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(54) Belt-shaped fibrous material superior in openability and dimensional stability and process for producing the same.

(57) A belt-shaped fibrous material of 2-30 cm width, 2-50 mm thickness, and 0.01-0.50 g/cm^3 density, superior in openability and dimensional stability, the component short fibers of which are previously opened and arranged in web or sliver form, and which has 5-25 corrugated or depressive crimps/inch of its length.

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BELT-SHAPED FIBROUS MATERIAL SUPERIOR IN OPENABILITY AND DIMENSIONAL STABILITY AND PROCESS FOR PRODUCING THE SAME

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to dense and compact belt-shaped fibrous materials superior in openability, dimensional stability or deformation resistance, and flexibility.

DESCRIPTION OF THE PRIOR ART

Heretofore, the technique of opening a fiber bundle by use of a opening system comprising a feed rollber, a disk plate, and a taker-in roller around which a garnet wire is coiled, to form an intended fibrous web has been applied widely to the production of cushioning fibrous layers for use in sanitary materials such as napkins and non-reusable baby diapers and to other purposes.

Usually, slivers prepared from short fibers by carding are used as fiber bundles for the purpose of forming more uniform fibrous webs. However, said technique has the following disadvantages: Because such slivers are bulky, a large space is required for the fiber-bundle feed section of the facility even when the size of opening system is reduced to compact the facility, since said slivers are instable in shape or in dimension, that is, since they are readily elongated by tension resulting in irregularities or breaks, the speed of supplying the fiber bundle cannot be increased or said slivers must be exchanged frequently one for another.

SUMMARY OF THE INVENTION

It is the primary object of the present invention to solve the above noted problems of the prior art, in other words, to provide belt-shaped fibrous materials which can be put or enclosed in small spaces and are superior in dimensional stability, particularly in resistance to tension, and simultaneously in openability.

The present invention involves (i) a beltshaped fibrous material of 2-30 cm width, 2-50 mm thickness, and 0.01-0.50 g/cm^3 density, superior in openability and dimensional stability, the component short fibers of which are previously opened and arranged in sliver form said fibrous material having 5-25 corrugated or depressive crimps/inch of its length and (ii) a process for producing such belt-shaped fibrous materials, which comprises opening and arranging base short fibers by carding to form webs or slivers, piling up or bundling these webs or slivers, and crimping the piled or bundled material by forcing it into a crimper.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a side view showing an example of the facility to produce belt-shaped fibrous materials of the present invention.

Figs. 2 and 3 are partially-enlarged perspective views showing states wherein webs or slivers are bundled and forced into crimpers.

Fig. 4 is an enlarged perspective view of a section wherein a fiber bundle is forced into a crimpers.

Fig. 5 is a perspective view of a belt-shaped fibrous material produced according to the present invention.

Fig. 6 is a side view showing a state wherein belt-shaped fibrous material is opened by an opener and a web is formed on a nonwoven fabric.

Fig. 7 is a perspective view of a device for heat-treating a belt-shaped bundle formed of card webs or slivers.

Fig. 8 is a chart showing the distribution of irregularities in the thickness (basis weight) of the fibrous web obtained in Example 1 of the present invention.

Fig. 9 is a similar chart for the fibrous web obtained in a comparative example.

Fig. 10 is a similar chart for the fibrous web obtained in Example 2 of the present invention.

Meaning of principal notations in the drawings:

1 ... Belt-shaped fibrous material
2 ... Carding opener
3 ... Short fibers
4 ... Web
5 ... Sliver
6 ... Forced-feed type of crimper
12 ... Fine crimps in projective or depressive form
15 ... Garnet wire
16 ... Taker in roller
17 ... Base fibrous material
19 ... Nonwoven fabric
21 ... Fibrous web structure
22 ... Hot-air blowout hole

DESCRIPTION OF THE PREFERRED EMBODI-

MENT

There is no particular restriction on the source of short fibers to be used in the present invention. The short fibers are free to choose from; thermoplastic synthetic fibers, e.g. polyester fibers, nylon fibers, acrylic fibers, and polypropylene fibers; semi-synthetic fibers, e.g. acetate fibers; regenerated fibers, e.g. rayon; and natural fibers, e.g. cotton. These fibers may be used separately or in blends one with another.

The belt-shaped fibrous material of the present invention can be produced with ease in the manner that, as illustrated in Fig. 1, short fibers 3 are opened and arranged by using a carding opener 2, the resulting webs 4 or slivers 5 are piled up or bundled and then pressed in a forced-feed type of crimper 6 to form fine projective or depressive crimps.

More specifically, the web 4 or sliver 5 formed by the carding opener 2 is divided into parts of suitable width by passing over a doffer 7 provided with separator collars and the separated webs or slivers are superposed one upon another as shown in Fig. 2 or a suitable number of separated slivers 5 are arranged in near parallel one to another to give a sliver of suitable width as shown in Fig. 3. Then the resulting web or sliver is fed to the gap between the crimper rolls 9 and 10 of the forced-feed type crimper 6, which is illustrated in Fig. 4. The web or sliver nipped by the crimper rolls 9 and 10 is forced into a crimper box 11 and pressed therein to form the intended belt-shaped fibrous material 1, which is then taken out.

This belt-shaped material 1, as illustrated in Fig. 5, is in the shape of a belt composed of aggregated fibers and has fine crimps in projective or depressive form distributed length-wise. That is, the belt-shaped material 1 constructed of short fibers 3 which have been opened once, arranged by carding, and then compressed.

The opener illustrated in Fig. 6 comprises a feed roller 13, a disk plate 14, and a taker-in roller 16 around which a garnet wire 15 is coiled. The belt-shaped fibrous material 1 is fed to the opener through a feed roller 13. Opened fibers 17 obtained are sucked by an aspirator 18 to pile over a continuously traveling nonwoven fabric 19, whereby it is possible to form a fibrous web structure 21 that is a single body combining the nonwoven fabric 19 with the fibrous web 20.

When the web 4 or sliver 5 is subjected to heat treatment just prior to the forced feed to the crimper, the compression by the forced feeding and the formation of fine projective or depressive crimps are performed efficiently and a belt-shaped fibrous material 1 higher in density and good in dimensional stability can be obtained.

A device for heat treatment of the web 4 or sliver 5 is illustrated in Fig. 7. The traveling web 4 or sliver 5 is heated with high temperature steam or air 23 ejected through blowout holes 22 bored in the upper and lower plates of the heat treatment device, and then is fed to the gap between the crimper rolls 9 and 10 of the forced-feed type crimper 6.

For the purpose of producing fibrous webs good in uniformity by using a small and simple opener, it is desirable, in the present invention, to form fiber bundles in the first place from short fibers which are previously opened uniformly and arranged by using a suitable system such as a carding opener. When a belt-shaped fibrous aggregate, e.g. a lap, prepared by simple bundling of short fibers or a similar aggregate prepared by simple arrangement of short cut fibers having a definite length is fed to an opener, the opening will be insufficient and non-uniform, yielding only a fibrous web having a large number of clouds and a large variation in basis weight.

In the present invention it is desirable that a bulky web or sliver prepared, as described above, through a suitable system such as a carding opener be compressed in the forced-feed type crimper to form a belt-shaped fibrous material having fine corrugated or depressive crimps distributed length-wise. A bulky web or sliver can be converted into such a dense belt-shaped fibrous material as that of the present invention only by applying a compressive pressure exceeding 1200 kg/cm^2.

In the present invention, the base fibers when crimped previously are crimped again by a forced-feed type crimper; hence the later opening of the fibrous belt crimped again yields fibrous webs of favorable quality provided with prominent bulkiness and high compressive resilience.

The belt-shaped fibrous material of the present invention must be 2-30 cm wide and 2-50 mm thick. Since fibrous webs used for sanitary materials such as napkins and disposable diapers are 2-30 cm wide, the width of the belt-shaped fibrous material to be fed to an opener is chosen properly from the above range of widths according to the width of the objective sanitary material. The thickness of the belt-shaped fibrous material depends on its bulk density, the speed of its feed to opener, and the basis weight of the intended fibrous web. When the thickness of said fibrous material is less than 2 mm, the speed of feeding it to the opener needs to be increased and the resulting fibrous web will be inferior in uniformity. When the thickness of the belt-shaped fibrous material exceeds 50 mm, such a fibrous material will be difficult to feed to the opener. The density of the belt-shaped fibrous material is at least 0.01 g/cm^3 and the higher density is the better, since the fibrous ma-

terial of high density can be put or enclosed in a small space and is superior in dimensional stability, particularly in the stability to tension. But the density exceeding 0.50 g/cm^3 makes the opening difficult.

The belt-shaped fibrous material of the present invention should be provided with 5-25 fine crimps in corrugated or depressive form per/inch of its length. When said number of crimps is less than 5, such fibrous material will be fluffy and inferior in bundling workability and their lengthwise tensile strengths will be unsatisfactory. On the other hand when the number of crimps exceed 25, such fibrous materials will be hard, that is, they will be deficient in flexibility and hence it will be difficult to fold and compact them so as to put or enclose them in a small space.

The belt-shaped fibrous material is desired to have a tensile strength at break of at least 20 g 10^4d. The tensile strength at break is determined by measuring the strength at break of cut test pieces of 2 x 10^4d each and 150 mm length by using a Tensilon tensile tester at a distance of 100 mm between the chucks and at a strain rate of 100%/min, and the found value is expressed in the strength per 10^4 deniers. When the tensile strength at break is less than 20 g/10^4d, such belt-shaped fibrous materials in traveling will be elongated, resulting in irregularities or breaks.

When fibrous webs resulting from opening the belt-shaped fibrous material are used as cushioning fibrous layers for sanitary materials such as napkins and disposable diapers and for other materials and are required to be bulky and have high compressive resilience, it is desirable that at least 50% by weight of the thermoplastic synthetic short fibers constituting the belt-shaped fibrous material have cushioning properties which do not deteriorate even under wet conditions. If the proportion of the thermoplastic synthetic short fibers having such moisture-resistant cushioning properties is less than 50% by weight, the cushioning property of such fibrous web will be poor particularly under wet conditions. Further, the fibers used herein is desired to have 1.5-15 d fiber size, 25-128 mm length, 5-25 crimps/ inch, and 5-25% degree of crimping. In any of these characteristics is lower than the lower limit of the above defined range, the cushioning property of the fibrous web will be inferior and upon using such a fibrous web, for instance, as a sanitary material, the comfortable wearing feel of the end product (napkin or diaper) will be impaired. In addition, said fibrous web will bring about such lowering in the performance of end product that it is difficult for body fluids and/or excretions to diffuse through voids in the cushioning fibrous layer in the thickness direction and toward the outer surface and in particular, that body fluids absorbed in the absorber wet back or the cushioning fibrous layer has a low capacity to hold excretions such as slushy feces. If the used fiber has more than 15 d fiber size, more than 128 mm length, more than 25 crimps/inch, or more than 25% degree of crimping, the cushioning layer will have a high rigidity, being hard to the touch and excretions such as slushy feces will not readily permeate the cushioning layer.

In the case of hydrophobic fibers, the finish to make their surfaces hydrophilic is favorable for the present invention since such finish improves the hydrophilic property and retentivity for body fluids and/or excretions. Known agents suitable for this surface finishing are, for example, anionic or nonionic surface active agents having phase-inversion viscosities of 10,000 cps and more and/or block copolymers of polyoxyalkylenes with oligomers or low-molecular copolymers, the monomers constituting these oligomers or copolymers being the same as those constituting polymers for thermoplastic synthetic fibers, said block copolymers having molecular weights of 1000 to 10,000. It is possible, of course, to use other durable finishing agents which can make the fiber surface hydrophilic.

For the purpose of more improving the compressive resilience of fibrous webs formed from the belt-shaped fibrous material, it is desirable to use base fibers which exhibit high compressive resilience, e.g. polyester fibers, and moreover have hollow structures. When the hollow volume fraction of these base fibers is less than 5%, the resilience improving effect is limited and when the hollow volume fraction exceeds 35%, the resilience is not improved over the value of base fibers having a hollow volume fraction of 35%.

In the present invention, the card web or sliver is desirably constituted of fibers whose shrinkages due to heat treatment are from 2 to 35% when the shrinkage is less than 2%, such fibers cannot be effectively bundled and hence, upon feeding the resulting bulky web or sliver as such to the gap between the crimper rolls of a forced-feed type crimper, the nip by the crimper rolls will be instable. When the shrinkage exceeds 35%, such fibers are too strongly bundled by shrinking treatment and additionally the compression in a forced-feed type crimper results in very hard belt-shaped fibrous materials which will be difficult to open.

The following examples illustrate the present invention in more detail.

Example 1

Hollow polyester fibers (fiber size 6 d, fiber length 51 mm, number of crimps 14/inch, degree of crimping 16%, shrinkage in boiling water 13%,

hollow volume fraction 15%) finished to make the surface hydrophilic were opened by using a roller card of 2 m width. The resulting fibrous web, leaving a doffer roll, was divided once into 6 slivers. As shown in Fig. 7, the slivers were then arranged in parallel one to another and subjected to wet heat treatment with steam. The treated slivers were fed to a forced-feed type crimper comprising crimper rolls and a crimper box and compressed to form a belt-shaped fibrous material (width 13 cm, thickness 5 mm, density 0.25 g/cm^3) having 15 crimps/inch. The tensile strength at break of this fibrous belt was found to be 82 g/10^{4}d. This fibrous belt was fed to a small, simple opening machine as shown in Fig. 6, and the opened fibers were piled to form a fibrous web 20 (basis weight 19 g/m^2, width 13 cm, thickness 3 mm, density 0.006 g/cm^3) on a nonwoven fabric 19 moved continuously at a speed of 230 m/min. The nonwoven fabric 19 retains its own shape with hydrophobic polypropylene fibers of 1.5 d fiber size being interlaced and has numerous perforations of 1.5 mm diameter at intervals of 1.5 mm. While moving the nonwoven fabric continuously at a speed of 230 m/min, the underlying aspirator 18 was operated to suck and deposit said opened short polyester fibers in web form on the nonwoven fabric, thereby yielding a fibrous web structure 21. This fibrous web structure 21 was cut transversly at intervals of 40 cm to sample 125 pieces. Results of weighing these pieces are shown in Fig. 8.

The fibrous web structure ,21, showing slight variation in basis weight, was superior in uniformity, disposable diapers made from this fibrous web structure 21 were good in cushioning property and prominent in wearing feel and exhibited such superior performance as to absorb and hold body fluids and/or excretions efficiently and not to allow them to flow back to the surface.

Example 2

Short rayon fibers (fiber size 4 d, fiber length 32 mm, number of crimps 12/inch, degree of crimping 7%) were opened by using a roller card of 1 m width. The resulting fibrous web after leaving a doffer roll was divided once into 4 slivers. As shown in Fig. 7, the slivers were then arranged in parallel one to another and subjected to wet heat treatment with steam. The treated slivers were fed to a forced-feed type crimper comprising crimper rolls and a crimper box and compressed to form a belt-shaped fibrous material of 5 cm width, 5 mm thickness, and 0.25 g/cm^3 density, having 15 crimps/inch. The tensile strength at break of this fibrous belt was found to be 56 g/10^{4}d. This fibrous belt was fed to a small, simple opening machine as shown in Fig. 6, and the opened fibers were piled to form a fibrous web 20 (basis weight 10 g/m^2, width 5 cm, thickness 3 mm, density 0.003 g/cm^3) on a nonwoven fabric 19 moved continuously at a speed of 230 m/min. The nonwoven fabric 19 retains its own shape with hydrophobic polypropylene fibers of 1.5 d fiber size being interlaced and has numerous perforations of 1.5 mm diameter at intervals of 1.5 mm. While moving the nonwoven fabric continuously at a speed of 230 m/min, the underlying aspirator 18 was operated to suck and deposit said opened short rayon fibers in web form on the nonwoven fabric, thereby yielding a fibrous web structure 21. This fibrous web structure 21 was cut transversly at intervals of 15 cm to sample 100 pieces. Results of weighing these pieces are shown in Fig. 10.

The birous web structure, showing slight variation in basis weight, was superior in uniformity. Napkins made from this fibrous web structure 21 were good in cushioning property and prominent in wearing feel and exhibited such superior performance as to absorb and hold body fluids and/or excretions and not to allow them to wet back to the surface.

Comparative Example 1

Hollow polyester fibers (the same as used in Example 1, fiber size 6 d, fiber length 51 mm, number of crimps 14/inch, degree of crimping 16%, shrinkage in boiling water 13%, hollow volume fraction 15%, finished to make the surface hydrophilic) were opened by using a roller card of 1 m width. The resulting webs leaving a doffer roll were bundled to form a sliver (whole fiber size 150,000 d, density 0.005 g/cm^3, tensile strength at break 15 g/10^4 d), which was then cut into six parts and once contained in 6 cans by using a coiler. These slivers were taken out of the cans, and arranged in parallel one to another. Then tensions on these slivers under traveling were controlled by using guide bars so as to become equal. In the same manner as in Example 1, these six slivers were fed to a small, simple opening machine, and short opened fibers therefrom were piled over a nonwoven fabric. But the above slivers under traveling were elongated by tension. Accordingly, no uniform fibrous web could be obtained.

Comparative Example 2

Hollow polyester fibers (the same as used in Example 1 and Comparative Example 1, fiber size 6 d, fiber length 51 mm, number of crimps 14/inch, degree of crimping 16%, shrinkage in boiling water

13%, hollow volume fraction 15%, finished to make the surface hydrophilic) were opened coarsely by using a beater opener, and the resulting lap was once wound up. The lap, unwound, was compressed with hot calender rolls (150°C) and then slit into strips 13 cm wide, that is, belt-shaped fibrous materials of 10 mm thickness and 0.15 g/cm^3 density. The tensile strength at break of these belt-shaped fibrous materials was found to be 1100 g/25 mm width.

In the same manner as in Example 1, these belt-shaped fibrous materials were fed to a small, simple opening machine, and resulting short fibers were piled on a nonwoven fabric traveling at a speed of 230 m/min, thereby yielding a fibrous web structure of 12 g/m^3 basis weight, 13 cm width, and 0.004 g/cm^3 density.

This fibrous web structure was cut transversely at intervals of 40 cm to sample 125 pieces (total length 50 m). Results of weighing these pieces are shown in Fig. 9.

The basis weight of this fibrous web structure varies largely as is apparent from Fig. 9 and a number of clouds were observed on the web structure.

EFFECT OF THE INVENTION

According to the present invention that is characterized as described hereinbefore, there are provided belt-shaped fibrous materials of high densities which are superior in dimensional stability and can be opened easily and uniformly by a small, simple opening machine and it is possible to produce, from the resulting opened fibers, fibrous webs which are superior in uniformity, bulkiness, and compressive resilience and best suited for use as cushioning fibrous layers in sanitary materials. That is, the present invention has such distinguished effects.

Claims

1. A belt-shaped fibrous material of 2-30 cm width 2-50 mm thickness, and 0.01-0.50 g/m^3 density, superior in openability and dimensional stability, the component short fibers of which are previously opened and arranged in web or sliver form, said fibrous material having 5-25 corrugated or depressive crimps/inch of its length.

2. The belt-shaped fibrous material of Claim 1, wherein the short fibers are thermoplastic synthetic fibers finished to make the surface hydrophilic.

3. The belt-shaped fibrous material of Claim 2, wherein the thermoplastic synthetic fibers are hollow polyester fibers having a hollow volume fractions of 5 to 35%.

4. A process for producing belt-shaped fibrous materials superior in openability and dimensional stability, which comprises opened and arranging base short fibers by carding to form webs or slivers, laminating or bundling these webs or slivers, and crimping the laminates or bundle by forcing it into a crimper.

5. The process of Claim 4, wherein the laminated or bundled webs or slivers are subjected to heat treatment just prior to the forced feed to the crimper.

6. The process of Claim 4, wherein the base short fibers are thermoplastic synthetic fibers finished to make the surface hydrophilic.

7. The process of Claim 6, wherein the thermoplastic synthetic fibers are hollow polyester fibers having a hollow volume fraction of 5 to 35%.

FIG. 1

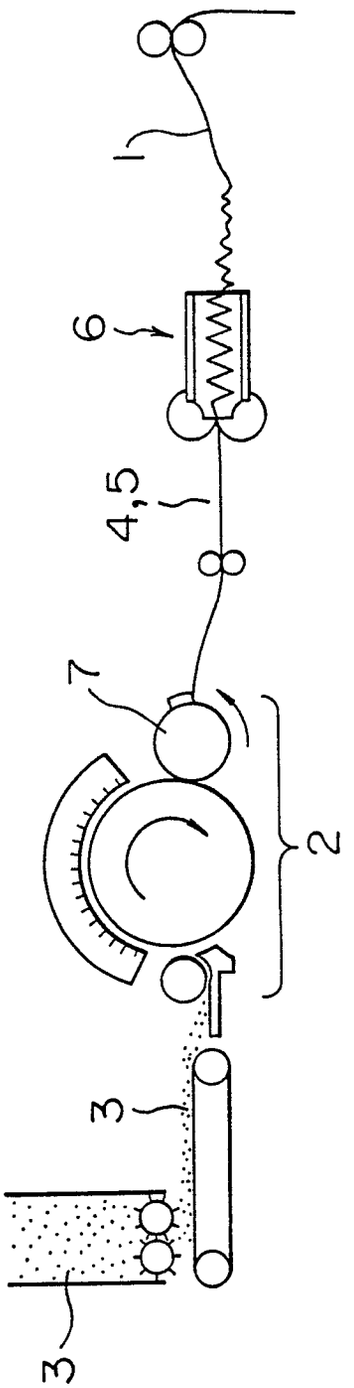

FIG. 2

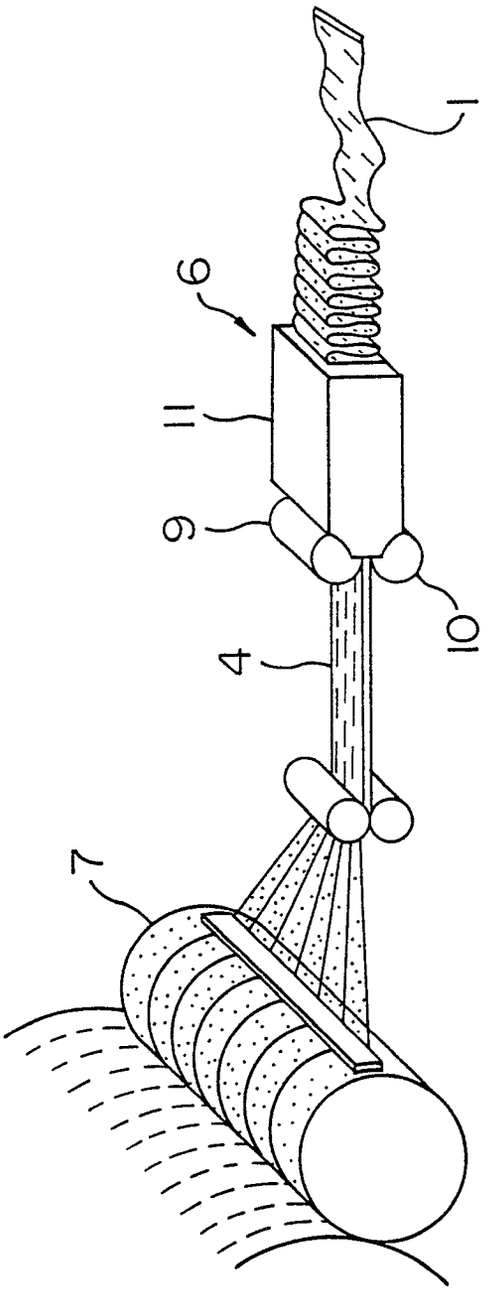

FIG. 3

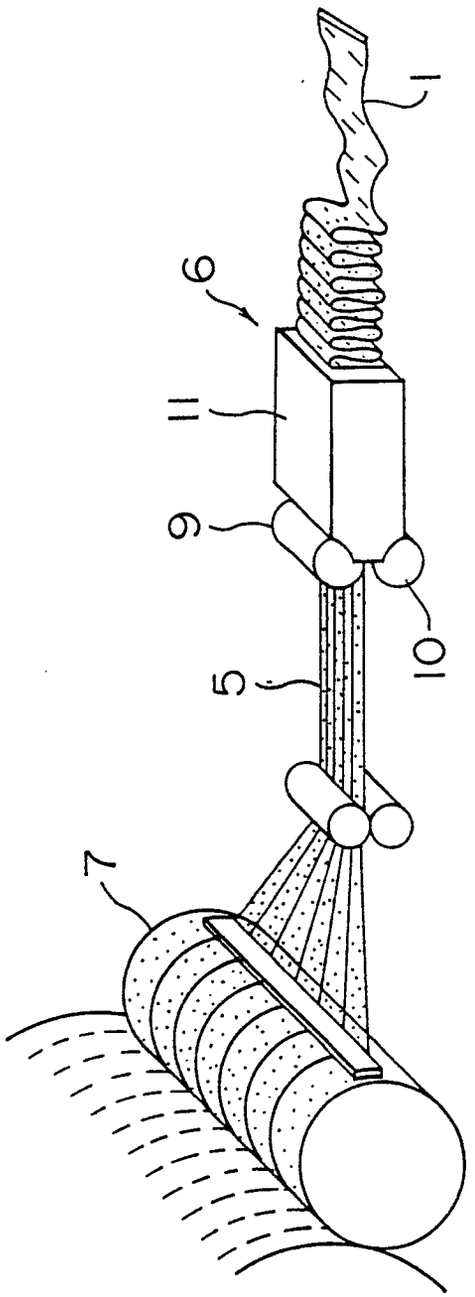

FIG. 4

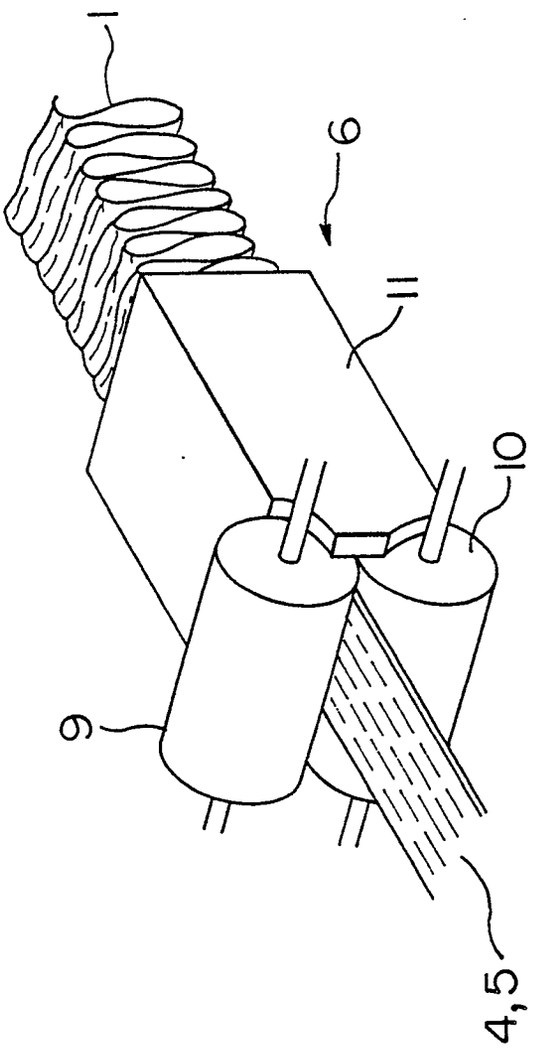

FIG. 5

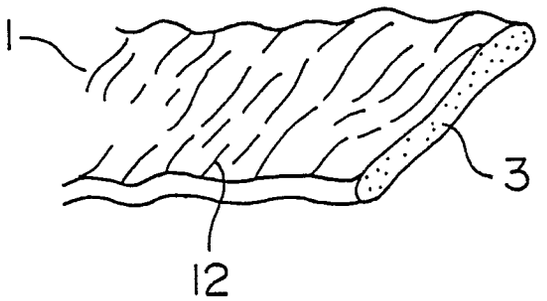

FIG. 6

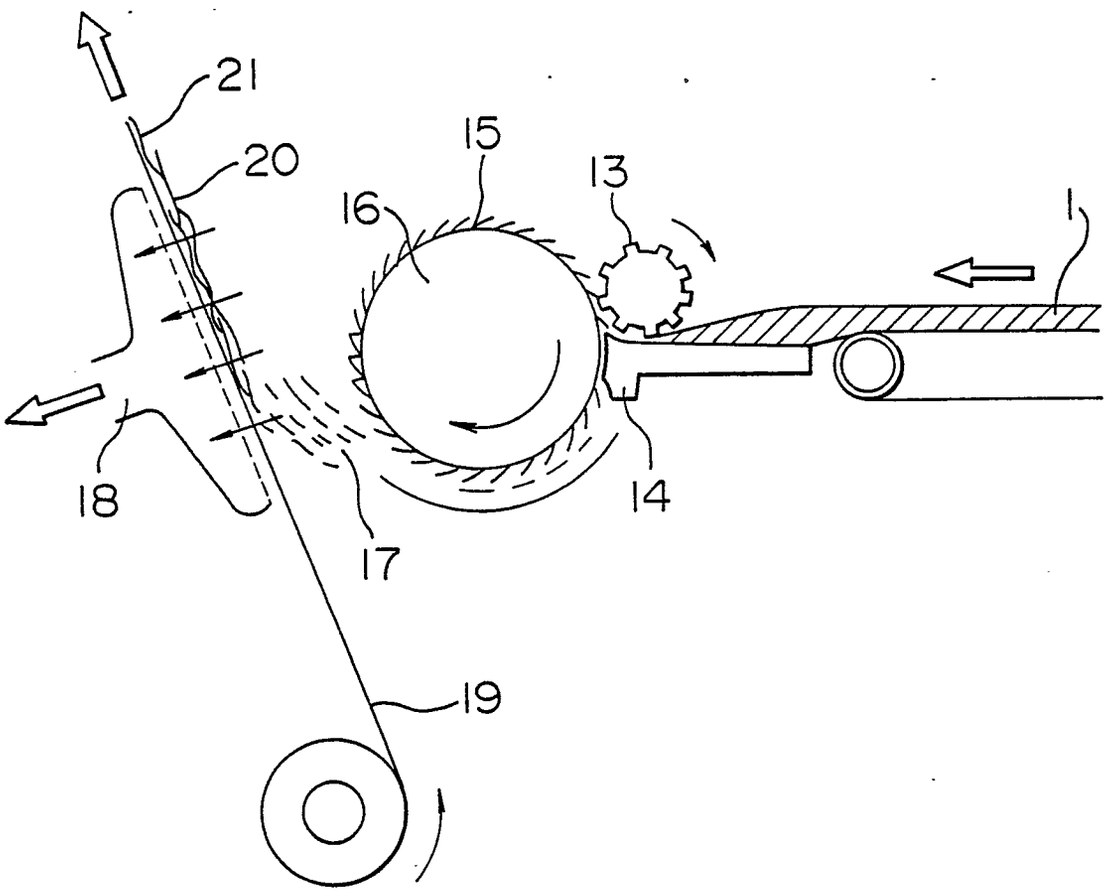

FIG. 7

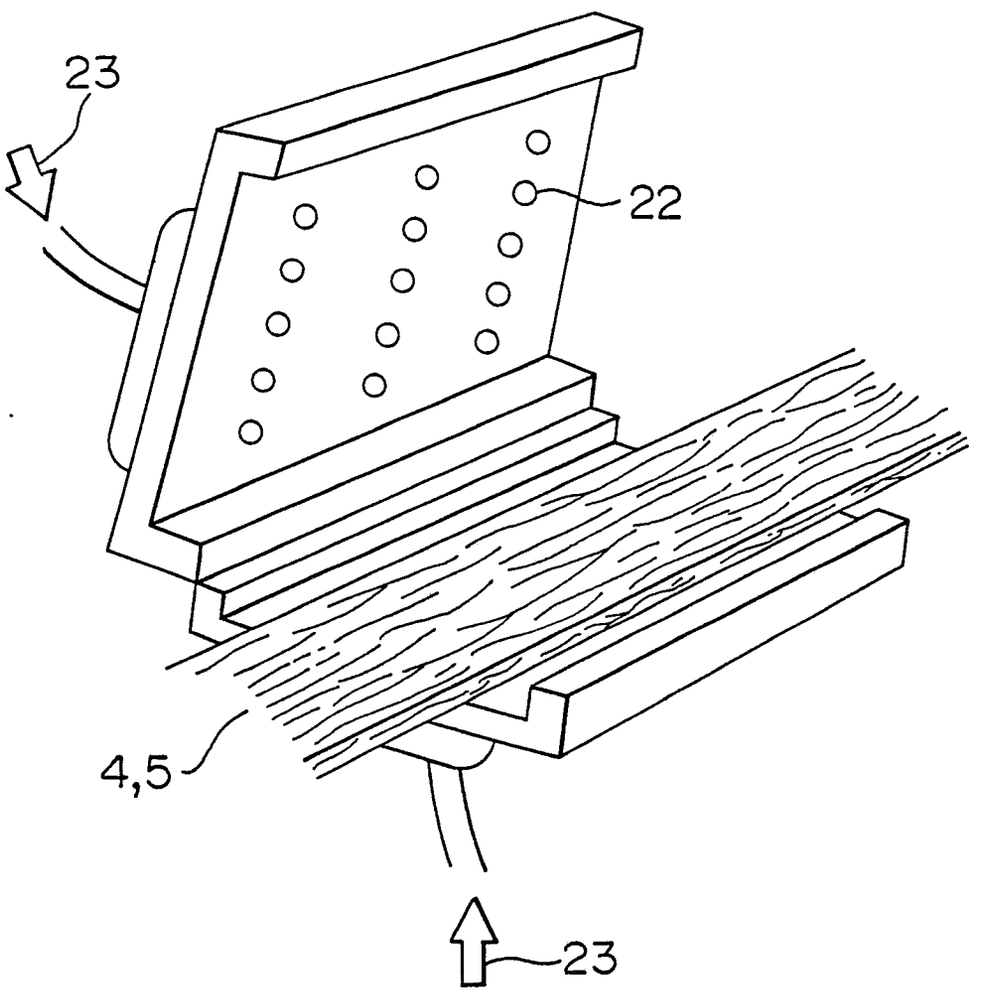

FIG. 8

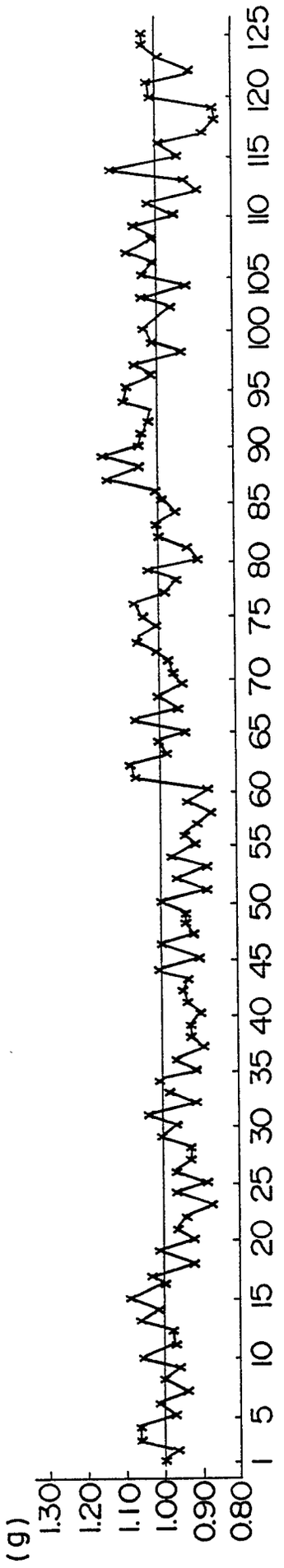
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FIG. 9

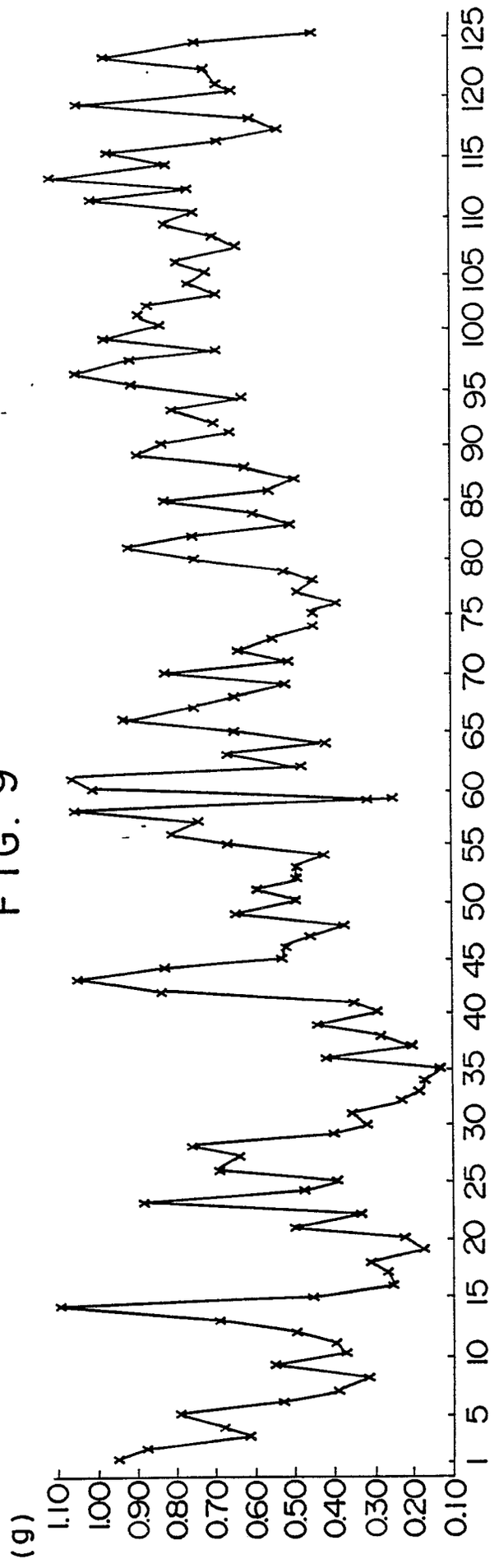
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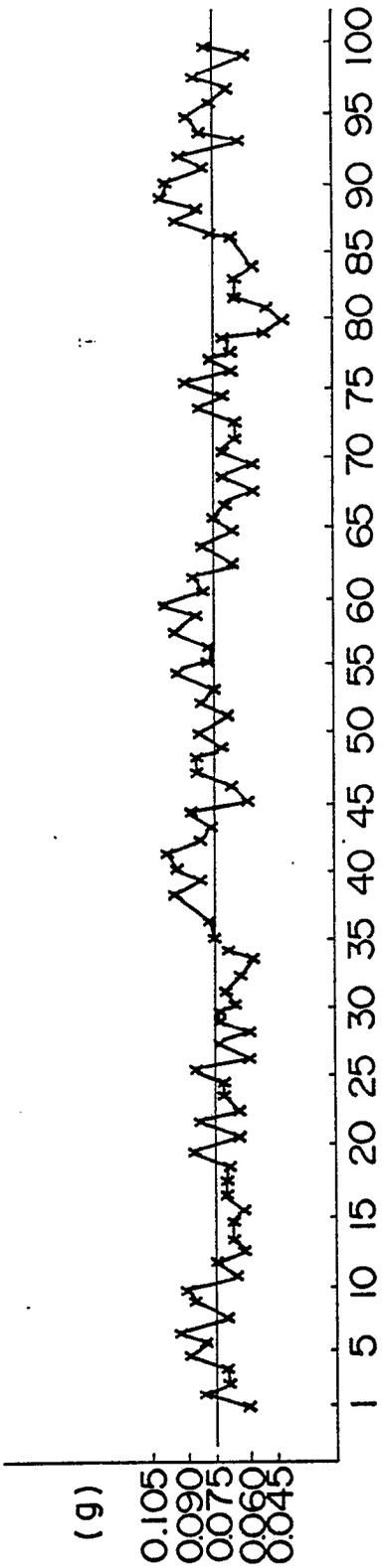
FIG. 10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