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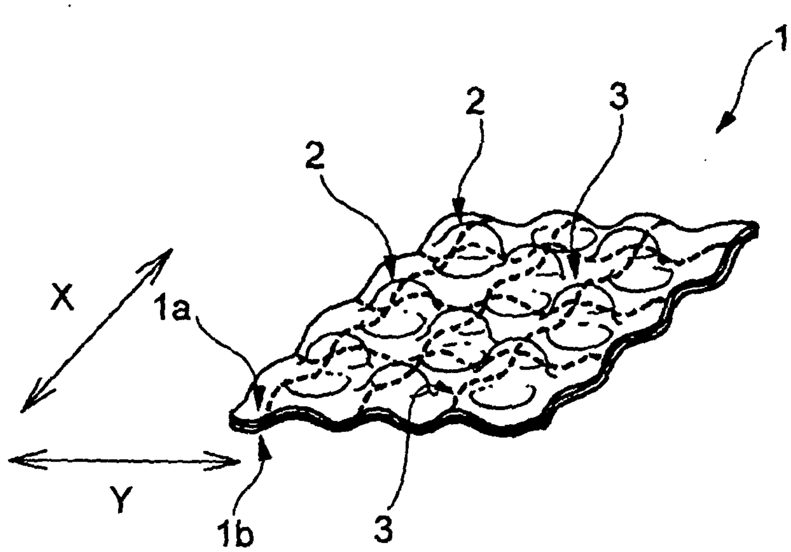
(54) Bulky sheet and process of producing the same

(57) A bulky sheet 1 has a network sheet 11 and a nonwoven fabric-like fiber aggregate 10 having fibers arranged on at least one side of the network sheet 11. The fibers of the fiber aggregate 10 is in entanglement among themselves and with the network sheet 11 to be unitary with the network sheet 11. The network sheet 11 is three-dimensionally shaped to form a number of protrusions and depressions, and the fiber aggregate 10 is united with the network sheet 11 along the contour of the three-dimensionally shaped network sheet 11 such that the bulky sheet, as a whole, has a three-dimensional profile with a number of protrusions and depressions.

Fig. 1



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Description

[0001] The present invention relates to a bulky sheet having a three-dimensional profile with numerous protrusions and depressions and a process of producing the same.

[0002] Applicant previously proposed in JP-A-5-25763 and JP-A-5-192285 a sheet comprising a network sheet and a nonwoven fabric-like fiber aggregate on one or both sides of the network sheet. The fiber aggregate is formed by entanglement of a fiber web. The fibers constituting the fiber aggregate are in entanglement not only among themselves but with the network sheet to form a unitary sheet. The fiber aggregate forms a large number of protrusions and depressions.

[0003] Applicant further proposed a bulky sheet in JP-A-2001-336052 comprising a network sheet and a fiber aggregate formed by hydro-entanglement of a fiber web and having a large number of protrusions and depressions formed of the fiber aggregate. The protrusions and depressions are results of second hydro-entanglement that is performed on the fiber aggregate in such a manner that the fibers of the fiber aggregate are rearranged and that the fiber aggregate bends zigzag along its planar direction so that the protrusions and depressions per se exhibit shape retention.

[0004] In applications as a dry type cleaning sheet, all the above-described bulky sheets are capable of catching up dust and debris of relatively large size such as fluff, lint, and hairs, which have been difficult to trap with conventional cleaning sheets, with their fibers having high freedom and of surely collecting dust from a wide area while keeping adequate strength while in use. With high bulk, they are capable of conforming to the grooves of floors and uneven surfaces of furniture, appliances, etc. to remove dirt and dust from such grooves or recesses. Because these bulky sheets as produced in continuous form are usually wound in roll for storage before fabrication into final products, the three dimensional profile with the protrusions and depressions is liable to be collapsed due to the winding pressure. Collapse of the profile can also occur when the bulky sheet in roll form is unrolled and processed under tension or between the nip of rolls.

[0005] The present invention provides a bulky sheet having a network sheet and a nonwoven fabric-like fiber aggregate formed by entanglement of fibers. The fiber aggregate is present on at least one side of the network sheet. The fibers of the fiber aggregate are in entanglement not only among themselves but with the network sheet to be unitary with the network sheet. The network sheet is three-dimensionally shaped to form a number of protrusions and depressions, and the fiber aggregate is united with the network sheet along the contour of the protrusions and the depressions of the network sheet such that the bulky sheet, as a whole, has a three-dimensional profile with a number of protrusions and depressions.

[0006] The present invention also provides a preferred process of producing the bulky sheet. The process includes the steps of (1) superposing a fiber web on at least one side of a network sheet, (2) hydro-entangling the fibers constituting the fiber web among themselves and with the network sheet to convert the fiber web into a nonwoven fabric-like fiber aggregate and to unite the fiber aggregate with the network sheet, and (3) heat embossing the resulting unitary sheet by inserting the sheet between a pair of matched engraved rolls both having a number of protrusions and depressions or between an engraved roll having a number of protrusions and depressions and a smooth roll made of or covered with an elastic material to shape the sheet to the contour of the engraved roll.

Fig. 1 is a perspective of an embodiment of the bulky sheet according to the present invention.
Fig. 2 is an exploded perspective view of the bulky sheet of Fig. 1.
Fig. 3 schematically illustrates apparatus suitable for the production of the bulky sheet shown in Fig. 1.
Fig. 4 schematically shows another configuration of the cooling part of the apparatus shown in Fig. 3.
Fig. 5 is a schematic illustration of another apparatus suitable for the production of the bulky sheet of Fig. 1.

[0007] The present invention will be described with reference to its preferred embodiments by referring to the accompanying drawings. An embodiment of the bulky sheet according to the invention is shown in Fig. 1. Fig. 2 represents an exploded, perspective view of the bulky sheet of Fig. 1. The bulky sheet 1 of the embodiment has a first side 1a and a second side 1b. The bulky sheet 1 has many protrusions 2 protruding from one side to the other. The protrusions 2 are regularly spaced in both the machine direction X and the cross direction Y in lines and rows, respectively, to form a rhombic lattice pattern as a whole. Between every adjacent protrusions 2 in every line and every row are made depressions 3 to form a rhombic lattice pattern as a whole. With the protrusions 2 and the depressions 3 the bulky sheet 1 has a three-dimensional surface profile as a whole.

[0008] The individual protrusions 2 are almost hemispherical, and so are the depressions 3. It is preferred for the bulky sheet 1 of the present embodiment to exhibit the same performance on both sides thereof particularly where it is used as a cleaning sheet. In this connection, it is preferred that the shape and the spacing of the protrusions 2 on the first side 1a and those on the second side 1b be substantially the same. It is preferred that the back of the depressions 3 on the first side 1a correspond to the protrusions 2 on the second side 1b and vise versa. It is also preferred that the shape of the individual protrusions 2 be an inversion of the individual depressions 3.

[0009] The protrusions 2 are preferably distributed on either side at an average density of 50 to 850, more preferably 100 to 600, per 10 cm square at any site on that side. With the density of the protrusions 2 falling within that range, the bulky sheet 1 has protrusions 2 and depressions 3 arranged in good balance and, when used as a cleaning sheet, for example, exhibits still superior performance in catching up and holding relatively large dust including bread crumbs as well as fine dust.

[0010] As will be understood from a preferred process of producing the bulky sheet 1 described infra, the shape and arrangement of the protrusions 2 and the depressions 3 can be freely designed by designing the engraved pattern on an engraved roll used in the production.

[0011] The individual protrusions 2 preferably have an area of 1 to 100 mm^2, more preferably 4 to 25 mm^2, in their plan view from the standpoint of dust trapping capabilities and stable three-dimensional shape retention. The same preference applies to the area of the individual depressions 3. From the same standpoint, the distance between adjacent protrusions 2 and between adjacent depressions 3 in the machine direction X is preferably 1 to 20 mm, more preferably 4 to 20 mm. The same applies to the cross direction Y.

[0012] The thickness of the bulky sheet 1, i.e., the distance from the plane connecting the apices of the protrusions 2 on the first side 1a to the plane connecting the apices of the protrusions 2 on the second side 1b is preferably 0.5 to 8 mm, more preferably 1 to 4 mm. The bulky sheet 1 with that thickness encompasses ample voids to provide high bulk and is fit for use as, for example, a cleaning sheet. Sheet 1 thickness measurement is taken under a load of 0.3 kPa, which corresponds to the pressure applied when the sheet is lightly pressed by a hand, using, for example, a thickness gauge FS60DS supplied by Mitutoyo Corp.

[0013] To maintain bulk while in use, the sheet 1 preferably has a thickness of 0.5 to 6 mm, more preferably 1 to 3 mm, under a load of 0.7 kPa, which is greater than the above-recited measuring load and corresponds to the load applied while the sheet 1 attached to a cleaning tool is used to clean a floor, etc.

[0014] The bulky sheet 1 is composed of a fiber aggregate 10 formed by hydro-entangling a fiber web and a network sheet 11 disposed inside the fiber aggregate 10. As described infra in detail, the fibers constituting the fiber aggregate 10 are entangled with the network sheet 11 by hydro-entanglement so that the fiber aggregate 10 and the network sheet 11 are unitary with each other.

[0015] As is clear from Fig. 2, the network sheet 11 is shaped in three dimensions to form a number of protrusions and depressions. As will be apparent from a preferred process of producing the bulky sheet 1 described later, the three dimensional shaping of the network sheet 11 is based on plastic deformation so that the three dimensionally uneven profile of the network sheet 11 is retained stably.

[0016] The fiber aggregate 10 is present on both sides of the network sheet. The fiber aggregate 10 on both sides of the network sheet is integral with the network sheet in conformity with the contour of the three dimensionally shaped profile of the network sheet 11. As a result, the whole sheet 1 has a three dimensional profile with a number of the protrusions 2 and depressions 3. In other words, the shapes of the protrusions 2 and the depressions 3 of the bulky sheet 1 are substantially the same as those of the network sheet 11.

[0017] The protrusions 2 and the depressions 3 of the bulky sheet 1 are formed by integrally joining the fiber aggregates 10 with the network sheet 11 along the contour of the three dimensionally shaped profile of the network sheet 11. Accordingly, the shapes of the protrusions 12 and the depressions 3 are stably retained by the three-dimensionally shaped and plastically deformed network sheet 11. Therefore, the protrusions 2 and the depressions 3 hardly collapse to lose their shapes even under load. The bulky sheets described in JP-A-5-25763 and JP-A-5-192285 supra, in contrast, are more liable to lose their shapes under load because the protrusions are formed by shrinkage of a network sheet. In applications as a cleaning sheet, the bulky sheet 1, which is less liable to collapse its three-dimensional shape, is superior in capabilities of cleaning grooves of floors or uneven surfaces and of catching up and holding such dust and debris like bread crumbs. This superiority is particularly outstanding when the bulky sheet 1 is used as attached to a cleaning tool.

[0018] The fiber aggregate 10 and the network sheet 11 that make up the bulky sheet 1 will be described more specifically. The fiber aggregate 10 has a nonwoven fabric-like structure formed by entangling fibers constituting a fiber web among themselves through hydro-entanglement. Formed only by entanglement of the constituent fibers, the fiber aggregate 10 provides the constituent fibers with more freedom to move than nonwoven fabric in which the constituent fibers are joined by fusion or with an adhesive. For this reason, the bulky sheet 1 is excellent in capabilities of catching up and holding hairs, fine dust, etc. and feels soft.

[0019] The fibers making up the fiber aggregate 10 include those recited in U.S. Patent 5,525,397, cl. 4, 11. 3-10. It is preferred for the fiber aggregate 10 to contain at least 50% by weight of fibers having a fineness of 5 dtex or smaller, more preferably at least 70% by weight of 3.5 dtex or finer fibers, so as to avoid holes being created during the hydro-entangling process and to provide and retain sufficiently high bulk. The recited fiber constitution is also advantageous in view of hair catching up and holding capabilities in applications as a cleaning sheet. The grammage (basis weight) of the fiber aggregate 10 and the fiber length of the fibers used in the fiber aggregate 10 should be determined according to the use of the bulky sheet 1 in comprehensive consideration of processability and cost. In applications as a cleaning sheet, for instance, it is desirable that the fiber aggregate 10 have a grammage of 30 to 100 g/m^2, more desirably 40 to 70 g/m^2, and that the constituent fibers have a length of 20 to 100 mm, more desirably 30 to 65 mm, to avoid holes being created during hydroentanglement and to obtain and retain sufficiently high bulk. The fiber aggregate 10 may be provided with a surface active agent or lubricant that can improve the surface physical properties and dust trapping capabilities of the fiber aggregate 10.

[0020] The network sheet 11 is a resin-made net having a lattice mesh as illustrated in Fig. 2. The network sheet 11 preferably has an air permeability of 0.1 to 1000 cm^3/cm^2·sec. Nonwoven fabric, paper, film, etc. may also serve as a network sheet as long as their air permeability falls within that range. The fibers of the fiber aggregate 10 are in entanglement not only among themselves but also with the network sheet 11 so that the fiber aggregate 10 exhibits increased tensile strength. The diameter of the strands making the net is preferably 50 to 600 μm, more preferably 100 to 400 μm. The mesh size (distance between adjacent strands) is preferably 2 to 30 mm, more preferably 4 to 20 mm. Unlike the network sheet used in JP-A-5-25763 and JP-A-5-192285 supra, the network sheet 11 used in the present embodiment does not need to have thermal shrinkability. To use a thermally shrinkable network sheet in the present invention causes no problem of course.

[0021] Useful materials to make the network sheet 11 include those described in U.S. Patent 5,525,397, cl. 3, 11. 39-46. In particular, various thermoplastic resins are preferred. In order for the bulky sheet 1 to be capable of retaining its bulkiness even with a load applied thereon, the network sheet 11 is preferably of an elastic material. Examples of suitable materials of the network sheet 11 include polyolefin resins, such as polyethylene, polypropylene, and polybutene; polyester resins, such as polyethylene terephthalate and polybutylene terephthalate; polyamide resins, such as nylon; acrylonitrile resins; vinyl resins, such as polyvinyl chloride; and vinylidene resins, such as polyvinylidene chloride. Modified products or blends of these resins are also useful.

[0022] The bulky sheet 1 preferably has a weight of 30 to 110 g/m^2, more preferably 40 to 80g/m^2, for assuring both bulkiness and processability. Where the fiber aggregate 10 is present on both sides of the network sheet 1, the part of the fiber aggregate 10 that is on one side and the part of the fiber aggregate 10 that is on the other side may be the same or different in weight per unit area.

[0023] A preferred process of producing a bulky sheet according to the present invention will be described with reference to Fig. 3. In this process, a fiber web is superposed on one or both sides of a network sheet 11. The superposed three layers are hydroentangled to entangle the fibers of the fiber web(s) among themselves and with the network sheet 11 thereby to convert the fiber web(s) into a nonwoven fabric-like fiber aggregate 10 and at the same time to unite the fiber aggregate 10 and the network sheet 11. The resulting unitary sheet is subsequently heat embossed between a set of matched engraved rolls having a number of protrusions and depressions. As a result of heat embossing, the unitary sheet is shaped to have a three dimensional profile corresponding to the shape of the nip of the engraved rolls.

[0024] Fig. 3 schematically shows apparatus 20 that is preferably used to make the bulky sheet 1 of the present embodiment. The apparatus 20 is sectioned into a superposing part 20A, an entangling part 20B, a shaping part 20C, and a cooling part 20D.

[0025] The superposing part 20A has cards 21A and 21B for forming fiber webs 10a and 10b, respectively, feed rolls 22 for feeding the fiber webs 10a and 10b, and a feed roll 24 for feeding a network sheet 11.

[0026] The entangling part 20B has an endless belt 25 for supporting webs and a group of water jet nozzles 26.

[0027] The shaping part 20C has a pair of matched engraved rolls 27 each having a number of protrusions and depressions. Each engraved roll 27 rotates in the direction indicated with the arrow shown in Fig. 3. Each engraved roll 27 is made of metal and is equipped with a heater (not shown) for heating the roll to a prescribed temperature.

[0028] The cooling part 20D includes an air blow duct 28 facing one side of a laminate sheet and a vacuum conveyor 29. The air blow duct 28 blows cool air to the sheet. The vacuum conveyor 29 has an endless mesh belt for conveying the sheet and is designed to vacuum up the cool air from the air blow duct 28 through the mesh belt.

[0029] The apparatus 20 operates as follows. In the superposing part 20A, the cards 21A and 21B continuously feed the respective fiber webs 10a and 10b via the respective feed rolls 22. Between the cards 21A and 21B is placed a roll 23 of a network sheet 11, from which the network sheet 11 is fed via a feed roll 24 and sandwiched in between the fiber webs 10a and 10b with the aid of the feed rolls 22 to form a three-ply composite 5.

[0030] In the entangling part 20B, the water jet nozzles 26 eject high-pressure water jets against the composite 5, whereby the fibers of each of the fiber webs 10a and 10b are entangled among themselves to convert the fiber webs into a fiber aggregate 10 and, at the same time, the fibers of the two fiber webs are entangled with the network sheet 11 to provide a unitary laminate 6.

[0031] The laminate 6 is dried in a drier 30 and then forwarded to the shaping part 20C, where the laminate 6 is embossed between the nip of the engraved rolls 27. Since the engraved rolls 27 engage with each other, that is, they are matched steel engraved rolls, the laminate 6 is shaped to the profile of the engraved rolls 27. It is preferred that the rolls 27 be preheated to a prescribed temperature so that the network sheet 11 in the laminate 6 may undergo thermal plastic deformation and be thereby shaped without fail and with stable shape retention. From this viewpoint, the heat embossing between the engraved rolls 27 is preferably carried out at a temperature lower than the melting point of the thermoplastic resin making the network sheet 11. It is also effective to conduct the heat embossing at or above the softening point of the thermoplastic resin. By making a clearance between the engraved rolls 27 it is possible to set the temperature of the engraved rolls 27 at or above the melting point of the thermoplastic resin of the network sheet 11 provided that the heat transmitted to the network sheet 11 is lower than the melting point. The shaping part may be designed to fold the laminate 6 into two, three or four and then heat emboss the folded laminate.

[0032] It is preferred that the heat embossing step be effected under such conditions that do not cause the fiber aggregate in the laminate 6 to reduce its dust trapping capabilities. For example, when the fiber aggregate contains a thermoplastic resin, should heat embossing be conducted at temperatures causing the resin to melt, the fiber aggregate would reduce its dust trapping performance. Where both the network sheet and the fiber aggregate contain a thermoplastic resin, it is preferred that the melting point of the thermoplastic resin making the network sheet be lower than that of the thermoplastic resin making the fiber aggregate and that the heat embossing be carried out at a temperature lower than the melting point of the thermoplastic resin of the network sheet.

[0033] The thus shaped laminate 6, i.e., a bulky sheet 1 has an elevated temperature due to the heat of the embossing. If the bulky sheet 1 continues to have the elevated temperature after the shaping, there is a possibility that the bulk of the network sheet having been three-dimensionally deformed by the embossing may be reduced. Hence, the bulky sheet 1 is preferably passed through the cooling part 20D, where the three-dimensional deformation of the network sheet in the bulky sheet 1 is set. The cooling step makes it possible to stably maintain the bulk of the network sheet and therefore the bulky sheet 1. Accordingly, the cooling step is not required under some heat embossing conditions, for instance, when the heating temperature is low enough.

[0034] In the present embodiment, the cooling step is conducted by blowing cool air to the bulky sheet 1. Cool air is blown from the air blow duct 28 toward one side of the sheet 1, pushed through the sheet 1, and vacuumed up from the other side by the vacuum conveyor 29. Note that the cooling mode is not limited to the means shown in Fig. 3. For example, the bulky sheet 1 from the shaping part 20C may be cooled by wrapping around cooling rolls 30 cooled to a prescribed temperature. The cooling rolls 30 include water-cooled rolls having cooling water flowing therein and perforated suction rolls that suck in air from their peripheral surface.

[0035] When needed, the resulting bulky sheet 1 can be napped on both sides thereof. Napping is desired when the freedom of movement of the fibers making up the fiber aggregate has been reduced by the nip pressure of the engraved rolls in the preceding shaping step. Where the bulky sheet 1 is used as a cleaning sheet, reduction in freedom of fiber movement can result in reduction of dust trapping performance. Napping can be carried out by rubbing or brushing with sandpaper, a metallic file, raising wires, a brush, etc.

[0036] In addition to, or in place of, the nap finish, a textile oil may be applied to the bulky sheet 1. Textile oils containing at least one of a mineral oil, a synthetic oil, a silicone oil, and a surface active agent are preferably used. Examples of the mineral oil include paraffinic hydrocarbons, naphthenic hydrocarbons, and aromatic hydrocarbons. Examples of the synthetic oil include alkylbenzene oils, polyolefin oils, and polyglycol oils. Examples of the silicone oil are acyclic dimethyl polysiloxane, cyclic dimethyl polysiloxane, methylhydrogen polysiloxane, and various modified silicones. Examples of the surface active agent include cationic ones, such as mono(long-chain alkyl)trimethylammonium salts, di(long-chain alkyl)dimethylammonium salts, and mono(long-chain alkyl)dimethylbenzylammonium salts each having an alkyl or alkenyl group having 10 to 22 carbon atoms; and nonionic ones, such as polyethylene glycol ethers, e.g., polyoxyethylene (6 to 35 mol) long-chain, primary or secondary, C8-C22 alkyl or alkenyl ethers and polyoxyethylene (6 to 35 mol) C8-C18 alkyl phenyl ethers, polyoxyethylene-polyoxypropylene block copolymers, and polyhydric alcohol derivatives, e.g., glycerol fatty acid esters, sorbitan fatty acid esters, and alkyl glycosides. The textile oil can be applied either before or after the heat embossing step.

[0037] The above-described process of producing the bulky sheet 1 can also be carried out using apparatus shown in Fig. 5. The apparatus of Fig. 5 has basically the same configuration as the apparatus of Fig. 3, except for the following. In Fig. 3, the parts from the superposing part 20A to the cooling part 20D make a single assembly, whereas the apparatus of Fig. 5 has two divided assemblies: a first assembly 201 including the superposing part 20A and the entangling part 20B and a second assembly 202 including the shaping part 20C and the cooling part 20D. The system shown in Fig. 5 is advantageous in that the first assembly 201 and the second assembly 202 may be installed at different sites, which allows for division of work, and that the freedom of production design is increased. More specifically, in the first assembly 201, the laminate 6 dried in the drier 30 is once taken up in roll form 6A. The roll 6A is then set on the second assembly 202 installed at a different site. The laminate 6 is unwound from the roll 6A and shaped in the second assembly 202.

[0038] The bulky sheet thus produced is fit for use as a dry type cleaning sheet. It is particularly suited as a cleaning sheet that is to be attached to a cleaning tool having a flat head and a stick handle connected to the head. Because the bulky sheet stably retains its uneven profile and therefore shows a reduced degree of collapse on getting wet, it is also suitable as a wet type cleaning sheet impregnated with various cleaning fluids. The bulky sheet is also preferably applicable to absorbent articles such as disposable diapers and sanitary napkins and hygiene articles such as masks and gauze.

[0039] The present invention is by no means limited to the foregoing embodiment. For example, while the fiber aggregate is present on both sides of the network sheet in the foregoing embodiment, a bulky sheet having the fiber aggregate on only one side of the network sheet is useful for some applications.

[0040] While in the foregoing embodiment the type of the nip of the two matched engraved rolls 27 used in the shaping part 20C is steel-to-steel, it can be paper-to-steel. Otherwise, a combination of an engraved roll with an engraved pattern and a smooth roll made of or covered with an elastic material is employable. In this case, the surface of the engraved roll bites the elastic material of the opposing roll in the embossing nip to deform the laminate 6.

[0041] The present invention will now be illustrated in greater detail with reference to Examples, but it should be understood that the invention is not limited thereto. Unless otherwise noted, all the percents are by weight.

EXAMPLE 1

[0042] A bulky sheet was produced using the apparatus shown in Fig. 3. Polyester fiber (a 70%/30% mixture of polyester fiber with a fineness of 0.8 denier (0.9 dtex) and a length of 38 mm and polyester fiber with a fineness of 1.45 denier (1.6 dtex) and a length of 51 mm) was carded in a usual manner into a fiber web having a weight of 29 g/m^2. The fiber web was superposed on each of the upper and the lower sides of a polypropylene net having a lattice mesh (distance between adjacent strands: 8 mm; strand diameter: 300 μm) as a network sheet. The superposed three layers were entangled with water jets ejected from nozzles under water pressure of 1 to 5 MPa to obtain a unitary laminate having a fiber aggregate on its both sides. The laminate was embossed between the nip of matched steel-to-steel engraved rolls heated to 105°C to become a bulky sheet having a three-dimensional profile with a number of protrusions and depressions. Cool air at 20°C was blown at a speed of 10 m/sec for 0.2 seconds to the bulky sheet from the engraved rolls to cool the sheet. After the cooling, each side of the sheet was rubbed once with #1200 sandpaper to have the fibers napped. Finally, a textile oil consisting of 90% liquid paraffin and 10% nonionic surface active agent (polyoxyethylene alkyl ether) was applied to the sheet in an amount of 5% based on the sheet.

COMPARATIVE EXAMPLE 1

[0043] Polyester fiber (1.5 denier, 51 mm) was carded in a usual manner into a fiber web having a weight of 8 g/m^2. Five carded fiber webs thus prepared were lapped to make a 5-ply fiber aggregate having a weight of 40 g/m^2. The fiber aggregate was superposed on each side of a biaxially shrinkable polypropylene net (distance between adjacent strands: 9 mm; strand diameter: 0.2 mm) as a network sheet. The superposed three layers were hydroentangled under conditions of a water pressure of 40 kg/cm^2, a nozzle pitch of 1.6 mm, and a water jet speed of 5 m/min. Hot air at 130°C was applied to the resulting unitary laminate for 50 seconds to dry the laminate and simultaneously shrink the network sheet. The percent shrinkage was about 10% in both the MD and CD. An uneven bulky sheet was thus obtained.

Evaluation:

[0044] The bulky sheets obtained in Example 1 and Comparative Example 1 were measured for thickness under a load of 0.3 kPa and 0.7 kPa. The bulky sheets were evaluated for (1) soil dust trapping capabilities, (2) hair trapping capabilities, (3) yarn trapping capabilities, and (4) conformability to grooves in accordance with the following methods. The results of measurement and evaluation are shown in Table 1 below.

1) Soil dust trapping capabilities

[0045] The bulky sheet was attached to a cleaning tool Quickle Wiper available from Kao Corp. JIS test powder class 7 (fine particles of the Kanto loam) weighing 0.4 g was uniformly spread on a 100 cm side square of a floor (NEW Woody Super Z, available from Matsushita Electric Works, Ltd.) with a brush. The dusted area of the floor was imaginarily divided into 4 parallel sections (25 cm x 100 cm each) and cleaned by sliding the Quickle Wiper back and forth once on each of the sections. Without removing the soil dust caught on the cleaning sheet, spreading dust and cleaning the dusted area were repeated 6 times in total. The amount of dust trapped on/in the bulky sheet was obtained by subtracting the weight of the intact bulky sheet from the weight of the soiled bulky sheet detached from the cleaning tool. The percentage of the weight of the dust trapped to the total weight of the dust spread (6 x 0.4 g = 2.4 g) was taken as a dust trapping ratio.

2) Hair trapping capabilities

[0046] The bulky sheet was attached to Quickle Wiper. Ten human hairs of about 20 cm in length were scattered over an area of 30 cm by 60 cm of a floor (NEW Woody Super Z). The hairs were wiped up by sliding the Quickle Wiper back and forth twice with a stroke of 60 cm, and the number of hairs caught on the bulky sheet was counted. The same operation was successively carried out 6 times using the same bulky sheet. The percentage of the total number of hairs caught up to the total number of hairs scattered (60) was taken as a hair trapping ratio (%).

3) Yarn trapping capabilities

[0047] The bulky sheet was attached to Quickle Wiper. Three millimeter long cut pieces of commercially available 100% acrylic yarn weighing 0.4 g were scattered over an area of 30 cm by 60 cm of a floor (NEW Woody Super Z). The area of the floor with yarn was cleaned by sliding the Quickle Wiper back and forth 30 times. The amount of yarn caught up on the bulky sheet was obtained by subtracting the weight of the intact bulky sheet from the weight of the bulky sheet detached from the cleaning tool. The percentage of the weight of the yarn trapped to the total weight of the yarn scattered (0.4 g) was taken as a yarn trapping ratio.

4) Conformability to grooves

[0048] An acrylic resin plate having six grooves at a 3 cm interval was used as an object to be cleaned. Each groove had an inverted triangle-shaped cross section with an opening width of 3.0 mm and a depth of 1.5 mm. JIS test powder class 7 was spread in the grooves over a length of 20 cm each in an amount of 0.01 g per groove (total amount of dust = 0.06 g). The bulky sheet was attached to Quickle Wiper and slid on the acrylic plate back and forth twice along the grooves. The weight of the dust trapped on/in the sheet was measured, and a dust trapping ratio was calculated as a percentage of the weight of the dust trapped to the weight of the dust spread in the grooves. The conformability of the bulky sheet to the grooves was graded A (dust trapping ratio of 70% or higher), B (dust trapping ratio of 50% to 70%) or C (dust trapping ratio of less than 50%).

TABLE 1

		Example 1	Comparative Example 1
Thickness (mm)	under 0.3 kPa	1.97	1.35
	under 0.7 kPa	1.63	1.11
Trapping Capabilities (trapping ratio/grade)	test powder class 7	76/A	70/A
	hairs	88/A	64/B
	yarn	93/A	80/A
	conformability to grooves	95/A	70/A

[0049] As is apparent from the results in Table 1, the bulky sheet of Example 1 is endurable against loads applied as compared with that of Comparative Example 1. It is seen that the bulky sheet of Example 1 is superior to that of Comparative Example 1 in capabilities of trapping all kinds of dust and debris from fine dust to relatively large one.

[0050] The bulky sheet according to the present invention stably retains its three-dimensional profile, being supported by the three-dimensionally shaped network sheet. Therefore the bulky sheet undergoes reduced loss of its bulk even when stored in roll form or processed under tension or between the nip of rolls. Having a three-dimensional profile with numerous protrusions and depressions, the bulky sheet applied as a cleaning sheet effectively catches up dust and debris and conforms to the unevenness of a surface to be cleaned, such as grooves of floors. Having an increased surface area because of the protrusions and depressions, the bulky sheet as a cleaning sheet exhibits increased dust collecting capacity.

Claims

1. A bulky sheet comprising a network sheet and a nonwoven fabric-like fiber aggregate having fibers arranged on at least one side of the network sheet, the fibers of the fiber aggregate being in entanglement among themselves and with the network sheet to be unitary with the network sheet,

the network sheet being three-dimensionally shaped to form a number of protrusions and depressions, and

the fiber aggregate being unitary with the network sheet along the contour of the protrusions and the depressions of the network sheet such that the bulky sheet, as a whole, has a three-dimensional profile with a number of protrusions and depressions.

2. The bulky sheet according to claim 1, wherein the three-dimensional shaping of the network sheet is by plastic deformation.

3. The bulky sheet according to claim 2, wherein the plastic deformation of the network sheet is carried out by heat embossing using a pair of matched engraved rolls both having a number of protrusions and depressions or a combination of an engraved roll having a number of protrusions and depressions and a smooth roll comprising an elastic material.

4. The bulky sheet according to any one of claims 1 to 3, wherein the network sheet comprises a first thermoplastic resin, and the fiber aggregate comprises a second thermoplastic resin, the first thermoplastic resin having a lower melting point than the second thermoplastic resin.

5. The bulky sheet according to any one of claims 1 to 4, which is for use as a cleaning sheet.

6. A process of producing the bulky sheet according to claim 1, comprising the steps of:

superposing a fiber web on at least one side of a network sheet,
hydro-entangling fibers of the fiber web among themselves and with the network sheet to convert the fiber web into a nonwoven fabric-like fiber aggregate and to unite the fiber aggregate with the network sheet, and
heat embossing the resulting unitary sheet by inserting the sheet between a pair of matched engraved rolls both having a number of protrusions and depressions or between an engraved roll having a number of protrusions and depressions and a smooth roll comprising an elastic material to shape the unitary sheet to the contour of the engraved roll.

7. The process according to claim 6, wherein the network sheet comprises a first thermoplastic resin, and the fiber aggregate comprises a second thermoplastic resin, the first thermoplastic resin having a lower melting point than the second thermoplastic resin, and the step of heat embossing is carried out at a temperature lower than the melting point of the first thermoplastic resin.

8. The process according to claim 6 or 7, wherein the step of heat embossing is followed by the step of cooling the resulting sheet.

9. The process according to claim 8, wherein the step of cooling is carried out by blowing cool air to the sheet or wrapping the sheet around a cooling roll.

Fig. 1

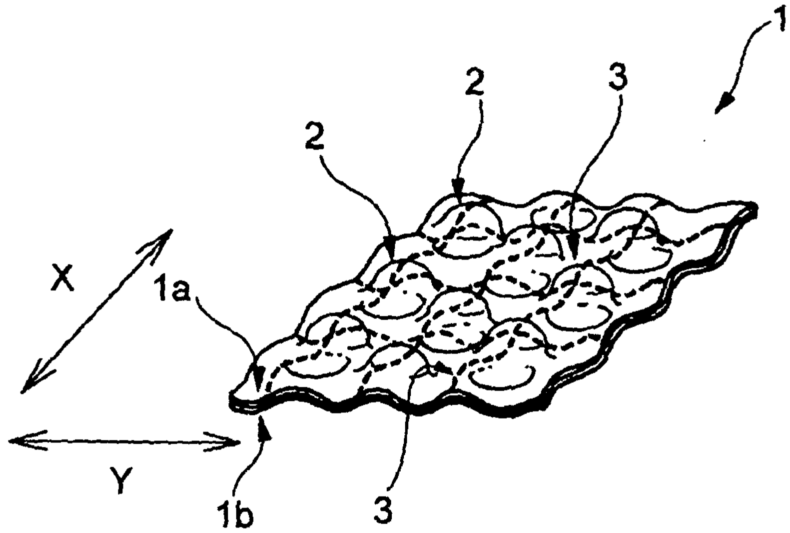

Fig. 2

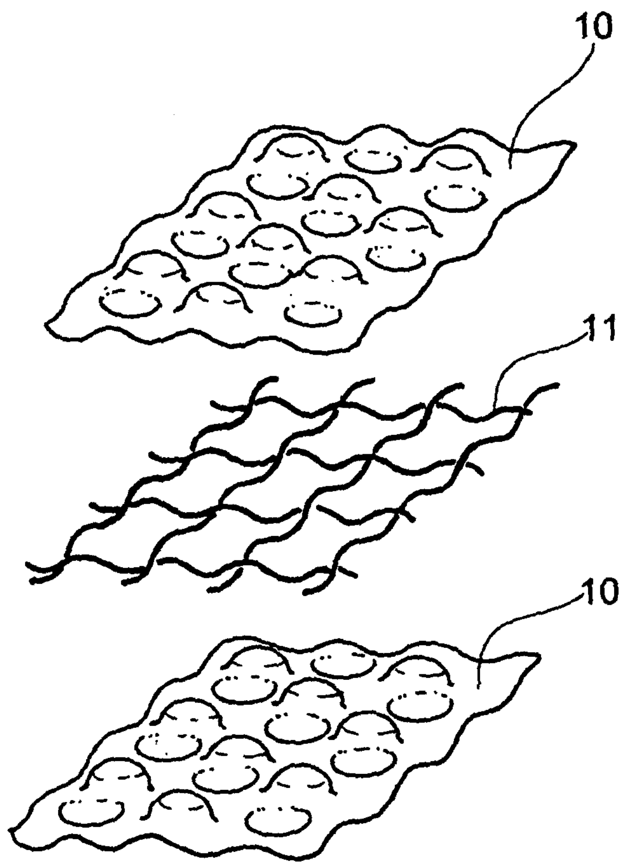

Fig. 3

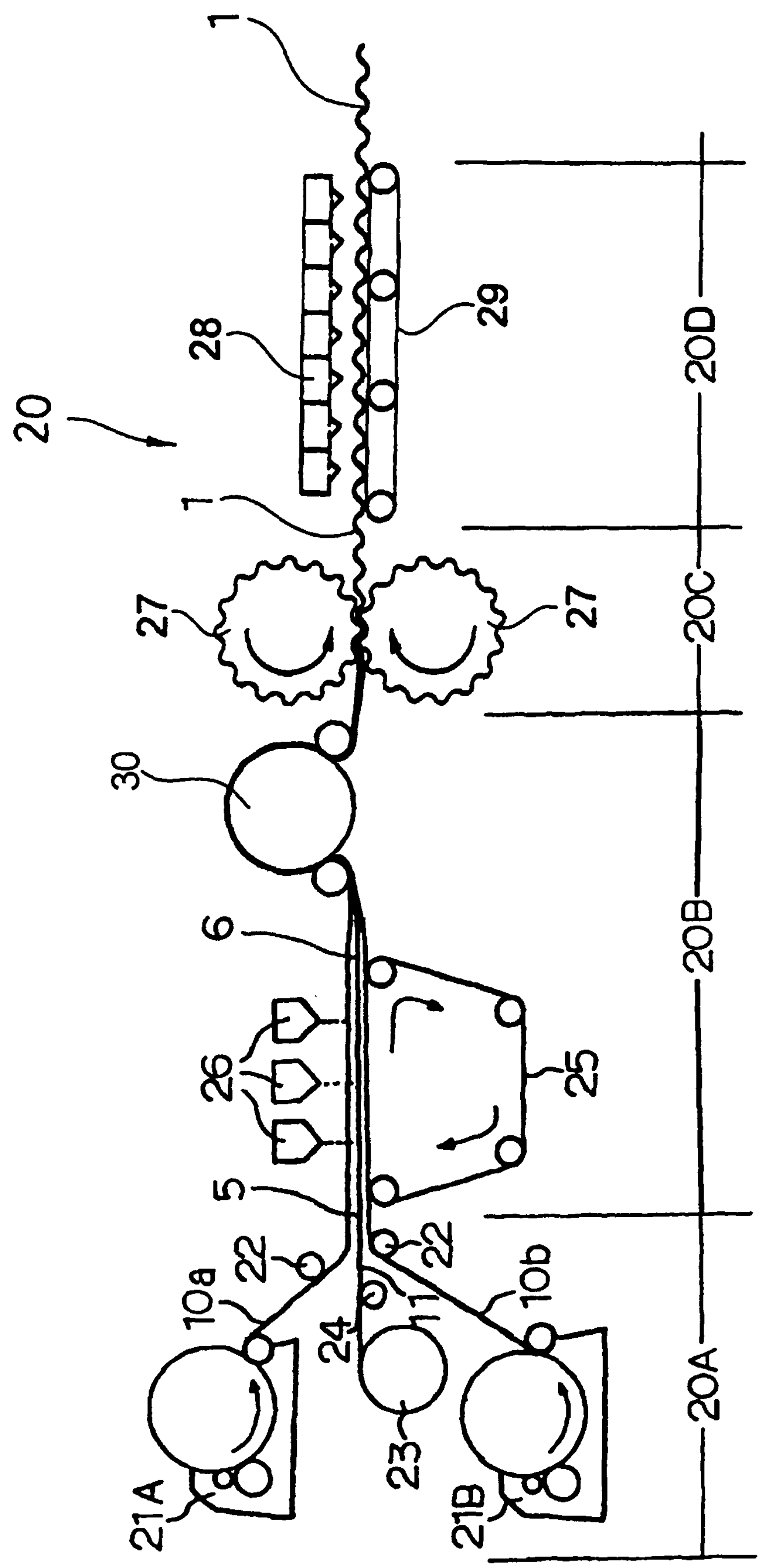
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Fig. 4

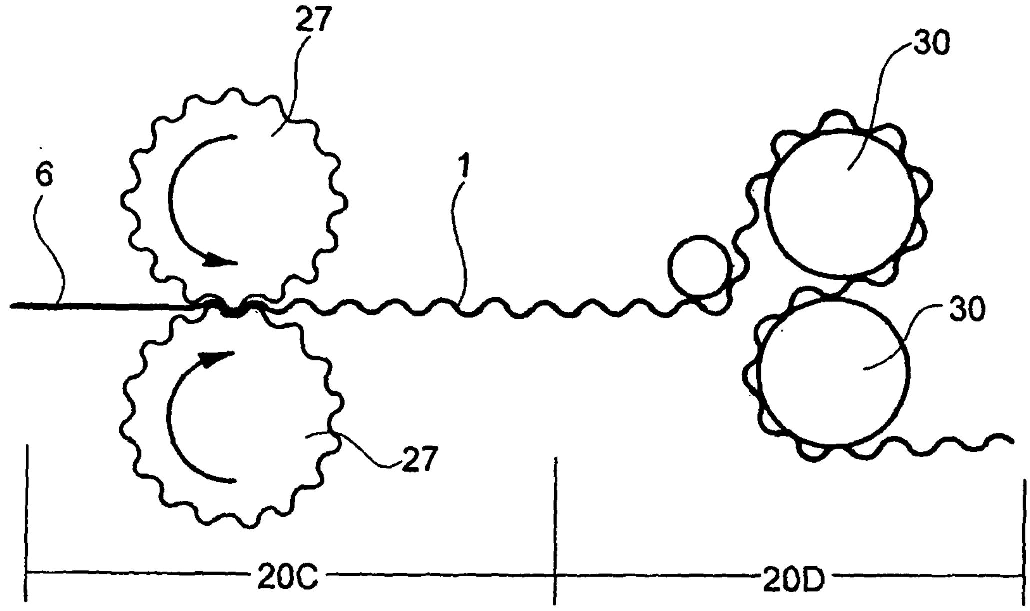
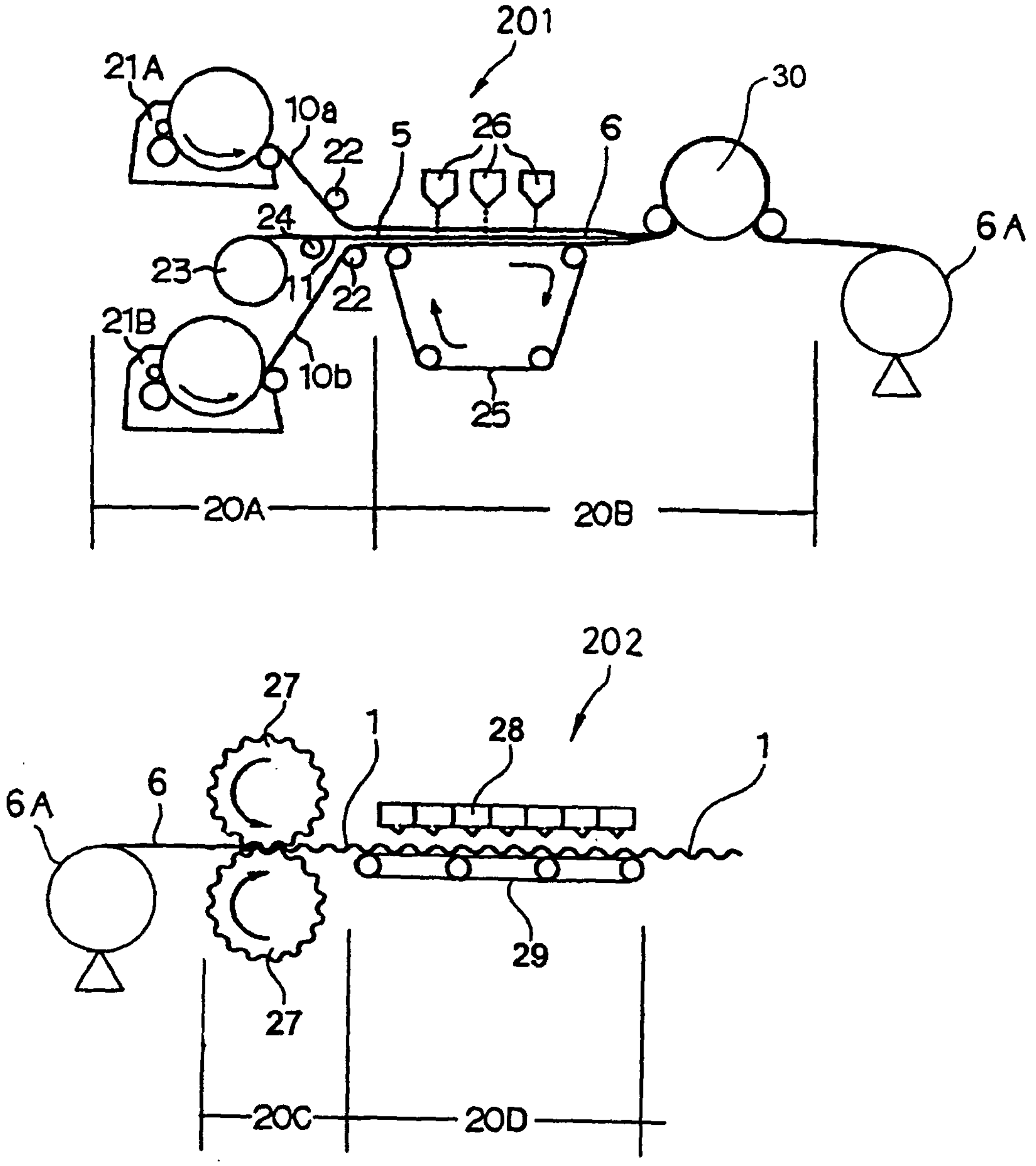


Fig. 5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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 August 2005	Barathe, R

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2

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