United States Patent

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[54] WATER-ABSORBING MATERIAL

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 784,699, Dec. 18, 1968, abandoned.

[52] **U.S. Cl.** **128/284**
[51] **Int. Cl.** **A61f 13/16**
[58] **Field of Search** 128/284, 285, 287, 290, 296

[56] **References Cited**

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[57] **ABSTRACT**

A sheet which is a blend of water-insoluble fibers and pieces of film of a dry material which converts to a gel quickly on contact with a large amount of water. The blend is formed by suspending the fibers and film pieces in air. The sheet is useful in structures designed for absorbing body fluids, e.g. disposable diapers.

6 Claims, 3 Drawing Figures

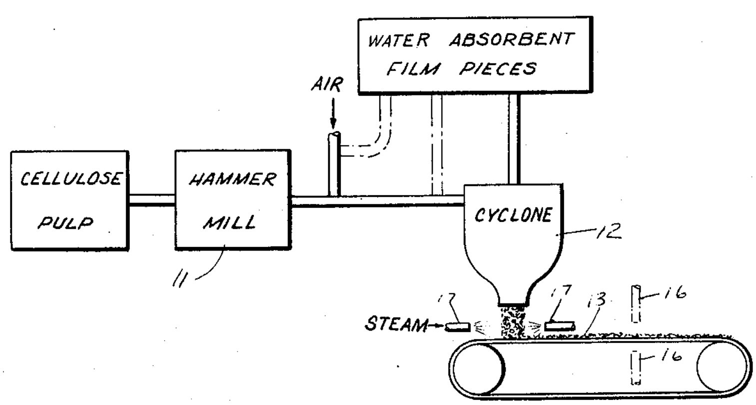


FIG. 1

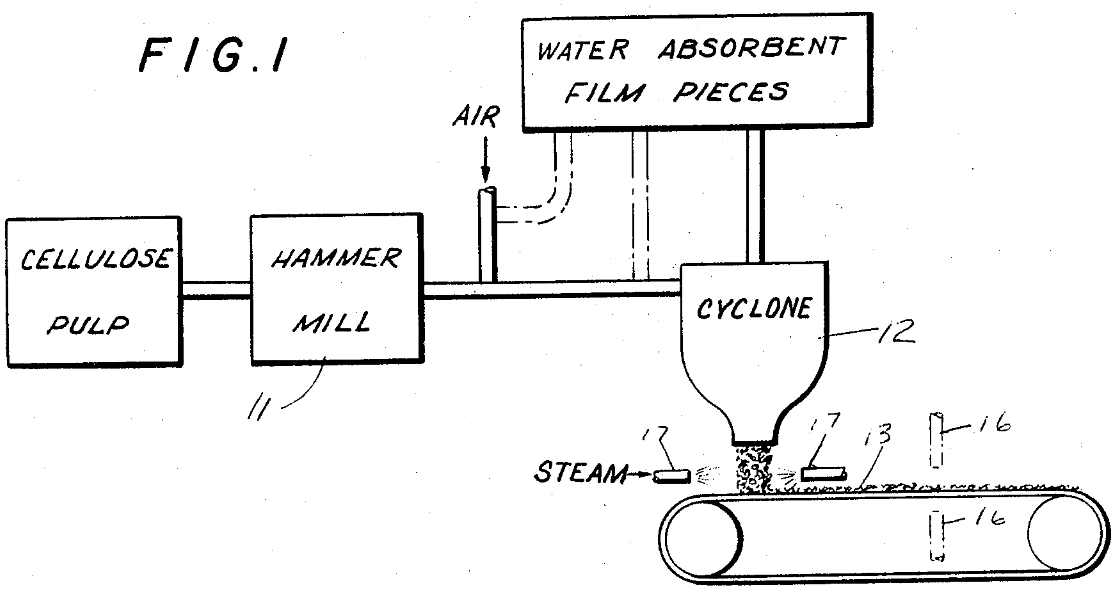
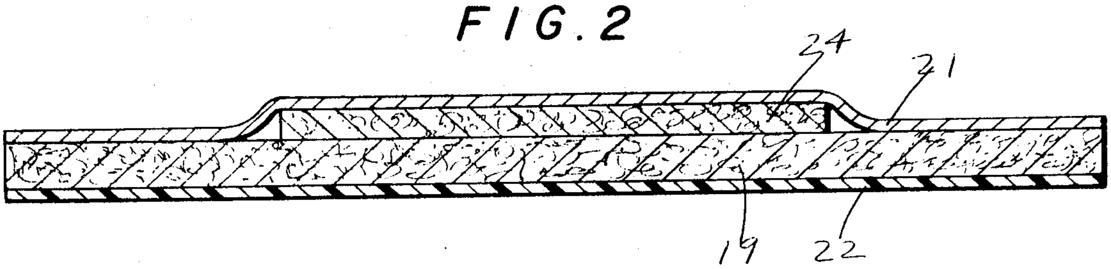


FIG. 2



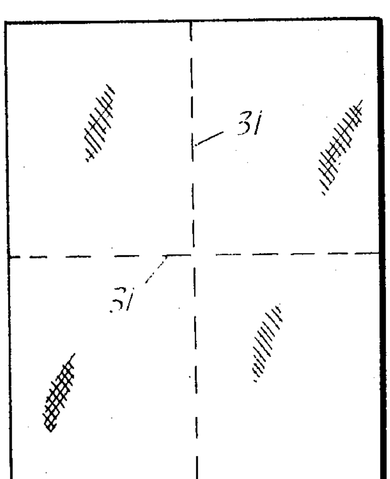


FIG. 3

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WATER-ABSORBING MATERIAL

This application is a continuation-in-part of my application Ser. No. 784,699 filed Dec. 18, 1968 now abandoned.

This invention relates to the production of structures designed for absorbing body fluids, e.g. diapers, catamenial devices such as sanitary napkins or vaginal tampons, pads for protecting the bed against wetting, surgical sheets and surgical and medical applications.

In one aspect of this invention, there is produced a sheet comprising a blend of water-insoluble fibers and pieces of film of a dry material which on contact with water (e.g. on contact with 10, 15, or more preferably 20 or more, times its weight of water at 25° C.) loses its film-like character within a very short period of time (e.g. less than a minute) and forms a soft plastic gel. The invention is particularly useful when the water-insoluble fibers are cellulose fibers and, especially, short cellulose fibers such as woodpulp cellulose (e.g. bleached sulfite or sulfate pulp) and when the absorbent product is a diaper, most preferably a disposable diaper. Thus, unlike ordinary diapers made wholly of cellulose, which can give up their absorbed urine when pressed or squeezed, diapers containing the fibers of this invention retain the moisture in the form of the soft non-fibrous gel and are therefore more comfortable in use. The gel is harmless and inert to the body of the wearer.

In the accompanying drawing is

FIG. 1 is a schematic representation of a suitable process,

FIG. 2 is a schematic view, in cross section, of one form of disposable diaper, and

FIG. 3 is a schematic plan view of a disposable diaper having lines of weakness for easy tearability of the product.

To form a substantially uniform blend of the pieces of film and the fibers, the film pieces and the fibers are suspended together in air or other gas and a layer of the mixture is deposited from the suspension. About 1 to 50 parts of the film pieces are used per 100 parts of the cellulose fibers; in one preferred form the proportion of the film pieces is on the order of about 5 to 10 parts per 100 parts of the cellulose fibers. In one embodiment a mass of wood pulp fibers is broken up in a hammer mill **11** (FIG. **1**) and then the fibers are conveyed from the mill with a current of air to an air-separating zone such as a cyclone type of separator **12**, at the bottom of which the blend of fibers and film pieces is continuously collected in fluffy form and continuously deposited as a sheet, **13** of substantially uniform thickness, of said blend on a continuously moving belt **14**. The deposited sheet may be a batt whose thickness is, say, about ¼ to 1 inch. Alternatively the airstream carrying said blend of fibers and film pieces is blown against a moving continuous screen to form the sheet directly.

The film pieces may be fed to the airstream in any suitable manner. For instance, they may be metered into the cyclone (e.g. by means of a feed screw, or by conveying them while dispersed in another current of air which is fed to the cyclone chamber, e.g. at the top thereof, and which may be at a somewhat higher pressure than the air pressure in the cyclone which itself may be at substantially atmospheric pressure. The cyclone may be operated under such conditions that the film pieces, or at least those pieces of larger size, are broken up to form smaller film pieces therein by the action of the rapidly moving air, turbulence, and impacts against the cellulose fiber, against the walls or any baffles of the chamber or against other film pieces. The film pieces may also be metered into any conveyor in which the fibers are transported from the mill to the air stream. They may also be pre-dispersed in the same airstream used to take up the fibers; that is an airstream carrying the film pieces can be used to pick up the fibers from the outlet of the mill. A higher pressure airstream carrying the film pieces may be discharged in a countercurrent or transverse direction into a main airstream carrying the fibers so as to create a localized zone in which the turbulence and the particle impacts are increased, to produce a blend which may then travel in the general direction of the main stream of suspended fibers.

To improve the adhesion of the film pieces to the fibers the mixture thereof may be humidified, preferably by injecting steam (e.g. saturated steam) into or onto the mixture. Thus a current of steam may be directed at the deposited sheet **13** e.g. at **16** in FIG. **1**) or at the stream of collected fiber-film piece blend at the bottom of, or just below, the cyclone (e.g. at **17** in FIG. **1**), from one or both sides. The pressure, temperature, speed and width of the steam current or currents is preferably such as to cause the surfaces of the film pieces to become adhesive without destroying their integrity; such conditions can be readily determined by simple experiment with each particular product.

After deposition of the blend in sheet form the sheet may then be compacted into the desired thickness (e.g. ⅛ to 1 inch, preferably about one-fourth to one-half inch) as by passing it between pressure rolls and may then be cut to a width suitable for the final product (e.g. for a diaper the width may be, say, 6 to 24 inches).

The sheet (compacted or uncompacted) may be assembled with other layers to form the final product. For instance, in a typical diaper this base sheet **19** (FIG. **2**) may be covered with a thin water-permeable layer of soft non-woven fabric **21** (e.g. of bonded cellulose fibers) or woven or knitted fabric, to form the body-contacting side of the diaper, and may be covered on its other side with a water-impermeable or water-repellant material, which may be, for instance, a preformed film **22** (e.g. of polyethylene) or may be a coating of water repellant material which may or may not be air permeable.

To give additional absorbency there may be superimposed, directly on the base sheet, an additional thickness of a sheet **24** of cellulose fiber material (or, more preferably, of the blend of fibers and film pieces). This additional sheet may be narrower than the base sheet (e.g. it may be 3 to 12 inches wide) and it may be disposed along the center portion of the diaper at the area most likely to be wetted. It may be the same thickness as, or thicker or thinner than, the base sheet.

In one embodiment of this invention, the diaper or other product may be made more readily disposable by having predetermined tear lines (i.e. lines where the product, or merely the base sheet, is weaker, such as lines along which the product is scored, perforated, partly cut, or merely much thinner). Preferably there are a plurality of such tear lines extending across the sheet. In one example, the tear lines **31** (FIG. **3**) form a cross made up of two intersecting perpendicular lines each of which is parallel to a side of the diaper; of course there may be more than two such lines. The housewife may then tear the diaper, after use, easily into a number of smaller, and more easily disposable, portions.

To produce the film pieces, a solution of the highly absorbent material may be cast as a layer onto any suitable casting surface and then dried and stripped from the casting surface. The casting surface may be a rotating drum which may be heated to drive off the solvent (which is preferably aqueous). The film may be stripped intact and then (with or without rolling it up for intermediate storage or transit) sent to a zone where it is broken mechanically, or cut, to form pieces of substantially the same thickness as the original film. Or the film may be broken or cut up during the stripping operation or during the solvent removal. The film may have visible pores; in one form it has substantially uniformly distributed fine holes, about one-half mm or less in diameter, extending through the film and has the appearance of a network having a total hole area of the same order of magnitude as the solid material of the film, e.g. a hole area one-third to twice the solid area. Or the films may be substantially nonporous to the naked eye.

The areas of the film pieces which are fed to the air stream may be, for instance, from about one-twentieth or one-fourth square inch (e.g. a square piece about one-half by one-half inch) to about 20 square inches (e.g. a rectangular piece about 5 by 4 inches). In the airstream the larger pieces (particularly when the film is relatively brittle) are broken up by impacts, as previously described, and the smaller pieces may also be broken.

Starch (particularly cooked or gelatinized starch) has been found to be a very suitable material for making the film. An excellent material is starch which has been cooked in dilute aqueous acetic acid and then cast from the same solvent. Starches of various types, e.g. potato starch, corn starch, rice starch, tapioca starch, etc. may be used. Another suitable material is guar which is a natural gum of polysaccharide character, soluble in cold water. Chemically guar is a galactomannan and is believed to consist essentially of a straight chain of d-mannose units, linked to each other by means of beta (1–4) glycosidic linkages, the chain having single-membered d-galactose side branches; the branches are found on alternate mannose units. The guar may be the natural product or a chemically modified type such as the self-complexing guars. The guar may be admixed with other hydrophilic materials, e.g. with a proportion of a cold-water-swelling starch such as pre-gelatinized starch or a chemically modified starch.

It is within the broader scope of the invention to employ as all or part of the film material other polysaccharide gums, pectin, algin or highly water-absorbent polymeric materials which form gels quickly on contact with large amounts of water. Also the polysaccharide gum may be of the chemically modified type; among the known chemical modifications are oxidation, esterification such as acetylation, carboxylation, etherification such as methylation, amination, phosphation or sulfation; other possible derivatives contain carboxyalkyl, cyanoalkyl or hydroxyalkyl substituents.

The following examples of the preparation of films given to illustrate this invention further. All proportions are by weight unless otherwise indicated, in the examples and in the rest of the application. In the examples all pressures are atmospheric unless otherwise indicated.

EXAMPLE 1

5 to 10 grams of raw potato starch powder (standard food grade) are dispersed with agitation in 100 grams of water at room temperature and the resulting translucent mixture is heated to a temperature just below the boiling point (e.g. 93°–98 C.) and maintained at that temperature for 4 hours during which time the mixture becomes viscous but is still pourable. It is cast onto a glass plate to form a thin layer of the material and thoroughly dried in an oven, in air, at about 50° C. The resulting dry film is stripped, while remaining intact and flat, from the plate with the aid of a scraper (e.g. a spatula).

Various thickness of films (ranging from about 0.001 to 0.02 inch) are produced according to the above method by varying the thickness of the casting on the plate. The thinner films, in this particular experiment, are visibly (and substantially uniformly) porous, while the thicker ones are nonporous to the naked eye.

EXAMPLE 2

Example 1 is repeated using dilute acetic acid (e.g. of 1 to 5 percent concentration) in place of water. In comparison with Example 1, the resulting product has an increased water-absorption and forms a firmer gel with water.

It will be appreciated that in the cyclone separator the gaseous dispersion of fibers and film pieces is whirled to cause the mixture of fibers and film pieces to separate from the air and settle in fluffy form.

The process of this invention has shown a remarkable ability to combine the dry polymeric material of high water absorption (e.g. the film pieces of the starch material) with the cellulose fibers. Thus in a run in which starch film pieces were supplied to the cyclone separator together with the cellulose fibers, the final product appeared to be quite uniform, without any detectable separation of, or even any readily visible evidence of the presence of, the starch. In this process the starch or other polymeric film pieces of high water absorption may be replaced in whole or in part by short fibers or filaments of the same material. Such fibers or filaments may be obtained by extruding the material in a thick viscous condition (e.g. a viscous aqueous solution of the starch material, which may be a chemically modified starch) through fine orifices and passing the extruded filaments into, for example, a heated evaporative zone; for instance the viscous solution may be extruded into air and onto a moving belt which conveys the extruded filaments into a drying oven. The resulting substantially dry fibers or filaments may then be cut to the desired length, e.g. one-eighth to one-half inch or more. The diameters of these fibers or filaments may be, for instance, about 0.0005 to 0.002 inch or more. An extruded film of the starch or other polymeric material (which may be plasticized) may also be cut into thin strips to form filaments of the desired width (e.g. 0.005 to 0.2 inch or more).

The cellulose fibers used for making the sheet are usually relatively short, e.g. about one-sixteenth to one-half, preferably about one-eighth to one-half inch in length. Wood pulp fibers such as bleached sulfite pulp or "wood fluff" are suitable, for instance. It is within the broader scope of the invention to use other fibers, such as non-cellulose fibers which retain their fibrous structure when wet, alone or in admixture with the cellulose fibers. In the sheet the fibers are preferably non-aligned.

The humidification technique described above may be applied to blends of fiber and the particulate water-absorbing material in which the latter is in a form other than film pieces, e.g. spray-dried beads, granules, powder, fibers, etc., instead of, or in admixture with, film pieces. The humidified (e.g. steamed) blend may be suitably dried in various ways, as by passing it through a spray tower, or in an oven, and/or by a stream of hot air.

It is advantageous to assembly the humidified blend with the other layers previously mentioned (for example with the waterproof layer **22** and/or the layer **21**) before the blend is dried, or after only partial drying. At this stage the blend tends to adhere to said other layers; this avoids, or reduces, slippage between the cellulose fiber layer containing the somewhat tack, moist, particulate water-absorbing material (in the form of film pieces, beads, granules, powder, fibers, etc.) and the waterproof layer **22**. The preferred waterproof layer is of polyethylene film and may be of the type whose surfaces (or at least the surface which is in contact with the blend of cellulose fiber and water-absorbing particulate material) have been pretreated in well known manner to make them printable (e.g. by corona discharge treatment) and more wettable. The precise residual moisture content for best adhesion can be determined readily by experiment. In making the assemblage the layers can be brought together in any suitable fashion as by passing the layers together between pressure rolls, after which the assemblage may be dried.

The water-absorbing particulate materials of types other than film pieces (e.g. beads, granules, powder, fibers, etc.) may be combined with the cellulose or similar fibers by the same techniques and in the same proportions as described above for the film pieces.

Another technique for obtaining a blend of the cellulose fibers and the water-absorbing material is by spraying a mist of a solution of the water-absorbing material in a liquid solvent into the suspension of cellulose fibers in the airstream. For instance, a 5 percent aqueous solution of a mixture of equal parts of guar gum and starch may be injected into the cyclone previously described, in such proportions as to provide, say, 2 to 5 percent of the water-absorbing, solid material based on the weight of the cellulose. It will be understood that more concentrated solutions may be used, particularly when the solutions are heated so as to reduce their viscosity prior to spraying. The resulting blend may be dried partially so as to obtain a moist mixture having superior adhesion to the adjacent layers (e.g. the waterproof layer).

Another technique for combining the cellulose fibers and the water-absorbing material is by combining a foamed solution of the water-absorbing material with the cellulose fibers. The foam may be prepared, for example, by beating a gas into the solution (e.g. in an Oakes device, to produce a foam having very fine air bubbles). The cellulose fibers may be mixed with the solution prior to foaming or after foaming and a sheet may be formed of the foamy mixture, or the foam of the solution of water-absorbing material may be applied to one or both sides of a layer of cellulose.

It is understood that the foregoing detailed description is given merely by way of illustration and that variations may be made therein without departing from the spirit of the invention. The "abstract" given above is merely for the convenience of technical searchers and is not to be given any weight with respect to the scope of the invention.

I claim:

1. Process for making water-absorbent products which comprises forming a blend of cellulose fibers and solid particles of a material which on contact with 10 times its weight of water loses its shape rapidly and forms a soft plastic gel, and humidifying said blend by injecting steam into said blend to improve the adhesion of said particles to said fibers, the proportion of said particles in said blend being about 1 to 50 percent.

2. Process as in claim 1 in which said particles are pieces of film of said material.

3. Process as in claim 1 in which said particles comprise starch.

4. Process as in claim 1 in which said humidification is effected by injecting a current of steam into said blend.

5. Process as in claim 4 in which the steam injection is such as to cause the surfaces of said particles to become adhesive without destroying their integrity.

6. Process as in claim 5 in which said particles comprise guar.

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