressed and recovered and an excellent fiber removal resisting ability. If the felt is used as a felt for papermaking, then it has an excellent compression ratio and an excellent recovery ratio when pressurized by a roll or a shoe press in a papermaking process.

[0059] The felt according to the present invention does not lose a wet paper web smoothing ability, prevents fibers from being removed, has a good water squeezing ability, and keeps the water squeezing ability at a high level for a long period of time. The felt is also capable of high performance compatible with higher-speed operation of papermaking machines and higher pressurization in pressing zones thereof in recent years.

Brief description of the drawings:

[0060]

Fig. 1 is a cross-sectional view of a general felt for papermaking according to the background art;
Fig. 2 is a cross-sectional view of felts for papermaking according to Inventive examples 1 through 4 of the present invention;
Fig. 3 is a cross-sectional view of a felt for papermaking according to Comparative example 1 of the present invention;
Fig. 4 is a view of an experimental apparatus according to the present invention; and
Fig. 5 is a schematic view of a press apparatus.

Best mode for carrying out the invention:

[0061] Felts for papermaking according to embodiments of the present invention will be described as shown in Fig. 2. Fig. 2 is a cross-sectional view of felt for papermaking according to embodiments the present invention.

[0062] As shown in Fig. 2, a felt 100 for papermaking according to the present invention comprises a base layer 200 and a batt fiber layer 300. The batt fiber layer 300 is produced by integrally intertwining batt fibers (staple fibers) with the base layer 200 by needle punching.

[0063] The base layer 200 comprises a stack of two bases (i.e., a first base 210 and a second base 220). In the base layer 200, the single first base 210 serves as a medium for imparting mechanical strength to the felt 100. The first base

210 is not limited to a particular material, but may be made of any of various materials insofar as they are sufficiently strong. For example, the first base 210 may comprise a woven fabric formed of warp yarns (MD yarns) 212 and weft yarns (CD yarns) 211.

[0064] In the felt 100 shown in Fig. 2, the first base 210 and the second base 220 which are of different types are stacked one on the other. However, the first base 210 and the second base 220 may be of the same kind insofar as the second base 220 satisfies the requirements of the present invention.

[0065] According to a modification, a woven fabric that is narrower than the felt 100 to be completed may be formed of warp yarns (MD yarns) and weft yarns (CD yarns). Thereafter, the woven fabric may be helically wound, and the edges of adjacent woven fabric strips may be joined together to produce a joined woven fabric for use as the first base 210.

[0066] According to another modification, a base that has the same width as the felt 100 to be completed and is formed of warp yarns (MD yarns) and weft yarns (CD yarns) may be coaxially wound into a base for use as the first base 210.

[0067] According to still another modification, rather than a woven base, a base formed of warp yarns (MD yarns) bonded together by an adhesive or a base formed of nonwoven superposed warp yarns (MD yarns) and weft yarns (CD yarns) may be used as the first base 210.

[0068] According to the present invention, the second base 220 is also stacked in addition to the first base 210, making up the base layer 200 as a whole. The second base 220 comprises a woven fabric formed of warp yarns (MD yarns) 222 and weft yarns (CD yarns) 221.

[0069] Specifically, either the warp yarns 222 or the weft yarns 221 comprise soft-twisted yarns including core-in-sheath composite fibers, which are made up of filaments having a fineness in the range from 50 to 400 dtex. The other of the warp yarns 222 and the weft yarns 221 comprise a woven fabric formed of filaments or solvent-soluble filaments in the range from 50 to 600 dtex.

[0070] In the felt 100 shown in Fig. 2, the batt fibers are integrally intertwined with the both surfaces of the base layer 200 by needle punching. The batt fiber layer 300, which includes core-in-sheath composite fibers, is disposed as a batt layer on the front side (the wet paper web side) of the second base 220. When the low-melting-point component of the batt fibers including the core-in-sheath composite fibers and the low-melting-point component of the yarns are melted, they tend to close the interstices between the yarns.

[0071] According to the present invention, during a heat treatment step in the felt production process, the low-melting-point component (sheath component) of the core-in-sheath composite fibers (staple fibers) included in the batt fiber layer 300 and the low-melting-point component (sheath component) of the core-in-sheath composite fibers (filaments) included in the soft-twisted yarns are fused and joined together.

Inventive examples:

[0072] The present invention will specifically be described below with respect to a plurality of inventive examples.

[0073] In each of the inventive examples, the second base 220 (or a second base 230, 240 or 250) which has the features of the present invention is stacked on the first base 210, making up the overall base layer 200. In all the inventive examples, the first base 210 comprises a base having the following structure:

(Inventive example 1)

· Structure of the first base 210:

[0074]

(1) MD yarns and CD yarns: Both the MD yarns and the CD yarns comprised twisted yarns in common described below.
(2) Twisting conditions: "2/2/220"
The twisted yarn representation in the above quotation [" / / "] indicates [(the number of preliminarily twisted strand bundles when they are finally twisted)/(the number of single strand bundles when they are preliminarily twisted)/(single yarn fineness = dtex)].
(3) Preliminary twist: 250 S-twists/m
(4) Final twist: 160 Z-twists/m
Since the yarns are preliminarily twisted more than 150 times/m and are finally twisted more than 150 times/m, they are hard-twisted yarns. "S-twist" means that the twisted strands on the yarn surface extend downwardly to the right, and "Z-twist" means that the twisted strands on the yarn surface extend downwardly to the left.
(5) Twist ratio (preliminary/final): 1.56
(6) Weaving:
The first base (woven fabric) 210 was woven of MD yarns: 120 yarns/5 cm and CD yarns: 40 yarns/5 cm as a 3/1,

1/3 hollow warp double-ply weave.
As shown in Fig. 2, the felt 100 was produced in which the batt fiber layer 300 was stacked on the base layer 200 made up of the first base 210 and the second base 220 stacked thereon.

· Structure of the second base 220:

[0075]

(1) MD yarns: They comprised the following twisted yarns:

(a) Twisting conditions: "2/2/220"
(b) The proportion of filaments in the core-in-sheath composite fibers: The yarns included one filament (25 %).
(c) Preliminary twist: 42 S-twists/m
(d) Final twist: 30 Z-twists/m
(e) Twist ratio (preliminary/final): 1.40

(2) CD yarns: Single yarn (diameter of 330 dtex)
(3) Weaving:
The second base (woven fabric) 220 was woven of MD yarns: 40 yarns/5 cm and CD yarns: 34 yarns/5 cm as a 3/1 flat hollow single-ply weave.
(4) The formation of the batt fiber layer 300:
The batt fiber layer 300 including core-in-sheath composite fibers was formed on the upper surface of the second base 220. The content percentage of the core-in-sheath composite fibers was 25 %.

(Inventive example 2)

[0076] The felt 100 according to Inventive example 2 was produced by stacking a base 230, described below, as the second base instead of the base 220 according to Inventive example 1. Specifically, the second base 230 is stacked in place of the base 220 in Fig. 2.

· Structure of the second base 230:

[0077]

(1) MD yarns: They comprised the following twisted yarns:

(a) Twisting conditions: "2/2/220"
(b) The proportion of filaments in the core-in-sheath composite fibers: The yarns included two filaments (50 %).
(c) Preliminary twist: 42 S-twists/m
(d) Final twist: 30 Z-twists/m
(e) Twist ratio (preliminary/final): 1.40

(2) CD yarns: Single yarn (diameter of 330 dtex)
(3) Weaving:
The second base (woven fabric) 230 of a stacked structure was produced by winding into two stacked layers a woven fabric which was woven of MD yarns: 40 yarns/5 cm and CD yarns: 34 yarns/5 cm as a 3/1 flat single-ply weave having an ended structure.
(4) The formation of the batt fiber layer 300: The same as with Inventive example 1.

(Inventive example 3)

[0078] The felt 100 according to Inventive example 3 was produced by stacking a base 240, described below, as the second base instead of the base 220 according to Inventive example 1. Specifically, the second base 240 is stacked in place of the base 220 in Fig. 2.

· Structure of the second base 240:

[0079]

(1) MD yarns: They comprised the following twisted yarns:

(a) Twisting conditions: "2/2/220"
(b) The proportion of filaments in the core-in-sheath composite fibers: The yarns included two filaments (50 %).
(c) Preliminary twist: 70 S-twists/m
(d) Final twist: 50 Z-twists/m
(e) Twist ratio (preliminary/final): 1.40

(2) CD yarns: Single yarn (diameter of 330 dtex)
(3) Weaving:

The second base (woven fabric) 240 of a stacked structure was produced by winding into two stacked layers a woven fabric which was woven of MD yarns: 40 yarns/5 cm and CD yarns: 34 yarns/5 cm as a 3/1 flat single-ply weave having an ended structure.

(4) The formation of the batt fiber layer 300:
The batt fiber layer 300 including core-in-sheath composite fibers was formed on the upper surface of the second base 240. The content percentage of the core-in-sheath composite fibers was 50 %.

(Inventive example 4)

[0080] The felt 100 according to Inventive example 4 was produced by stacking a base 250, described below, as the second base instead of the base 220 according to Inventive example 1. Specifically, the second base 250 is stacked in place of the base 220 in Fig. 2.

· Structure of the second base 250:

[0081]

(1) MD yarns: They comprised the following twisted yarns:

(a) Twisting conditions: "2/2/220"
(b) The proportion of filaments in the core-in-sheath composite fibers: The yarns included three filaments (75 %).
(c) Preliminary twist: 120 S-twists/m
(d) Final twist: 100 Z-twists/m
(e) Twist ratio (preliminary/final): 1.20

(2) CD yarns: Filaments of polyvinyl alcohol resin (water-soluble) of 400 dtex
(3) Weaving:

The second base (woven fabric) 250 was woven of MD yarns: 90 yarns/5 cm and CD yarns: 30 yarns/5 cm as a 3/1, 1/3 hollow warp double-ply weave.

(4) The formation of the batt fiber layer 300:

The batt fiber layer 300 including core-in-sheath composite fibers was formed on the upper surface of the second base 250. The content percentage of the core-in-sheath composite fibers was 75 %.

(5) Hot water scouring:

After the batt fiber layer 300 was formed, the assembly was immersed in hot water at 40°C for 30 minutes to dissolve the CD yarns according to a hot water scouring process. Then, the base 250 made up of only MD yarns were formed on the first base 210.

(Comparative example 1)

[0082] Fig. 3 is a cross-sectional view of a felt 100a for papermaking according to Comparative example 1.
[0083] As shown in Fig. 3, the felt 100a according to Comparative example 1 comprises a first base 210 and a base

210 which has the same structure as the first base 210 and stacked on the first base 210. The first base 210 and the base 210 make up a base layer 260. A batt fiber layer 300 is stacked on the base layer 260 and is of the same structure as with the Inventive example 1.

[0084] The felts according to Inventive examples 1 through 4 and Comparative example 1 were circulatingly rotated around a pair of rolls at a speed of 2 m/min., and heated by hot air at 180°C. Then, a heated pressing roll having a surface temperature of 160°C was applied to the batt layer on the surface of the felt, so that a felt for papermaking was produced.

[0085] All the felts according to the inventive examples and comparative example were produced with the same amount (basis weight: g/m^2) of the batt fiber layer 300, and evaluated for a paper web smoothing index, an ability to be compressed and recovered, an ability to sustain the ability to be compressed and recovered, and a fiber removal resisting ability by the following process:

(1) Paper web smoothing index: This is represented by the reciprocal of a numerical value determined from a variance of the distances between adjacent peaks and valleys of the surface irregularities of the felts for papermaking according to JIS B061-1982 (surface irregularities). As the paper web smoothing index is higher, the variation in the distances between the surface irregularities is smaller, and the smoothing ability is higher.

(2) Ability to be compressed and recovered and an ability to sustain the ability to be compressed and recovered: The felts 100, 100a were passed through an experimental apparatus shown in Fig. 4. The felts 100, 100a were measured for their thicknesses by sensors when they were not pressurized initially, when they were compressed by pressing rolls, and after they were released of the pressure, respectively. Compression ratios and recovery ratios of the felts 100, 100a were calculated according to the following equations, thereby evaluating the ability of the felts 100, 100a to be compressed and recovered and the ability to sustain the ability to be compressed and recovered:

$$\text{Compression ratio (\%)} = (\text{the thickness of a felt when it is compressed})/(\text{the thickness of a felt when it is not pressurized initially}) \times 100$$

$$\text{Recovery ratio (\%)} = (\text{the thickness of a felt immediately after when it is released of the pressure})/(\text{the thickness of a felt when it is compressed}) \times 100$$

The experimental apparatus has a pair of pressing rolls PR, a plurality of guide rolls GR for supporting the felts 100, 100a under constant tension, and a first sensor and a second sensor, not shown.

The first sensor measures the thickness of the felts 100, 100a when they are pressurized by the pressing rolls PR.

The second sensor measures the thickness of the felts 100, 100a immediately after they are released of the pressure from the pressing rolls PR.

The experimental apparatus was operated under such conditions that the felts were pressed under the pressure of 100 kg/cm and were driven at the speed of 1,000 m/min, continuously for 120 hours.

Based on the compression and the recovery ratio values obtained by the above measurement, the abilities to sustain the abilities of the felts 100, 100a to be compressed and recovered were evaluated and indicated by relative evaluation points.

The numerical value of the Inventive example 1 was regarded as an evaluation point "3" to be used as a standard evaluation point. If numerical values are greater than the standard evaluation point "3", then they are judged as "good". If numerical values are smaller than the standard evaluation point "3", then they are judged as "not good". Therefore, as the numerical values are higher, the evaluation points are higher. The results of the sustaining ability (relative comparison) are shown in Table 1.

(3) Fiber removal resisting ability: The amounts of fibers removed from the felts ware measured using a Taber abrasion tester based on JIS 1023-1992 in a fiber removal resisting ability experiment.

[0086] The tester operates as follows: A disk-shaped test piece is placed on a rotatable turntable, and a highly resistive rotary roll is held against the test piece to measure the amount of fibers removed from the test piece. In the experiment, the amount of removed fibers was measured after the turntable was rotated 5,000 times.

[0087] The amount of removed fibers was evaluated in relative comparison with the amount of removed fibers, set to "100", from the felt according to Comparative example 1. The results of the amount of removed fibers (relative comparison) are shown in Table 1.

Table 1

	STRUCTURE OF 2ND BASE				RESULTS OF EVALUATION				
	REFERENCE NUMERALS	WEAVE	PROPORTION OF CORE-IN-SHEATH FILAMENT	NUMBER OF FINALLY TWISTED STRAND BUNDLES	PAPER WEB SMOOTHING INDEX	COMPRESSION RATIO	RECOVERY RATIO	SUSTAINING ABILITY (RELATIVE COMPAIRISON)	AMOUNT OF REMOVED FIBERS (RELATIVE COMPARISON)
INVENTIVE EXAMPLE 1	220	WOVEN FABRIC OF HOLLOW SINGLE-PLY WEAVE	25%	30	0.013	35%	30%	3	60
INVENTIVE EXAMPLE 2	230	WOVEN FABRIC, WOUND AS TWO STACKED LAYERS, OF SINGLE-PLY WEAVE HAVING ENDED STRUCTURE	50%	30	0.015	36%	32%	4	50
INVENTIVE EXAMPLE 3	240	DITTO	50%	50	0.017	40%	35%	5	30
INVENTIVE EXAMPLE 4	250	WOVEN FABRIC OF HOLLOW DOUBLE-PLY WEAVE	75%	100	0.014	37%	31%	4	50

(continued)

	STRUCTURE OF 2ND BASE				RESULTS OF EVALUATION				
	REFERENCE NUMERALS	WEAVE	PROPORTION OF CORE-IN-SHEATH FILAMENT	NUMBER OF FINALLY TWISTED STRAND BUNDLES	PAPER WEB SMOOTHING INDEX	COMPRESSION RATIO	RECOVERY RATIO	SUSTAINING ABILITY (RELATIVE COMPAIRISON)	AMOUNT OF REMOVED FIBERS (RELATIVE COMPARISON)
COMPARATIVE EXAMPLE 1	210	DITTO	0%	30	0.006	30%	25%	2	100

[0088] In the felt 100 for papermaking according to the present invention, one of the stacked bases is formed of soft-twisted yarns including core-in-sheath composite fibers. The yarns (twisted yarns) are flat with the interstices therebetween being closed by the melted low-melting-point component.

[0089] As can be seen from the results shown in Table 1, the felt 100 for papermaking according to the present invention had a good paper web smoothing ability, a good ability to be compressed and recovered, a good ability to sustain the ability to be compressed and recovered, and a good fiber removal resisting ability.

[0090] In the felt 100a according to Comparative example 1, the two first bases 210 are stacked one on the other. Each woven of MD yarns and CD yarns of the first bases 210 are identical to each other. The felt 100a according to Comparative example 1 had a poor paper web smoothing ability, a poor ability to be compressed and recovered, a poor ability to sustain the ability to be compressed and recovered, and a poor fiber removal resisting ability.

[0091] The embodiments of the present invention (including modifications and inventive examples) have been described above. The present invention is not limited to the above embodiment, and various changes and additions may be made to the embodiment within the scope of the invention.

[0092] Identical reference characters denote identical or corresponding parts throughout views.

Industrial applicability:

[0093] The felt for papermaking according to the present invention is applicable as a felt, which can be pressurized in a pressing zone of a papermaking machine, for squeezing water from a wet paper web.

Claims

1. A felt for papermaking comprising two or more bases of one type or different types and batt fibers including core-in-sheath composite fibers and integrally intertwined with one surface or both surfaces of the bases by needling, wherein at least one of the bases is formed of twisted yarns comprising soft-twisted warp yarns or weft yarns including core-in-sheath composite fibers.

2. A felt for papermaking according to claim 1,
wherein said base is formed of warp yarns and weft yarns and has an ended structure,
said base is wound a plurality of times into a stacked base, and
the soft-twisted warp yarns or weft yarns including said core-in-sheath composite fibers of said stacked base are flat with interstices between the yarns being closed by a melted low-melting-point component of said batt fibers including the core-in-sheath composite fibers and a melted low-melting-point component of said yarns.

3. A felt for papermaking according to claim 1,
wherein said base comprises a multiple-ply woven fabric woven as at least a double-ply weave, and
the soft-twisted warp yarns or weft yarns including said core-in-sheath composite fibers of said multiple-ply woven fabric are flat with interstices between the yarns being closed by a melted low-melting-point component of said batt fibers including the core-in-sheath composite fibers and a melted low-melting-point component of said yarns.

4. A felt for papermaking according to any one of claims 1 through 3,
wherein either said warp yarns or said weft yarns of said base comprise yarns including the core-in-sheath composite fibers and are twisted of filaments having a fineness ranging from 50 to 400 dtex.

5. A felt for papermaking according to any one of claims 1 through 4,
wherein said soft-twisted yarns have 30 through 100 final twists per meter, with the ratio of the number of preliminary twists/the number of final twists being in the range from 1.2 to 1.4.

6. A felt for papermaking according to any one of claims 1 through 3, wherein either said warp yarns or said weft yarns of said base comprise solvent-soluble filaments.

FIG.1

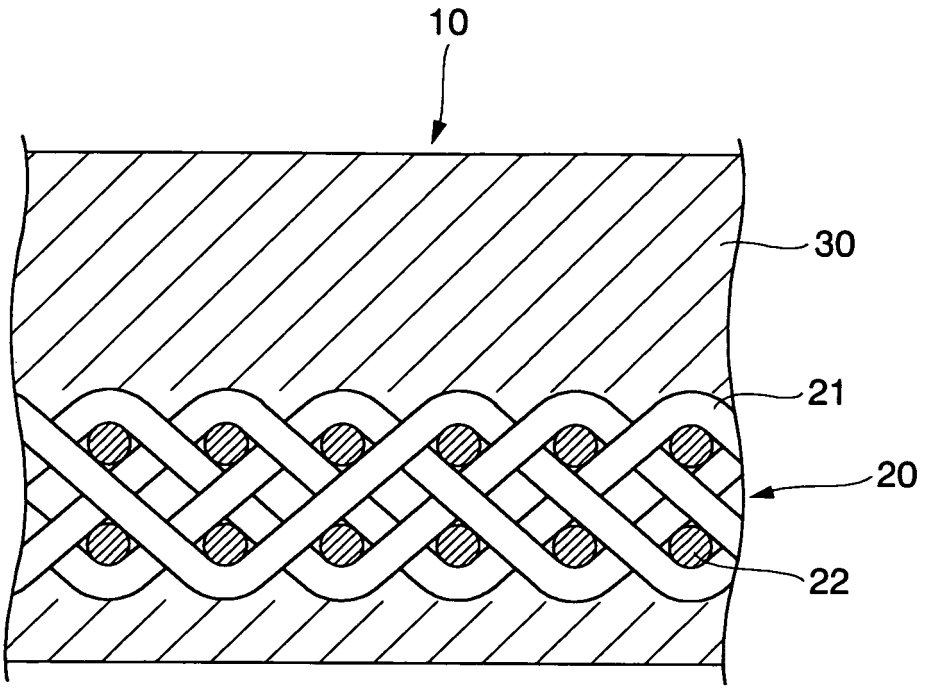


FIG.2

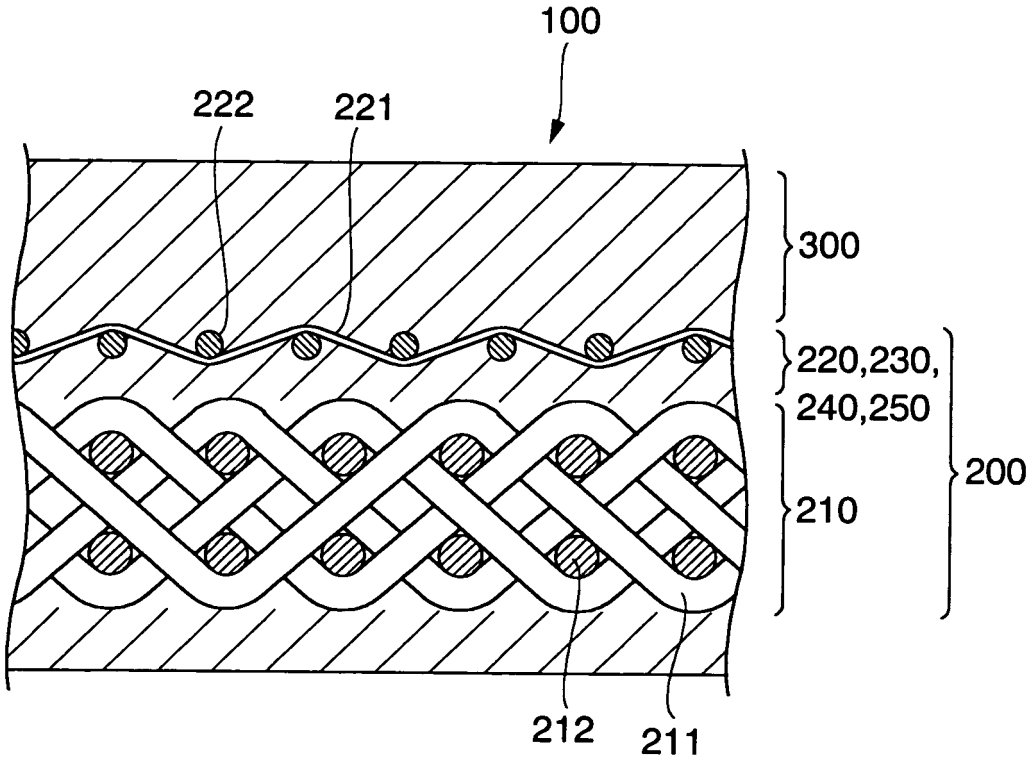


FIG.3

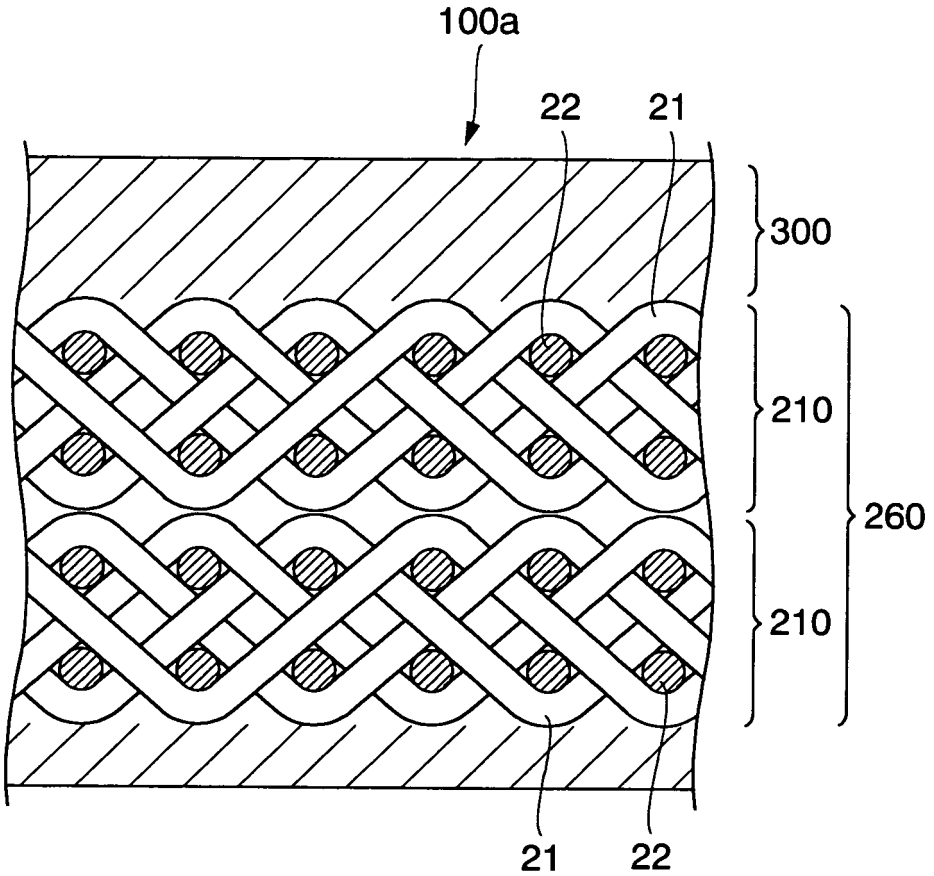


FIG.4

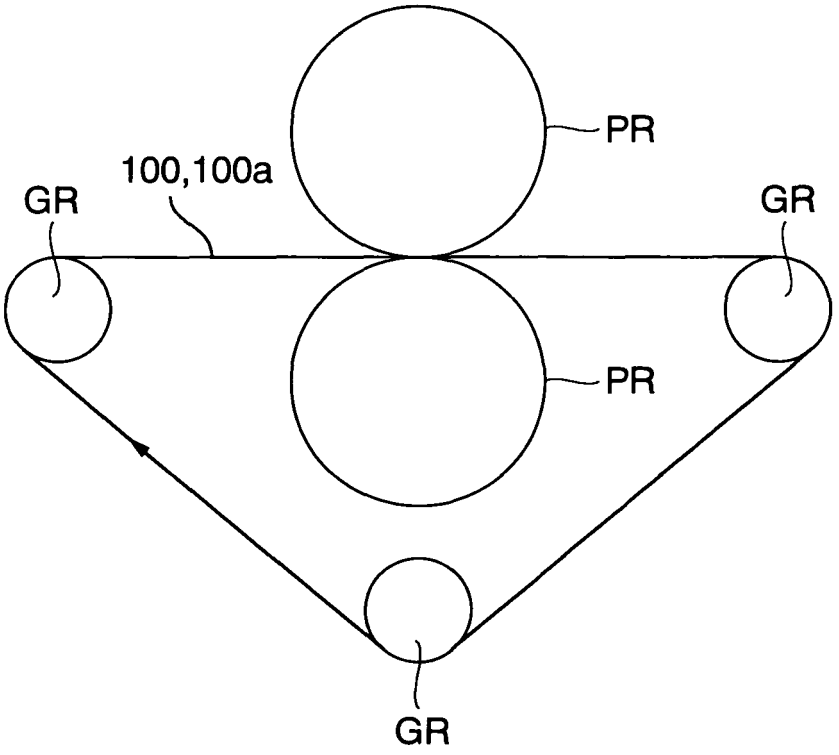
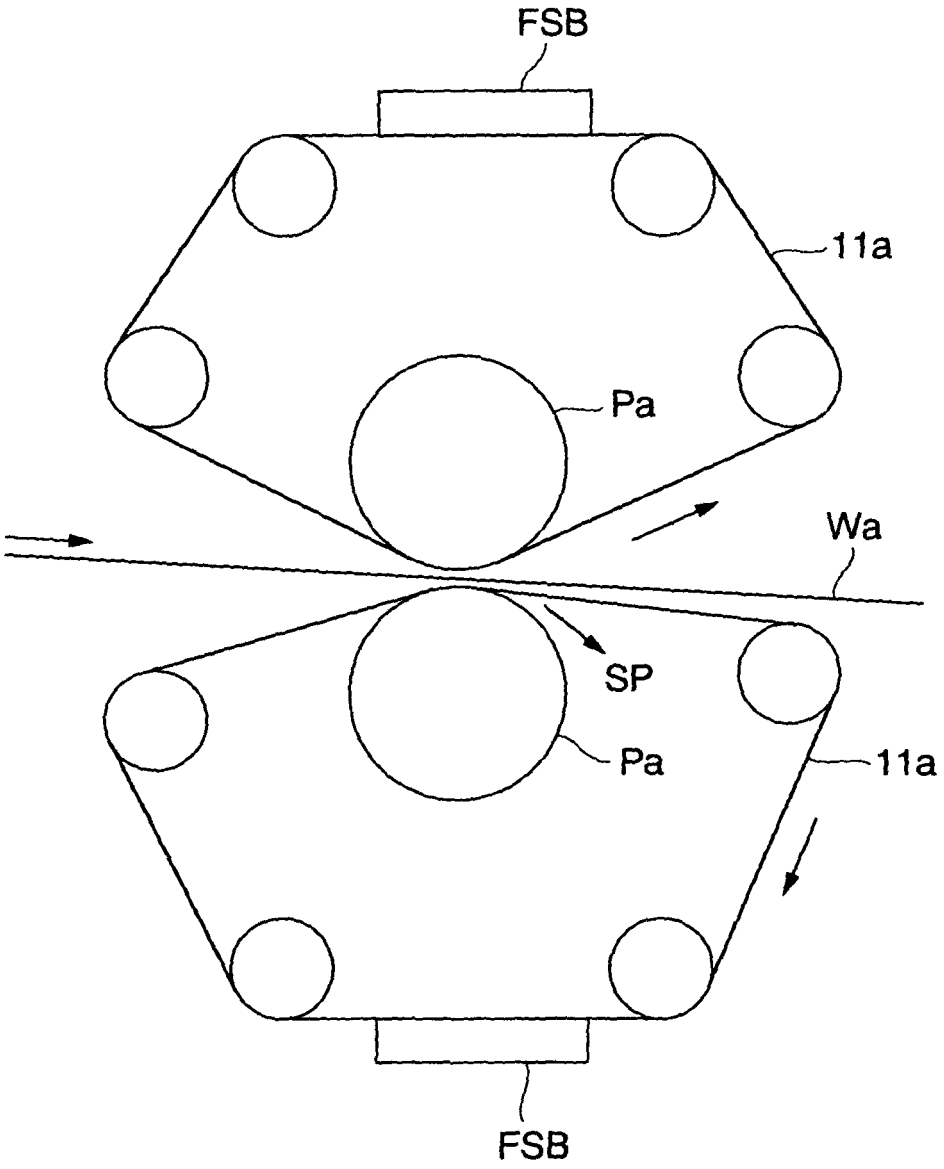


FIG.5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/063462

A. CLASSIFICATION OF SUBJECT MATTER
D21F7/08(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D21F7/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2005-200819 A (Ichikawa Keori Kabushiki Kaisha), 28 July, 2005 (28.07.05), Claims; Par. Nos. [0034] to [0036]; Figs. 2, 3 & US 2005/0167069 A1 & EP 1544351 A2 & CA 2490185 A1	1,4-6 2,3
Y A	JP 03-104995 A (Daiwabo Co., Ltd.), 01 May, 1991 (01.05.91), Claims; page 2, upper right column, lines 2 to 8; Fig. 1 (Family: none)	1,4-6 2,3
Y	JP 2002-161492 A (Nippon Felt Co., Ltd.), 04 June, 2002 (04.06.02), Par. Nos. [0004], [0007] (Family: none)	4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 September, 2007 (26.09.07)	09 October, 2007 (09.10.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/063462

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 09-209290 A (Ichikawa Keori Kabushiki Kaisha), 12 August, 1997 (12.08.97), Abstract; drawings (Family: none)	1-6
A	JP 2000-273786 A (Ichikawa Keori Kabushiki Kaisha), 03 October, 2000 (03.10.00), Abstract; drawings & US 6358369 B1 & EP 1482090 A1	1-6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8302584 A **[0011] [0020] [0020] [0021] [0022]**
- JP 2003013385 A **[0019] [0020] [0021]**