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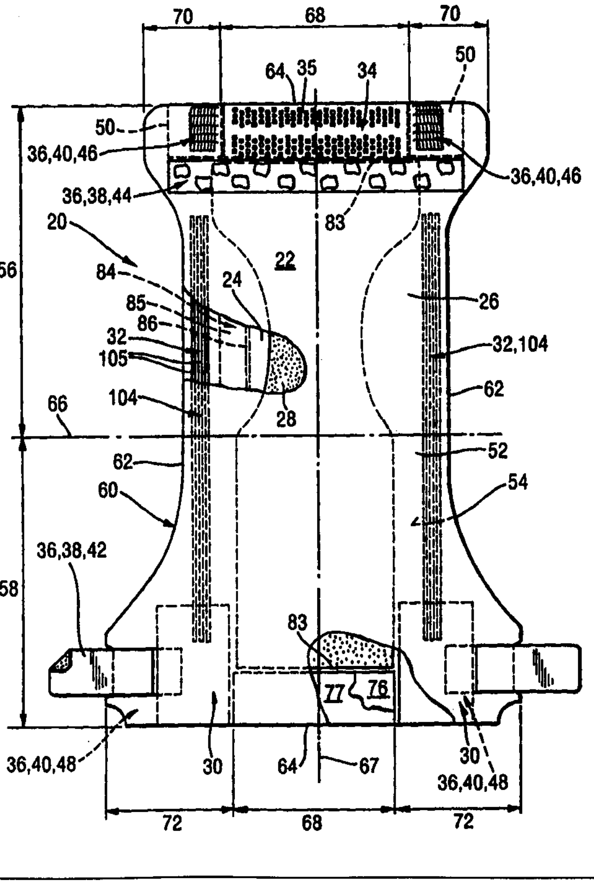
(54) Title: ABSORBENT STRUCTURES COMPRISING FLUID STORAGE MEMBERS WITH IMPROVED ABILITY TO DEWATER HIGH FLUX DISTRIBUTION MEMBERS

(57) Abstract

The present invention relates to absorbent structures for use in absorbent articles, comprising a first region for acquisition/distribution of fluid and a second region for storage of fluid. The first region comprises materials, which may have a relatively high capillary desorption pressure, as the second region comprises materials or members exhibiting a sufficiently high capillary absorption pressure so as to still efficiently drain the first region. Thus, the first region comprises material having a cumulative flux of more than 0.075 g/cm^2/sec at 12.4 cm heights, and/or a wicking time of less than 120 seconds at this height, and second region comprises material which satisfies at least one of following requirements: (a) an absorption capacity of at least 15 g/g at 35 cm in the capsorption test; and/or (b) an absorption capacity of at least 15 g/g at 0 cm in the capsorption test and an absorption efficiency of at least 55 % at 40 cm, and/or (c) a Capillary Sorption Absorption height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 35 cm in the capsorption test.



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Absorbent structures comprising
fluid storage members with improved
ability to dewater high flux distribution members

General field of the invention

The present invention relates to absorbent structures which are primarily designed to receive and retain bodily discharges such as urine. Such structures are useful for absorbent disposable hygiene articles like baby diapers, training pants, adult incontinence articles and the like.

Background / Prior art

Absorbent Articles for receiving and retaining bodily discharges such as urine or feces such as disposable diapers, training pants, adult incontinence articles are well known in the art, and significant effort has been spent against improving their performance. The ability to provide better performing absorbent articles such as diapers has been contingent on the ability to develop relatively thin absorbent cores or structures that can acquire and store large quantities of discharged body fluids, in particular urine.

In this regard, the use of certain absorbent polymers often referred to as "hydrogels," "superabsorbents" or "hydrocolloid" or “hydrogel forming” material has been particularly important. See, for example, U.S. Patent 3,699,103 (Harper et al), issued June 13, 1972, and U.S. Patent 3,770,731 (Harmon), issued June 20, 1972, that disclose the use of such absorbent polymers (hereafter "hydrogel-forming absorbent polymers") in absorbent articles. Indeed, the development of thinner diapers has been the direct consequence of thinner absorbent cores that take advantage of the ability of these hydrogel-forming absorbent polymers to absorb large quantities of discharged body fluids, typically when used in combination with a fibrous matrix. See, for example, U.S. Patent 4,673,402 (Weisman et al), issued June 16, 1987 and U.S. Patent 4,935,022 (Lash et al), issued June 19, 1990, that disclose dual-layer core structures comprising a fibrous matrix and hydrogel-forming absorbent polymers useful in fashioning thin, compact, nonbulky diapers. See also, U.S. Patent 5,562,646 (Goldman et al.), issued Oct. 8, 1996 and U.S. Patent 5,599,335 (Goldman et al.), issued Feb. 4, 1997, both of which relate to absorbent cores comprising regions of high concentrations of hydrogel-forming polymer, where the polymer forms a gel-continuous fluid transportation zone upon swelling.

In addition or alternatively to the use of hydrogel-forming absorbent polymers as the primary component in absorbent article storage structures, the use of polymeric foam materials derived from high internal phase water-in-oil emulsions ("HIPEs") has been identified. See, e.g., U.S. Patent 5,260,345 (DesMarais et al.), issued November 9, 1993, U.S. Patent 5,387,207 (Dyer et al.) issued Feb. 7, 1995, and U.S. Patent 5,560,222 (DesMarais et al.), issued July 22, 1997.

Also the application of such materials in absorbent structures and absorbent articles focused on storage of the fluids within the structure, often considering comfort aspects like thinness of the structure, such as disclosed U.S. Patent 4,610,678 entitled "High-Density Absorbent Structures" issued to Weisman et al. on September 9, 1986; U.S. Patent 4,673,402 entitled "Absorbent Articles With Dual-Layered Cores" issued to Weisman et al. on June 16, 1987; U.S. Patent 4,888,231 entitled "Absorbent Core Having A Dusting Layer" issued to Angstadt on December 19, 1989; EP-A-0 640 330 of Bewick-Sonntag et al.; US 5 180 622 (Berg et al.); US 5 102 597 (Roe et al.); US 5 387 207 (LaVon); EP-A-774.242;or European patent applications 96105023.4, filed on March 29, 1996, and 96108394.6, filed on May 28, 1996, or EP-A- 0.797.968 and EP-A- 0.810.078.

Further disclosure is made of structures having a low capacity in the regions between the legs of the wearer such as in PCT application US 97/05046, filed on March 27, 1997, relating to the movement of fluid through certain regions of the article comprising materials having good acquisition and distribution properties to other regions comprising materials having specific liquid storage capabilities.

Objects of the invention

Whilst such materials have been designed with capillary transport mechanisms in mind, thus aiming at positioning materials with smaller capillaries and/ or increased hydrophilicity closer to the ultimate storage material, and materials with larger pores and less hydrophilicity closer to the loading zone, it has not been recognized, that acquisition / distribution materials have the tendency to not only transport the fluid, but also to retain the liquid, which can result under specific conditions to undesired effects, such as rewet or reduced fluid acquisition and/or distribution performance, which is particularly pronounced for acquisition / distribution materials being designed to balance acquisition and distribution properties.

Accordingly, it is an object of the present invention to provide an absorbent structure, which has an improved balance of the fluid handling properties such that well performing acquisition / distribution materials or members, in particular such materials exhibiting improved fluid distribution behavior, can be dewatered efficiently by the storage materials or members.

It is a further object of the present invention where this is achieved by fluid storage materials or members having a high liquid suction capability.
It is an even further object of the present invention, to provide an absorbent storage material or member having a high capillary suction capacity, wherein the absorbent storage material or member comprises hydrogel-forming absorbent polymer.
It is as further object of the invention, to select combinations of suitable materials for such absorbent structures by applying the capsorption test as laid out hereinafter.

Summary

The present invention is an absorbent structure with a first region and a second region in liquid communication with each other, whereby the first region comprises a material having good liquid transport properties, and the second region comprises a material which has good liquid absorbency properties to be able to dewater the first region.

Thus, the material in the first region can be described by having a cumulative flux of more than 0.075 g/cm2/sec at 12.4 cm height, preferably of more than 0.12 g/cm2/sec. Alternatively, the fluid distribution property of the first material can be expressed by this material having a wicking time at 12.4 cm of less than 120 seconds, preferably less than 50 seconds. In a preferred execution, the wicking time at 8.3 cm is in one preferential direction (such as the longitudinal direction) less than 80% of the wicking time in a direction perpendicular thereto, and the cumulative flux is more than 0.120 g/cm2/sec for this preferential direction.

In order to be able to dewater this first region, a material in the second region must satisfy good absorbency properties, such as can be evaluated in the Capillary Sorption Test.

Thus, such a material has a Capillary Sorption Absorption Capacity at 35 cm (CSAC 35) of at least 15 g/g, preferably of at least 20g/g. In alternative embodiments, such a material has a Capillary Sorption Absorption Capacity at 0 cm (CSAC 0) of at least 15 g/g, preferably 20 g/g, more preferably more than 25 g/g and even more preferably more than 35 g/g, and a Capillary Sorption Absorption Efficiency at 40 cm (CSAE 40) of at least 55%, preferably 65 %.

Or, the such a material has a CSAC at the actual CSDH 90 of the first material of at least 15 g/g, or a CSAC 0 of at least 15 g/g and a CSAE at the actual CSDH 90 of the first material of at least 55 %.

Alternatively, such a material in the second region has a Capillary Sorption Absorption Height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 35 cm, preferably of at least 45 cm, more preferably of at least 60 cm, and even more preferably of at least 80 cm.

In preferred executions of the present invention, the first region of the absorbent structure contains fibrous material, preferably chemically stiffened cellulose or synthetic fibers. In an further embodiment, the first region can contains a fibrous web which has been mechanically treated after web formation.

In an alternative embodiment, the first region contains foam material, preferably a said polymeric foam material, even more preferably derived from high internal phase water-in-oil emulsions.

In a specific, preferred embodiment, the present invention is an absorbent structure, wherein the second region contains a high surface area material, preferably microfibers. Alternatively, the high surface area material is an open celled hydrophilic foam, preferably a polymeric foam derived from a high internal phase water-in-oil emulsion (HIPE). This open celled hydrophilic foam is collapsed, optionally in particulate form.

In a further embodiment, the second region contains hydrogel forming materials, preferably at least 15 % by total weight of the second region or less than 75 % by total weight of the second region.

Further aspects of the present invention relate to absorbent articles, such as baby diaper, adult incontinence article, feminine hygiene article, training pant and the like, containing such absorbent structures, optionally containing more than one of such second regions, which are not in direct contact , but in fluid communication with each other via the first region, preferably such that they are positioned longitudinally spaced away from each other and are separated by at least a part of the crotch region, as defined herein.

Brief description of drawings

Figure 1 - Shows a diaper as example for an absorbent article
Figure 2 - Shows the Capillary Sorption test stand
Figure 3 - Shows the Vertical wicking test

Definitions

As used herein, the term "absorbent articles" refers to devices which absorb and contain body exudates, and, more specifically, refers to devices which are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body. As used herein, the term "body fluids" includes, but is not limited to, urine, menses, vaginal discharges, sweat and feces.

The term "disposable" is used herein to describe absorbent articles which are not intended to be laundered or otherwise restored or reused as an absorbent article (i.e., they are intended to be discarded after use and, preferably, to be recycled, composted or otherwise disposed of in an environmentally compatible manner).

As used herein, the term "Z-dimension" refers to the dimension orthogonal to the length and width of the member, core or article. The Z-dimension usually corresponds to the thickness of the member, core or article. As used herein, the term "X-Y dimension" refers to the plane orthogonal to the thickness of the member, core or article. The X-Y dimension usually corresponds to the length and width, respectively, of the member, core or article.

As used herein, the term "absorbent core" refers to the component of the absorbent article that is primarily responsible for fluid handling properties of the article, including acquiring, transporting, distributing and storing body fluids. As such, the absorbent core typically does not include the topsheet or backsheet of the absorbent article.

As used herein, the term "absorbent structure" or "absorbent member" refers to the components of the absorbent core that typically provide one or more fluid handling functionality, e.g., fluid acquisition, fluid distribution, fluid transportation, fluid storage, etc. The absorbent member can comprise the entire absorbent core or only a portion of the absorbent core, i.e., the absorbent core can comprise one or more absorbent members. The "storage absorbent member" is the absorbent member component(s) of the absorbent core that function primarily to ultimately store absorbed fluids. As discussed above, the storage absorbent member may also distribute fluid as a result of its vertical wicking capability. An "absorbent structure" can comprise one or more absorbent members, and thus can be used interchangeably with the term "absorbent member, unless any of the two terms is further specified, such as being, e.g., a "distribution member".

As used herein, the terms "region(s)" or "zone(s)" refer to portions or sections of the absorbent member.

As use herein, the term "layer" refers to an absorbent member whose primary dimension is X-Y, i.e., along its length and width. It should be understood that the term layer is not necessarily limited to single layers or sheets of material. Thus the layer can comprise laminates or combinations of several sheets or webs of the requisite type of materials. Accordingly, the term "layer" includes the terms "layers" and "layered."

For purposes of this invention, it should also be understood that the term "upper" refers to absorbent members, such as layers, that are nearest to the wearer of the absorbent article, and typically face the topsheet of an absorbent article; conversely, the term "lower" refers to absorbent members that are furthermost away from the wearer of the absorbent article and typically face the backsheet.

All percentages, ratios and proportions used herein are calculated by weight unless otherwise specified.

Absorbent Articles - general description

An absorbent article generally comprises:

- an absorbent core (which may consist of sub-structures or absorbent members);
- a fluid pervious topsheet;
- a fluid impervious backsheet;
- optionally further features like closure elements or elastification.

Figure 1 is a plan view of an exemplary embodiment of an absorbent article of the invention which is a diaper.

The diaper 20 is shown in Figure 1 in its flat-out, uncontracted state (i.e. with elastic induced contraction pulled out except in the side panels wherein the elastic is left in its relaxed condition) with portions of the structure being cut-away to more clearly show the construction of the diaper 20 and with the portion of the diaper 20 which faces away from the wearer, the outer surface 52, facing the viewer. As shown in Figure 1, the diaper 20 comprises a liquid pervious topsheet 24, a liquid impervious backsheet 26 joined with the topsheet 24, and an absorbent core 28 positioned between the topsheet 24 and the backsheet 26; elasticized side panels 30; elasticized leg cuffs 32; an elastic waist feature 34; and a closure system comprising a dual tension fastening system generally multiply designated as 36. The dual tension fastening system 36 preferably comprises a primary fastening system 38 and a waist closure system 40. The primary fastening system 38 preferably comprises a pair of securement members 42 and a landing member 44. The waist closure system 40 is shown in Figure 1 to preferably comprise a pair of first attachment components 46 and a second attachment component 48. The diaper 20 also preferably comprises a positioning patch 50 located subjacent each first attachment component 46.

The diaper 20 is shown in Figure 1 to have an outer surface 52 (facing the viewer in Figure 1), an inner surface 54 opposed to the outer surface 52, a first waist region 56, a second waist region 58 opposed to the first waist region 56, and a periphery 60 which is defined by the outer edges of the diaper 20 in which the longitudinal edges are designated 62 and the end edges are designated 64. The inner surface 54 of the diaper 20 comprises that portion of the diaper 20 which is positioned adjacent to the wearer's body during use (i.e. the inner surface 54 generally is formed by at least a portion of the topsheet 24 and other components joined to the topsheet 24). The outer surface 52 comprises that portion of the diaper 20 which is positioned away from the wearer's body (i.e. the outer surface 52 generally is formed by at least a portion of the backsheet 26 and other components joined to the backsheet 26). The first waist region 56 and the second waist region 58 extend, respectively, from the end edges 64 of the periphery 60 to the lateral centerline 66 of the diaper 20. The waist regions each comprise a central region 68 and a pair of side panels which typically comprise the outer lateral portions of the waist regions. The side panels positioned in the first waist region 56 are designated 70 while the side panels in the second waist region 58 are designated 72. While it is not necessary that the pairs of side panels or each side panel be identical, they are preferably mirror images one of the other. The side panels 72 positioned in the second waist region 58 can be elastically extensible in the lateral direction (i.e. elasticized side panels 30). (The lateral direction (x direction or width) is defined as the direction parallel to the lateral centerline 66 of the diaper 20; the longitudinal direction (y direction or length) being defined as the direction parallel to the longitudinal centerline 67; and the axial direction (Z direction or thickness) being defined as the direction extending through the thickness of the diaper 20).

Figure 1 shows a specific execution of the diaper 20 in which the topsheet 24 and the backsheet 26 are unitary across the core and the chassis region and have length and width dimensions generally larger than those of the absorbent core 28. The topsheet 24 and the backsheet 26 extend beyond the edges of the absorbent core 28 to thereby form the periphery 60 of the diaper 20. The periphery 60 defines the outer perimeter or, in other words, the edges of the diaper 20. The periphery 60 comprises the longitudinal edges 62 and the end edges 64.

While each elasticized leg cuff 32 may be configured so as to be similar to any of the leg bands, side flaps, barrier cuffs, or elastic cuffs described above, it is preferred that each elasticized leg cuff 32 comprise at least an inner barrier cuff 84 comprising a barrier flap 85 and a spacing elastic member 86 such as described in the above-referenced US Patent 4,909,803. In a preferred embodiment, the elasticized leg cuff 32 additionally comprises an elastic gasketing cuff 104 with one or more elastic strands 105, positioned outboard of the barrier cuff 84 such as described in the above-references US Patent 4,695,278.

The diaper 20 may further comprise an elastic waist feature 34 that provides improved fit and containment. The elastic waist feature 34 at least extends longitudinally outwardly from at least one of the waist edges 83 of the absorbent core 28 in at least the central region 68 and generally forms at least a portion of the end edge 64 of the diaper 20. Thus, the elastic waist feature 34 comprises that portion of the diaper at least extending from the waist edge 83 of the absorbent core 28 to the end edge 64 of the diaper 20 and is intended to be placed adjacent the wearer's waist. Disposable diapers are generally constructed so as to have two elastic waist features, one positioned in the first waist region and one positioned in the second waist region.

The elasticized waist band 35 of the elastic waist feature 34 may comprise a portion of the topsheet 24, a portion of the backsheet 26 that has preferably been mechanically stretched and a bi-laminate material comprising an elastomeric member 76 positioned between the topsheet 24 and backsheet 26 and resilient member 77 positioned between backsheet 26 and elastomeric member 76.

This as well as other components of the diaper are given in more detail in WO 93/16669 which is incorporated herein by reference.

While it is preferred to have a topsheet as the material nearest the wearer's skin, it is not necessary. It is contemplated that a suitable absorbent core configuration could be used without a topsheet and still produce desirable results such as comfort and absorbency as well as simplicity in manufacturing and material cost savings. For example, the body-side surface of the absorbent core itself could be made of liquid pervious, soft, compliant, non-irritating materials that substitute for a separate topsheet. Such an absorbent core would only need to be used in combination with a backsheet to provide for comfort and absorbency in an absorbent article.

Regions of absorbent articles and their relative arrangement

Generally, absorbent hygienic articles are intended for being worn around the lower end of the body torso. It is an essential design feature of these articles to cover the regions of the body where the discharges occur ("discharge regions"), which extend around the respective body openings. The respective zones of the absorbent article covering the discharge regions are correspondingly referred to as "loading zones". Thus during use, the articles are generally arranged on the wearer such that they extend (for a standing position of the wearer) from the crotch between the legs upwards, both in the front and the back of the wearer.

Generally, such articles have a length dimension exceeding their width dimension, whereby the article is worn such that the axis of the length dimension is aligned with the height direction of the wearer when standing, whilst the width direction of the article is aligned with a line extending from left to right of the wearer.

Because of the anatomy of the human wearer, the space between the legs of the wearer generally confines the space available for the article in this region. For good fit, an absorbent article should be designed such that it fits well in the crotch region. If the width of the article is excessively wide relative to the crotch width of the wearer, the article may be deformed, which might results in deteriorated performance, and reduced wearers comfort .

The point, where the article has its smallest width to fit best between the legs of the wearer then coincides with the point on the wearer, where the distance between the legs is the narrowest, and is - for the scope of the present invention - referred to as the "crotch point".

If the crotch point of an article is not obvious from its shape, it can be determined by placing the article on a wearer of the intended user group (e.g. a toddler) preferably in a standing position, and then placing an extensible filament around the legs in a figure eight configuration. The point in the article corresponding to the point of intersection of the filament is deemed to be the crotch point of the article and consequently also of the absorbent core being affixed within this article.

Whilst this crotch point of the article is often in the middle of the article (in longitudinal direction) this is not necessarily the case. It can very well be, that the part of the article which is intended to be worn in the front is smaller than the back (or rear) part - either in its length dimension, or width, or both, or surface area. Also, the crotch point does not need to be positioned in the middle of the absorbent core, in particular when the absorbent core is not placed longitudinally centered within the article.

The crotch region is the area surrounding the crotch point, so as to cover the respective body openings, respectively discharge regions. Unless otherwise mentioned, this region extends over a length of 50% of the total core length (which, in turn is defined as the distance between the front and rear waist edges of the core, which might be approximated by straight lines perpendicular to the longitudinal center line). If the crotch point is positioned in the middle of the article, then the crotch region starts (when counting from the front core edge) at 25% of total length and extends up to 75% of the total core length. Or, the front and the rear quarter of the length of the absorbent core do not belong to the crotch region, the rest does.

The crotch region length being 50% of the total absorbent core length has been derived for baby diapers, where it has been confirmed that this is a suitable means to describe the fluid handling phenomena. If the present invention is applied in articles having drastically different dimensions, it might become necessary to reduce these 50% (as in the case for Severe Incontinence articles) or to increase this ratio (as in the case for Ultra Light or Light Incontinence articles). In more general terms, this crotch region of the article should not extend much beyond the discharge region of the wearer.

If the crotch point is positioned offset from the mid-point of the article, the crotch region still covers 50% of the total article length (in longitudinal direction), however, not evenly distributed between front and back, but proportionally adjusted to this off-set.

As an example for an article having a total core length of 500 mm, and having a crotch point which is positioned centered, the crotch region will extend from 125 mm away from the front edge up to 375 mm away from front edge. Or, if the crotch point lies 50 mm offset towards the front core edge, (i.e. being 200 mm away from front core edge), the crotch region extends from 100 mm to 350 mm.

In general terms, for an article having a total core length of L_C, a crotch point being at a distance L_{cp} away from the front core edge, and a crotch zone length of L_{cz}, the front edge of said crotch zone will be positioned at a distance

$$L_{fecz} = L_{cp} *(1 - L_{cz} / L_c).$$

For example the absorbent article can be a baby diaper, for being worn by toddlers (i.e. of about 12 to 18 kg baby weight) whereby the size of the article in the trade is generally referred to as MAXI size. Then the article has to be able to receive and retain both fecal materials and urine, whereas for the context of the present invention the crotch region has to be capable to primarily receive urine loadings.

The total area and size of the crotch region is - of course - also depending on the respective width of the absorbent core, i.e. if the core is narrower in the crotch region than outside the crotch region, the crotch region has a smaller area (surface) than the remaining area of the absorbent core.

Whilst it can be contemplated, that the boundaries between crotch region and the rest of the article can also be curvilinear, they are approximated within the present description to be straight lines, perpendicular to the longitudinal axis of the article.

The "crotch region" is further confined by the width of the core in this respective region, and the "crotch region area" by the surface as being defined by the crotch region length and the respective width.

As a complementary element to the crotch region, the absorbent core also comprises at least one but mostly two waist region(s) , extending towards the front and/or the rear of the absorbent core outside the crotch region.

The various elements of the absorbent article and especially of the absorbent core can further be distinguished by their functionality.
Thereby, the region being closest to the loading point of the articles needs generally to ensure that the body exudates which are to be absorbed by the article are sufficiently quickly acquired so as to not remain on the surface of the article, where it might have too much undesired contact with the wearers skin. This region is often referred to as acquisition region.

Another region can be considered where the received body exudates are to be ultimately stored. This can be done in one region, which might be directly adjacent to the acquisition region, or this might be done primarily in a region somewhat distant from the acquisition region. Also, there can be more than one storage regions, either in direct contact with each other (such as when placing two storage material layers on top of each other), or which can have no direct contact with each other (such as when placing each one storage region in the front and back parts of the article).

In any of the above cases, it can be desirable to have a further region, which has a primary functionality of fluid distribution, i.e. transporting the fluid primarily in x.y. direction of the article, such as from the acquisition region to the storage regions or regions.

In an absorbent article, the regions can be combined in one unitary and homogeneous structure or material. More preferably, however, at least some of the regions have different fluid handling properties different so as to be better adapted for their specific functionality. Often it is preferred to design the regions from materials having different properties.

For the particularly preferred designs according to the present invention, there must be at least one fluid storage region, and at least one other fluid acquisition/distribution region.

Each of the regions can have various shapes, such as being flat, (i.e. having essentially an x,y extension with essentially constant thickness dimension), or three-dimensionally shaped. Further, these regions can be arranged in various relative positions to each other, such as being layered, or circumscribing in x.y-direction each other.

Preferred executions of the article comprising the various region have these arranged such that they have only little negative impact on the comfort of the wearer, and ideally no negative impact at all. This has to be considered for the article in its unloaded ("dry") state, as well as in its loaded state. For the latter a particularly preferred execution has a small width dimension in the crotch region, and also has relatively lower fluid storage capability in this region, so as to not increase the bulk between the legs even for a loaded article.

Whilst the various regions must be in fluid communicating contact with each other (i.e. the must be the possibility of the body exudates to move from the acquisition zone to the storage zone, and doing so by moving through the distribution region, if present.

Whilst the respective regions are referred to by their primary functionality, they generally also have at least to a certain degree other functionality. Thus, a fluid absorbent storage region will also have a fluid distribution functionality, and a fluid acquisition / distribution region will have some fluid retention capability.

Absorbent structures or members

Apart from looking at the various regions of the absorbent core from a functionality point of view, it is often desirable to consider an absorbent core to be composed of one or more absorbent members or structures, which might consist of sub-structures, such than an absorbent core can be considered to be composed of one or - as in most cases of modern absorbent article designs - several different "materials". Within the context of the present invention, a material forming an absorbent member is an element which can be tested for its "material properties", independent of whether the material is a "pure" material (e.g. a particle of superabsorbent material), an accumulation of homogeneous material (e.g. a mass of cellulose fibers, or a foam structure, or a mass of superabsorbent particles), a mixture of two or more pure materials or material accumulations (e.g. a mixture of superabsorbent particles having different properties, or a blend of superabsorbent particles and cellulosic fibers); or a further arrangement of several materials forming a distinctable absorbent member (such as a two layer composite).

Hence, it will be possible to assess the fluid handling properties of a 'fluid handling member", and for certain members it will also be possible to assess the properties of the substructures or materials comprised therein.

The functional regions as described above can be formed out of the same material (for example cellulose web, or a mixture of cellulose and superabsorbent material), whereby the different regions are defined for example by varying densities. More preferably, such different properties can be achieved by using different members and/or materials, allowing a wider range of design flexibility by allowing hydrophilicity, or pore size or other properties relevant for fluid handling to be varied over a much wider range.

Properties of member

Distribution region requirements

Whilst the required properties of well functioning materials or members in one region are depending on properties of the absorbent members or materials in the other region, the following characteristics have been found to provide suitable distribution members - provided they are combined with high suction storage members at outlined below.

Fluid distribution materials in the context of the present invention are materials for applications such as in absorbent articles, which are intended to support the fluid transport mechanisms in such articles. Such articles generally have two centerlines, a longitudinal and a transverse one. The term "longitudinal" as used herein, refers to a line axis or direction in the plane of the article, that is generally aligned with (e.g. approximately parallel to) a vertical plane which bisects a standing wearer of such an article into left and right body halves. The fluid transport mechanisms may then be required to effectively use absorbent material which can be spread in the article over a larger region than the loading regions, i.e. this region of the articles where bodily discharges are disposed onto the surface of the absorbent article. Such transport can occur through driving forces such as gravity, which will not allow fluid distribution against the direction of the gravity, and hence often not satisfy requirements as set out for absorbent articles, whereby fluid needs to be transported from the loading point, where discharged fluids are discharged onto the absorbent article, to other parts of the article, which are positioned "higher", i.e. upwards against the direction of gravity.

This wicking is generally achieved by exploiting capillary forces, and can be best assessed by testing the materials in the vertical orientation, i.e. positioning these along the direction of gravity.

A key functionality of the materials- suitable for being used for the present invention is the combination of increased wicking height and flux.

As absorbent articles can have significant dimensions due to the anatomy of the wearer and the dimensions of the absorbent article, the ability of wicking high up is important, and vertical wicking distances such as 12.4 cm (5 inch) or 8.3 cm (3.3 inch) can be typical for realistic conditions.

Equally important is the amount of fluid which has to be transported. Characteristic loadings for baby diapers can be more than 300 ml of urine loading, in voidings often at 75 ml per voiding, and voiding rates of up to 15 ml/sec. Hence the need for the ability to transport significant amounts becomes obvious. There is, however, a further need for low material usage both due to economical use of materials and due to comfort and fit requirements for the wearer. Hence, materials are required to allow transport of large amounts of fluids in short times through a small cross section of such material. This can generally be expressed by the "vertical wicking flux" parameter, being defined by the cumulative amount of fluid being transported to a given height through a certain cross-section of material in a certain time, expressed in ml/cm2/sec , and by the time the fluid front penetrates up to a certain height in the material against gravity.

These parameter can be easiest determined by using the vertical wicking test, such as specified below, measuring the ability of a material to transport fluid through its internal voids (such as pores) at constancy or absence of external forces, such as gravity or centrifugal forces. Essentially, a specimen of the material is placed in a vertical position extending out of a fluid reservoir. The transport against the gravity can be monitored by measuring both the upward movement of the wetting front and the amount of fluid which is picked up by the material.

Wicking height can be easily increased by decreasing the effective pore size of the distribution material, according to the generally known Lucas-Washburn relationship for capillary systems, which often has been applied to also approximate porous systems. For a given fluid - be this urine or menstrual fluid - and a certain material exhibiting a certain surface energy, the required capillary (or pore) diameter can be approximated to allow wicking up to a certain required height. Obviously, when aiming for large wicking heights, this relation requires small capillary diameter.

However, such small capillaries are not able to handle high amounts fluid, and the cumulative flux for such fluids through such a material with small pores is significantly reduced. This is caused by the high internal friction (or low permeability) that is linked to small pores (according to the Hagen-Poisseuille relationship).

Thus, whilst conventional materials exhibit either large heights combined with low flux or large flux values at low heights, it has been found that this trade off can be overcome such as by materials described further below.

Thus, the material in the first region can be described by having a cumulative flux of more than 0.075 g/cm2/sec at 12.4 cm height, preferably of more than 0.12 g/cm2/sec. Alternatively, the fluid distribution property of the first material can be expressed by this material having a wicking time at 12.4 cm of less than 120 seconds, preferably less than 50 seconds. In a preferred execution, the wicking time at 8.3 cm is in one preferential direction (such as the longitudinal direction) less than 80% of the wicking time in a direction perpendicular thereto, and the cumulative flux is more than 0.120 g/cm2/sec for this preferential direction.

Materials suitable to achieve distribution requirements

Fluid acquisition/distribution members suitable for being used in the present invention, can comprise various materials and can be made by various processes.

A suitable member can be a web comprising resilient fibers, which are formed into this web by well known processes, such as air-laying, or wetlaying and the like.

A wide variety of resilient fibers can be envisaged to perform well in members according to the present invention. Apart from well know synthetic fibers such as being based on polyethyleneterephtalate, polyester, polyamine, resilient polyolefins or combinations thereof e.g. in bi-component fiber form, a particularly preferred fiber is a chemically-stiffened, twisted bulking cellulosic fiber.

As used herein, the term "chemically stiffened, twisted, and curled fibers" means any fibers which have been stiffened by chemical means to increase stiffness of the fibers under both dry and aqueous conditions. Such means include the addition of chemical stiffening agents which, for example, coat and/or impregnate the fibers. Such means also include the stiffening of the fibers by altering the chemical structure of the fibers themselves, e.g., by cross-linking polymer chains.

Fibers stiffened by crosslink bonds in individualized (i.e., fluffed) form are disclosed, for example, in Bernardin, U.S. Patent 3,224,926, Issued December 21, 1965; Chung, U.S. Patent 3,440,135, Issued April 22, 1969; Chatterjee, U.S. Patent 3,932,209, Issued January 13, 1976 and Sangenis et al., U.S. Patent 4,035,147, Issued July 12, 1977. More preferred fibers are disclosed in Dean et al., U.S. Patent 4,822,453, issued April 18, 1989, Dean et al., U.S. Patent 4,888,093, issued December 19, 1989, and Moore et al., U.S. Patent 4,898,642, issued February 6, 1990.

Other polymeric stiffening agents which can coat or impregnate cellulosic fibers include: cationic modified starch having nitrogen-containing groups (e.g., amino groups) such as those available from National Starch and Chemical Corp., Bridgewater, NJ, USA; latex; wet strength resins such as polyamide-epichlorohydrin resin (e.g., Kymene^{TM} 557H, Hercules, Inc. Wilmington, Delaware, USA), polyacrylamide resin (described, for example, in U.S. Patent 3,556,932 issued January 19, 1971 to Coscia, et al.; also, for example, the commercially available polyacrylamide marketed by Cytec Industries, West Patterson, NJ, USA, under the trade name Parez^{TM} 631 NC); urea formaldehyde and melamine formaldehyde resins, and polyethylenimine resins.

The fibers suitable for the fluid absorbent members herein are preferably stiffened by means of chemical reaction. For example crosslinking agents can be applied to the fibers which, subsequent to application, are caused to chemically form intra-fiber crosslink bonds. These crosslink bonds can increase stiffness of the fibers. Whereas the utilization of intrafiber crosslink bonds to chemically stiffen the fibers is preferred, it is not meant to exclude other types of reactions for chemical stiffening of the fibers.

In the more preferred stiffened fibers, chemical processing includes intrafiber crosslinking with crosslinking agents while such fibers are in a relatively dehydrated, defibrillated (i.e., individualized), twisted, curled condition. Suitable chemical stiffening agents include monomeric crosslinking agents including, but not limited to, C_2-C_8 dialdehydes and C_2-C_8 monoaldehydes having an acid functionality can be employed to form the crosslinking solution. These compounds are capable of reacting with at least two hydroxyl groups in a single cellulose chain or on approximately located cellulose chains in a single fiber. Such crosslinking agents contemplated for use in preparing the stiffened cellulose fibers include, but are not limited to, glutaraldehyde, glyoxal, formaldehyde, and glyoxylic acid. Other suitable stiffening agents are polycarboxylates, such as citric acid. The polycarboxylate stiffening agents and a process for making stiffened fibers from them are described in U.S. Patent No. 5,190,563, issued March 2, 1993. The effect of crosslinking under these conditions is to form fibers which are stiffened and which tend to retain their twisted, curled configuration during use in the absorbent articles herein. Such fibers, and processes for making them are described in the above incorporated patents.

Stiffened cellulose fibers can be prepared by internally crosslinking such fibers in relatively dehydrated form while or after such fibers are being or have been dried and defibrated (i.e., "fluffed") as described in U.S. Patent Application Serial No. 304,925. It is not, however, meant to necessarily exclude other hydrophilic, chemically stiffened, twisted, and curled fibers from this invention, such other fibers being described in (but, not limited to) the previously mentioned U.S. Patents 3,224,926, 3,440,135, 4,035,147, and 3,932,209. Other non-chemical means of providing stiffened, twisted, and curled cellulose fibers are also contemplated as being within the scope of the present invention, such as high consistency (generally greater than about 30%) mechanical treatment (e.g., frotapulping and/or refining, etc.). Such methods are described in greater detail in U.S. Patent Nos. 4,976,819 and 5,244,541, issued December 11, 1990 and September 14, 1993, respectively, to Mary L. Minton and entitled "Pulp Treatment Methods".

Other, more preferred webs further comprise a second type of fibers having a relatively high surface area.

Whilst also synthetic fibers such as having a very small diameter ("microfibers") or having a special surface configuration are contemplated to be suitable, a presently preferred fiber for this high surface application is the eucalyptus family of wood pulp fibers. Eucalyptus provides desirable capillary pressure characteristics in combination with the chemically stiffened, twisted, and curled fibers and will not easily pass through the forming screen, as does a significant amount of the cellulose fines described below. Particularly suitable eucalyptus fibers include those of the eucalyptus grandis species.

Other suitable surface area generating fibers for addition to the stiffened cellulosic fibers prior to formation of the wet web from a pulp slurry include, but are not limited to, a variety of cellulosic and synthetic fibrous materials such as those disclosed in U.S. Patent No. 5,217,445, issued to Young et al. on June 8, 1993. Such materials include nonstiffened cellulosic fibers (i.e., conventional cellulosic pulp fibers), highly refined, stiffened and nonstiffened, cellulosic fibers referred to herein as "crill", and high surface area cellulosic material such as expanded cellulose fibers (hereinafter described). The high surface area cellulose is well mixed with the stiffened fibers in slurry and the slurry is wetlaid. A blender, a repulper, a deflaker, a valley beater, a refiner (e.g., single, cone, or double disk refiner), or other equipment known in the art, can be used to mix, declump, or refine the stiffened fibers and high surface area cellulose.

High surface area cellulose can also be made from cellulosic fibers by passing a liquid suspension of cellulose fibers through a small diameter orifice, in which the suspension is subjected to a pressure drop of at least 4.3 Pa (3000 psig) and a high velocity shearing action, followed by a high velocity decelerating impact. Passage of the suspension through the orifice is repeated until a substantially stable suspension is obtained. See U.S. Patent 4,483,743, Turbak et al., November 20, 1984.

When resilient fibers such as the crosslinked, twisted, stiffened fibers are combined with high surface area fibers as described above, the resulting web can have significantly reduced tensile strength, particular in a wet condition.

Therefore, in order to facilitate processing and provide product-specific mechanical properties, in both wet and dry states, a binding means can be integrally incorporated into or onto the web. This can be done by adding the binding means to pulp prior to web formation, by applying the binding means to a wetlaid web after deposition on a forming wire, and before drying, after drying, or a combination thereof.

Whilst the specific binding means to provide this certain strength to the formed web is believed to not be critical to the fluid handling performance, thermoplastic fibers have been found to provide a preferred option, and a chemically bound web an even more preferred execution.

In an preferred execution, the fluid acquisition / distribution material comprises a wetlaid web of stiffened cellulosic fibers wherein the web is reinforced with between about 0% to about 50%, preferably between about 5% to about 25%, more preferably between about 7% to about 15%, of a thermoplastic binding material, wherein the thermoplastic binding material provides bond sites at intersections of the binding fibers with either other binding fibers, chemically stiffened, twisted, and curled cellulosic fibers, or high surface area fibers. Such thermally bonded webs can, in general, be made by forming a web comprising the stiffened cellulosic fibers and thermoplastic fibers, which are preferably evenly distributed throughout. The thermoplastic fibrous material can be intermixed with the stiffened cellulosic fibers and fine fibers in the aqueous slurry prior to web formation. Once formed, the web is thermally bonded by heating the web until the thermoplastic portion of the fibers melt. Specific non-limiting examples of suitable fibrous materials include polyester hot melt fibers (KODEL 410), bicomponent fibers, tricomponent fibers, mixtures thereof, and the like.

In addition, a crimped type polymer-based binder fiber will contribute added bulk to the web. A presently preferred polymer-based binder fiber of the crimped variety is Hoechst-Celanese Copolyolefin Bicomponent fiber, commercially available under the tradename CELBOND® from Hoechst Celanese Corporation, type 255, lot 33865A, having a dTex of about 3.3, or a denier of about 3.0, and a fiber length of about 6.4 mm.

The thermoplastic binding materials useful for the fluid acquisition / distribution members also include any hot melt adhesive which can be melted at temperatures which will not extensively damage the cellulosic fibers. Preferably, the melting point of the thermoplastic binding material will be less than about (175°C), preferably between about 75°C and about 175°C. In any case, the melting point should be no lower than temperatures at which the articles of this invention are likely to be stored, whereby melting point will be typically no lower than about 50°C.

The thermoplastic binding material may, for example, be polyethylene, polypropylene, polyester, polyvinyl chloride, polyvinylidene chloride. Preferably, the thermoplastic fibers will not significantly imbibe or absorb aqueous fluid. However, the surface of the thermoplastic material can be hydrophilic or hydrophobic. (As used herein, the terms "hydrophilic" and "hydrophobic" shall refer to the extent to which the surfaces are wetted by water.) Hydrophilic material becomes more preferred at higher thermoplastic levels, particularly at levels above about 40%.

Thermoplastic fibers for use herein can be on the order of about 0.1 cm to about 6 cm long, preferably from about 0.3 cm to about 3.0 cm.

The thermoplastic is preferably melted by through-air bonding, however other methods such as infra red light, steam drum drying, Yankee, etc. are not meant to be excluded. In another variation, the web is subjected to heat embossing on one or both faces of the web. This technique is described in further detail in U.S. Patent 4,590,114.

As discussed previously, scrims such as tissue sheets and other water pervious nonwoven sheets can be used as external support in addition to or in place of the binding means described above.

An even preferred starting material comprises chemical binders. Such chemical additive binding means for increasing physical integrity of the absorbent member and/or facilitating processing of webs, especially wetlaid webs, can be resinous binders, latex, and starch known in the art for providing increased integrity to fibrous webs. Suitable resinous binders include those which are known for their ability to provide wet, dry, or both wet and dry strength in paper structures, such as can be found in TAPPI monograph series No. 29, Wet Strength in Paper and Paperboard, Technical Association of the Pulp and Paper Industry (New York, 1965). Suitable resins include polyamide-epichlorohydrin and polyacrylamide-glyoxal resins. Other resins finding utility in this invention are urea formaldehyde and melamine formaldehyde resins. The more common functional groups of these polyfunctional resins are nitrogen containing groups such as amino groups and methylol groups attached to nitrogen. Polyethylenimine type resins may also find utility in the present invention. A presently preferred chemical additive binding means is the commercially available polyacrylamide-glyoxal resin marketed by Cytec Industries, West Patterson, NJ, USA, under the trade name Parez^{TM} 631 NC.

Starch, particularly cationic, modified starches may also find utility as chemical additives in the present invention. Such cationic starch materials, generally modified with nitrogen containing groups such as amino groups and methylol groups attached to nitrogen, may be obtained from National Starch and Chemical Corporation, located in Bridgewater, New Jersey. Other suitable binders include, but are not limited to, polyacrylic acid, polyvinyl alcohol, polyvinyl acetate.

The level of chemical additive binders which are added will typically be from about 0% to about 5% total web weight basis. Chemical additive binders which are hydrophilic, however, can be utilized in larger quantities. If the chemical binder additives are added to the stiffened fibers in aqueous slurry, conventional, nonstiffened cellulosic fibers or high surface area cellulose is preferably also present, to enhance retention of the chemical additive binder. Chemical additive binders can be applied to dried or undried webs by printing, spraying, or other methods known in the art.

In addition to the use of a chemical binding means, fluid distribution materials may also benefit from the integration of a thermally bonded polymer micro web in the material as explained above.

The described constituents for suitable and preferred fluid acquisition / distribution materials according may be blended together and formed into webs by a variety of methods, including wet-laying methods, air-laying methods, carding, and other methods, of which wet-laying methods are presently preferred.

Techniques for wetlaying cellulosic fibrous material to form sheets such as dry lap and paper are well known in the art. These techniques are generally applicable to the wet-laying of the stiffened fibers to form wetlaid sheets useful in the absorbent structures of this invention. Suitable wetlaying techniques include handsheeting, and wetlaying with the utilization of paper making machines as disclosed, for instance, by L. H. Sanford et al. in U.S. Patent 3,301,746. Due to the behavior of chemically stiffened, twisted, and curled fibers, particularly their tendency to flocculate in aqueous slurries, certain processing modifications, hereafter described, are preferably implemented when wetlaying with paper making machines.

In general, wetlaid webs can be made by depositing an aqueous slurry of fibers on to a foraminous forming wire, dewatering the wetlaid slurry to form a wet web, and drying the wet web. Preferably, the aqueous slurries of fibers for wetlaying will have a fiber consistency of between about 0.02% and about 2.0%, preferably between about 0.02% and about 0.2%, total slurry weight basis. Deposition of the slurry is typically accomplished using an apparatus known in the art as a headbox. The headbox has an opening, known as a slice, for delivering the aqueous slurry of fibers onto the foraminous forming wire. The forming wire can be of construction and mesh size used for dry lap or other paper making processing. Conventional designs of headboxes known in the art for drylap and tissue sheet formation may be used. Suitable commercially available headboxes include, for example, open, fixed roof, twin wire, inclined wire, and drum former headboxes.

Once formed, the wet web is dewatered and dried. Dewatering can be performed with foils, suction boxes, or other vacuum devices or gravitational flow. Typically, dewatering increases the fiber consistency to between about 8% and about 30%, total wet web weight basis, preferably between about 8% and about 23%. Dewatering to consistencies above about 23% may require wet-pressing and is less preferred. After dewatering, the web can be, but is not necessarily, transferred from the forming wire to a drying fabric which transports the web to drying apparatuses.

Drying of the wet web may be accomplished utilizing many techniques known in the art. When thermoplastic binding materials are included in the web, is particularly important that the web be dried thoroughly and uniformly at a temperature which fuses the thermoplastic binding material to other fibrous materials, but not so high as to cause the thermoplastic binding material to flow into the void volume of the network. Drying can be accomplished via, for example, a thermal blow-through dryer, a thermal air-impingement dryer, and heated drum dryers, including Yankee dryers. The wetlaid webs are preferably dried to completion (generally to fiber consistencies between about 95% to about 99%). The flexibility of the fully dried web is preferably increased such as by techniques well known in the art such as creping the web using a Yankee dryer with a doctor blade.

In order to achieve particularly preferred properties according to the present invention, the prior art materials as discussed above can be subjected to an additional process step after being formed. Similar processes have been developed for treating stretch laminate materials and are described in US-A-5.167.897 (Weber) relating to stretch materials or in and are for fluid distribution materials described in EP-A- 0.810.078 included herein by reference.

Essentially, this process provides mechanical treatment of the web, by feeding the starting material through at least two rolls each with circumferential ridges and grooves, which are run at such a close tolerance that the web undergoes permanent deformation.

Thereby, the essentially untensioned web is directed through an incremental cross-directional web stretching system employing opposed pressure applicators having three dimensional surfaces which at least to a degree are complementary to one another and can overlap or “intermesh” so as to strain the material thereinbetween.

The arrangement of the ridges and grooves both in circumferential and axial direction of the corrugated rolls, can be uniform, specific executions can comprise regions with different patterns, be this in an axial arrangement, e.g. widths of grooves and / or ridges changing across the axial direction of the rolls, or be this in circumferential direction, e.g. the ridges and grooves have a changing depth across the circumference of at least one roll, or at least one of the rolls has an macroscopically curvatured shape, e.g. is thicker in the center portion than towards the edges..

Also, the use of more than two corrugated rolls can be beneficial, such at when to avoid too strong treatment in one step.

A further enhancement of the process can be achieved further adding a process step of heating the web, either by a separate process step directly after the post formation treatment as disclosed in the above, or by heating the means that applies the mechanical stress to the web, e.g. one or both of the corrugated rolls. Preferentially, this is applied for webs comprising thermofusible materials (such as the materials comprising thermoplastic fibers). The beneficial effect of this additional heat treatment lies in that the webs can be formed such as to allow relatively easy plastic deformation by the mechanical process, then reaching a desired resiliency and/ or strength by the heat curing.

It is further recognized that while the preferred processes employ meshing cylindrical corrugated rolls, the present invention may also be carried out utilizing an intermittent stamping operation employing meshing platens to incrementally stretch the web in question.

Alternatively to the fibrous webs as described hereinbefore, relatively open-celled polymeric foams can be used, in particular hydrophilic, flexible polymeric foam structures of interconnected open-cells.

Storage Absorbent Member requirements

As described in the above the distribution members exhibit certain desorption properties, which have to be matched by the absorption properties of the absorbent storage members or materials.

Thus, the storage absorbent members suitable for the present invention exhibit high capillary suction capacities. For purposes of the present disclosure, this high suction capacity is measured in terms of the member's ability to uptake fluid at certain capillary heights, which are generally encountered when the member is positioned in an absorbent article. The Capillary Sorption Absorbent Capacity test (also referred to herein as the Capsorption test) measures the amount of test fluid per gram of absorbent storage member that is taken up when the storage member is placed at varying heights on a capillary sorption apparatus. The Capillary Sorption Absorbent Capacity test is described in greater detail in the Test Methods section below.

In one aspect, the high capillary suction capacity storage absorbent member suitable for the present invention has a capillary sorption absorbent capacity (CSAC) at a height of 35 cm of at least about 15 g/g, preferably at least about 18 g/g, more preferably at least about 20 g/g, still more preferably at least about 22 g/g. Typically, these storage absorbent members will have a capillary sorption absorbent capacity at a height of 35 cm of from about 15 g/g to about 60 g/g, more typically from about 18 g/g to about 55 g/g, still more typically from about 20 g/g to about 50 g/g.

In another aspect, the high capillary suction capacity storage absorbent member has a CSAC at a height of 50 cm of at least about 8 g/g, preferably at least about 11 g/g, more preferably at least about 15 g/g, still more preferably at least about 19 g/g. Typically, these storage absorbent members will have a CSAC at a height of 50 cm of from about 8 g/g to about 40 g/g, more typically from about 11 g/g to about 35 g/g, still more typically from about 15 g/g to about 30 g/g.

In still another aspect, the high capillary suction capacity storage absorbent member has a CSAC at a height of 80 cm of at least about 6 g/g, preferably at least about 9 g/g, more preferably at least about 12 g/g, still more preferably at least about 15 g/g. Typically, these storage absorbent members will have a capillary sorption absorbent capacity at a height of 80 cm of from about 6 g/g to about 35 g/g, more typically from about 9 g/g to about 30 g/g, still more typically from about 12 g/g to about 25 g/g.

In yet another aspect, the high capillary suction capacity storage absorbent member has a CSAC at a height of 100 cm of at least about 5 g/g, preferably at least about 7 g/g, more preferably at least about 10 g/g, still more preferably at least about 14 g/g. Typically, these storage absorbent members will have a capillary sorption absorbent capacity at a height of 100 cm of from about 5 g/g to about 30 g/g, more typically from about 7 g/g to about 25 g/g, still more typically from about 10 g/g to about 20 g/g.

While the above minimum capillary suction capacities are important to the storage absorbent members of the present invention, these members will also preferably, though not necessarily, have a capillary sorption absorbent capacity at zero head pressure (i.e., at 0 cm in the Capsorption test) of at least about 15 g/g. In another preferred aspect, the storage absorbent members will concurrently exhibit the required g/g uptake at least two suction heights discussed above. That is, for example, preferred storage absorbent members will have 2 or more of the following properties: (i) a capillary sorption absorbent capacity (CSAC) at a height of 35 cm of at least about 10 g/g, preferably at least about 13 g/g, more preferably at least about 20 g/g, still more preferably at least about 22 g/g; (ii) a CSAC at a height of 50 cm of at least about 8 g/g, preferably at least about 11 g/g, more preferably at least about 15 g/g, still more preferably at least about 19 g/g; (iii) a CSAC at a height of 80 cm of at least about 6 g/g, preferably at least about 9 g/g, more preferably at least about 12 g/g, still more preferably at least about 15 g/g; (iv) a CSAC at a height of 100 cm of at least about 5 g/g, preferably at least about 7 g/g, more preferably at least about 10 g/g, still more preferably at least about 14 g/g.

A yet another way to describe storage absorbent members suitable for the invention is that the high capillary suction storage absorbent member needs to have a high medium absorption pressure The medium absorption pressure of material is defined as the pressure for which the material has a capillary absorption efficiency of 50 % and is measured in the capillary absorption test described in the test method section, by determining the height at which the material will achieve 50% of it's maximum absorption capacity in this test, and is referred to as CSAH 50.

Preferred storage absorbent members suitable for the present invention are high capillary suction capacity storage absorbent members having a capillary sorption absorbent capacity at a height of 0 cm of at least about 15 g/g, preferably at least about 20 g/g, more preferably at least about 25g/g, most preferably at least about 35 g/g and having a medium capillary absorption height CSAH 50 of at least 35 cm, preferably at least 45 cm, more preferably at least 60 cm, most preferably at least 80 cm.

Materials to achieve Storage Absorbent Member requirements

High Surface Area Materials

The storage absorbent members useful for the present invention preferably comprise a high surface area material. It is this high surface area material that provides, either itself or in combination with other elements such as hydrogel-forming absorbent polymer, the members with high capillary sorption absorbent capacity. As discussed herein, high surface area materials are described, at least in one regard, in terms of their capillary sorption absorbent capacity (measured without hydrogel-forming polymer if present in the member or any other optional material contained in the actual storage absorbent member, such as adhesives, bonding agents, etc.). It is recognized that materials having high surface areas may have uptake capacities at very high suction heights (e.g., 100 cm or higher). This allows the high surface area materials to provide one or both of the following functions: i) a capillary pathway of liquid to the other absorbents, such as osmotic absorbents, and/or ii) additional absorbent capacity. Thus, while the high surface area materials may be described in terms of their surface area per weight or volume, Applicants herein alternatively use capillary sorption absorbent capacity to describe the high surface area material because capillary sorption absorbent capacity is a performance parameter that generally will provide the absorbent members for the present invention with the requisite suction capabilities to provide improved absorbent articles. It will be recognized that certain high surface area materials, e.g. glass microfibers, will themselves not exhibit particularly high capillary sorption absorbent capacity at all heights, especially very high heights (e.g., 100 cm and higher). Nonetheless, such materials may provide the desired capillary pathway of liquid to the hydrogel-forming absorbent polymer or other absorbents to provide the requisite capillary sorption absorbent capacities, even at relatively high heights.

Any material having sufficient capillary sorption absorbent capacity will be useful in the storage absorbent members of the present invention. In this regard, the term "high surface area material" refers to any material that itself (i.e., as measured without the osmotic absorbent or any other optional material that makes up the storage absorbent member) exhibits one or more of the following capillary sorption absorbent capacities: (I) A capillary sorption absorbent capacity of at least about 2 g/g at a suction height of 100 cm, preferably at least about 3 g/g, still more preferably at least about 4 g/g, and still more preferably at least about 6 g/g, at a height of 100 cm; (II) A capillary sorption absorbent capacity at a height of 35 cm of at least about 5 g/g, preferably at least about 8 g/g, more preferably at least about 12 g/g; (III) A capillary sorption absorbent capacity at a height of 50 cm of at least about 4 g/g, preferably at least about 7 g/g, more preferably at least about 9 g/g; (IV) A capillary sorption absorbent capacity at a height of 140 cm of at least about 1 g/g, preferably at least about 2 g/g, more preferably at least about 3 g/g, still more preferably at least about 5 g/g; or (V) A capillary sorption absorbent capacity at a height of 200 cm of at least about 1 g/g, preferably at least about 2 g/g, more preferably at least about 3 g/g, still more preferably at least about 5 g/g.

In one embodiment, the high surface area material will be fibrous (hereafter referred to as "high surface area fibers") in character, so as to provide a fibrous web or fibrous matrix when combined with the other absorbent such as hydrogel-forming absorbent polymer or other osmotic absorbent. Alternatively, and in a particularly preferred embodiment, the high surface area material will be an open-celled, hydrophilic polymeric foam (hereafter referred to as "high surface area polymeric foams" or more generally as "polymeric foams"). These materials are described in detail below.

High Surface Area Fibers

High surface area fibers useful in the present invention include those that are naturally occurring (modified or unmodified), as well as synthetically made fibers. The high surface area fibers have surface areas much greater than fibers typically used in absorbent articles, such as wood pulp fibers. The high surface area fibers used in the present invention will desirably be hydrophilic. As used herein, the term "hydrophilic" describes fibers, or surfaces of fibers, that are wettable by aqueous liquids (e.g., aqueous body liquids) deposited on these fibers. Hydrophilicity and wettability are typically defined in terms of contact angle and the surface tension of the liquids and solids involved. This is discussed in detail in the American Chemical Society publication entitled Contact Angle, Wettability and Adhesion, edited by Robert F. Gould (Copyright 1964). A fiber, or surface of a fiber, is said to be wetted by a liquid (i.e., hydrophilic) when either the contact angle between the liquid and the fiber, or its surface, is less than 90°, or when the liquid tends to spread spontaneously across the surface of the fiber, both conditions normally co-existing. Conversely, a fiber or surface is considered to be hydrophobic if the contact angle is greater than 90° and the liquid does not spread spontaneously across the surface of the fiber. The hydrophilic character of the fibers useful herein may be inherent in the fibers, or the fibers may be naturally hydrophobic fibers that are treated to render them hydrophilic. Materials and methods for providing hydrophilic character to naturally hydrophobic fibers are well known.

High surface area fibers useful herein will have capillary suction specific surface areas in the same range as the polymeric foams described below. Typically, however, high surface area fibers are characterized in terms of the well known BET surface area.

High surface area fibers useful herein include glass microfibers such as, for example, glass wool available from Evanite Fiber Corp. (Corvallis, OR). Glass microfibers useful herein will typically have fiber diameters of not more than about 0.8 μm, more typically from about 0.1 μm to about 0.7 μm. These microfibers will have surface areas of at least about 2 m^2/g, preferably at least about 3 m^2/g. Typically, the surface area of glass microfibers will be from about 2 m^2/g to about 15 m^2/g. Representative glass microfibers for use herein are those available from Evanite Fiber

Corp. as type 104 glass fibers, which have a nominal fiber diameter of about 0.5 μm. These glass microfibers have a calculated surface area of about 3.1 m^2/g.

Another type of high surface area fibers useful herein are fibrillated cellulose acetate fibers. These fibers (referred to herein as "fibrets") have high surface areas relative to cellulose-derived fibers commonly employed in the absorbent article art. Such fibrets have regions of very small diameters, such that their particle size width is typically from about 0.5 to about 5 μm. These fibrets typically have aggregate surface areas of about 20 m^2/g. Representative fibrets useful as the high surface area materials herein are available from Hoechst Celanese Corp. (Charlotte, NC) as cellulose acetate Fibrets®. For a detailed discussion of fibrets, including their physical properties and methods for their preparation, see "Cellulose Acetate Fibrets: A Fibrillated Pulp With High Surface Area", Smith, J. E., Tappi Journal, Dec. 1988, p. 237; and U.S. Patent No.5,486,410 (Groeger et al.) issued Jan. 23, 1996; the disclosure of each of which is incorporated by reference herein.

In addition to these fibers, the skilled artisan will recognize that other fibers well known in the absorbency art may be modified to provide high surface area fibers for use herein. Representative fibers that may be modified to achieve high surface areas required by the present invention are disclosed in U.S. Patent No. 5,599,335, supra (see especially columns 21-24).

Regardless of the nature of the high surface area fibers utilized, the fibers and the other absorbent material such as the osmotic absorbent will be discrete materials prior to combination. As used herein, the term “discrete” means that the high surface area fibers and the other absorbents are each formed prior to being combined to form the storage absorbent member. In other words, the high surface area fibers are not formed subsequent to mixing with the other absorbent (e.g., hydrogel-forming absorbent polymer), nor is the other absorbent formed after combination with the high surface area fibers. Combining of the discrete respective components ensures that the high surface area fibers will have the desired morphology and, more importantly, the desired surface area.

High Surface Area Polymeric Foams

The high surface area polymeric foams useful herein are described in some respects below in terms of their physical properties. To measure certain of these properties, it is necessary to perform analysis on the foam in sheet form. Thus, insofar as a foam is used in particulate form and is prepared from a previously formed sheet, physical property measurements will be conducted on the sheet foam (i.e., prior to forming particulates). Where the foam is formed in situ into particles (or beads) during the polymerization process, a similar foam (in terms of chemical composition, cell size, W:O ratio, etc.) can be formed into sheets for the purpose of making such measurements.

High surface area polymeric foams useful in the high capillary suction storage absorbent members of the present invention are known in the art. Particularly preferred foams are those obtained by polymerizing a high internal phase water-in-oil emulsion, such as those described in U.S. Patent No. 5,387,207 and U.S. Patent No. 5,650,222. Other particularly preferred polymeric foams are described in more detail in co-pending **U.S. Patent Application Serial No.** _____, filed March _, 1998 by T. DesMarais et al. titled "HIGH SUCTION POLYMERIC FOAM MATERIALS" (P&G Case ____) and co-pending **U.S. Patent Application Serial No.** _____, filed March _, 1998 by T. DesMarais et al. titled "ABSORBENT MATERIALS FOR DISTRIBUTING AQUEOUS LIQUIDS" (P&G Case ____), the disclosure of each of which is incorporated by reference herein. (Specific preferred foams described in one or both of these copending applications are described in the Examples section below.) Polymeric foams useful herein are those which are relatively open-celled. This means many of the individual cells of the foam are in unobstructed communication with adjoining cells. The cells in such relatively open-celled foam structures have intercellular openings or "windows" that are large enough to permit ready liquid transfer from one cell to the other within the foam structure.

These relatively open-celled foam structures will generally have a reticulated character with the individual cells being defined by a plurality of mutually connected, three dimensionally branched webs. The strands of polymeric material making up these branched webs can be referred to as "struts." For purposes of the present invention, a most preferred foam material will have at least about 80% of the cells in the foam structure that are at least 1 μm in size in liquid communication with at least one adjacent cell.

In addition to being open-celled, these polymeric foams are sufficiently hydrophilic to permit the foam to absorb aqueous liquids. The internal surfaces of the foam structures are rendered hydrophilic by residual hydrophilizing surfactants left in the foam structure after polymerization, or by selected post-polymerization foam treatment procedures, as described hereafter.

The extent to which these polymeric foams are "hydrophilic" can be quantified by the "adhesion tension" value exhibited when in contact with an absorbable test liquid. The adhesion tension exhibited by these foams can be determined experimentally using a procedure where weight uptake of a test liquid, e.g., synthetic urine, is measured for a sample of known dimensions and capillary suction specific surface area. Such a procedure is described in greater detail in the Test Methods section of U.S. Patent 5,387,207, *infra*. Foams which are useful high surface area materials in the present invention are generally those which exhibit an adhesion tension value of from about 15 to about 65 dynes/cm, more preferably from about 20 to about 65 dynes/cm, as determined by capillary absorption of synthetic urine having a surface tension of 65 ± 5 dynes/cm.

The polymeric foams useful herein are preferably prepared in the form of collapsed (i.e., unexpanded), polymeric foams that, upon contact with aqueous liquids, absorb such liquids and expand when the amount absorbed lowers the combined capillary pressure plus confining pressure to below the expansion pressure (described below) of the foam. These collapsed polymeric foams are usually obtained by expressing the water phase from the polymerized HIPE foam through compressive forces, and/or thermal drying and/or vacuum dewatering. After compression, and/or thermal drying/vacuum dewatering, these polymeric foams are in a collapsed, or unexpanded state.

The cellular structure of a representative collapsed HIPE foam from which water has been expressed by compression is shown in the photomicrograph of Figs. 3 and 4 of U.S. Patent No. 5,650,222, discussed above. As shown in these figures, the cellular structure of the foam is distorted, especially when compared to the expanded HIPE foam structures shown in Figs. 1 and 2 of the '222 patent. As can also be seen in Figs. 3 and 4 of the '222 patent, the voids or pores (dark areas) in the collapsed foam structure have been flattened or elongated. (It is noted that the foams depicted in the '222 patent are in sheet form; as discussed below, while foams in sheet forms are useful herein, in a preferred embodiment, the foam will be in particulate form.) The cellular structure of another HIPE-derived foam (in its expanded state) useful herein is depicted in Figures 3 and 4 herein. The preparation of this particular foam and related foams are described herein in Examples 2 through 4, and these very high surface area foams are described in more detail in co-pending **U.S. Patent Application Serial No. ____, filed** March _, 1998 by T. A. DesMarais et al. titled "HIGH SUCTION POLYMERIC FOAM MATERIALS" (P&G Case _____) and co-pending **U.S. Patent Application Serial No.** ____, filed March _, 1998 by T. A. DesMarais et al. titled "ABSORBENT MATERIALS FOR DISTRIBUTING AQUEOUS LIQUIDS" (P&G Case _____), the disclosure of each of which is incorporated by reference herein.

Following compression and/or thermal drying/vacuum dewatering, the collapsed polymeric foam may reexpand when wetted with aqueous liquids. Surprisingly, these polymeric foams remain in this collapsed, or unexpanded, state for significant periods of time, e.g., up to at least about 1 year. The ability of these polymeric foams to remain in this collapsed/unexpanded state is believed to be due to capillary forces, and in particular the capillary pressures developed within the foam structure. As used herein, "capillary pressures" refers to the pressure differential across the liquid/air interface due to the curvature of meniscus within the narrow confines of the pores in the foam. [See Chatterjee, "Absorbency," Textile Science and Technology, Vol. 7, 1985, p. 36.]

After compression, and/or thermal drying/vacuum dewatering to a practicable extent, these polymeric foams have residual water that includes both the water of hydration associated with the hygroscopic, hydrated salt incorporated therein, as well as free water absorbed within the foam. This residual water (assisted by the hydrated salts) is believed to exert capillary pressures on the resulting collapsed foam structure. Collapsed polymeric foams of the present invention can have residual water contents of at least about 4%, typically from about 4 to about 40%, by weight of the foam when stored at ambient conditions of 72°F (22°C) and 50% relative humidity. Preferred collapsed polymeric foams have residual water contents of from about 5 to about 30% by weight of the foam.

A key parameter of these foams is their glass transition temperature. The Tg represents the midpoint of the transition between the glassy and rubbery states of the polymer. Foams that have a higher Tg than the temperature of use can be very strong but will also be rigid and potentially prone to fracture. Such foams also typically take a long time to recover to the expanded state when wetted with aqueous liquids colder than the Tg of the polymer after having been stored in the collapsed state for prolonged periods. The desired combination of mechanical properties, specifically strength and resilience, typically necessitates a fairly selective range of monomer types and levels to achieve these desired properties.

For foams useful in the present invention, the Tg should be as low as possible, so long as the foam has acceptable strength at in-use temperatures. Accordingly, monomers are selected as much as possible that provide corresponding homopolymers having lower Tg's. It has been found that the chain length of the alkyl group on the acrylate and methacrylate comonomers can be longer than would be predicted from the Tg of the homologous homopolymer series. Specifically, it has been found that the homologous series of alkyl acrylate or methacrylate homopolymers have a minimum Tg at a chain length of 8 carbon atoms. By contrast, the minimum Tg of the copolymers of the present invention occurs at a chain length of about 12 carbon atoms. (While the alkyl substituted styrene monomers can be used in place of the alkyl acrylates and methacrylates, their availability is currently extremely limited).

The shape of the glass transition region of the polymer can also be important, i.e., whether it is narrow or broad as a function of temperature.

This glass transition region shape is particularly relevant where the in-use temperature (usually ambient or body temperature) of the polymer is at or near the Tg. For example, a broader transition region can mean an incomplete transition at in-use temperatures. Typically, if the transition is incomplete at the in-use temperature, the polymer will evidence greater rigidity and will be less resilient. Conversely, if the transition is completed at the in-use temperature, then the polymer will exhibit faster recovery from compression when wetted with aqueous liquids. Accordingly, it is desirable to control the Tg and the breadth of the transition region of the polymer to achieve the desired mechanical properties. Generally, it is preferred that the Tg of the polymer be at least about 10°C lower than the in-use temperature. (The Tg and the width of the transition region are derived from the loss tangent vs. temperature curve from a dynamic mechanical analysis (DMA) measurement, as described in the Test Methods section of U.S. Patent No. 5,650,222).

While the high surface area materials in general have been described in terms of their capillary sorption absorbent capacity, the high surface area polymeric foams useful herein may also be described in terms of their capillary suction specific surface area (hereafter referred to as "CSSSA"). In general, CSSSA is a measure of the test-liquid-accessible surface area of the polymeric network forming a particular foam per unit mass of the bulk foam material (polymer structural material plus solid residual material). Capillary suction specific surface area is determined both by the dimensions of the cellular units in the foam and by the density of the polymer, and is thus a way of quantifying the total amount of solid surface provided by the foam network to the extent that such a surface participates in absorbency. For purposes of characterizing the foams useful herein, CSSSA is measured on a sheet of the foam in question, even where the foam is in particle form when incorporated in a storage absorbent member.

The CSSSA of a foam is particularly relevant to whether the foam will provide the requisite capillary suction for use in preparing storage absorbent members of the present invention. This is because the capillary pressure developed within the foam structure is proportional to the capillary suction specific surface area. In addition, the CSSSA is relevant to whether adequate capillary pressures are developed within the foam structure to keep it in a collapsed state until wetted with aqueous liquids. Assuming other factors such as the foam density and adhesion tension are constant, this means that, as the CSSSA is increased (or decreased), the capillary pressure within the foam structure also increases (or decreases) proportionately.

For purposes of the present invention, CSSSA is determined by measuring the amount of capillary uptake of a low surface tension liquid (e.g., ethanol) which occurs within a foam sample of a known mass and dimensions. A detailed description of such a procedure for determining foam specific surface area is set forth in the Test Methods section of U.S. Patent 5,387,207, which is incorporated by reference. Any reasonable alternative method for determining CSSSA can also be utilized.

The collapsed polymeric foams of the present invention useful as absorbents are those that have a CSSSA of at least about 3 m^2/g. Typically, the CSSSA is in the range from about 3 to about 30 m^2/g, preferably from about 4 to about 17 m^2/g, most preferably from about 5 to about 15 m^2/g. Foams having such CSSSA values (with expanded state densities of from about 0.010 to about 0.033 g/cm^3) will generally possess an especially desirable balance of absorbent capacity, liquid-retaining and liquid-wicking or distribution characteristics for aqueous liquids such as urine. In addition, foams having such CSSSA can develop a sufficient capillary pressure to keep the foam in a collapsed, unexpanded state until wetted with such aqueous liquids.

As discussed above, for particularly preferred collapsable polymeric foams, in their collapsed state the capillary pressures developed within the foam structure at least equal the forces exerted by the elastic recovery or modulus of the compressed polymer. In other words, the capillary pressure necessary to keep the collapsed foam relatively thin is determined by the countervailing force exerted by the compressed polymeric foam as it tries to "spring back." The elastic recovery tendency of polymeric foams can be estimated from stress-strain experiments where the expanded foam is compressed to about 1/6 (17%) of its original, expanded thickness and then held in this compressed state until a relaxed stress value is measured. Alternatively, and for the purposes of the present invention, the relaxed stress value is estimated from measurements on the polymeric foam in its collapsed state when in contact with aqueous liquids, e.g., water. This alternative relaxed stress value is hereafter referred to as the "expansion pressure" of the foam. The expansion pressure for collapsed polymeric foams of the present invention is about 50 kiloPascals (kPa) or less and typically from about 7 to about 40 kPa. A detailed description of a procedure for estimating the expansion pressure of foams is set forth in the Test Methods section of U.S. Patent 5,387,207.

Another important property of the high surface area polymeric foams useful in the present invention is their free absorbent capacity. "Free absorbent capacity" (or “FAC”) is the total amount of test liquid (synthetic urine) which a given foam sample will absorb into its cellular structure per unit mass of solid material in the sample. To be especially useful in the storage absorbent members of the present invention, the polymeric foams should have a free absorbent capacity of from about 30 to about 100 ml, preferably from about 30 to about 75 ml of synthetic urine per gram of dry foam material. The procedure for determining the free absorbent capacity of the foam is described hereafter in the Test Methods section of U.S. Patent No. 5,650,222.

Upon exposure to aqueous liquids, preferred collapsed polymeric foams absorb the liquids and expand. The polymeric foams, in their expanded state, absorb more liquid than most other foams. The "expansion factor" for these foams is at least about 4X, i.e. the thickness of the foam in its expanded state is at least about 4 times the thickness of the foam in its collapsed state. The collapsed foams preferably have an expansion factor in the range of from about 4X to about 15X, more preferably from about 5X to about 10X.

For the purposes of the present invention, the relationship between expanded and collapsed thickness for compressively dewatered foams can be empirically predicted from the following equation:

$$\text{thickness}_{\text{expanded}} = \text{thickness}_{\text{collapsed}} \times ((0.133 \times \text{W:O ratio}) \pm 2)$$

where: $\text{thickness}_{\text{expanded}}$ is the thickness of the foam in its expanded state;

$\text{thickness}_{\text{collapsed}}$ is the thickness of the foam in its collapsed state;

and W:O ratio is the water-to-oil ratio of the HIPE from which the foam is made. Thus, a typical polymeric foam made from an emulsion with a water-to-oil ratio of 60:1 would have a predicted expansion factor of 8.0, i.e., an expanded thickness 8 times the collapsed thickness of the foam. The procedure for measuring the expansion factor is described hereafter in the Test Methods section of U.S. Patent 5,650,222.

A relevant mechanical feature of the high surface area polymeric foams useful in the present invention is their strength in their expanded state, as determined by resistance to compression deflection (RTCD). The RTCD exhibited by the foams herein is a function of the polymer modulus, as well as the density and structure of the foam network. The polymer modulus is, in turn, determined by: a) the polymer composition; b) the conditions under which the foam is polymerized (for example, the completeness of polymerization obtained, specifically with respect to crosslinking); and c) the extent to which the polymer is plasticized by residual material, e.g., emulsifiers, left in the foam structure after processing.

To be useful as the high surface area portion of the absorbent members of the present invention, the polymeric foams should be suitably resistant to deformation or compression by forces encountered in use. Foams which do not possess sufficient foam strength in terms of RTCD may provide the requisite capillary suction capacity under no-load conditions but will not provide those capacities under the compressive stress caused by the motion and activity of the user of the absorbent articles that contain the foam.

The RTCD exhibited by the polymeric foams useful in the present invention can be quantified by determining the amount of strain produced in a sample of saturated foam held under a certain confining pressure for a specified temperature and period of time. The method for carrying out this particular type of test is described hereafter in the Test Methods section of U.S. Patent No. 5,650,222. Foams useful herein will preferably exhibit a RTCD such that a confining pressure of 5.1 kPa produces a strain of typically about 90% or less compression of the foam structure when it has been saturated to its free absorbent capacity with synthetic urine having a surface tension of 65±5 dynes/cm. Preferably the strain produced under such conditions will be in the range from about 1 to about 90%, more preferably from about 1 to about 25%, still more preferably from about 2 to about 10%, still more preferably from about 2 to about 5%.

The high surface area polymeric foams useful herein can be also be described in terms of their vertical hang sorption height (hereafter "VHSH"). The VHSH height at X % is the height in cm where X % of the 0 cm capacity (or FAC) is retained in the foam. A typical value of importance is the VHSH at 90%, though in principle X may be any value. The most reproducible measure for VHSH is achieved at X = 90%, within the experience of the inventors. It will be obvious to one skilled in the art that this single point value does not fully express the shape of the curve obtained in a plot of capacity vs. height. The single point however serves as a practical point of comparison for the foams useful herein. In this regard, the foams will typically have an equilibrium 90% VHSH of at least about 20 cm, preferably at least about 40 cm, still more preferably at least about 60 cm, still more preferably at least about 70 cm and still more preferably at least about 80 cm. Typically, preferred polymeric foams will have a 90% VHSH of from about 20 to about 90 cm, more typically from about 60 to about 90 cm, more typically from about 70 to about 90 cm, still more typically from, about 80 to about 90 cm. The method for measuring 90% VHSH is described in detail in the Test Methods section below. As indicated, where the high surface area polymeric foam is in particulate form when combined with the other absorbent, such as an osmotic absorbent, 90% VHSH is measured on the corresponding foam in sheet form (i.e., prior to forming particulates). Where the foam is formed into particles (or beads) during the polymerization process, a similar foam can be formed into sheets for assessing the foam's 90% VHSH.

Foam cells, and especially cells that are formed by polymerizing a monomer-containing oil phase that surrounds relatively monomer-free water-phase droplets, will frequently be substantially spherical in shape. The size or "diameter" of such spherical cells is a commonly used parameter for characterizing foams in general. Since cells in a given sample of polymeric foam will not necessarily be of approximately the same size, an average cell size, i.e., average cell diameter, will often be specified.

A number of techniques are available for determining the average cell size of foams. The most useful technique, however, for determining cell size in foams involves a simple measurement based on the scanning electron photomicrograph of a foam sample.

The cell size measurements given herein are based on the number average cell size of the foam in its expanded state, e.g., as shown in Fig. 1 of U.S. Patent No. 5,650,222. The foams useful in accordance with the present invention will preferably have a number average cell size of about 80 μm or less, and typically from about 5 to about 50 μm.

"Foam density" (i.e., in grams of foam per cubic centimeter of foam volume in air) is specified herein on a dry basis. The amount of absorbed water-soluble residual materials, e.g., residual salts and liquid left in the foam, for example, after HIPE polymerization, washing and/or hydrophilization, is disregarded in calculating and expressing foam density. Foam density does include, however, other water-insoluble residual materials such as emulsifiers present in the polymerized foam. Such residual materials can, in fact, contribute significant mass to the foam material.

Any suitable gravimetric procedure that will provide a determination of mass of solid foam material per unit volume of foam structure can be used to measure foam density. For example, an ASTM gravimetric procedure described more fully in the Test Methods section of U.S. Patent No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995, supra, is one method that can be employed for density determination. In their collapsed state, polymeric foams useful in the present invention have dry basis density values (exclusive of any residual salts and or water) in the range of from about 0.1

to about 0.2 g/cm^3, preferably from about 0.11 to about 0.19 g/cm^3, and most preferably from about 0.12 to about 0.17 g/cm^3. In their expanded state, polymeric foams useful herein will have dry basis density values in the range of from about 0.01 to about 0.033 g/cm^3, preferably from about 0.013 to about 0.033 g/cm^3.

Vertical wicking, i.e., liquid wicking in a direction opposite from gravitational force, is a desirable performance attribute for polymeric foams useful herein. For the purposes of this invention, vertical wicking rate is reflective of the permeability of the material, and thus, the ability of the material to deliver liquid to the other absorbent, such as a hydrogel-forming absorbent polymer or other osmotic absorbent.

Vertical wicking rate is determined by measuring the time taken for a colored test liquid (e.g., synthetic urine) in a reservoir to wick a vertical distance of 5 cm through a test strip of foam of specified size. The vertical wicking procedure is described in greater detail in the Test Methods section of U.S. Patent No. 5,387,207, but is performed at 31°C, instead of 37°C. To be especially useful in absorbent members for absorbing urine, the foams useful herein will preferably wick synthetic urine (65 + 5 dynes/cm) to a height of 5 cm in no more than about 15 minutes. More preferably, the preferred foam absorbents of the present invention wick synthetic urine to a height of 5 cm in no more than about 10 minutes.

The vertical wicking absorbent capacity test measures the amount of test liquid per gram of absorbent foam that is held within each one in. (2.54 cm) vertical section of the same standard size foam sample used in the vertical wicking test. Such a determination is generally made after the sample has been allowed to vertically wick test liquid to equilibrium (e.g., after about 18 hours). Like the vertical wicking test, the vertical wicking absorbent capacity test is described in greater detail in the Test Methods section of U.S. Patent No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995, supra. High vertical wicking absorbent capacities at high heights are theoretically equivalent to high capillary sorption absorbent capacities at high heights. Since the sheet form of the foams useful herein is amenable to the former test and the former test is more easily and cheaply performed, the data from the former test are recommended as the means of characterizing this important parameter of the foams of this invention.

While high capillary suction foams may be in sheet form when combined with other absorbent such as osmotic absorbent (e.g., hydrogel-forming absorbent polymer), in a particularly preferred embodiment, the polymeric foam will be in particle form and will be mixed with particles of hydrogel-forming polymer to provide a blend. That is, while the foam may initially be prepared in sheet form, these sheets may be processed to provide particles of foam which are then combined with the hydrogelling polymer. As discussed above, the foams useful herein, and processes for their preparation, are described in great detail in U.S. Patent No. 5,387,207, U.S. Patent No. 5,650,222, co-pending **U.S. Patent Application Serial No.** ___, filed March _, 1998 by T. A. DesMarais et al. titled "HIGH SUCTION POLYMERIC FOAM MATERIALS" (P&G Case _) and co-pending **U.S. Patent Application Serial No.** _____, filed March _, 1998 by T. A. DesMarais et al. titled "ABSORBENT MATERIALS FOR DISTRIBUTING AQUEOUS LIQUIDS"(P&G Case __). Foam particles may be prepared by first forming a sheet of foam per the teachings of these references, followed by mechanical processing the foam to provide particles (e.g., pulverizing, cutting, chopping, etc.) of the desired dimension. Alternatively, foam particles may be prepared directly from emulsion in the form of polymeric microbeads, as described in U.S. Patent 5,653,922, issued Aug. 5, 1997 to Li et al., and U.S. Patent 5,583,162, issued Dec. 10, 1996 to Li et al., the disclosure of each of which is incorporated by reference herein. Specific embodiments for making polymer foam/hydrogel-forming polymer blends are discussed in more detail below.

Applicants have also found that the high surface area foams may optionally comprise a fluid so as to provide increased transfer of urine to the other absorbent or osmotic absorbent of the storage absorbent member. The pre-wetting fluid partially fills the polymeric foam and, without wishing to be held to a particular theory, increases the uptake rate of the foam. Ideally, polymeric foam comprising pre-wetting fluid(s) should be shelf stable, with sufficiently low water activity to prevent microbial growth and prevent evaporative water loss and not migrate out of the foam over time.

Water can be used as a pre-wetting fluid to provide the absorption performance but may not by itself meet the other requirements.

Hydrogel-Forming Absorbent Polymers

The storage absorbent members of the present invention further preferably comprise at least one hydrogel-forming absorbent polymer (also referred to as hydrogel-forming polymer). Hydrogel-forming polymers useful in the present invention include a variety of water-insoluble, but water-swellable polymers capable of absorbing large quantities of liquids. Such hydrogel-forming polymers are well known in the art and any of these materials are useful in the high capillary suction absorbent members of the present invention.

Hydrogel-forming absorbent polymers materials are also commonly referred to as "hydrocolloids," or "superabsorbent" materials and can include polysaccharides such as carboxymethyl starch, carboxymethyl cellulose, and hydroxypropyl cellulose; nonionic types such as polyvinyl alcohol, and polyvinyl ethers; cationic types such as polyvinyl pyridine, polyvinyl morpholinione, and N,N-dimethylaminoethyl or N,N-diethylaminopropyl acrylates and methacrylates, and the respective quaternary salts thereof. Typically, hydrogel-forming absorbent polymers useful in the present invention have a multiplicity of anionic, functional groups, such as sulfonic acid, and more typically carboxy, groups. Examples of polymers suitable for use herein include those which are prepared from polymerizable, unsaturated, acid-containing monomers. Thus, such monomers include the olefinically unsaturated acids and anhydrides that contain at least one carbon to carbon olefinic double bond. More specifically, these monomers can be selected from olefinically unsaturated carboxylic acids and acid anhydrides, olefinically unsaturated sulfonic acids, and mixtures thereof. As indicated above, the nature of the hydrogel-forming absorbent polymer is not critical to the members of the present invention. Nonetheless, the selection of the optimal polymeric material may enhance the performance characteristics of the present members. The disclosure that follows describes preferred properties of the absorbent polymers useful herein. These properties should not be interpreted as limitations; rather, they merely indicate the progression that has occurred in the absorbent polymer art over the past several years.

Some non-acid monomers can also be included, usually in minor amounts, in preparing the hydrogel-forming absorbent polymers herein. Such non-acid monomers can include, for example, the water-soluble or water-dispersible esters of the acid-containing monomers, as well as monomers that contain no carboxylic or sulfonic acid groups at all. Optional non-acid monomers can thus include monomers containing the following types of functional groups: carboxylic acid or sulfonic acid esters, hydroxyl groups, amide-groups, amino groups, nitrile groups, quaternary ammonium salt groups, aryl groups (e.g., phenyl groups, such as those derived from styrene monomer). These non-acid monomers are well-known materials and are described in greater detail, for example, in U.S. Patent 4,076,663 (Masuda et al.), issued February 28, 1978, and in U.S. Patent 4,062,817 (Westerman), issued December 13, 1977, both of which are incorporated by reference.

Olefinically unsaturated carboxylic acid and carboxylic acid anhydride monomers include the acrylic acids typified by acrylic acid itself, methacrylic acid, ethacrylic acid, α-chloroacrylic acid, a-cyanoacrylic acid, β-methylacrylic acid (crotonic acid), α-phenylacrylic acid, β-acryloxypropionic acid, sorbic acid, α-chlorosorbic acid, angelic acid, cinnamic acid, p-chlorocinnamic acid, β-sterylacrylic acid, itaconic acid, citroconic acid, mesaconic acid, glutaconic acid, aconitic acid, maleic acid, fumaric acid, tricarboxyethylene and maleic acid anhydride.

Olefinically unsaturated sulfonic acid monomers include aliphatic or aromatic vinyl sulfonic acids such as vinylsulfonic acid, allyl sulfonic acid, vinyl toluene sulfonic acid and styrene sulfonic acid; acrylic and methacrylic sulfonic acid such as sulfoethyl acrylate, sulfoethyl methacrylate, sulfopropyl acrylate, sulfopropyl methacrylate, 2-hydroxy-3-methacryloxypropyl sulfonic acid and 2-acrylamide-2-methylpropane sulfonic acid.

Preferred hydrogel-forming absorbent polymers for use in the present invention contain carboxy groups. These polymers include hydrolyzed starch-acrylonitrile graft copolymers, partially neutralized hydrolyzed starch-acrylonitrile graft copolymers, starch-acrylic acid graft copolymers, partially neutralized starch-acrylic acid graft copolymers, saponified vinyl acetate-acrylic ester copolymers, hydrolyzed acrylonitrile or acrylamide copolymers, slightly network crosslinked polymers of any of the foregoing copolymers, partially neutralized polyacrylic acid, and slightly network crosslinked polymers of partially neutralized polyacrylic acid. These polymers can be used either solely or in the form of a mixture of two or more different polymers. Examples of these polymer materials are disclosed in U.S. Patent 3,661,875, U.S. Patent 4,076,663, U.S. Patent 4,093,776, U.S. Patent 4,666,983, and U.S. Patent 4,734,478.

Most preferred polymer materials for use in making the hydrogel-forming absorbent polymers are slightly network crosslinked polymers of partially neutralized polyacrylic acids and starch derivatives thereof. Most preferably, the hydrogel-forming absorbent polymers comprise from about 50 to about 95%, preferably about 75%, neutralized, slightly network crosslinked, polyacrylic acid (i.e., poly (sodium acrylate/acrylic acid)). Network crosslinking renders the polymer substantially water-insoluble and, in part, determines the absorptive capacity and extractable polymer content characteristics of the hydrogel-forming absorbent polymers. Processes for network crosslinking these polymers and typical network crosslinking agents are described in greater detail in U.S. Patent 4,076,663.

While the hydrogel-forming absorbent polymer is preferably of one type (i.e., homogeneous), mixtures of polymers can also be used in the present invention. For example, mixtures of starch-acrylic acid graft copolymers and slightly network crosslinked polymers of partially neutralized polyacrylic acid can be used in the present invention.

The hydrogel-forming polymer component may also be in the form of a mixed-bed ion-exchange composition comprising a cation-exchange hydrogel-forming absorbent polymer and an anion-exchange hydrogel-forming absorbent polymer. Such mixed-bed ion-exchange compositions are described in, e.g., **U.S. Patent Application Serial No. _____, filed**

January 7, 1998 by Hird, et al. (P&G Case 6975 - titled "ABSORBENT POLYMER COMPOSITIONS HAVING HIGH SORPTION CAPACITIES UNDER AN APPLIED PRESSURE"); **U.S. Patent Application Serial No. _____, filed January 7, 1998 by Ashraf, et al.** (P&G Caes 6976 - titled "ABSORBENT POLYMER COMPOSITIONS WITH HIGH SORPTION CAPACITY AND HIGH FLUID PERMEABILITY UNDER AN APPLIED PRESSURE"); **and U.S. Patent Application Serial No. _____, filed January 7, 1998 by Ashraf, et al.** (P&G Case 6977 - titled "ABSORBENT POLYMER COMPOSITIONS HAVING HIGH SORPTION CAPACITIES UNDER AN APPLIED PRESSURE AND IMPROVED INTEGRITY IN THE SWOLLEN STATE"); the disclosure of each of which is incorporated herein by reference.

The hydrogel-forming absorbent polymers useful in the present invention can have a size, shape and/or morphology varying over a wide range. These polymers can be in the form of particles that do not have a large ratio of greatest dimension to smallest dimension (e.g., granules, pulverulents, interparticle aggregates, interparticle crosslinked aggregates, and the like) and can be in the form of fibers, sheets, films, foams, flakes and the like. The hydrogel-forming absorbent polymers can also comprise mixtures with low levels of one or more additives, such as for example powdered silica, surfactants, glue, binders, and the like. The components in this mixture can be physically and/or chemically associated in a form such that the hydrogel-forming polymer component and the non-hydrogel-forming polymer additive are not readily physically separable.

The hydrogel-forming absorbent polymers can be essentially non-porous (i.e., no internal porosity) or have substantial internal porosity.

For particles as described above, particle size is defined as the dimension determined by sieve size analysis. Thus, for example, a particle that is retained on a U.S.A. Standard Testing Sieve with 710 micron openings (e.g., No. 25 U.S. Series Alternate Sieve Designation) is considered to have a size greater than 710 microns; a particle that passes through a sieve with 710 micron openings and is retained on a sieve with 500 micron openings (e.g., No. 35 U.S, Series Alternate Sieve Designation) is considered to have a particle size between 500 and 710 μm; and a particle that passes through a sieve with 500 micron openings is considered to have a size less than 500 μm. The mass median particle size of a given sample of hydrogel-forming absorbent polymer particles is defined as the particle size that divides the sample in half on a mass basis, i.e., one-half of the sample by weight will have a particle size less than the mass median size and one-half of the sample will have a particle size greater than the mass median size. A standard particle-size plotting method (wherein the cumulative weight percent of the particle sample retained on or passed through a given sieve size opening is plotted versus sieve size opening on probability paper) is typically used to determine mass median particle size when the 50% mass value does not correspond to the size opening of a U.S.A. Standard Testing Sieve. These methods for determining particle sizes of the hydrogel-forming absorbent polymer particles are further described in U.S. Patent 5,061,259 (Goldman et al.), issued October 29, 1991, which is incorporated by reference.

For particles of hydrogel-forming absorbent polymers useful in the present invention, the particles will generally range in size from about 1 to about 2000 μm, more preferably from about 20 to about 1000 μm. The mass median particle size will generally be from about 20 to about 1500 μm, more preferably from about 50 μm to about 1000 μm, and even more preferably from about 100 to about 800 μm.

Where relatively high concentrations (e.g. 40%, 60%, or greater, by weight) of hydrogel forming absorbent polymer are utilized in the absorbent members of the present invention, still other properties of the absorbent polymer may be relevant. In such embodiments, the materials may have one or more of the properties described by U.S. Patent No. 5,562,646, issued Oct. 8, 1996 to Goldman et al. and U.S. Patent No. 5,599,335, issued Feb. 4, 1997 to Goldman et al., the disclosure of each of which is incorporated by reference herein.

The basic hydrogel-forming absorbent polymer can be formed in any conventional manner. Typical and preferred processes for producing these polymers are described in U.S. Reissue Patent 32,649 (Brandt et al.), issued April 19, 1988, U.S. Patent 4,666,983 (Tsubakimoto et al.), issued

May 19, 1987, and U.S. Patent 4,625,001 (Tsubakimoto et al.), issued November 25, 1986, all of which are incorporated by reference.

Preferred methods for forming the basic hydrogel-forming absorbent polymer are those involving aqueous solution or other solution polymerization methods. As described in the above-referenced U.S. Patent Reissue 32,649, aqueous solution polymerization involves the use of an aqueous reaction mixture to carry out polymerization. The aqueous reaction mixture is then subjected to polymerization conditions which are sufficient to produce in the mixture, substantially water-insoluble, slightly network crosslinked polymer. The mass of polymer formed can then be pulverized or chopped to form individual particles.

More specifically, the aqueous solution polymerization method for producing the hydrogel-forming absorbent polymer comprises the preparation of an aqueous reaction mixture in which to carry out the polymerization. One element of such a reaction mixture is the acid group-containing monomer that will form the "backbone" of the hydrogel-forming absorbent polymer to be produced. The reaction mixture will generally comprise about 100 parts by weight of the monomer. Another component of the aqueous reaction mixture comprises a network crosslinking agent. Network crosslinking agents useful in forming the hydrogel-forming absorbent polymer according to the present invention are described in more detail in the above-referenced U.S. Reissue Patent 32,649, U.S. Patent 4,666,983, and U.S. Patent 4,625,001. The network crosslinking agent will generally be present in the aqueous reaction mixture in an amount of from about 0.001 mole percent to about 5 mole percent based on the total moles of monomer present in the aqueous mixture (about 0.01 to about 20 parts by weight, based on 100 parts by weight of the monomer). An optional component of the aqueous reaction mixture comprises a free radical initiator including, for example, peroxygen compounds such as sodium, potassium, and ammonium persulfates, caprylyl peroxide, benzoyl peroxide, hydrogen peroxide, cumene hydroperoxides, tertiary butyl diperphthalate, tertiary butyl perbenzoate, sodium peracetate, sodium percarbonate, and the like. Other optional components of the aqueous reaction mixture comprise the various non-acidic co-monomers, including esters of the essential unsaturated acidic functional group-containing monomers or other co-monomers containing no carboxylic or sulfonic acid functionalities at all.

The aqueous reaction mixture is subjected to polymerization conditions which are sufficient to produce in the mixture substantially water-insoluble, but water-swellable, hydrogel-forming absorbent slightly network crosslinked polymers. The polymerization conditions are also discussed in more detail in the three above-referenced patents. Such polymerization conditions generally involve heating (thermal activation techniques) to a polymerization temperature from about 0° to about 100°C, more preferably from about 5° to about 40°C. Polymerization conditions under which the aqueous reaction mixture is maintained can also include, for example, subjecting the reaction mixture, or portions thereof, to any conventional form of polymerization activating irradiation. Radioactive, electronic, ultraviolet, or electromagnetic radiation are alternative conventional polymerization techniques.

The acid functional groups of the hydrogel-forming absorbent polymer formed in the aqueous reaction mixture are also preferably neutralized. Neutralization can be carried out in any conventional manner that results in at least about 25 mole percent, and more preferably at least about 50 mole percent, of the total monomer utilized to form the polymer being acid group-containing monomers that are neutralized with a salt-forming cation. Such salt-forming cations include, for example, alkali metals, ammonium, substituted ammonium and amines as discussed in further detail in the above-references U.S. Reissue Patent 32,649.

While it is preferred that the particulate versions of hydrogel-forming absorbent polymer be manufactured using an aqueous solution polymerization process, it is also possible to carry out the polymerization process using multi-phase polymerization processing techniques such as inverse emulsion polymerization or inverse suspension polymerization procedures. In the inverse emulsion polymerization or inverse suspension polymerization procedures, the aqueous reaction mixture as described before is suspended in the form of tiny droplets in a matrix of a water-immiscible, inert organic solvent such as cyclohexane. The resultant particles of hydrogel-forming absorbent polymer are generally spherical in shape. Inverse suspension polymerization procedures are described in greater detail in U.S. Patent 4,340,706 (Obaysashi et al.), issued July 20, 1982, U.S. Patent 4,506,052 (Flesher et al.), issued March 19, 1985, and U.S. Patent 4,735,987 (Morita et al.), issued April 5, 1988, all of which are incorporated by reference.

Surface crosslinking of the initially formed polymers is a preferred process for obtaining hydrogel-forming absorbent polymers having relatively high porosity hydrogel-layer ("PHL"), performance under pressure ("PUP") capacity and saline flow conductivity ("SFC") values, which may be beneficial in the context of the present invention. Suitable general methods for carrying out surface crosslinking of hydrogel-forming absorbent polymers according to the present invention are disclosed in U.S. Patent 4,541,871 (Obayashi), issued September 17, 1985; published PCT application WO92/16565 (Stanley), published October 1, 1992, published PCT application WO90/08789 (Tai), published August 9, 1990; published PCT application WO93/05080 (Stanley), published March 18, 1993; U.S. Patent 4,824,901 (Alexander), issued April 25, 1989; U.S. Patent 4,789,861 (Johnson), issued January 17, 1989; U.S. Patent 4,587,308 (Makita), issued May 6, 1986; U.S. Patent 4,734,478 (Tsubakimoto), issued March 29, 1988; U.S. Patent 5,164,459 (Kimura et al.), issued November 17, 1992; published German patent application 4,020,780 (Dahmen), published August 29, 1991; and published European patent application 509,708 (Gartner), published October 21, 1992; all of which are incorporated by reference. See also, U.S. Patent 5.562.646 (Goldman et al.), issued October 8, 1996, and U.S. Patent 5.599.335 (Goldman et al.), issued February 4, 1997.

The hydrogel-forming absorbent polymer particles prepared according to the present invention are typically substantially dry. The term "substantially dry" is used herein to mean that the particles have a liquid content, typically water or other solution content, less than about 50%, preferably less than about 20%, more preferably less than about 10%, by weight of the particles. In general, the liquid content of the hydrogel-forming absorbent polymer particles is in the range of from about 0.01% to about 5% by weight of the particles. The individual particles can be dried by any conventional method such as by heating. Alternatively, when the particles are formed using an aqueous reaction mixture, water can be removed from the reaction mixture by azeotropic distillation. The polymer-containing aqueous reaction mixture can also be treated with a dewatering solvent such as methanol. Combinations of these drying procedures can also be used. The dewatered mass of polymer can then be chopped or pulverized to form substantially dry particles of the hydrogel-forming absorbent polymer.

Combination of high capillary suction materials

Whilst materials as described in the above can satisfy the requirements as such (e.g. a pure hydrogel forming material, or a pure foam material), preferred members for being used as storage absorbent member comprise two or more of the materials. This allows often to utilize materials which on their own do not satisfy the criteria, but the combination does.

The principle function of such fluid storage members is to absorb the discharged body fluid either directly or from other absorbent members (e.g., fluid acquisition/distribution members), and then retain such fluid, even when subjected to pressures normally encountered as a result of the wearer's movements.

Thus, high capillary suction absorbent members can be made by combination of hydrogel forming materials with high surface area materials.

The amount of hydrogel-forming absorbent polymer contained in the absorbent member may vary significantly. Furthermore, the concentration of hydrogel may vary throughout a given member. In other words, a member may have regions of relatively higher and relatively lower hydrogel concentration.

In measuring the concentration of hydrogel-forming absorbent polymer in a given region of an absorbent member, the percent by weight of the hydrogel-forming polymer relative to the combined weight of hydrogel-forming polymer and any other components (e.g., fibers, polymeric foams, etc.) that are present in the region containing the hydrogelling polymer is used. With this in mind, the concentration of the hydrogel-forming absorbent polymers in a given region of an absorbent member of the present invention can be at least about 50%, at least about 60%, at least about 70%, or at least about 80%, by total weight of the absorbent member.

Notwithstanding the fact that regions of an absorbent member may comprise relatively high concentrations of hydrogel-forming absorbent polymer, where the high surface area material is fibrous in nature, the aggregate concentration of absorbent polymer in a given absorbent member (i.e., total weight of the hydrogel-forming absorbent polymer divided by the total weight of the absorbent member X 100%) will be up to about 75% by weight, preferably up to about 70% by weight, more preferably up to about 65% by weight. Then, with these high surface area fiber-containing members, the concentration of the hydrogel-forming absorbent polymer will be from about 10 to about 75 % by weight, more typically from about 15 to about 70% by weight, still more typically from about 20 to about 65% by weight.

In those embodiments where the high surface area material is a polymeric foam, the absorbent members will preferably comprise at least about 1% by weight (on an aggregate basis), more preferably at least about 10% by weight, more preferably at least about 15% by weight, still more preferably at least about 20% by weight, polymeric foam. Typically, such storage absorbent members will comprise from about 1 to about 98% by weight, more typically from about 10 to about 90% by weight, still more typically from about 15 to about 85% by weight, and still more typically from about 20 to about 80% by weight, of the polymeric foam material. As discussed above, these weight % ranges are based on the aggregate weights of the respective materials in an absorbent member; it is recognized that regions of the absorbent member may contain greater and lesser amounts of the materials.

Of course, the relative levels of the absorbent polymer and high surface area material will be dictated by, for example, the absorptive capacity of the hydrogel-forming absorbent polymer, the specific high surface area material used, the nature of the high surface area material (e.g., sheet or particle foam, particle size), etc. In this regard, although high levels of hydrogel-forming absorbent polymer provide absorbent members for making thin absorbent articles, to achieve the requisite level of capillary suction discussed above, there must be sufficient high surface area material to provide such suction capacity. Thus, where relatively higher capillary suction foam is used, higher levels of hydrogel-forming polymer may be employed. Conversely, where relatively lower capillary suction fibers are used, somewhat lower leves of hydrogel-forming polymer will be employed. (Of course, where both high surface area fibers and polymeric foams are employed, the level of total high surface area material may vary, again depending on the relative concentration of each of these materials.) It is the difference in capillary sorption capacity between the polymeric foams and high surface area fibers described above that accounts for the different ranges of hydrogel-forming polymer to be used in a given absorbent member.

As another example of a material that will provide integrity of the mixture, in absorbent members comprising a blend of hydrogel-forming polymer and high surface area fibers and/or particulate polymeric foam, the member can comprise a thermoplastic material. Upon melting, at least a portion of this thermoplastic material migrates to the intersections of the respective member components, typically due to interparticle or interfiber capillary gradients. These intersections become bond sites for the thermoplastic material. When cooled, the thermoplastic materials at these intersections solidify to form the bond sites that hold the matrix of materials together.

Optional thermoplastic materials useful herein can be in any of a variety of forms including particulates, fibers, or combinations of particulates and fibers. Thermoplastic fibers are a particularly preferred form because of their ability to form numerous bond sites. Suitable thermoplastic materials can be made from any thermoplastic polymer that can be melted at temperatures that will not extensively damage the materials that comprise absorbent member. Preferably, the melting point of this thermoplastic material will be less than about 190°C, and preferably between about 75°C and about 175°C. In any event, the melting point of this thermoplastic material should be no lower than the temperature at which the thermally bonded absorbent structures, when used in absorbent articles, are likely to be stored. The melting point of the thermoplastic material is typically no lower than about 50°C.

The thermoplastic materials, and in particular the thermoplastic fibers, can be made from a variety of thermoplastic polymers, including polyolefins such as polyethylene (e.g., PULPEX®) and polypropylene, polyesters, copolyesters, polyvinyl acetate, polyethylvinyl acetate, polyvinyl chloride, polyvinylidene chloride, polyacrylics, polyamides, copolyamides, polystyrenes, polyurethanes and copolymers of any of the foregoing such as vinyl chloride/vinyl acetate, and the like. One preferred thermoplastic binder fiber is PLEXAFIL® polyethylene microfibers (made by DuPont) that are also available as an about 20% blend with 80% cellulosic fibers sold under the tradename KITTYHAWK® (made by Weyerhaeuser Co.) Depending upon the desired characteristics for the resulting thermally bonded absorbent member, suitable thermoplastic materials include hydrophobic fibers that have been made hydrophilic, such as surfactant-treated or silica-treated thermoplastic fibers derived from, for example, polyolefins such as polyethylene or polypropylene, polyacrylics, polyamides, polystyrenes, polyurethanes and the like. The surface of the hydrophobic thermoplastic fiber can be rendered hydrophilic by treatment with a surfactant, such as a nonionic or anionic surfactant, e.g., by spraying the fiber with a surfactant, by dipping the fiber into a surfactant or by including the surfactant as part of the polymer melt in producing the thermoplastic fiber. Upon melting and resolidification, the surfactant will tend to remain at the surfaces of the thermoplastic fiber. Suitable surfactants include nonionic surfactants such as Brij® 76 manufactured by ICI Americas, Inc. of Wilmington, Delaware, and various surfactants sold under the Pegosperse® trademark by Glyco Chemical, Inc. of Greenwich, Connecticut. Besides nonionic surfactants, anionic surfactants can also be used. These surfactants can be applied to the thermoplastic fibers at levels of, for example, from about 0.2 to about 1 g. per sq. of centimeter of thermoplastic fiber.

Suitable thermoplastic fibers can be made from a single polymer (monocomponent fibers), or can be made from more than one polymer (e.g., bicomponent fibers). As used herein, "bicomponent fibers" refers to thermoplastic fibers that comprise a core fiber made from one polymer that is encased within a thermoplastic sheath made from a different polymer. The polymer comprising the sheath often melts at a different, typically lower, temperature than the polymer comprising the core. As a result, these bicomponent fibers provide thermal bonding due to melting of the sheath polymer, while retaining the desirable strength characteristics of the core polymer.

Suitable bicomponent fibers for use in the present invention can include sheath/core fibers having the following polymer combinations:

polyethylene/polypropylene, polyethylvinyl acetate/polypropylene, polyethylene/polyester, polypropylene/polyester, copolyester/polyester, and the like. Particularly suitable bicomponent thermoplastic fibers for use herein are those having a polypropylene or polyester core, and a lower melting copolyester, polyethylvinyl acetate or polyethylene sheath (e.g., DANAKLON®, CELBOND® or CHISSO® bicomponent fibers). These bicomponent fibers can be concentric or eccentric. As used herein, the terms "concentric" and "eccentric" refer to whether the sheath has a thickness that is even, or uneven, through the cross-sectional area of the bicomponent fiber. Eccentric bicomponent fibers can be desirable in providing more compressive strength at lower fiber thicknesses. Suitable bicomponent fibers for use herein can be either uncrimped (i.e. unbent) or crimped (i.e. bent). Bicomponent fibers can be crimped by typical textile means such as, for example, a stuffer box method or the gear crimp method to achieve a predominantly two-dimensional or "flat" crimp.

In the case of thermoplastic fibers, their length can vary depending upon the particular melt point and other properties desired for these fibers. Typically, these thermoplastic fibers have a length from about 0.3 to about 7.5 cm long, preferably from about 0.4 to about 3.0 cm long, and most preferably from about 0.6 to about 1.2 cm long. The properties, including melt point, of these thermoplastic fibers can also be adjusted by varying the diameter (caliper) of the fibers. The diameter of these thermoplastic fibers is typically defined in terms of either denier (grams per 9000 meters) or decitex (grams per 10,000 meters). Suitable bicomponent thermoplastic fibers can have a decitex in the range from about 1.0 to about 20, preferably from about 1.4 to about 10, and most preferably from about 1.7 to about 3.3.

The compressive modulus of these thermoplastic materials, and especially that of the thermoplastic fibers, can also be important. The compressive modulus of thermoplastic fibers is affected not only by their length and diameter, but also by the composition and properties of the polymer or polymers from which they are made, the shape and configuration of the fibers (e.g., concentric or eccentric, crimped or uncrimped), and like factors. Differences in the compressive modulus of these thermoplastic fibers can be used to alter the properties, and especially the density characteristics, of the respective absorbent members during preparation of the absorbent core.

Other fluid handling member components and materials

Storage absorbent members according to the present invention can include other optional components that can be present in absorbent webs. For example, a reinforcing scrim can be positioned within the storage absorbent member, or between the respective absorbent members of the absorbent core. Such reinforcing scrims should be of such configuration as to not form interfacial barriers to liquid transfer, especially if positioned between the respective absorbent members of the absorbent core. In addition, several binders may be used to provide dry and wet integrity to the absorbent core and/or the absorbent storage member itself. In particular, hydrophilic glue fibers may be used to provide bonds between the high surface area materials and the other absorbent such as osmotic absorbent material. This is in particular critical for particulate high surface area materials. It is preferred that the amount of binder used is as low as possible, so as not to impair the capillary sorption properties of the absorbent member. However, the skilled artisan will recognize that there are also binders that may enhance the capillary sorption properties of the absorbent member such as fiberized hydrophilic glue with sufficiently high surface area. In this case, the high surface area hydrophilic glue may provide both the liquid handling function and the integrity function, in one material. Also, the respective absorbent member, or the entire absorbent core, can be enveloped within a liquid pervious sheet, such as a tissue paper sheet, to obviate user concern regarding loose particulate absorbent polymer, as long as the capillary continuity is not disturbed.

Other optional components that can be included are materials to control odor, contain fecal matter, etc. Also, any absorbent member comprising particulate osmotic absorbent or high surface area material, or the entire absorbent core, can be enveloped within a liquid pervious sheet, such as a tissue paper sheet, to obviate user concern regarding loose particulate absorbent polymer.

When integrity is introduced via a binder material, suitable binders are melt-blown adhesives such as those described in U.S. Patent No. 5,560,878, issued Oct. 1, 1996 to Dragoo et al., the disclosure of which is incorporated herein by reference. Processes for combining melt-blown adhesives with the requisite hydrogel-forming polymer and high surface area material is also described in detail in the '878 patent.

Requirements for combining fluid distribution members and absorbent fluid storage members.

A key element of the present invention aims at the combination of suitable fluid acquisition/distribution members with suitable fluid storage materials so as to achieve the best fluid handling functionality with regard to properties like ultimate fluid storage without allowing rewetting, or enhanced fluid movement throughout the article so as to also enhance fluid pick up of the article.

Thus, the invention aims at defining the absorption properties of the storage absorbent member in combination with the desorption properties of the acquisition/ distribution member such that the acquisition / distribution members are still effectively and efficiently dewatered by the storage absorbent member, whereby the fluid acquisition/distribution materials still exhibit good fluid distribution properties and thus have comparatively high capillary pressures.

Thus in one aspect of the invention, the fluid distribution material has a

- large flux of at least 0.075 ml/sec/cm2, preferably more than 0.12 ml/sec/cm2 and even more preferably more than 0.25 ml/sec/cm2, and / or
- fast wicking of less than 120 seconds and more preferably less than 50 seconds to relatively large height of 12.4 cm,
  and at the same time
  and the fluid storage region has high suction liquid absorbency properties.

In one aspect, the dewatering mechanism can be expressed in terms of the Capillary Sorption Desorption Height (CSDH 90) of the acquisition / distribution material at 90% of the maximum amount of liquid (i.e. the amount of fluid at 0 cm desorption height) being released. Then, the absorbent article according to the present invention contains an absorbent structure comprising a first region primarily for acquisition / distribution of liquid and a second region primarily for liquid storage, which are in liquid communication with each other, wherein the first region comprises material having a Capillary Sorption Desorption Height CSDH 90 of more than 40 cm and the second region comprises material which has sufficient capillary absorbent suction to dewater such a material. This dewatering will be achieved to a sufficient degree, if the materials used in the storage regions satisfy at least one of following requirements:

(a) a Capillary Sorption Absorption Capacity at 35 cm (CSAC 35) of at least 15 g/g in the capsorption test; and/or
(b) a Capillary Sorption Absorption Capacity at 0 cm (CSAC 0) of at least 15 g/g in the capsorption test and an Capillary Sorption Absorption Efficiency at 40 cm (CSAE 40) of at least 55 %; and/or
(c) a Capillary Sorption Absorption Height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 35 cm in the capsorption test.

In a preferred embodiment, the second region comprises material having a CSAC at 40 cm (CSAC 40) of at least 20 g/g, or alternatively at least 15 g/g at the actual CSDH 90 of the first material.

In another preferred embodiment, the second region comprises material having a CSAC 0 of at least 20 g/g, preferably more than 25g/g, and even more preferably at least 35 g/g, when having a CSAE 40 of at least 50 %.

Alternatively, the second region can comprise material having CASC 0 of at least 15 g/g and a CSAE of at least 55 % at the actual CSDH 90 of the first material.

In a further, preferred embodiment, the second region comprises material having a CSAC 0 of at least 15 g/g and a CSAE 40 of at least 65 % .

In another preferred embodiment, the second region comprises material having a Capillary Sorption Absorption Height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 45 cm, preferably at least 60 cm, and even more preferably at least 80 cm.

If, as another alternative aspect, the first region comprises material having a reduced tendency to release the liquid, such as can be expressed by a Capillary Soprtion Desorption Height (CSDH 90) of more than 100 cm, then the liquid storage (or second) region comprises material which has an increased ability to still dewater the first region, and thus comprises material which satisfies at least one of following requirements:
(a) a CSAC 100 of at least 5 g/g;

(b) a CSAC 0 of at least 15 g/g and a CSAE 100 of at least 25 %;
(c) a CSAH 50 of at least 35 cm.

In a preferred embodiment of this aspect, the second region comprises material having an CSAC 0 of at least 20 g/g, preferably at least 25 g/g, and even more preferably at least 35 g/g, whereby the CSAE {60cm} is at least 50%.

In an alternative aspect of this embodiment, the second region comprises material having CSAC 0 of at least 15 g/g and a CSAE at the actual CSDH 90 of the first material of at least 50 %.

In a further aspect of the present invention, the second region comprises material having a CSAH 50 of at least 45 cm, preferably of at least 60 cm, and even more preferably of at least 80cm.

In yet another aspect of the invention, the absorbent structure comprises an acquisition / distribution region as a first region, comprising a material, for which the fluid handling properties can be expresses by a CSDH 80 of more than 35 cm. In order to be able to dewater a material of such properties, the second (liquid storage) region comprises material which can be described by satisfying at least one of following requirements:

(a) an absorption capacity of at least 15 g/g at 35 cm in the capsorption test; and/or
(b) an absorption capacity of at least 15 g/g at 0 cm in the capsorption test and an absorption efficiency of at least 50 % at 35 cm; and/or
(c) a Capillary Sorption Absorption height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 35 cm in the capsorption test.

In a preferred embodiment of this aspect, the second region comprises material having an absorption capacity of at least 18 g/g at 35 cm in the capsorption test, preferably of at least 21 g/g at 35 cm in the capsorption test, and even more preferably at least 30 g/g at 35 cm in the capsorption test.

In an alternative embodiment of this aspect, the second region comprises material having an absorption capacity of at least 15 g/g at the actual CSDH 80 of the first material.

In a preferred embodiment of this aspect, the second region comprises material having an absorption capacity of at least 20 g/g, preferably at least 25 g/g, even more preferably of at least 35 g/g at 0 cm in the capsorption test and an absorption efficiency of at least 50 % at 35 cm.

In an alternative to this embodiment, the second region comprises material having an absorption capacity of at least 15 g/g at 0 cm in the capsorption test and an absorption efficiency of at least 60 %, even more preferably of at least 85 % at 35 cm.

Alternatively, the second region comprises material having an absorption capacity of at least 15 g/g at 0 cm in the capsorption test and an absorption efficiency of at least 50 % at the actual CSDH 80 of the first material.

In yet another preferred embodiment, the second region comprises material having a Capillary Sorption Absorption height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 45 cm, even more preferably of at least 60, and most preferably of at least 80 cm in the capsorption test.

In yet another aspect of the present invention, the first region comprises material having a CSDH 80 of more than 60 cm and the second region comprises material which satisfies at least one of following requirements:

(a) a CSAC 60 of at least 11 g/g ;
(b) a CSAC 0 of at least 15 g/g and a CSAE 60 of at least 50%;
(c) a CSAH 50 of at least 35 cm.

In a preferred embodiment of this aspect, the second region comprises material having a CSAC at the actual CSDH 80 of the first material of at least 11 g/g.

In another embodiment of this aspect, the second region comprises material having CSAC 0 of at least 20 g/g, preferably more than at least 25 g/g, even more preferably more than at least 35 g/g and CSAE 60 of at least 50 %.

In an alternative embodiment of this aspect, the second region comprises material having CSAC 0 of at least 15 g/g and CSAE at the actual CSDH 80 of the first material of at least 50 %.

In a further embodiment of this aspect, the second region comprises material having a CSAH 50 of at least 45 cm, preferably more than 60 cm, even more preferably more than 80 cm.

In yet another aspect the present invention is concerned with an absorbent structure, wherein the first region comprises material having a CSDH 80 of more than 90 cm, and the second region comprises material which satisfies at least one of following requirements

(a) a CSAC 90 of at least 8.5 g/g;
(b) a CSAC 0 of at least 15 g/g and CSAE 90 of at least 20%;
(c) a CSAH 50 of at least 45 cm.

In a preferred embodiment of this aspect, the second region comprises material having a CSAC at the actual CSDH 80 of the first material of at least 8.5 g/g.

In a further preferred embodiment of this aspect, the second region comprises material having a CSAC 0 of at least 20 g/g, preferably more than 25g/g, even more preferably more than 35 g/g and a CSAE 60 of at least 50 %.

In an alternative embodiment of this aspect, the second region comprises material having a CSAC 0 of at least 15 g/g and a CSAE at the actual CSDH 80 of the first material of at least 20 %.

In an even further preferred embodiment of this aspect, the second region comprises material having a CSAH 50 of at least 45 cm, more preferably of at least 60 cm, even more preferably of at least 80 cm.

Resulting benefits of the absorbent article

When combining suitable materials or members, the absorbent core for being used in an absorbent article provides the following benefits:

One benefit is, that the acquisition/distribution members or materials are effectively dewatered, so as to contain smaller amounts of fluid which might rewet to the skin of the wearer, such as can be evaluated by well known rewet test methods, e.g. by the PACORM test as described in EP -A- 0.797.966.

Also, the better dewatering results in an improvement for liquid handling capability for repeated gushes, such as an improved liquid acquisition handling such as can be measured in well known acquisition test, e.g. as described in EP-A-0.799.966, too.

This improved dewatering can be well demonstrated by the partitioning test, such as described hereinafter, whereby combinations of acquisition/distribution and storage materials are loaded in varying arrangements with test liquid, and allowing the fluid to equilibrate throughout the materials or members. Then the members or materials are separated again, and the respective amount of liquid is determined by differential weighing. Good dewatering can be seen by low residual liquid in an acquisition / distribution material, be this in absolute measure (g/g) or relative to its saturation capacity.

This partitioning test allows to assess a further benefit of structures designed according to the principles of the present invention, which relates to the movement of the liquid thought the various members, thus allowing more design flexibility for absorbent articles.

For example, if the partitioning test is executed such that test liquid is loaded onto a section which does not comprise any liquid storage material but only a liquid acquisition/distribution material, which is, however, in liquid communication with a storage material (e.g. by placing the latter horizontally offset from the loading point on the acquisition/distribution material), it can be seen that in combinations satisfying the requirements of the present invention, the liquid is transferred to a larger extend into the storage material, and the acquisition/distribution materials is loaded to a much lower degree.

The gained design flexibility can be exploited to design articles with an increased comfort to the wearer without compromising on performance, such as by distributing the absorbent storage material to regions of the article where they hinder the wearer less in case of being loaded, e.g. by removing fluid storage material out of the crotch region of the article.

Whilst the above focused on the benefits as occurring in structures having two members, analogue benefits arise when even more members are designed together, such as can arise when the acquisition and distribution functionality is not combined into one acquisition / distribution member, but rather into separate members. Then, a high capillary suction material according to the teachings herein will be able to drain efficiently the distribution member, which in turn can dewater the acquisition material, thereby enhancing the overall performance of the article even more.

Examples

Materials / components

Acquisition / distribution materials (Samples A...)

Sample A.1

A first acquisition / distribution member has been produced by using chemically-stiffened, twisted cellulose (CS), commercially available under the designation "CMC" from Weyerhaeuser Co., US, and forming these into a web such as by air-laying. A suitable structure has a basis weight of 195 gsm and a dry density of about 0.07 g/cm3.

Sample A.2

The further material has a basis weight of 150 gsm and a density of 0.105g/cm3, consisting of

- 45% by weight of chemically-stiffened, twisted cellulose (CS), commercially available under the designation "CMC" from Weyerhaeuser Co., US;
- 45% by weight of eucalyptus type fibers
- 10% by weight of CELBOND® from Hoechst Celanese Corporation, US, type 255, lot 33865A, having a dTex of about 3.3, a denier of about 3.0, and a fiber length of about 6.4 mm.

This material has been air-laid and subsequently heatbonded.

Sample A.3

An alternative material is a wetlaid chemically bonded web as explained above having a basis weight of 150 gsm and a density of 0.094 g/cm3, consisting of a fiber blend of

- 90% by weight of chemically-stiffened, twisted cellulose (CS), commercially available under the designation "CMC" from Weyerhaeuser Co., US;
- 10% y weight of eucalyptus type fibers, bonded by 2 % per weight of fiber blend of a polyacrylamide-glyoxal resin marketed by Cytec Industries, West Patterson, NJ, USA, under the trade name Parez™ 631 NC.

Sample A.4

Materials made in example A.3 having a basis weight of 150 gsm and a density of 0.105g/cm3, have been subjected to the post formation treatment as described above and in EP-A-0.810.078, by treating the material between two rolls at an overlap depth of the peaks of 0.2 mm each with a width of a the teeth of 0.6 mm, being 1.0 mm spaced apart.

High capillary suction storage member (Samples S..)

Sample S.1 Storage Absorbent Member Comprising Glass Microfibers

This example describes a high capillary suction absorbent member comprising hydrogel-forming absorbent polymer and high surface area glass micro fibers as formed using a wet end forming process for increased density and structural organization over conventional air deposition processes. In order to construct such a hydrogel-forming absorbent polymer containing member which approaches a homogeneous distribution of absorbent polymer in the glass micro fiber matrix, the following procedure is followed.

A mixture of 4.0 gms of ASAP 2300 (available from Chemdal LTD, a subsidiary of American Colloid Co., Arlington Heights, IL; also available from The Procter & Gamble Co., Paper Technology Division, Cincinnati, OH) and 4.0 gms of glass micro fiber (available as "Q-FIBERS, Code 108, 110 Bulk" from Manville Sales Corp., Denver, Co.) are combined in an explosion resistant 3-gallon Commercial grade Warner blender with approximately 500 ml of 3A alcohol (95% ethanol, 5% methanol), or Isopropanol, or similar liquids which will not degrade nor absorb into the structure or composition of the involved polymers. The mixture is stirred on low speed for approximately 5 min. The mixture is poured into a 6 in. x 6 in. "Paper Formation Box" with an 80 mesh Nylon Forming Wire (available from Appleton Mfg. Div., Productive Solutions, Inc., Neenah, WI) at the bottom of the upper portion of the Formation Box. Liquid level is brought to about 8 in (about 20.3 cm) above the screen with addition of 3A alcohol, or appropriate solution. A paddle is used to mix the solution thoroughly in the top of the Formation box before liquid evacuation. A valve is opened below the forming wire and liquid is drained rapidly to ensure a uniform deposition on the forming wire. The screen is removed from the "Formation box", pulled across a vacuum source for removal of loosely held liquid, and allowed to air dry overnight in a desiccator containing a desiccant (such as DRIERITE, Sigme Chem. Co., St. Louis, MO 63178) to ensure uniform moisture content. Once dry, the absorbent member is removed from the forming screen. A 5.4 cm cylindrical-shaped structure is arch-punched from the member for measurement of capillary sorption absorbent capacity.

Sample S.2 Preparation of High Surface Area Foam from a HIPE

Anhydrous calcium chloride (36.32 kg) and potassium persulfate (189 g) are dissolved in 378 liters of water. This provides the water phase stream to be used in a continuous process for forming a HIPE emulsion.

To a monomer combination comprising distilled divinylbenzene (42.4% divinylbenzene and 57.6% ethyl styrene) (2640 g), 2-ethylhexyl acrylate (4400 g), and hexanedioldiacrylate (960 g) is added a diglycerol monooleate emulsifier (480 g), ditallow dimethyl ammonium methyl sulfate (80g), and Tinuvin 765 (20 g). The diglycerol monooleate emulsifier (Grindsted Products; Brabrand, Denmark) comprises approximately 81% diglycerol monooleate, 1% other diglycerol monoesters, 3% polyols, and 15% other polyglycerol esters, imparts a minimum oil/water interfacial tension value of approximately 2.7 dyne/cm and has an oil/water critical aggregation concentration of approximately 2.8 wt%. After mixing, this combination of materials is allowed to settle overnight. No visible residue is formed and all of the mixture is withdrawn and used as the oil phase in a continuous process for forming a HIPE emulsion.

Separate streams of the oil phase (25°C) and water phase (53°-55°C) are fed to a dynamic mixing apparatus. Thorough mixing of the combined streams in the dynamic mixing apparatus is achieved by means of a pin impeller. The pin impeller comprises a cylindrical shaft of about 36.5 cm in length with a diameter of about 2.9 cm. The shaft holds 6 rows of pins, 3 rows having 33 pins and 3 rows having 34 pins, each of the three pins at each level disposed at an angle of 120° to each other, with the next level down disposed at 60° to its neighboring level with each level separated by 0.03 mm, each having a diameter of 0.5 cm extending outwardly from the central axis of the shaft to a length of 2.3 cm. The pin impeller is mounted in a cylindrical sleeve which forms the dynamic mixing apparatus, and the pins have a clearance of 1.5 mm from the walls of the cylindrical sleeve.

A minor portion of the effluent exiting the dynamic mixing apparatus is withdrawn and enters a recirculation zone, as shown in the Figure of copending U.S. Patent application Serial No. 08/716,510, filed September 17, 1996 by DesMarais, the disclosure of which is incorporated by reference herein. The Waukesha pump in the recirculation zone returns the minor portion to the entry point of the oil and water phase flow streams to the dynamic mixing zone.

The static mixer (TAH Industries Model 100-812) has 12 elements with a 1 in. (2.5 cm) outside diameter. A hose is mounted downstream from the static mixer to facilitate delivery of the emulsion to the device used for curing. Optionally an additional static mixer is used to provide addition back pressure to keep the hose filled. The optional static mixer can be a 1 in. (2.5 cm) pipe, 12 element mixer (McMaster-Carr, Aurora, OH, Model 3529K53).

The combined mixing and recirculation apparatus set-up is filled with oil phase and water phase at a ratio of 4 parts water to 1 part oil. The dynamic mixing apparatus is vented to allow air to escape while filling the apparatus completely. The flow rates during filling are 7.57 g/sec oil phase and 30.3 cm^3/sec water phase.

Once the apparatus set-up is filled, agitation is begun in the dynamic mixer, with the impeller turning at 1750 RPM and recirculation is begun at a rate of about 30 cm^3/sec. The flow rate of the water phase is then steadily increased to a rate of 151.3 cm^3/sec over a time period of about 1 min., and the oil phase flow rate is reduced to 3.03 g/sec over a time period of about 3 min. The recirculation rate is steadily increased to about 150 cm^3/sec during the latter time period. The back pressure created by the dynamic zone and static mixers at this point is about 19.9 PSI (137 kPa), which represents the total pressure drop of the system. The Waukesha pump (Model 30) speed is then steadily decreased to a yield a recirculation rate of about 75 cm^3/sec.

The HIPE flowing from the static mixer at this point is collected in a round polyethylene tub, 40 in. (102 cm) in diameter and 12.5 in. (31.8 cm) high, with removable sides, much like a springform pan used in cooking cakes. A pipe-like polyethylene insert 12.5 in. (31.8 cm) in diameter at its base is firmly affixed to the center of the base and is 12.5 in. (31.8 cm) high. The HIPE-containing tubs are kept in a room maintained at 65° C for 18 hours to effect polymerization and form the foam.

The cured HIPE foam is removed from the curing tubs. The foam at this point has residual water phase (containing dissolved emulsifiers, electrolyte, initiator residues, and initiator) about 48-52 times (48-52X) the weight of polymerized monomers. The foam is sliced with a sharp reciprocating saw blade into sheets which are 0.185 inches (4.7 mm) in thickness. These sheets are then subjected to compression in a series of 2 porous nip rolls equipped with vacuum which gradually reduce the residual water phase content of the foam to about 6 times (6X) the weight of the polymerized material. At this point, the sheets are then resaturated with a 1.5% $CaCl_2$ solution at 60°C., are squeezed in a series of 3 porous nip rolls equipped with vacuum to a water phase content of about 4X. The $CaCl_2$ content of the foam is between 8 and 10 %.

The foam remains compressed after the final nip at a thickness of about 0.021 in. (0.053 cm). The foam is then dried in air for about 16 hours. Such drying reduces the moisture content to about 9-17 % by weight of polymerized material. At this point, the foam sheets are very drapeable and "thin-after-drying".

Sample S.3 Preparation of High Surface Area Foam from a HIPE

The water and oil phase streams to be used in a continuous process for forming a HIPE emulsion is prepared according to Sample S.2. Separate streams of the oil phase (25°C) and water phase (53°-55°C) are fed to a dynamic mixing apparatus as detailed in Sample S.2.

Once the apparatus set-up is filled, agitation is begun in the dynamic mixer, with the impeller turning at 1700 RPM and recirculation is begun at a rate of about 30 cm^3/sec. The flow rate of the water phase is then steadily increased to a rate of 151.3 cm^3/sec over a time period of about 1 min., and the oil phase flow rate is reduced to 3.36 g/sec over a time period of about 3 min. The recirculation rate is steadily increased to about 150 cm^3/sec during the latter time period. The back pressure created by the dynamic zone and static mixers at this point is about 19.7 PSI (136 kPa), which represents the total pressure drop of the system. The Waukesha pump speed is then steadily decreased to a yield a recirculation rate of about 75 cm^3/sec.

The HIPE flowing from the static mixer at this point is collected and cured into a polymeric foam as detailed in Sample S.2.

The cured HIPE foam is removed from the curing tubs. The foam at this point has residual water phase (containing dissolved emulsifiers, electrolyte, initiator residues, and initiator) about 43-47 times (43-47X) the weight of polymerized monomers. The foam is sliced with a sharp reciprocating saw blade into sheets which are 0.185 inches (4.7 mm) in thickness. These sheets are then subjected to compression in a series of 2 porous nip rolls equipped with vacuum which gradually reduce the residual water phase content of the foam to about 6 times (6X) the weight of the polymerized material. At this point, the sheets are then resaturated with a 1.5% $CaCl_2$ solution at 60°C., are squeezed in a series of 3 porous nip rolls equipped with vacuum to a water phase content of about 4X. The $CaCl_2$ content of the foam is between 8 and 10 %.

The foam remains compressed after the final nip at a thickness of about 0.028 in. (0.071 cm). The foam is then dried in air for about 16 hours.

Such drying reduces the moisture content to about 9-17 % by weight of polymerized material. At this point, the foam sheets are very drapeable and "thin-after-drying".

Sample S.4 Preparation of High Surface Area Foam from a HIPE

The water and oil phase streams to be used in a continuous process for forming a HIPE emulsion is prepared according to Sample S.2. Separate streams of the oil phase (25°C) and water phase (53°-55°C) are fed to a dynamic mixing apparatus as detailed in Sample S.2.

Once the apparatus set-up is filled, agitation is begun in the dynamic mixer, with the impeller turning at 1750 RPM and recirculation is begun at a rate of about 30 cm^3/sec. The flow rate of the water phase is then steadily increased to a rate of 151.3 cm^3/sec over a time period of about 1 min., and the oil phase flow rate is reduced to 3.78 g/sec over a time period of about 3 min. The recirculation rate is steadily increased to about 150 cm^3/sec during the latter time period. The back pressure created by the dynamic zone and static mixers at this point is about 18.7 PSI (129 kPa), which represents the total pressure drop of the system. The Waukesha pump speed is then steadily decreased to a yield a recirculation rate of about 75 cm^3/sec.

The HIPE flowing from the static mixer at this point is collected and cured into a polymeric foam as detailed in Sample S.2.

The cured HIPE foam is removed from the curing tubs. The foam at this point has residual water phase (containing dissolved emulsifiers, electrolyte, initiator residues, and initiator) about 38-42 times (38-42X) the weight of polymerized monomers. The foam is sliced with a sharp reciprocating saw blade into sheets which are 0.185 inches (4.7 mm) in thickness. These sheets are then subjected to compression in a series of 2 porous nip rolls equipped with vacuum which gradually reduce the residual water phase content of the foam to about 6 times (6X) the weight of the polymerized material. At this point, the sheets are then resaturated with a 1.5% $CaCl_2$ solution at 60°C., are squeezed in a series of 3 porous nip rolls equipped with vacuum to a water phase content of about 4X. The $CaCl_2$ content of the foam is between 8 and 10 %.

The foam remains compressed after the final nip at a thickness of about 0.028 in. (0.071 cm). The foam is then dried in air for about 16 hours. Such drying reduces the moisture content to about 9-17 % by weight of polymerized material. At this point, the foam sheets are very drapeable and "thin-after-drying".

Sample S.5 Storage Absorbent Member Comprising High Surface Area Polymeric Foam Material

This example describes a high capillary suction absorbent member comprising hydrogel-forming absorbent polymer and the high suction polymeric foam material prepared according to Sample S.3. In order to construct a hydrogel-forming absorbent polymer containing member which approaches a relatively homogeneous distribution of absorbent polymer and polymeric foam, the following procedure is followed.

10 g of air dried polymeric foam (prepared according to Sample S.3 above) is placed in a blender (Osterizer model 848-36L) equipped with a 1.25 liter jar, into which 1 liter of 2% calcium chloride solution has been placed. After ensuring that all of the foam material is submerged, the blender is agitated on the 'Liquify' (high setting) for 10 seconds and then additionally agitated on the 'Grate' setting for 5 sec. The resultant slurry is then transferred to a Buchner funnel (Coors USA model 60283) lined with a paper towel. Approximately 500 ml of fluid is freely drained from the sample. The sample is then covered with a rubber membrane and vacuum is applied (approximately 500 mm Hg or about 66 kPa) to dewater the sample to a weight of 50 to 60 grams.

The sample is returned to a dry blender jar and dispersed with the agitation set on 'Liquify' while the jar and base are inverted and returned to upright several times to disperse the sample to approximately individual particles. The dispersed sample is then air dried under ambient conditions and then the foam particles are combined with hydrogel-forming absorbent polymer (ASAP 2300, available from Chemdal Corporation of Palantine, IL;

also available from The Procter & Gamble Co., Paper Technology Division, Cincinnati, OH), to provide a storage absorbent member consisting of a homogeneous blend of 50%, by weight, hydrogel forming polymer and 50%, by weight, high surface area polymeric foam.

Sample S.6 Storage Absorbent Member Comprising High Surface Area Fibrets

This example describes a high capillary suction absorbent member comprising hydrogel-forming absorbent polymer and high surface area fibrets. High surface area fibrets, available from Hoechst Celanese Corp. (Charlotte, NC) as cellulose acetate Fibrets®, are combined with hydrogel-forming absorbent polymer (ASAP 2300, available from Chemdal Corporation of Palantine, IL; also available from The Procter & Gamble Co., Paper Technology Division, Cincinnati, OH), to provide a storage absorbent member consisting of a homogeneous blend of 50%, by weight, hydrogel-forming polymer and 50%, by weight, fibrets.

Example Structures

As has been laid out in the general part of the description, the absorbent cores can be constructed in a wide variety of possibilities, provided these cores include an acquisition/distribution region, which is in liquid communication with an liquid storage region, and provided, that the materials used in these regions satisfy the respective requirements. Thus, such cores can be constructed from respective materials in a layered arrangement, with the basis weights and sizes adjusted to the requirements of the intended use as laid out in the above.

A specific core construction, which is useful for baby diapers of the commonly designated MAXI size, has a rectangular shape with about 450mm length and about 100 mm width. Therein, the acquisition /distribution region consists of a layer of material having a dimension of also rectangular shape, which covers the complete absorbent core. The liquid storage region can also be of rectangular shape, also extending over the complete size of the absorbent core, underlying as a layer the acquisition distribution region. The thickness of the materials can vary throughout the length and/or the width of the absorbent core, but in simple constructions it is a uniform thickness throughout the absorbent core.

It is essential for the functioning that the acquisition/distribution material and the storage materials are chosen according to their capillary suction properties as laid out in the above.

Thus, the exemplified acquisition/ distribution materials function well with all fluid storage samples with the exception of Samples S.2 and S.6, which both do not exhibit a sufficiently high capillary suction so as to satisfy the present invention.

Test procedures

Capillary Sorption

Purpose

The purpose of this test is to measure the capillary sorption absorbent capacity, as a function of height, of storage absorbent members of the present invention. (The test is also used to measure the capillary sorption absorbent capacity, as a function of height, of the high surface area materials - i.e., without osmotic absorbent, such as hydrogel-forming absorbent polymer, or other optional materials utilized in the absorbent member. Nonetheless, the discussion that follows discusses the Capillary Sorption method as it pertains to measuring an entire storage absorbent member.) Capillary sorption is a fundamental property of any absorbent that governs how liquid is absorbed into the absorbent structure. In the Capillary Sorption experiment, capillary sorption absorbent capacity is measured as a function of fluid pressure due to the height of the sample relative to the test fluid reservoir.

The method for determining capillary sorption is well recognized. See Burgeni, A.A. and Kapur, C., "Capillary Sorption Equilibria in Fiber Masses," Textile Research Journal, 37 (1967), 356-366; Chatterjee, P.K., Absorbency, Textile Science and Technology 7, Chapter II, pp 29-84, Elsevier Science Publishers B.V, 1985; and U.S. Patent No. 4,610,678, issued September 9, 1986 to Weisman et al. for a discussion of the method for measuring capillary sorption of absorbent structures. The disclosure of each of these references is incorporated by reference herein.

Principle

A porous glass frit is connected via an uninterrupted column of fluid to a fluid reservoir on a balance. The sample is maintained under a constant confining weight during the experiment. As the porous structure absorbs fluid upon demand, the weight loss in the balance fluid reservoir is recorded as fluid uptake, adjusted for uptake of the glass frit as a function of height and evaporation. The uptake or capacity at various capillary suctions (hydrostatic tensions or heights) is measured. Incremental absorption occurs due to the incremental lowering of the frit (i.e., decreasing capillary suction).

Time is also monitored during the experiment to enable calculation of initial effective uptake rate (g/g/h) at a 200 cm height.

Reagents

Test Liquid: Synthetic urine is prepared by completely dissolving the following materials in distilled water.

Compound	F.W.	Concentration (g/L)
KCl	74.6	2.0
Na_2SO_4	142	2.0
$(NH_4)H_2PO_4$	115	0.85
$(NH_4)_2HPO_4$	132	0.15
$CaCl_2 \cdot 2H_2O$	147	0.25
$MgCl_2.6H_2O$	203	0.5

General Description of Apparatus Set Up

The Capillary Sorption equipment, depicted generally as **520** in Figure 2A , used for this test is operated under TAPPI conditions (50% RH, 25°C). A test sample is placed on a glass frit shown in Figure 2A as **502** that is connected via a continuous column of test liquid (synthetic urine) to a balance liquid reservoir, shown as **506**, containing test liquid. This reservoir **506** is placed on a balance **507** that is interfaced with a computer (not shown). The balance should be capable of reading to 0.001 g; such a balance is available from Mettler Toledo as PR1203 (Hightstown, NJ). The glass frit **502** is placed on a vertical slide, shown generally in Figure 2A as **501**, to allow vertical movement of the test sample to expose the test sample to varying suction heights. The vertical slide may be a rodless actuator which is attached to a computer to record suction heights and corresponding times for measuring liquid uptake by the test sample. A preferred rodless actuator is available from Industrial Devices (Novato, CA) as item 202X4X34N-1D4B-84-P-C-S-E, which may be powered by motor drive ZETA 6104-83-135, available from CompuMotor (Rohnert, CA). Where data is measured and sent from actuator **501** and balance **507**, capillary sorption absorbent capacity data may be readily generated for each test sample. Also, computer interface to actuator **501** may allow for controlled vertical movement of the glass frit **502**. For example, the actuator may be directed to move the glass frit **502** vertically only after "equilibrium" (as defined below) is reached at each suction height.

The bottom of glass frit **502** is connected to Tygon® tubing **503** that connects the frit **505** to three-way drain stopcock **509**. Drain stopcock **509** is connected to liquid reservoir **505** via glass tubing **504** and stopcock **510**. (The stopcock **509** is open to the drain only during cleaning of the apparatus or air bubble removal.) Glass tubing **511** connects fluid reservoir **505** with balance fluid reservoir **506**, via stopcock **510**. Balance liquid reservoir **506** consists of a lightweight 12 cm diameter glass dish **506A** and cover **506B**. The cover **506B** has a hole through which glass tubing **511** contacts the liquid in the reservoir **506**. The glass tubing **511** must not contact the cover **506B** or an unstable balance reading will result and the test sample measurement cannot be used.

The glass frit diameter must be sufficient to accommodate the piston/cylinder apparatus, discussed below, for holding the test sample. The glass frit **502** is jacketed to allow for a constant temperature control from a heating bath. The frit is a 350 ml fritted disc funnel specified as having 4 to 5.5 μm pores, available from Corning Glass Co. (Corning, NY) as #36060-350F. The pores are fine enough to keep the frit surface wetted at capillary suction heights specified (the glass frit does not allow air to enter the continuous column of test liquid below the glass frit).

As indicated, the frit **502** is connected via tubing to fluid reservoir **505** or balance liquid reservoir **506**, depending on the position of three-way stopcock **510**.

Glass frit **502** is jacketed to accept water from a constant temperature bath. This will ensure that the temperature of the glass frit is kept at a constant temperature of 88°F (31°C) during the testing procedure. As is depicted in Figure 2A, the glass frit **502** is equipped with an inlet port **502A** and outlet port **502B**, which make a closed loop with a circulating heat bath shown generally as **508**. (The glass jacketing is not depicted in Figure 2A. However, the water introduced to the jacketed glass frit **502** from bath **508** does not contact the test liquid and the test liquid is not circulated through the constant temperature bath. The water in the constant temperature bath circulates through the jacketed walls of the glass frit **502**.)

Reservoir **506** and balance **507** are enclosed in a box to minimize evaporation of test liquid from the balance reservoir and to enhance balance stability during performance of the experiment. This box, shown generally as **512**, has a top and walls, where the top has a hole through which tubing **511** is inserted.

The glass frit **502** is shown in more detail in Figure 2B. Figure 2B is a cross-sectional view of the glass frit, shown without inlet port **502A** and outlet port **502B**. As indicated, the glass frit is a 350 ml fritted disc funnel having specified 4 to 5.5 μm pores. Referring to Figure 2B, the glass frit **502** comprises a cylindrical jacketed funnel designated as **550** and a glass frit disc shown as **560**. The glass frit **502** further comprises a cylinder/piston assembly shown generally as **565** (which comprises cylinder **566** and piston **568**), which confines the test sample, shown as **570**, and provides a small confining pressure to the test sample. To prevent excessive evaporation of test liquid from the glass frit disc **560**, a Teflon ring shown as **562** is placed on top of the glass frit disc **560**. The Teflon® ring **562** is 0.0127 cm thick (available as sheet stock from McMasterCarr as # 8569K16 and is cut to size) and is used to cover the frit disc surface outside of the cylinder **566**, and thus minimizes evaporation from the glass frit. The ring outer diameter and inner diameter is 7.6 and 6.3 cm, respectively. The inner diameter of the Teflon® ring **562** is about 2 mm less than the outer diameter of cylinder **566**. A Viton® O-ring (available from McMasterCarr as # AS568A-150 and AS568A-151) **564** is placed on top of Teflon® ring **562** to seal the space between the inner wall of cylindrical jacketed funnel **550** and Teflon® ring **562,** to further assist in prevention of evaporation. If the O-ring outer diameter exceeds the inner diameter of cylindrical jacketed funnel **550**, the O-ring diameter is reduced to fit the funnel as follows: the O-ring is cut open, the necessary amount of O-ring material is cut off, and the O-ring is glued back together such that the O-ring contacts the inner wall of the cylindrical jacketed funnel **550** all around its periphery.

As indicated, a cylinder/piston assembly shown generally in Figure 2B as **565** confines the test sample and provides a small confining pressure to the test sample **570**. Referring to Figure 2C, assembly **565** consists of a cylinder **566**, a cup-like Teflon® piston indicated by **568** and, when necessary, a weight or weights (not shown) that fits inside piston **568**. (Optional weight will be used when necessary to adjust the combined weight of the piston and the optional weight so a confining pressure of 0.2 psi is attained depending on the test sample's dry diameter. This is discussed below.) The cylinder **566** is Lexan® bar stock and has the following dimensions: an outer diameter of 7.0 cm, an inner diameter of 6.0 cm and a height of 6.0 cm. The Teflon® piston **568** has the following dimensions: an outer diameter that is 0.02 cm less than the inner diameter of cylinder **566**. As shown in Figure 2D, the end of the piston **568** that does not contact the test sample is bored to provide a 5.0 cm diameter by about 1.8 cm deep chamber **590** to receive optional weights (dictated by the test sample's actual dry diameter) required to attain a test sample confining pressure of 0.2 psi (1.4 kPa). In other words, the total weight of the piston **568** and any optional weights (not shown in figures) divided by the test sample's actual diameter (when dry) should be such that a confining pressure of 0.2 psi is attained. Cylinder **566** and piston **568** (and optional weights) are equilibrated at 31°C for at least 30 minutes prior to conducting the capillary sorption absorbent capacity measurement.

A non-surfactant treated or incorporated apertured film (14 cm x 14 cm) (not shown) is used to cover the glass frit **502** during Capillary Sorption experiments to minimize air destablization around the sample. Apertures are large enough to prevent condensation from forming on the underside of the film during the experiment.

Test Sample Preparation

The test sample can be obtained by punching out a 5.4 cm diameter circular-shaped structure from a storage absorbent member. When the member is a component of an absorbent article, other components of the article must be removed prior to testing. In those situations where the member cannot be isolated from other components of the article without significantly altering its structure (e.g., density, relative disposition of the component materials, physical properties of constituent materials, etc.) or where the member is not a component of an absorbent article, the test sample is prepared by combining all the materials that constitute the member such that the combination is representative of the member in question. The test sample is a 5.4 cm diameter circle and is obtained by cutting with an arch punch.

The dry weight of the test sample (used below to calculate capillary sorption absorbent capacity) is the weight of the test sample prepared as above under ambient conditions.

Experimental Set Up

1. Place a clean, dry glass frit **502** in a funnel holder attached to the vertical slide **501**. Move the funnel holder of the vertical slide such that the glass frit is at the 0 cm height.
2. Set up the apparatus components as shown in Figure 2A, as discussed above.
3. Place 12 cm diameter balance liquid reservoir **506** on the balance **507**. Place plastic lid **506B** over this balance liquid reservoir **506** and a plastic lid over the balance box **512** each with small holes to allow the glass tubing **511** to fit through. Do not allow the glass tubing to touch the lid **506B** of the balance liquid reservoir or an unstable balance reading will result and the measurement cannot be used.

4. Stopcock **510** is closed to tubing **504** and opened to glass tubing **511**. Fluid reservoir **505**, previously filled with test fluid, is opened to allow test fluid to enter tubing **511**, to fill balance fluid reservoir **506**.
5. The glass frit **502** is leveled and secured in place. Also, ensure that the glass frit is dry.
6. Attach the Tygon® tubing **503** to stopcock **509**. (The tubing should be long enough to reach the glass frit **502** at its highest point of 200 cm with no kinks.) Fill this Tygon® tubing with test liquid from liquid reservoir **505**.
7. Attach the Tygon® tubing **503** to the level glass frit **502** and then open stopcock **509** and stopcock **510** leading from fluid reservoir **505** to the glass frit **502**.. (Stopcock **510** should be closed to glass tubing **511**.) The test liquid fills the glass frit **502** and removes all trapped air during filling of the level glass frit. Continue to fill until the fluid level exceeds the top of the glass frit disc **560**. Empty the funnel and remove all air bubbles in the tubing and inside the funnel. Air bubbles may be removed by inverting glass frit **502** and allowing air bubbles to rise and escape through the drain of stopcock **509**. (Air bubbles typically collect on the bottom of the glass frit disc **560**.) Relevel the frit using a small enough level that it will fit inside the jacketed funnel **550** and onto the surface of glass frit disc **560**.
8. Zero the glass frit with the balance liquid reservoir **506**. To do this, take a piece of Tygon® tubing of sufficient length and fill it with the test liquid. Place one end in the balance liquid reservoir **506** and use the other end to position the glass frit **502**. The test liquid level indicated by the tubing (which is equivalent to the balance liquid reservoir level) is 10 mm below the top of the glass frit disc **560**. If this is not the case, either adjust the amount of liquid in the reservoir or reset the zero position on the vertical slide **501**.
9. Attach the outlet and inlet ports from the temperature bath **508** via tubing to the inlet and outlet ports **502A** and **502B**, respectively, of the glass frit. Allow the temperature of the glass

frit disc **560** to come to 31°C. This can be measured by partially filling the glass frit with test liquid and measuring its temperature after it has reached equilibrium temperature. The bath will need to be set a bit higher than 31°C to allow for the dissipation of heat during the travel of water from the bath to the glass frit.

10. The glass frit is equilibrated for 30 minutes.

Capillary Sorption Parameters

The following describes a computer program that will determine how long the glass frit remains at each height.

In the capillary sorption software program, a test sample is at some specified height from the reservoir of fluid. As indicated above, the fluid reservoir is on a balance, such that a computer can read the balance at the end of a known time interval and calculate the flow rate (Delta reading/time interval) between the test sample and reservoir. For purposes of this method, the test sample is considered to be at equilibrium when the flow rate is less than a specified flow rate for a specified number of consecutive time intervals. It is recognized, that for certain material, actual equilibrium may not be reached when the specified “EQUILIBRIUM CONSTANT” is reached. The time interval between readings is 5 seconds.

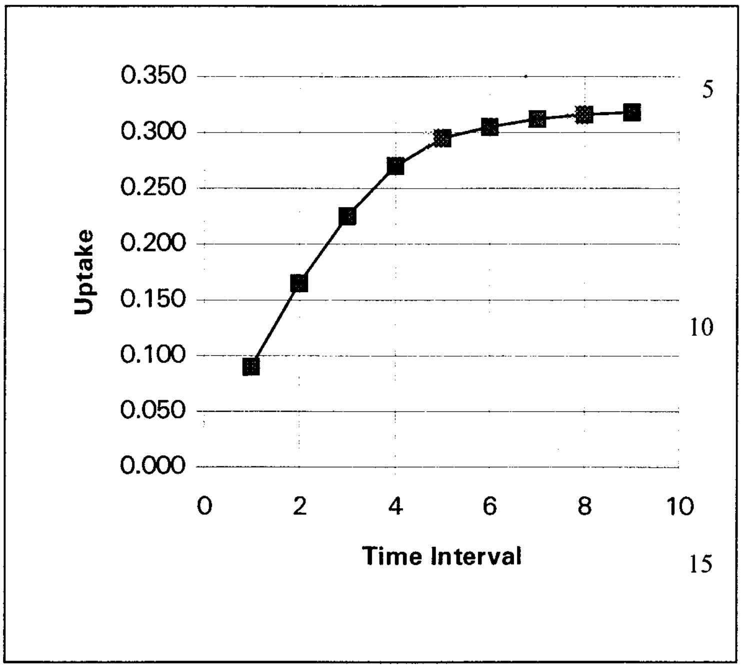
The number of readings in the delta table is specified in the capillary sorption menu as "EQUILIBRIUM SAMPLES". The maximum number of deltas is 500. The flow rate constant is specified in the capillary sorption menu as "EQUILIBRIUM CONSTANT".

The Equilibrium Constant is entered in units of grams/sec, ranging from 0.0001 to 100.000.

The following is a simplified example of the logic. The table shows the balance reading and Delta Flow calculated for each Time Interval.

Equilibrium Samples = 3

Equilibrium Constant = .0015



Time Interval	Balance Value (g)	Delta Flow (g/sec)
0	0	
1	0.090	0.0180
2	0.165	0.0150
3	0.225	0.0120
4	0.270	0.0090
5	0.295	0.0050
6	0.305	0.0020
7	0.312	0.0014
8	0.316	0.0008
9	0.318	0.0004

Delta Table:

Time	0	1	2	3	4	5	6	7	8	9
Delta1	9999	0.0180	0.0180	0.0180	0.0090	0.0090	0.0090	0.0014	0.0014	0.0014
Delta2	9999	9999	0.0150	0.0150	0.0150	0.0050	0.0050	0.0050	0.0008	0.0008
Delta3	9999	9999	9999	0.0120	0.0120	0.0120	0.0020	0.0020	0.0020	0.0004

The equilibrium uptake for the above simplified example is 0.318 gram.

The following is the code in C language used to determine equilibrium uptake:

```
/*                               takedata.c                               */
int take_data(int equil_samples,double equilibrium_constant)

{
double    delta;
static    double deltas[500];  /* table to store up to 500 deltas */
double    value;
double    prev_value;
clock_t   next_time;
int       i;

for (i=0; i<equil_samples; i++)
    deltas[i] = 9999.;                     /* initialize all values in the delta
table to 9999. gms/sec */
delta_table_index = 0;                     /* initialize where in the table to store
the next delta */
equilibrium_reached = 0;                   /* initialize flag to indicate equilibrium
has not been reached */
next_time = clock();                       /* initialize when to take the next
reading */
prev_reading = 0.;                         /* initialize the value of the previous
reading from the balance */

while (!equilibrium_reached) {                 /* start of loop for checking for
equilibrium  */
    next_time += 5000L;                        /* calculate when to take next reading
*/
    while  (clock() < next_time);              /* wait until 5 seconds has elasped
from prev reading */
    value = get_balance_reading();             /* read the balance in grams */
    delta = fabs(prev_value - value) / 5.0;    /* calculate absolute value of flow in
last 5 seconds */
    prev_value = value;                        /* store current value for next loop
*/
    deltas[delta_table_index] = delta;         /* store current delta value in the
table of deltas  */
    delta_table_index++;                       /* increment pointer to next position
in table */
    if (delta_table_index == equil_samples)    /* when the number of deltas = the
number of   */
        delta_table_index = 0;                 /* equilibrium samples specified, /*
                                               /* reset the pointer to the start of
the table.  This way  */
                                               /* the table always contains the last
xx current samples. */
    equilibrium_reached = 1;                   /* set the flag to indicate
equilibrium is reached */
    for (i=0; i < equil_samples; i++)          /* check all the values in the delta
table */
        if (deltas[i] >= equilibrium_constant)/* if any value is > or = to the
equilibrium constant */
            equilibrium_reached = 0;           /* set the equlibrium flag to 0 (not
at equilibrium)  */
    }                                          /* go back to the start of the loop */
}
```

Capillary Sorption Parameters

Load Description (Confining Pressure): 0.2 psi load

Equilibrium Samples (n): 50

Equilibrium Constant: 0.0005 g/sec

Setup Height Value: 100 cm

Finish Height Value: 0 cm

Hydrostatic Head Parameters: 200, 180, 160, 140, 120, 100, 90, 80, 70, 60, 50, 45, 40, 35, 30, 25, 20, 15, 10, 5 and 0 cm.

The capillary sorption procedure is conducted using all the heights specified above, in the order stated, for the measurement of capillary sorption absorbent capacity. Even if it is desired to determine capillary sorption absorbent capacity at a particular height (e.g., 35 cm), the entire series of hydrostatic head parameters must be completed in the order specified. Although all these heights are used in performance of the capillary sorption test to generate capillary sorption isotherms for a test sample, the present disclosure describes the storage absorbent members in terms of their absorbent properties at specified heights of 200, 140, 100, 50, 35 and 0 cm.

Capillary Sorption Procedure

1) Follow the experimental setup procedure.
2) Make sure the temperature bath **508** is on and water is circulating through the glass frit **502** and that the glass frit disc **560** temperature is 31°C.
3) Position glass frit **502** at 200 cm suction height. Open stopcocks **509** and **510** to connect glass frit **502** with the balance liquid reservoir **506**. (Stopcock **510** is closed to liquid reservoir **505**.) Glass frit **502** is equilibrated for 30 minutes.
4) Input the above capillary sorption parameters into the computer.
5) Close stopcocks **509** and **510**.
6) Move glass frit **502** to the set up height, 100 cm.
7) Place Teflon® ring **562** on surface of glass frit disc **560**. Put O-ring **564** on Teflon® ring. Place pre-heated cylinder **566** concentrically on the Teflon® ring. Place test sample **570** concentrically in cylinder **566** on glass frit disc **560**. Place piston **568** into cylinder **566**. Additional confining weights are placed into piston chamber **590**, if required.

8) Cover the glass frit **502** with apertured film.

9) The balance reading at this point establishes the zero or tare reading.

10) Move the glass frit **502** to 200 cm.

11) Open stopcocks **509** and **510** (stopcock **510** is closed to fluid reservoir **505**) and begin balance and time readings.

Glass Frit Correction (blank correct uptake)

Since the glass frit disc **560** is a porous structure, the glass frit (**502**) capillary sorption absorption uptake (blank correct uptake) must be determined and subtracted to get the true test sample capillary sorption absorption uptake. The glass frit correction is performed for each new glass frit used. Run the capillary sorption procedure as described above, except without test sample, to obtain the Blank Uptake (g). The elapsed time at each specified height equals the Blank Time (s).

Evaporation Loss Correction

1) Move the glass frit **502** to 2 cm above zero and let it equilibrate at this height for 30 minutes with open stopcocks **509** and **510** (closed to reservoir **505**).

2) Close stopcocks **509** and **510**.

3) Place Teflon® ring **562** on surface of glass frit disc **560**. Put O-ring **564** on Teflon® ring. Place pre-heated cylinder **566** concentrically on the Teflon® ring. Place piston **568** into cylinder **566**. Place apertured film on glass frit **502**.

4) Open stopcocks **509** and **510** (closed to reservoir **505**) and record balance reading and time for 3.5 hours. Calculate Sample Evaporation (g/hr) as follows:

[balance reading at 1 hr - balance reading at 3.5 hr] / 2.5 hr

Even after taking all the above precautions, some evaporative loss will occur, typically around 0.10 gm/hr for both the test sample and the frit correction. Ideally, the sample evaporation is measured for each newly installed glass frit **502**.

Cleaning the Equipment

New Tygon® tubing **503** is used when a glass frit **502** is newly installed. Glass tubing **504** and **511**, fluid reservoir **505**, and balance liquid reservoir **506** are cleaned with 50% Clorox Bleach® in distilled water, followed by distilled water rinse, if microbial contamination is visible.

a. Cleaning after each experiment

At the end of each experiment (after the test sample has been removed), the glass frit is forward flushed (i.e., test liquid is introduced into the bottom of the glass frit) with 250 ml test liquid from liquid reservoir **505** to remove residual test sample from the glass frit disc pores. With stopcocks **509** and **510** open to liquid reservoir **505** and closed to balance liquid reservoir **506**, the glass frit is removed from its holder, turned upside down and is rinsed out first with test liquid, followed by rinses with acetone and test liquid (synthetic urine). During rinsing, the glass frit must be tilted upside down and rinse fluid is squirted onto the test sample contacting surface of the glass frit disc. After rinsing, the glass frit is forward flushed a second time with 250 ml test liquid (synthetic urine). Finally, the glass frit is reinstalled in its holder and the frit surface is leveled.

b. Monitoring glass frit performance

Glass frit performance must be monitored after each cleaning procedure and for each newly installed glass frit, with the glass frit set up at 0 cm position. 50 ml of test liquid are poured onto the leveled glass frit disc surface (without Teflon® ring, O-ring and the cylinder/piston components). The time it takes for the test fluid level to drop to 5 mm above the glass frit disc surface is recorded. A periodic cleaning must be performed if this time exceeds 4.5 minutes.

c. Periodic cleaning

Periodically, (see monitoring frit performance, above) the glass frits are cleaned thoroughly to prevent clogging. Rinsing fluids are distilled water, acetone, 50% Clorox Bleach® in distilled water (to remove bacterial growth) and test liquid. Cleaning involves removing the glass frit from the holder and disconnecting all tubing. The glass frit is forward flushed (i.e., rinse liquid is introduced into the bottom of the glass frit) with the frit upside down with the appropriate fluids and amounts in the following order:

1. 250 ml distilled water.
2. 100 ml acetone.
3. 250 ml distilled water.
4. 100 ml 50:50 Clorox®/distilled water solution.
5. 250 ml distilled water.
6. 250 ml test fluid.

The cleaning procedure is satisfactory when glass frit performance is within the set criteria of fluid flow (see above) and when no residue is observable on the glass frit disc surface. If cleaning can not be performed successfully, the frit must be replaced.

Calculations

The computer is set up to provide a report consisting of the capillary suction height in cm, time, and the uptake in grams at each specified height. From this data, the capillary suction absorbent capacity, which is corrected for both the frit uptake and the evaporation loss, can be calculated. Also, based on the capillary suction absorbent capacity at 0 cm, the capillary absorption efficiency can be calculated at the specified heights. In addition, the initial effective uptake rate at 200 cm is calculated.

Blank Correct Uptake

$$\text{Blank Correct Uptake (g)} = \text{Blank Uptake(g)} - \frac{\text{Blank Time(s)} * \text{Sample Evap.(g / hr)}}{3600\text{(s / hr)}}$$

Capillary Suction Absorbent Capacity ("CSAC")

$$\text{CSAC}(g/g) = \frac{\text{Sample Uptake}(g) - \dfrac{\text{Sample Time}(s) * \text{Sample Evap.}(g/hr)}{3600\,s/hr} - \text{Blank Correct Uptake}(g)}{\text{Dry Weight of Sample}(g)}$$

Initial Effective Uptake Rate at 200 cm ("IEUR")

$$\text{IEUR}(g/g/hr) = \frac{\text{CSAC at 200 cm}(g/g)}{\text{Sample Time at 200 cm}(s)}$$

Reporting

A minimum of two measurements should be taken for each sample and the uptake averaged at each height to calculate Capillary Sorption Absorbent Capacity (CSAC) for a given absorbent member or a given high surface area material.

With these data, the respective values can be calculated:

- The Capillary Sorption Desorption Height at which the material has released x% of its capacity at 0 cm (i.e. of CSAC 0), (CSDH x) expressed in cm;

- The Capillary Sorption Absorption Height at which the material has absorbed y % of its capacity at 0 cm (i.e. of CSAC 0), (CSAH y) expressed in cm;

- The Capillary Sorption Absorbent Capacity at a certain height z (CSAC z) expressed in units of g {of fluid} / g { of material}; especially at the height zero (CSAC 0), and at heights of 35cm, 40cm, etc

- The Capillary Sorption Absorption Efficiency at a certain height z (CSAE z) expressed in %, which is the ratio of the values for CSAC 0 and CSAC z.

If two materials are combined (such as the first being used as acquisition / distribution material, and the second being used as liquid storage material), the CSAC value (and hence the respective CSAE value) of the second material can be determined for the CSDH x value of the first material .

Vertical wicking test

Synthetic urine formulation.

For this test, the specific synthetic urine used is commonly known as Jayco SynUrine and is available from Jayco Pharmaceuticals Company of Camp Hill, Pennsylvania. The formula for the synthetic urine is: 2.0 g/: of KCl; 2.0 g/l of Na2SO4; 0.85 g/l of (NH4)H2PO4; 0.15 g/l (NH4)H2PO4; 0.19 g/l of CaCl2; ad 0.23 g/l of MgCl2. All of the chemicals are of reagent grade. The pH of the synthetic Urine is in the range of 6.0 to 6.4.

The vertical wicking test is aiming at evaluating the time required for a fluid front to reach a certain height in a vertical arrangement, i.e. against gravity, as well as amount of fluid picked up by the material during this time.

The principle of this test is to place a sample onto a sample holder equipped with electrodes in form of pins, both functioning to fix the sample in a vertical position and to allow generation of an electrical timer signal. The reservoir of the fluid is positioned on a scale, such that the time dependency of the fluid pick up in the sample resulting from the vertical wicking can be monitored. Whilst not being essential to the test, the test is executed based on a commercially available equipment, the EKOTESTER of Ekotec Industrietechnik GmbH, Ratingen, Germany, which also allowed electronic processing of the data.

The test set up is schematically depicted in Figure 3 a and b.

The equipment is essentially made of perspex, and comprises a fluid reservoir (310) to hold 929 grams of test fluid at a liquid level height (311) of 17 mm and a sample holder (320). This reservoir is placed on a scale (315) with 0.1g accuracy, such as manufactured by Mettler GmbH, type PM3000. Optionally, and indicated through the connection (316), this scale can be connected to an electronic data gathering device (342).

The sample holder (320) is essentially a perspex plate of a width (330) of 10 cm, a length (331) of 15 cm, and a thickness of about 5 mm (not shown). A fixation means (325) is extending beyond these dimensions in the direction (332) which becomes the upward direction during the test to ensure reproducible positioning in exactly vertical direction (i.e. direction of gravity) at a reproducible immersion depth (333) of the bottom edge (321) of the sample holder of 12 mm into the test fluid level in the reservoir (310) during the test. The sample holder (320) is further equipped with 9 cathode electrode pins (326) , arranged in three rows in distances (334, 335, 336) of 56 mm, 95 mm, and 136 mm respectively from the bottom edge (321) of the sample holder. There are three electrodes in each of these rows, spaced evenly at distances (337) of 28 mm apart from each other, and the ones located to the longitudinal edge (322) being spaced at distances (338) of 22 mm away from these edges. The electrode pins have a length of about 10 mm, a diameter of about 1 mm, and are slightly sharpened at their end to ease application of the sample. The electrode pins are made of metal. A further anode electrode pin (327) is positioned 5 mm next to the middle cathode electrode pin of the bottom row. The anode (327) and the 9 cathodes (326) are connected (schematically indicated in figure 3a) (328) for two cathode pins and the anode pin) to a timing device (341) allowing to monitor the moment when the electric circuit between the anode and the individual cathodes is closed, such as by electrolyte test fluid in a wetted test sample which is positioned between these electrodes.

In contrast to the general procedures outlined above, this equipment is positioned and the test is executed in a temperature controlled hood set at 37°C and not deviating more than 3°C. The test fluid is also prepared at 37°C in a temperature controlled water bath for sufficient time to allow constant temperature of the fluid.

The test fluid is filled into the reservoir (310) to have the fluid surface (312) in level with the required height (311), e.g. by adding a predetermined amount of fluid, such as 927.3 gram plus / minus 1 gram.

The test specimen is equilibrated at laboratory conditions (see above), and put into the 37°C environment just prior to the test. Also prior to the test, the caliper of the sample is measured as outlined below.

The test sample is cut to the size of 10 cm by 15 cm by any convenient means which avoids as much as possible compression effects at the cutting edges, such as with sample cutter such as from JDC Corporation, or sharp cutters like a scalpel or - less preferred - a sharp pair of scissors.

The test specimen is carefully placed onto the sample holder such that the edges coincide with the bottom and side edges (321 and 322) of the sample holder, i.e. such that it does not extend outside the sample holder plate. At the same time, the sample has to be in an essentially flat but unstressed arrangement, i.e. that it should neither form waves, not be in under mechanical tension. Care must be taken, that the sample has only direct contact to the electrode pins and is not contacting the perspex plate of the holder.

The sample holder (320) is then placed in a vertical position into the test fluid reservoir (310), such that the sample holder (320) as well as the test specimen are immersed exactly by a depth (333) of 12 mm into the fluid. Consequently, the electrodes will now have distances (343, 338, and 339) of 44 mm, 83 mm and 124 mm respectively to the fluid level (312), respectively. As the immersion of the sample holder does change the reading of the scale (315), this is tared by an amount predetermined by inserting the sample holder without any sample, e.g. by 6 grams.

It will be acknowledged, that the positioning of the sample holder (320) and the test specimen in a non-tilted arrangement has to be very accurate on one side, but also quick, as the material will start sucking and wicking at first contact with the fluid. A frame (350) into which the sample holder can be readily inserted with the fixation means (325) is also a part of the EKOTESTER, but other means to achieve rapid and non-tilted fixation can be used.

The reading of the scale is monitored as a function of time immediately after positioning of the sample. It has been found advantageously to connect the scale to computerized equipment (340), such as being part of the EKOTESTER.

As soon as the fluid reaches the first row and closes the electrical connection between the anode (327) and the cathodes (326), these times can be recorded by any timing means, the timing unit (341) of the EKOTESTER being a convenient example. Whilst further data processing could be made with each of the three time values of one row, the further data refer to the average of all three electrodes per row, which generally did not spread more than approximately +/- 5% from the average.

Thus, the data generated are

- the time dependent amount of fluid which is picked up by the sample after immersion, and
- the time required for the fluid to reach certain heights.

From these, for each of the three heights two important values can be read and reported:

First, the times in seconds until the fluid front reaches the respective heights. Second, the "cumulative flux" for each of the heights, by dividing

- the amount of fluid picked up by the sample at the time when this height is reached
- by this time
- and by the cross-sectional area as defined by the caliper measurement and the 10 cm sample width.

Claims

1. Absorbent structure comprising a first region and a second region in liquid communication with said first region characterized in that said first region comprises material having a cumulative flux of more than 0.075 g/cm2/sec at 12.4 cm height and said second region comprises material which satisfies at least one of following requirements:
   (a) a Capillary Sorption Absorption Capacity at 35 cm (CSAC 35) of at least 15 g/g; and/or
   (b) a Capillary Sorption Absorption Capacity at 0 cm (CSAC 0) of at least 15 g/g and a Capillary Sorption Absorption Efficiency at 40 cm (CSAE 40) of at least 55%; and/or
   (c) a Capillary Sorption Absorption Height at 50 % of its capacity at 0 cm absorption height (CSAH 50) of at least 35 cm.

2. Absorbent structure according to claim 1, wherein said material comprised in said first region has at 12.4 cm height a wicking time of less than 120 seconds.

3. Absorbent structure according to claim 1, wherein said second region comprises material having
   (a) a CSAC 35 of at least 20 g/g.

4. Absorbent structure according to claim 1, wherein said second region comprises material having
   (a) a CSAC at the actual CSDH 90 of the first material of at least 15 g/g.

5. Absorbent structure according to claim 1, wherein said second region comprises material having
   (b) a CSAC 0 of at least 20 g/g and a CSAE 40 of at least 50%.

6. Absorbent structure according to claim 1, wherein said second region comprises material having
   (b) a CSAC 0 of at least 25 g/g and a CSAE 40 of at least 50%.

7. Absorbent structure according to claim 1, wherein said second region comprises material having
   (b) a CSAC 0 of at least 35 g/g and a CSAE 40 of at least 50%.

8. Absorbent structure according to claim 1, wherein said second region comprises material having
   (b) a CSAC 0 of at least 15 g/g and a CSAE 40 of at least 65%.

9. Absorbent structure according to claim 1, wherein said second region comprises material having
   (b) a CSAC 0 of at least 15 g/g and a CSAE at the actual CSDH 90 of the first material of at least 55 %.

10. Absorbent structure according to claim 1, wherein said second region comprises material having
    (c) a CSAH 50 f at least 45 cm.

11. Absorbent structure according to claim 1, wherein said second region comprises material having
    (c) a CSAH 50 of at least 60 cm.

12. Absorbent structure according to claim 1, wherein said second region comprises material having
    (c) a CSAH 50 of at least 80 cm.

13. Absorbent structure according to any of the preceding claims, wherein said first region comprises material having a wicking time of less than 50 seconds.

14. Absorbent structure according to any of the preceding claims, wherein said first region comprises material having and a cumulative flux of more than 0.120 g/cm2/sec for said preferential fluid distribution direction at 12.4 cm height.

15. Absorbent structure according to any of the preceding claims, wherein said first region comprises material wherein the wicking time is less than 80% of the wicking time of perpendicular direction for said preferential fluid

distribution direction at 8.3 cm height and a cumulative flux of more than 0.120 g/cm2/sec for said preferential fluid distribution direction at 12.4 cm height.

16. An absorbent structure according to any of the preceding claims, wherein the first region comprises fibrous material.

17. An absorbent structure according to claim 16, wherein said first region comprises fibrous material comprising chemically stiffened cellulose.

18. An absorbent structure according to claim 16, wherein said first region comprises fibrous material comprising synthetic fibers.

19. An absorbent structure according to claim 16, wherein said first region comprises fibrous web which has been mechanically treated after web formation.

20. An absorbent structure according to any of the preceding claims, wherein said first region comprises foam material.

21. An absorbent structure according to claim 20, wherein said polymeric foam material is derived from high internal phase water-in-oil emulsions.

22. An absorbent structure according to any of the preceding claims, wherein said second region comprises a high surface area material.

23. An absorbent structure according to claim 22, wherein the high surface area material comprises microfibers.

24. An absorbent structure according to claim 22, wherein the high surface area material is an open celled hydrophilic foam.

25. An absorbent structure according to claim 24, wherein said open celled hydrophilic foam is a polymeric foam derived from a high internal phase water-in-oil emulsion (HIPE).

26. An absorbent structure according to any of claims 24 or 25, wherein said open celled hydrophilic foam is collapsed.

27. An absorbent structure according to any of claims 24 to 26, wherein said open celled hydrophilic foam is in particulate form.

28. An absorbent structure according to any of the preceding claims, where said second region comprises hydrogel forming materials.

29. An absorbent structure according to claim 28, wherein said hydrogel forming material is present in at least 15 % by total weight of the second region.

30. An absorbent structure according to claim 28, wherein said hydrogel forming material is present in not more than 75 % by total weight of the second region.

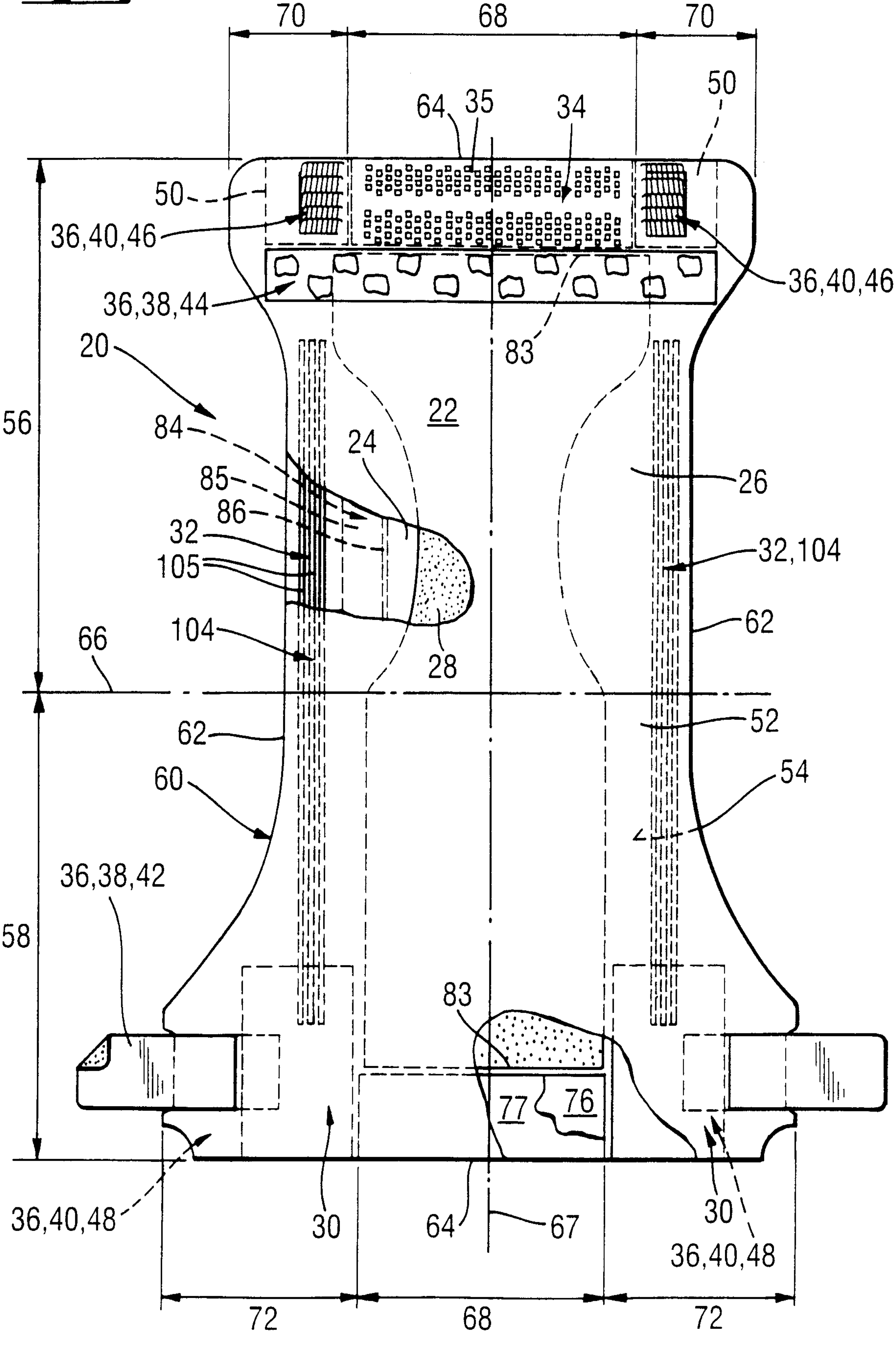
31. Disposable absorbent articles comprising at least one absorbent structure according to any of the preceding claims.

32. Disposable absorbent articles according to claim 31, whereby said absorbent structure comprises at least two of said second regions, which are not in direct contact with each other.

33. Disposable absorbent articles according to claim 32, whereby said at least two second regions are positioned longitudinally spaced away from each other and are separated by at least a part of the crotch region, as defined herein.

34. Disposable absorbent article according to any of the preceding claims for being used as baby diaper, adult incontinence article, feminine hygiene article, training pant and the like.

Fig. 1


70
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26
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86
32
105
32,104
62
104
28
66
62
52
60
54
36,38,42
58
83
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36,40,48
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64
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36,40,48
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68
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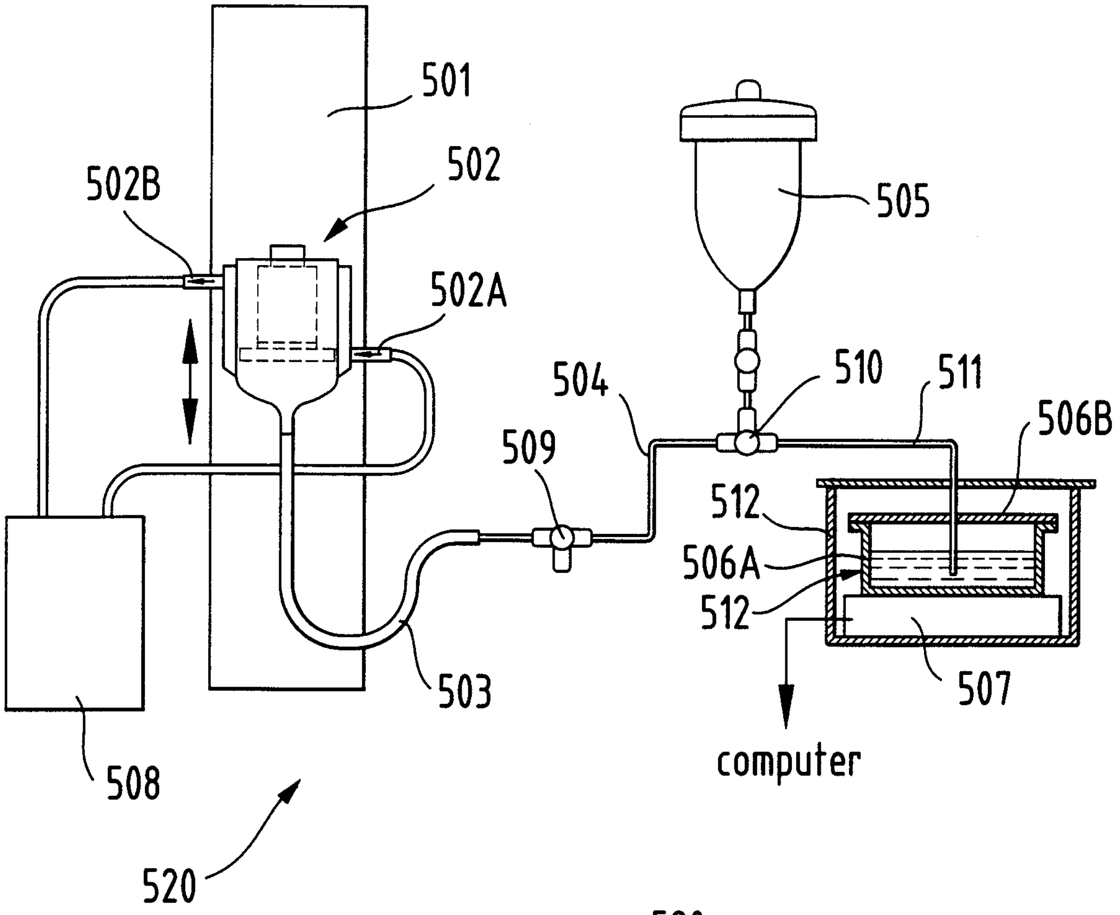
Fig. 2A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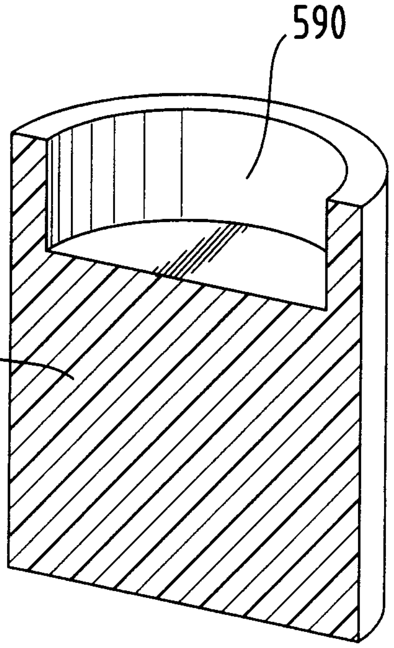
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Fig. 2D

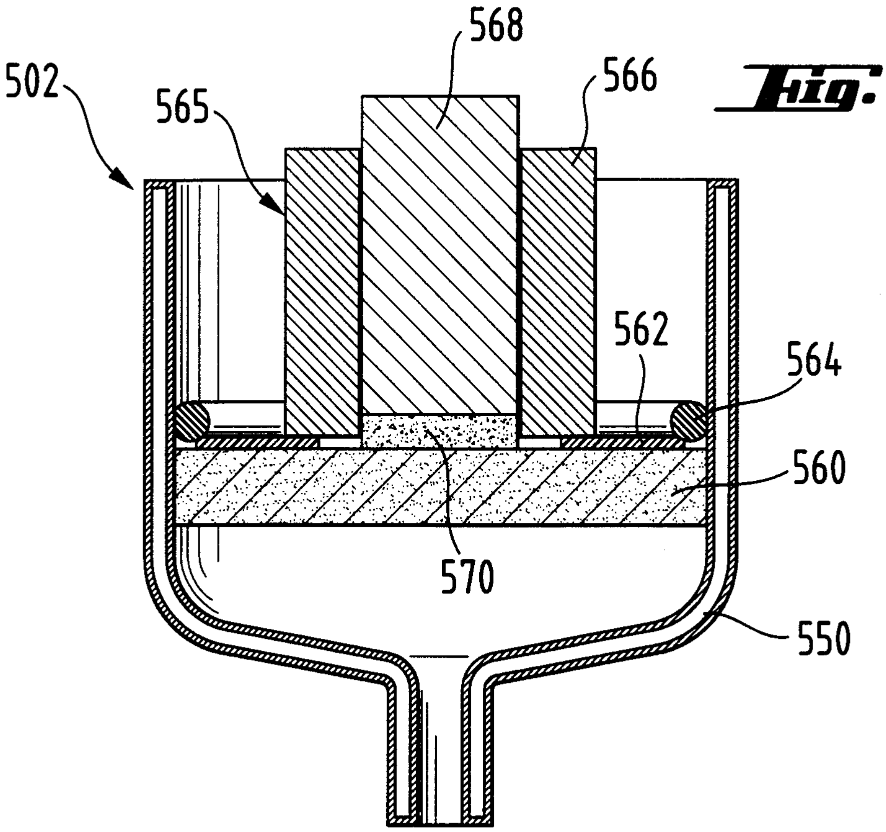
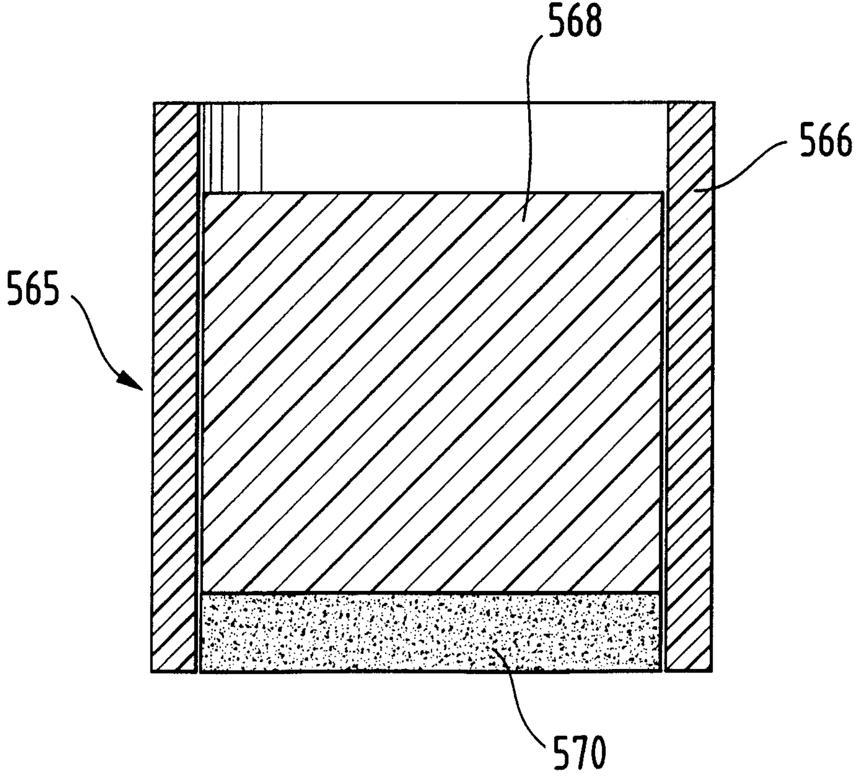


Fig. 2B

Fig. 2C



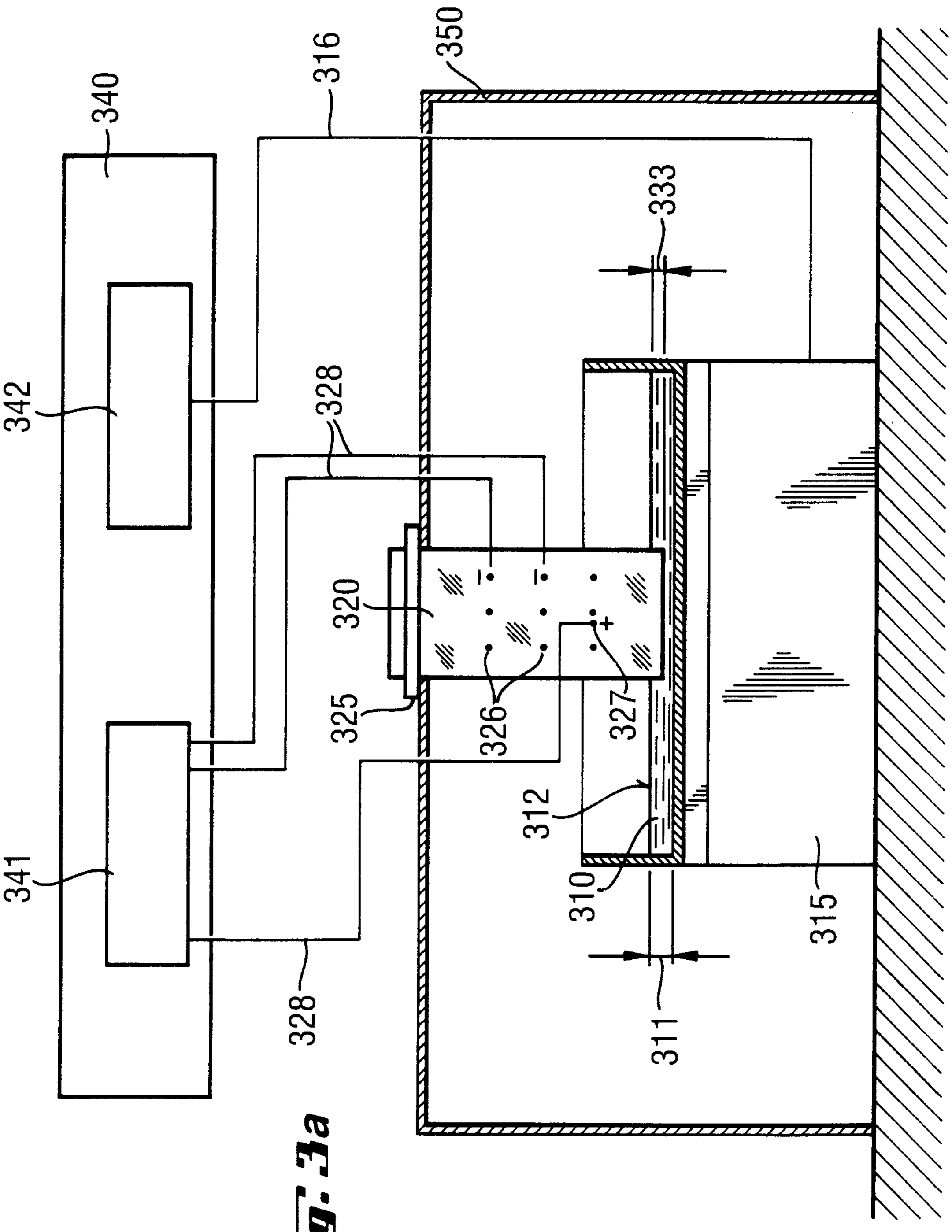
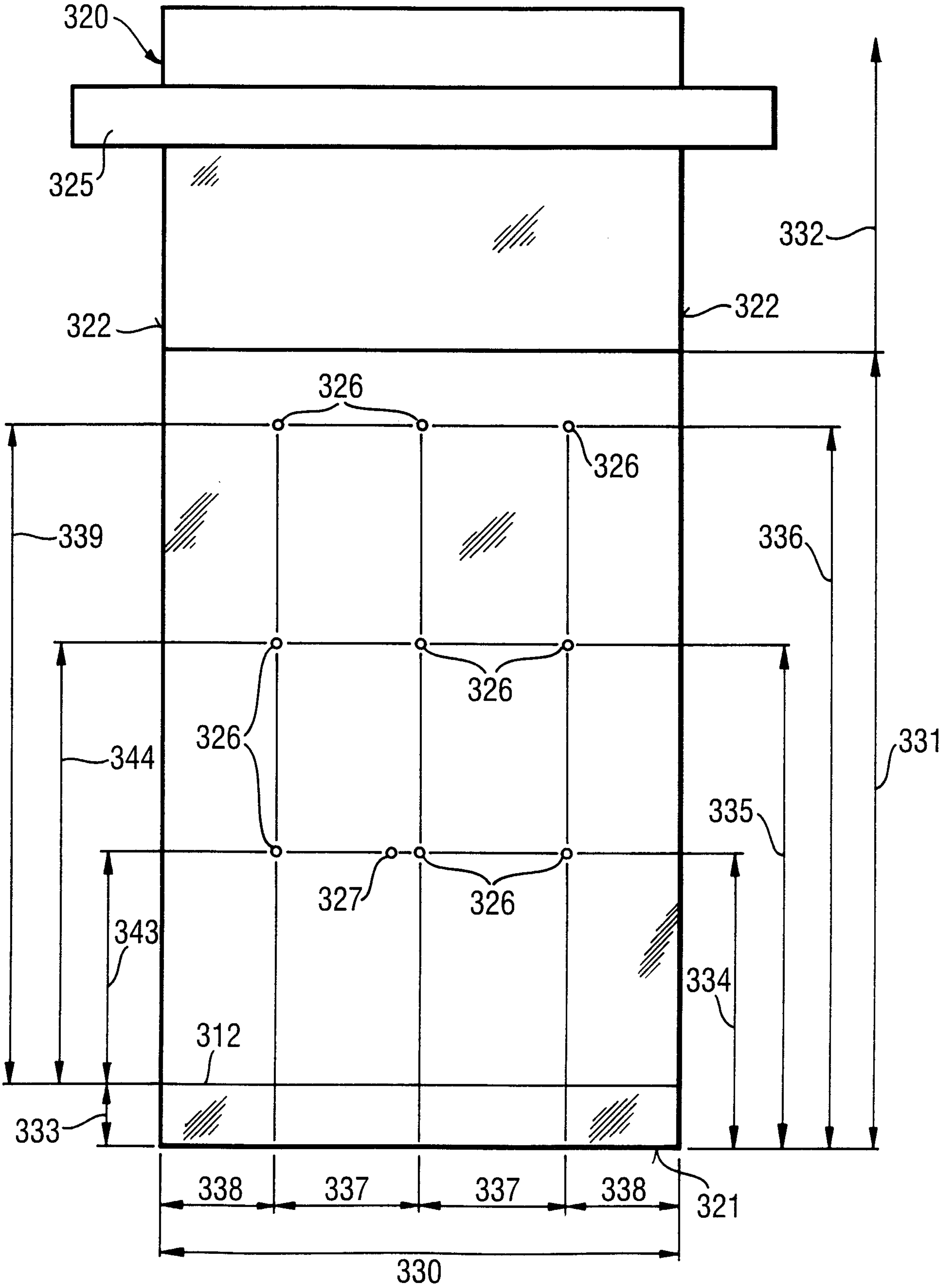


Fig. 3a

Fig. 3b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INTERNATIONAL SEARCH REPORT

rnational Application No
PCT/US 98/05043

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61F13/15

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)
IPC 6 A61F A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, 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	EP 0 809 991 A (PROCTER & GAMBLE) 3 December 1997 see the whole document	1-25,34
Y	US 5 387 207 A (DYER JOHN C ET AL) 7 February 1995 cited in the application see column 29, line 59 - column 31, line 26; figures	1-25,31, 34
Y	US 5 650 222 A (DESMARAIS THOMAS ALLEN ET AL) 22 July 1997 cited in the application see page 23, line 4 - line 43; figures see column 31, line 20 - column 32, line 34	1-25,31, 34

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search 4 November 1998	Date of mailing of the international search report 12/11/1998
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Mirza, A

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 96 21681 A (PROCTER & GAMBLE) 18 July 1996 see claims; figures	1-15, 20-22, 24,25, 31,34
A	WO 97 23184 A (KIMBERLY CLARK CO) 3 July 1997 see claims; tables	1,13,14, 16,31,34
A	US 5 147 345 A (YOUNG GERALD A ET AL) 15 September 1992 see abstract; figures 3,4 see column 3, line 48 - line 52	1-17, 31-34
A	WO 95 17869 A (MOELNLYCKE AB ;GUIDOTTI TED (SE); STEGER CHRISTINA (SE); WIDLUND U) 6 July 1995 see abstract; figures	31-34

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

national Application No

PCT/US 98/05043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0809991 A	03-12-1997	AU 3065097 A	05-01-1998
		AU 3147097 A	05-01-1998
		WO 9745085 A	04-12-1997
		WO 9745087 A	04-12-1997
US 5387207 A	07-02-1995	US 5260345 A	09-11-1993
		US 5352711 A	04-10-1994
		US 5198472 A	30-03-1993
		US 5149720 A	22-09-1992
		US 5318554 A	07-06-1994
		US 5147345 A	15-09-1992
		AU 693773 B	09-07-1998
		AU 5680394 A	04-07-1994
		CA 2151279 A	23-06-1994
		CN 1090863 A	17-08-1994
		CZ 9501402 A	17-01-1996
		EP 0673393 A	27-09-1995
		FI 952854 A	09-06-1995
		HU 75859 A	28-05-1997
		JP 8504474 T	14-05-1996
		MX 9307847 A	29-07-1994
		NO 952055 A	24-05-1995
		NZ 258765 A	22-08-1997
		WO 9413704 A	23-06-1994
		US 5652194 A	29-07-1997
		US 5649920 A	22-07-1997
		AU 671955 B	19-09-1996
		AU 2485692 A	16-03-1993
		BR 9206361 A	01-03-1995
		CA 2114524 A,C	04-03-1993
		CN 1071437 A	28-04-1993
		CZ 9400302 A	13-07-1994
		EG 19702 A	31-10-1995
		EP 0598062 A	25-05-1994
		FI 940652 A	14-03-1994
		HU 68794 A	28-07-1995
		JP 6509834 T	02-11-1994
		MX 9204673 A	01-03-1993
		NO 940454 A	12-04-1994
		NZ 243907 A	26-09-1995

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/05043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5387207 A		PL 171302 B	28-03-1997
		PT 100772 A	30-09-1993
		SK 15494 A	05-10-1994
		US 5292777 A	08-03-1994
		WO 9304115 A	04-03-1993
		AT 159730 T	15-11-1997
		AU 670244 B	11-07-1996
		AU 2475592 A	16-03-1993
		BR 9206375 A	30-05-1995
		CA 2114958 A,C	04-03-1993
		CN 1070922 A	14-04-1993
		CN 1168292 A	24-12-1997
		CZ 9400304 A	13-07-1994
		DE 69222945 D	04-12-1997
		DE 69222945 T	12-03-1998
US 5650222 A	22-07-1997	US 5741581 A	21-04-1998
		US 5744506 A	28-04-1998
		AU 4895796 A	31-07-1996
		BR 9606740 A	30-12-1997
		CA 2209928 A	18-07-1996
		CN 1175959 A	11-03-1998
		CZ 9702127 A	17-12-1997
		EP 0802929 A	29-10-1997
		FI 972913 A	09-09-1997
		NO 973183 A	10-09-1997
		WO 9621680 A	18-07-1996
WO 9621681 A	18-07-1996	US 5563179 A	08-10-1996
		AU 4694296 A	31-07-1996
		BR 9606741 A	30-12-1997
		CA 2208506 A	18-07-1996
		CZ 9702182 A	12-11-1997
		EP 0802927 A	29-10-1997
		FI 972915 A	09-09-1997
		HU 9800548 A	28-07-1998
		NO 973185 A	10-09-1997
		US 5632737 A	27-05-1997
		US 5786395 A	28-07-1998
		ZA 9600138 A	16-07-1996

INTERNATIONAL SEARCH REPORT

Information on patent family members

I. national Application No
PCT/US 98/05043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9723184 A	03-07-1997	AU 1337597 A	17-07-1997
		AU 5511098 A	15-07-1998
		WO 9826742 A	25-06-1998
US 5147345 A	15-09-1992	AT 149824 T	15-03-1997
		AU 669667 B	20-06-1996
		AU 2460892 A	16-03-1993
		BR 9206373 A	25-04-1995
		CA 2114957 A	04-03-1993
		CN 1074110 A	14-07-1993
		CZ 9400303 A	13-07-1994
		DE 69218219 D	17-04-1997
		DE 69218219 T	10-07-1997
		DK 598823 T	21-04-1997
		EG 19687 A	31-10-1995
		EP 0598823 A	01-06-1994
		ES 2099831 T	01-06-1997
		FI 940650 A	11-02-1994
		GR 3022800 T	30-06-1997
		HU 71533 A	28-12-1995
		JP 6509729 T	02-11-1994
		MX 9204675 A	01-03-1993
		NO 940451 A	11-04-1994
		NZ 243904 A	26-09-1995
		PL 169450 B	31-07-1996
		PT 8582 U	31-05-1993
		PT 101751 A,B	31-01-1996
		SG 48921 A	18-05-1998
		SK 18194 A	07-12-1994
		TR 26574 A	15-03-1995
		WO 9303699 A	04-03-1993
		US 5652194 A	29-07-1997
		US 5649920 A	22-07-1997
		US 5318554 A	07-06-1994
		US 5387207 A	07-02-1995
WO 9517869 A	06-07-1995	SE 508400 C	05-10-1998
		AT 169813 T	15-09-1998
		AU 683338 B	06-11-1997
		AU 1395395 A	17-07-1995

INTERNATIONAL SEARCH REPORT

Information on patent family members

national Application No

PCT/US 98/05043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9517869 A		CA 2177382 A	06-07-1995
		CN 1142180 A	05-02-1997
		CZ 9601803 A	13-11-1996
		DE 69412640 D	24-09-1998
		EP 0737055 A	16-10-1996
		FI 962650 A	26-06-1996
		GB 2285930 A,B	02-08-1995
		HU 76776 A	28-11-1997
		JP 9507135 T	22-07-1997
		NO 962498 A	13-06-1996
		NZ 278464 A	24-11-1997
		PL 315159 A	14-10-1996
		SE 9304320 A	30-06-1995
		SK 82396 A	06-08-1997
		ZA 9410358 A	05-09-1995