United States Patent

Kozak

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[54] **DISPOSABLE ABSORBENT ARTICLES**

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[22] Filed: **Dec. 4, 1972**

[21] Appl. No.: **312,131**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 73,185, Sept. 17, 1970, abandoned.

[52] **U.S. Cl.** **128/287**, 128/156, 128/296
[51] **Int. Cl.** **A41b 13/02**
[58] **Field of Search** ..... 128/156, 284, 286, 287, 128/290 W, 296

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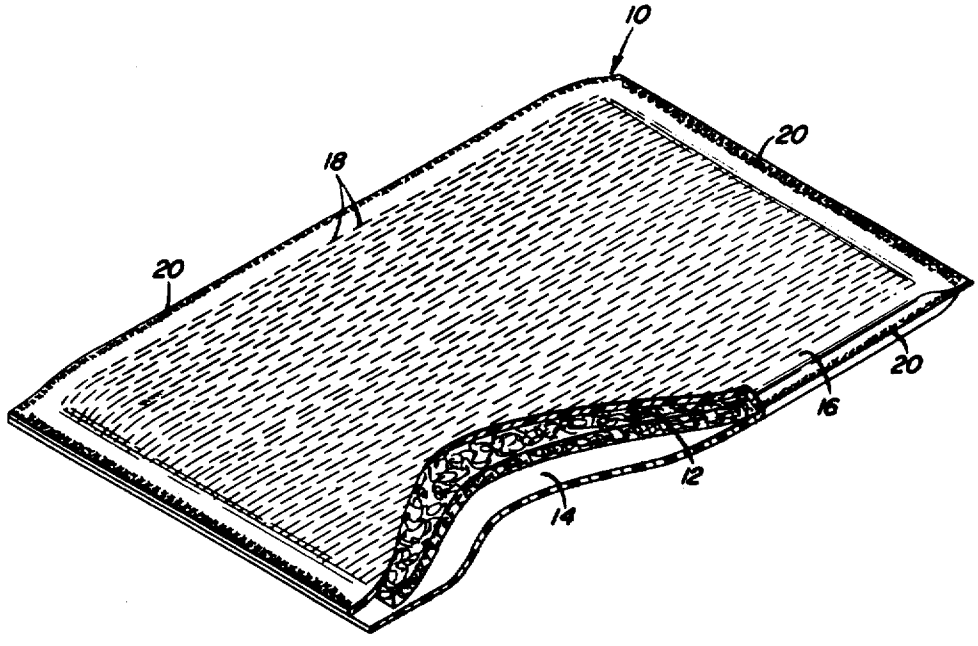
[57] **ABSTRACT**

Disposable absorbent articles are disclosed which include a topsheet of non-fibrous hydrophobic film having a plurality of valvular openings therein and a system of depressed areas disposed across the surface of the topsheet. The openings readily permit flow of liquid in the direction of the absorbent but substantially reduce the possibility of flow in the opposite direction.

59 Claims, 6 Drawing Figures



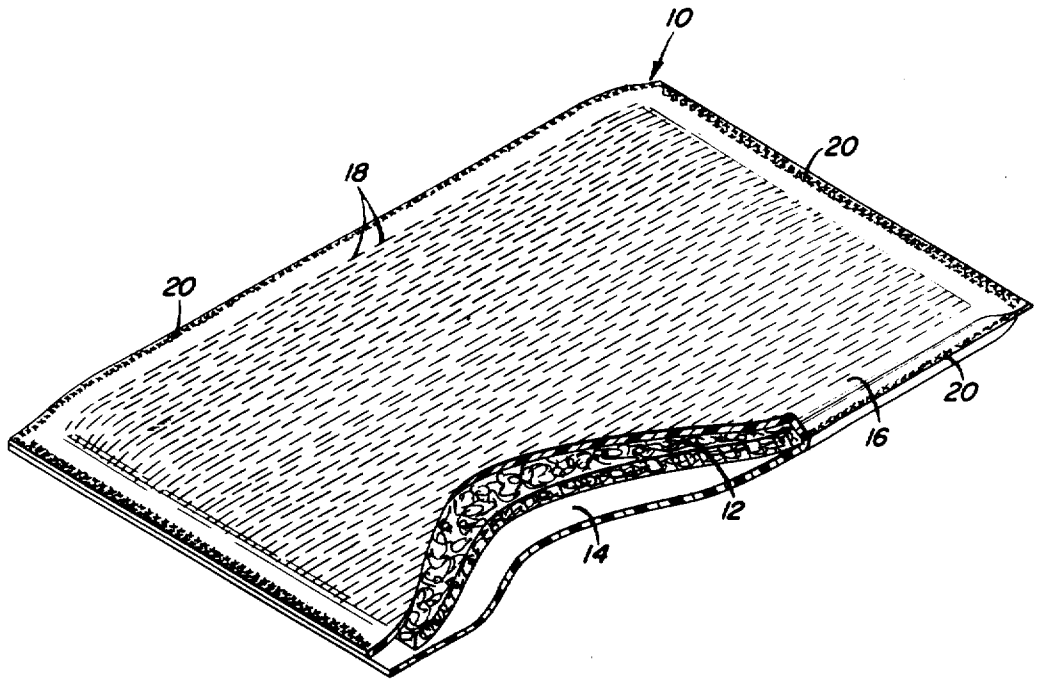


FIG. 1

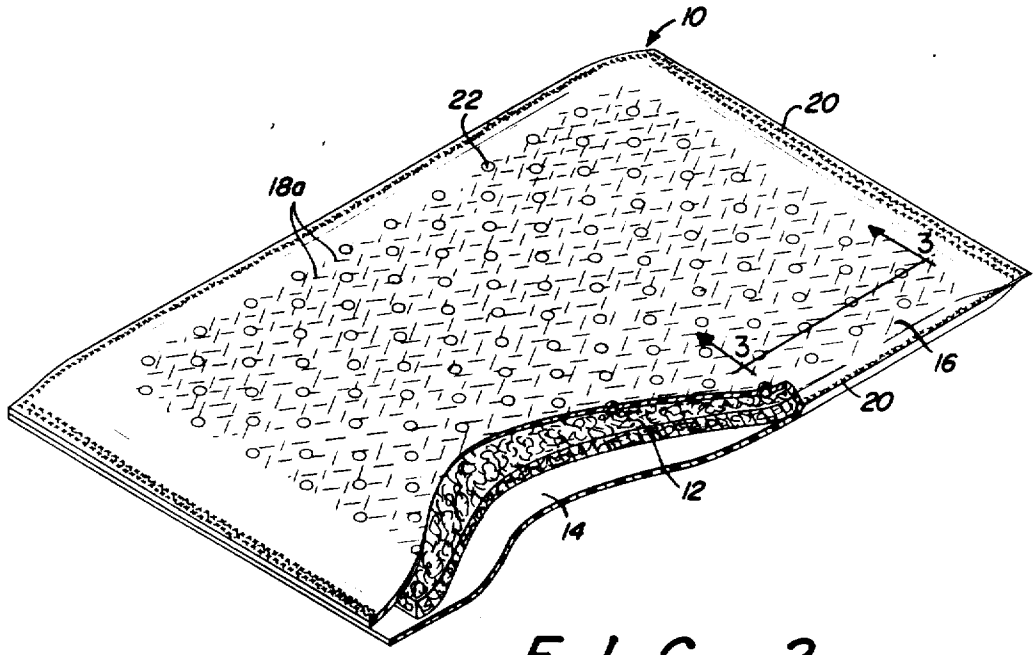
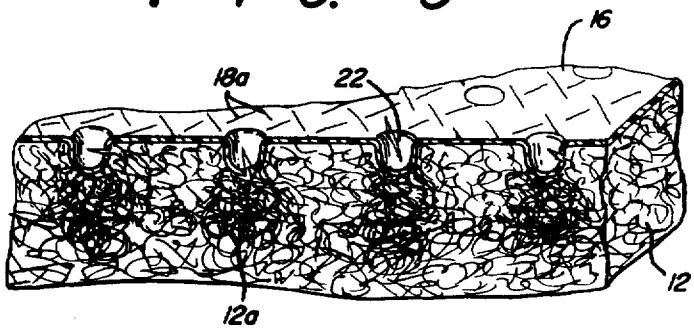


FIG. 2

FIG. 3



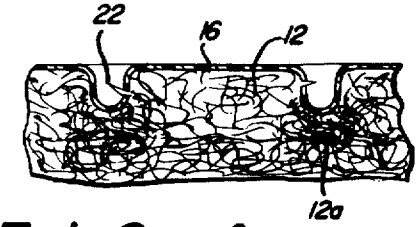


FIG. 4

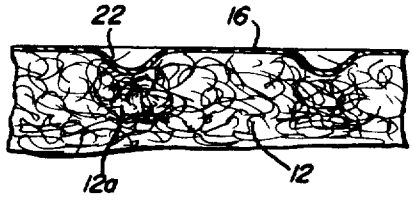


FIG. 5

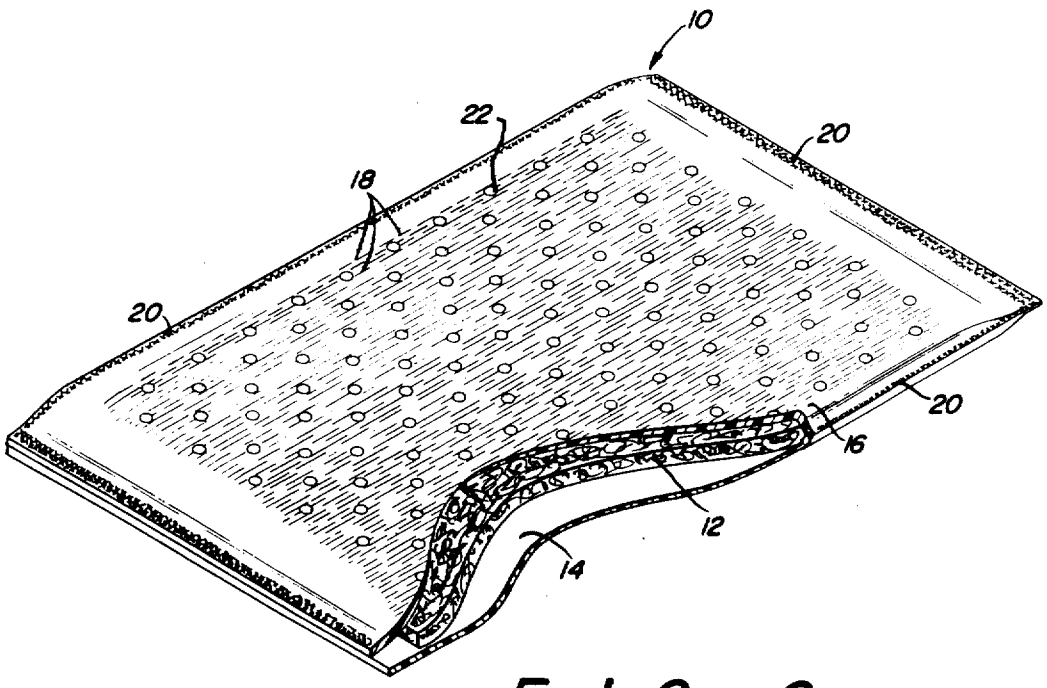


FIG. 6

DISPOSABLE ABSORBENT ARTICLES

This application is a continuation-in-part of copending application, Ser. No. 73,185 filed Sept. 17, 1970 and now abandoned.

This invention relates to disposable articles and more particularly relates to disposable absorbent articles such as diapers, incontinency pads and the like.

The use of disposable absorbent articles of the kind mentioned above has greatly increased in recent years due to their ease of use, low cost and the obvious sanitary value of having a clean, fresh, disposable absorbent article for use without the inconvenience of having to wash and reuse a previously used nondisposable article. The advantages of using disposable absorbent articles are particularly apparent in the widespread acceptance of disposable diapers as a replacement for the cloth diapers which have traditionally been used.

In addition to the advantages set forth above for disposable absorbent articles many of these articles include, as an integral part of their structure, a liquid impermeable backing sheet which offers other advantages in use. For example, disposable diapers which include such a backing sheet obviate the necessity of using rubber pants on the baby to prevent leakage through the diaper and consequently wetting of the baby's clothing.

The present invention will be described in detail with reference to a disposable diaper, but it will be obvious to those skilled in the art that the teachings are applicable to other disposable absorbent articles such as incontinency pads and the like.

In its most fundamental construction a disposable diaper merely comprises a layer of disposable absorbent material lining a backing sheet of liquid impermeable material which may be disposable or reusable. The thickness of the layer of absorbent material can be varied depending upon the desired use. For example, if the diaper were to be used overnight for an older baby it would be required to have a greater absorptive capacity than one used for a short time during the day or for an infant and consequently the absorbent layer would be thicker. The length and width of the diaper can also be varied for different size babies. Generally, the absorbent pad will be about one-eighth to one-half inch thick and the diaper will have a length of about 12 to 18 inches and a width of about 8 to 16 inches.

While a baby diaper constructed in this manner supplies the essential ingredients of a disposable diaper, namely an absorbent layer and a liquid impermeable backing sheet, modifications have previously been proposed to overcome one or more of the defects inherent in the basic construction. It was found, for example, that when the absorbent layer became soaked with urine it tended to wad together or lost most of its integral strength and began to shred.

In order to overcome these disadvantages it has been common to place a layer of non-woven, gauze, or other material which will maintain its integrity after wetting on top of the absorbent layer of the diaper thereby sandwiching the absorbent layer between a topsheet of self-supporting but liquid permeable material and a backing sheet of liquid impermeable material. Such a construction overcame the disadvantages of shredding but tended to make the baby uncomfortable after wetting since the urine would partially be absorbed by the topsheet which was against the skin of the baby. This contact of the baby's skin with urine on the surface of

the diaper is one of the principal causes of diaper-derived skin rash. Additionally, upon removal of a wet diaper, it was found that the baby's skin was wet and drying was necessary before a clean diaper could be applied.

In an attempt to overcome this deficiency it has been suggested that the topsheet be made hydrophobic or water-shedding to maintain the layer which is in contact with the baby's skin as dry as possible. This has been accomplished by forming the topsheet of the diaper in part or completely of hydrophobic fibers or by coating or impregnating an otherwise hydrophilic topsheet with a hydrophobic resin.

This procedure has not been completely satisfactory since the topsheet of the diaper, whether it be a woven or nonwoven material, will contain spaces between its fibers which are continually open to the passage of liquid in both directions. The spaces are necessary to allow urine to pass from the baby to the absorbent layer of the diaper. When the diaper has reached its maximum capacity or when pressure is applied to the absorbent layer, for example by the baby sitting in the wet diaper, the absorbent layer acts much like a sponge which has been fully saturated or compressed and exudes urine to its surface where it can pass through the openings in the topsheet and contact the skin of the baby.

It is an object of this invention to provide a disposable absorbent article, such as a disposable diaper, having a topsheet which will readily permit flow of liquid in the direction of the absorbent layer but which substantially reduces the possibility of flow in the opposite direction. This and other objects will readily become apparent to those skilled in the art in light of the teachings herein set forth.

In its broad aspect, the disposable absorbent articles of this invention are comprised of, in combination, at least one absorbent pad and a topsheet adjacent to said pad and having a plurality of valvular openings therein. The topsheet is preferably formed from a non-fibrous hydrophobic film such as thermoplastic film having a plurality of valvular apertures therein.

The invention will be described in detail with reference to the accompanying drawings in which:

FIG. 1 is a plan view, partially cut away, of a disposable diaper according to one embodiment of the invention;

FIG. 2 is a plan view, partially cut away of a disposable diaper according to another and preferred embodiment of the invention;

FIG. 3 is a section taken along the line 3—3 of FIG. 2.

FIG. 4 is an enlarged fragmentary cross-section of FIG. 3 showing a section of the absorbent article during unsaturation.

FIG. 5 is a view similar to FIG. 4 except that the absorbent article is saturated with liquid.

FIG. 6 is a plan view, partially cut away of a disposable diaper according to a further, but less preferred embodiment of the present invention.

Referring in detail to FIG. 1 there is shown a disposable diaper, generally designated **10**, comprising a rectangular absorbent pad **12** substantially centrally located and sandwiched between a thin, flexible backing sheet **14** of liquid impermeable material, such as polyethylene film, and a thin flexible topsheet **16** also of a normally liquid impermeable material. Topsheet **16** has

a plurality of slits **18** therein which slits will be described in greater detail hereinafter.

Backing sheet **14** and topsheet **16** are of approximately equal size and are of a length and width slightly greater than the corresponding dimensions of absorbent pad **12**. The edges of backing sheet **14** and topsheet **16** are sealed to each other around the entire periphery of the diaper and just outside the outermost edges of absorbent pad **12**. The sealing can be accomplished by any convenient means, such as the use of an adhesive, but heat sealing is preferred and is indicated by heat seal **20** around the periphery of the diaper.

The absorbent pad **12** is a plurality of layers of absorbent tissue paper or wadding stacked to the desired thickness. The wadding layers need not be adhered to each other but, since it has been common practice to adhesively, mechanically, or otherwise secure the layers to each other to maintain the relative position of the layers and the shape of the absorbent pad, such can also be done in the diaper of the present invention. The wadding can be stacked to form a pad of any desired thickness and hence absorbency can be controlled for any particular use. For example, in conventional disposable diaper constructions designed for use during the day it has been common to stack the absorbent wadding to a thickness of about one-eighth inch using generally from about 5 to 10 layers of wadding. For special uses, for example, as an overnight diaper, it may be desired to have a thicker and more absorbent pad-,and a thickness of about one-fourth inch, using about 10 to 20 layers of wadding, would usually be sufficient.

Absorbent materials other than tissue and wadding will of course be useful in the diaper construction of the present invention. For example, absorbent non-woven pads can be fabricated to any desired thickness and substituted for the absorbent pads described above. One such absorbent pad which has been used extensively in disposable diapers is a wood pulp product commonly known as wood fluff and is prepared in the same manner as a non-woven fabric.

The only criteria for utility in the present invention are that the material be absorbent, be capable of being fabricated in the form of a pad, be compatible with the waste products with which it will come in contact and be non-irritating to the skin.

Various natural and synthetic polymeric materials are themselves absorbent or can be made absorbent and will therefore be useful as, or in combination with, the absorbent pad of the present invention. One group of polymers which are particularly preferred are insoluble hydrophilic homopolymers and copolymers which form a gel upon absorption of water. These materials offer the obvious advantage of holding tenaciously to liquid and preventing the release of liquid from the absorbent article and leaking or wetting skin or clothing with which the absorbent article is in contact.

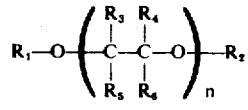
In practice, the materials which have been found particularly useful are insoluble hydrophilic polymers prepared from the following starting materials: poly(alkylene oxides), e.g. poly(ethylene oxide), polyvinyl alcohol, polyvinylmethyl ether, copolymers of maleic anhydride and ethylene, copolymers of maleic anhydride and vinylmethyl ether, polyelectrolytes, etc.

Insoluble hydrophilic polymers, sometimes referred to as "hydrogels," are especially useful in the present invention because they possess the ability to consume very large amounts of water in the order of 25 to 100 times their dry weight.

The term "insoluble" or "insolubilization" as employed in relation to these polymers is intended to define the formation of a gel which does not flow and does not expel water under the pressures encountered in the use of products described above.

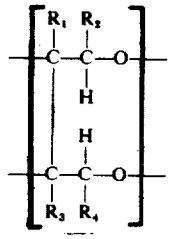
The insolubilization can be effected by a wide variety of methods and includes, but is not limited to, ionizing and nonionizing radiation and chemical cross-linking through covalent and ionic bonding.

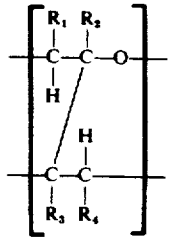
A particular preferred hydrogel for use in the articles of this invention is comprised of at least one hydrophilic polymer of the formula



which has been cross-linked and wherein R_1 and R_2 are selected from the group consisting of hydrogen, alkyl radicals and alkyl substituted aryl radicals, and whereby R_3—R_6 are selected from the group consisting of hydrogen, methyl, phenyl and vinyl radicals, and n is greater than one.

The hydrogels are polymeric compounds containing at least one of the structural units shown below:





wherein R_1—R_4 are selected from the group consisting of hydrogen, methyl, phenyl and vinyl radicals.

These hydrophilic polymers may include carbon-to-carbon cross-linking between straight chain carbon atoms and the carbon atoms of branch chain methyl groups and in addition a very minor and insignificant number of bonds may include two oxygen atoms linking the carbon atoms.

The polymeric gel compounds may contain cross-linking bonds present as inter-molecular bonds (e.g. between two different molecules) and intramolecular bonds (e.g. between carbon atoms of the same mole-

cule), and combinations of intra and intermolecular cross-linking bonds.

The hydrogels can be used in the diaper constructions of the present invention either in the form of thin transparent sheets disposed between or in place of wadding layers of the absorbent pad or can be embedded in the fibers of the absorbent pad as a powder or in shredded form. The manner in which the materials are incorporated into the pad is not critical since it is merely necessary to have the polymers come in contact with the liquid which penetrates the topsheet of the absorbent article.

The materials used in the fabrication of the topsheet and backing sheet of the absorbent articles of the present invention are also not limited to any particular chemical composition since it is their physical properties rather than their chemical properties which are important in the articles of the invention. These materials should, of course, be thin, flexible, self-supporting, and substantially water impermeable films. Preferably they are thermoplastic materials which are capable of being heat sealed to each other.

The backing sheet is preferably an olefinic or vinyl film. Polyethylene of a thickness of from about 0.4 to about 1.5 mils is most preferred. This type of film has previously been used extensively for this purpose and commonly has had an embossed design in its surface to simulate the appearance and hand of cloth. These manufacturing techniques will also find use in the absorbent articles of the present invention.

Any film which is useful as a backing sheet will also be useful as a topsheet for the disposable absorbent articles of the invention. It is preferable, however, to use a film for the topsheet which resembles cloth more closely in feel and appearance since it is this portion of the article which will come in contact with the skin of the user. One film which has been found particularly useful is ethylene-ethyl acrylate film. This copolymer is cloth-like, softer and stronger after slitting than polyethylene film. The film should have a thickness of from about 0.4 to about 2.0 mils with about 1.0 to 1.5 mils being preferred.

As described above, the topsheet is made from a substantially liquid impermeable film and must be provided with valvular openings to be effective in the absorbent articles of the present invention.

The term "valvular" as used throughout the specification and in the claims is intended to refer to apertures in the topsheet which are capable of opening to permit passage of liquid under certain circumstances and reclosing to retard passage of liquid under certain other circumstances. When open, the valvular openings should have the ability to pass at least 20 milliliters of liquid within 10 seconds when an area of about 20 square inches is wetted. These openings may be of two basic types, substantially straight slits and punctures.

The slits useful in the present invention must be substantially straight since, if they are curved, V-shaped or of any other configuration, they will form flaps in the surface of the film which are too easily opened and tend to remain open. Such slits, while permitting sufficient passage of liquid in the direction of the absorbent pad, do not act to substantially reduce backflow of liquid, which is the primary object of the present invention. This advantage is also present if holes are formed in the film by removing pieces of film material as opposed to puncturing the film without removal of film material. The film is thereby left open to the uncontrolled passage of liquid in both directions.

It has previously been suggested (see U.S. Pat. No. 2,877,765 and U.S. Pat. No. 3,399,672) to incorporate curved slits in the layer of a surgical dressing or bandage which is applied adjacent to the skin to permit easy removal of the dressing from the skin. It was found, however, for that particular use, that straight-sided slits were inoperative. Conversely, it has been found that, while straight-sided slits perform excellently and unexpectedly in topsheets for disposable diapers, curved slits are unsuitable for such use. This disparity in the performance of straight versus curved slits can probably best be explained by the different functions to be performed by the slits in each application.

In surgical dressings, for example, the topsheet must be permeable to liquid draining from a wound usually slowly over a long period of time. Backflow from the dressing is not a problem since the absorbent layer has ample time to distribute the liquid by wicking and no pool of liquid is formed at the interface between the absorbent layer and the topsheet.

In a disposable diaper a quite different method of operation is encountered. Rather than a slow steady flow, before bladder control is obtained, babies urinate from 5 to as many as 30 or 40 times a day and average about 10 times a day with about 40 grams of urine per urination. There are, therefore, intermittent floods of liquid contacting the topsheet of the diaper. The topsheet must quickly pass this liquid through to the absorbent layer and prevent backflow to a degree sufficient to permit the liquid to be absorbed. This task becomes increasingly more difficult after the second and subsequent urinations since the absorptive capacity of the absorbent layers is substantially reduced. In addition, as a baby sits in a wet diaper it releases liquid to the surface of the absorbent pad where it will pass through the topsheet and contact the baby's skin unless the openings in the topsheet act to prevent this backflow.

As will be demonstrated hereinafter, curved slits permit adequate drainage of liquid in the direction of the absorbent layer but do not prevent backflow to a degree sufficient to allow their use in an improved construction.

The appended drawing shows a preferred topsheet construction wherein the topsheet **16** contains a plurality of straight slits **18** arranged in staggered parallel rows along the surface of the topsheet. This construction is preferred since it yields a topsheet which is strong and yet permits maximum passage of liquid.

To be efficient, the topsheet should contain from about 10 to 1,000 valvular openings per square inch of film. When slits are used, they should each be from about 0.030 to about 0.5 inch in length. Preferably there are from about 30 to about 150 slits per square inch, each of such slits being from about 0.07 to about 0.2 inch in length. The most preferred film contains about 50 slits per square inch, each about 0.1 inch in length.

The slits enable the topsheet of the absorbent article to act as a kind of one-way valve to the flow of liquid. For example, in the case of a disposable diaper, the motion of the baby within the diaper, such as by walking or sitting, will cause the slits to open and close continually. When the baby wets, the urine will contact the topsheet of the diaper and any motion on the part of

the baby will cause numerous slits to open and allow the urine to drain through to the absorbent pad below. Even without motion on the part of the baby a number of slits will be open to the passage of liquid due to the contour of the diaper around the baby's bottom. Only minimum contact of liquid with absorbent is necessary. Once contact has been made and drainage has begun, a kind of siphon action is initiated which will cause substantially all of the urine to drain through the topsheet and into the absorbent pad. After the urine has drained through the slits, the outer surface of the topsheet will be almost dry due to its hydrophobic nature.

Passage of the urine back through the slits from the absorbent pad will be retarded since there will not be a pool of liquid in contact with the underside of the topsheet to flow back through the slits as they are opened and closed by motion of the baby. An effective barrier preventing the return of the urine to contact with the skin of the baby is thereby established and the outermost portion of the topsheet which contacts the baby's skin is kept relatively dry.

The valvular openings can be formed in the topsheet in a number of ways. The easiest involves the use of a roller having a number of razor edges protruding therefrom across the width of the roller and around its circumference. The cutting edges can be spaced as desired on the roller and, if the portion protruding from the roller is triangular in shape, the length of the slit made in the film can be controlled by limiting the depth to which the blade pierces the film. A resilient backup roller can be provided to assist the piercing of the film which is fed between the slitting roller and the backup roller. If desired, portions of the topsheet may be retained in their unpierced condition. This might be accomplished, for example, along a strip about one inch around the periphery of the topsheet. Such a strip would act as an additional safeguard against leakage at the edges of the diaper which might come into direct contact with the baby's clothing.

After the topsheet is slit, the assembly of the diaper follows, more or less, conventional methods of fabrication. The topsheet and backing sheet are cut to approximately the same dimensions which are equal to the desired size of the final diaper. The size can be varied according to the desired use, for example, in an infant's diaper a size of 10 × 14 inches might be sufficient whereas in a diaper for a large child a size of 12 × 16 inches would be better and a size of 14 × 18 inches might be preferred for a diaper which could accommodate a toddler.

The topsheet and backing sheet are juxtaposed one on the other with the absorbent pad sandwiched therebetween in approximately the center of the sheets. The absorbent pad should be of a length and width slightly smaller than the topsheet and backing sheet to permit sealing of the topsheet to the backing sheet around their periphery. An overhang of about one-half inch on each side should be sufficient. Sealing can conveniently be accomplished by heat sealing the edges. The heat sealing might also be used to simultaneously accomplish a cutting of the edges to trim excess sheet material from the diaper and yield a diaper structure which is neat in its appearance.

If desired, the absorbent pad may be of the same length as the topsheet and backing sheet and the top and bottom edges of the diaper may be left unsealed. Such a construction readily lends itself to mass production techniques since the diapers can be fabricated in a continuous line and cut to the desired length without the necessity of further finishing.

It has been found that the diaper can be assembled in the manner described above before the topsheet is slit and a rotary slitter can be used to cut the valvular openings in the topsheet of the finished diaper without damage to the backing sheet or loss of its liquid impermeability.

It will be obvious to those skilled in the art that applicant has disclosed a basic diaper construction which is adaptable to the inclusion of other materials for specific purposes. For example, it might be desired to add a perfume or deodorizer to the absorbent pad, to include baby powder or a soothing lotion on the outer surface of the topsheet, or to incorporate a germicidal agent somewhere in the diaper construction.

Moreover, it will be obvious to those skilled in the art that the above teaching, which is set forth in detail with respect to disposable baby diapers, will be equally applicable to similar disposable absorbent articles such as incontinency pads and the like. In each of these uses the construction of the absorbent article will be basically the same as that set forth for a diaper construction except that size, shape, and absorbency will be varied for the particular use. In addition, tabs, adhesives, or some other attachment means might suitably be included for the convenience of the wearer.

The following examples are merely illustrative of the present invention and are not intended to be limitative thereof.

EXAMPLE 1

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches × 16 inches ×3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by feeding it through the nip of a roller having a plurality of small blades spaced around its circumference in staggered parallel rows and a resilient backup roller. The perforating roller had a blade density of about 125 blades per square inch and the resulting perforated film had about 125 parallel slits per square inch each measuring about 0.1 inch in length.

The perforated film was cut to approximately 12¼ inches ×16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the two films were then heat sealed to each other with a bar sealer to complete the assembly procedure and the resulting disposable diaper functioned satisfactorily.

EXAMPLE 2

A disposable diaper was fabricated from a backing sheet of translucent polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil and a top sheet of translucent ethylene-ethyl acrylate film measuring about 12¼ inches × 16¼ inches × 1.25 mil. The absorbent pad was eight layers of absorbent wadding and measured about 12 inches × 16 inches × 3/16 inch. The three layers of the diaper were assembled and heat sealed in the manner set forth in Example 1 and the completed diaper

was run, topsheet side up under a rotary slitter. The blades of the slitter were set to pierce the topsheet and protrude partially into the absorbent pad but not to penetrate through the absorbent pad to contact the backing sheet. The slits formed were of the size and placement of those of Example 1 and the diaper performed as well as the diaper of Example 1.

EXAMPLE 3

A diaper was fabricated in the manner described in Example 2 except that the absorbent pad used was formed with about 2 grams of cross-linked powdered poly(ethylene oxide) sprinkled on 4 layers of wadding and covered with another 2 layers of wadding. The entire assembly was then used in the fabrication of the diaper.

The resulting diaper was thinner than the diaper of Example 2 yet had a greater absorptive capacity.

The following experiments were conducted to compare the performance of curved versus straight slits in the topsheet of a simulated diaper construction.

EXPERIMENT 1

A 5⅜ inch diameter circle of test film supported on a screen and covered by a 5⅜ inch diameter circle of absorbent was clamped between a 5⅜ inch diameter glass cylinder and a 5 inch diameter funnel leading to a graduate. A No. 13 rubber stopper was placed on top of the test film and 200 milliliters of water was quickly added to the glass cylinder. Times were recorded when the first drop of water was collected and when 100 milliliters had been collected.

Test films having about 45–48 slits per square inch and an average slit length of 0.10 inch were tested. When straight slits were tested, the first drop of water was collected in 2 seconds and 100 milliliters was collected in 14 seconds. When curved slits were tested the first drop was collected in 1 second and 100 milliliters was collected in 3 seconds.

The results of this comparison indicates that both straight and curved slits performed satisfactorily in passing liquid through an absorbent.

EXPERIMENT 2

The same glassware as in Experiment 1 was employed but the test procedure was modified to determine the backflow obtained with samples of test film identical to those of Experiment 1.

The film was placed across the top opening of the funnel such that it did not sag nor stretch open. A circle of wadding was placed over the film and the glass cylinder was clamped in place. One hundred milliliters of water was added to the cylinder and the times were recorded for collection of the first drop and 10 milliliters of water in the graduate.

The first drop through both straight slits and curved slits was collected in 1 second but curved slits collected 10 milliliters in 10 seconds whereas straight slits took 95 seconds to collect the same volume. Backflow for curved slits is therefore considerably faster than for straight slits and unsatisfactory for an improved diaper construction.

EXPERIMENT 3

Backflow was also measured for films having curved and straight slits of the same size and quantity as the films of Experiments 1 and 2 by wetting a 5 inch diameter absorbent pad with 30 milliliters of water covering the pad with the test film and covering the film with another dry absorbent pad of known weight and a 12 pound weight. After 2 seconds the dry pad was weighed to determine water pick-up.

The average backflow for curved slits was 5.1 grams while straight slits averaged only 3.0 grams, again indicating that straight slits would be more suitable for use in diaper constructions than curved slits.

As a control the experiment was also run with no film between the wet and dry pads and with a nonwoven having 50 per cent open spaces between the pads. Without any film between the pads 8.9 grams of water was picked-up while with the nonwoven 7.1 grams was absorbed.

As will be evident from the foregoing, the absorbent article described in connection with FIG. 1 solved many of the problems incident to prior art absorbent articles, particularly those problems associated with diapers, incontinency pads and the like.

Unfortunately, however, although the major problems of the conventional products were eliminated, nevertheless, the advantages of the novel absorbent articles were off-set, to a limited degree, by the creation of minor disadvantages which, although not as serious as the conventional problems, nevertheless served as a "stumbling-block" to the attainment of an absorbent article, particularly a baby diaper, which would have optimum characteristics of functional utility, dimensional (or relative) stability (including wet integrity), and consumer acceptance.

It should be remembered that the qualities or characteristics which render an absorbent article, e.g., a baby diaper, superior to any heretofore known are those characteristics which, among others:

a. permit (where a hydrophobic topsheet is employed) the necessary passage of urine through the openings of the hydrophobic sheet to the absorbent layer during a period of time such that the residence time, i.e., the time between urination and absorption, is below that which would cause discomfort, skin rashes, external leakage and the like,

b. substantially reduce the amount of urine exuding back through the openings of the hydrophobic sheet when the absorbent layer is wetted and compressed,

c. have dimensional or relative stability, and

d. have an aesthetic appearance, i.e., pleasing to the eye and touch.

The term "dimensional or relative stability" as it is employed in item (c) is intended to define the fixed relationship of the various constituents of the absorbent article. For example, where a baby diaper contains a topsheet and a backing sheet which sandwiches an absorbent material, it is advantageous that the absorbent material be fixed with respect to the topsheet or backing sheet so as to prevent "migration" of the absorbent material. An unfixed relationship would ultimately result in "bunching-up" or wadding of the absorbent particularly when a baby is sitting and moving in a wet diaper.

It is also intended that the term be used in connection with the wet integrity of the diaper, i.e., the ability of the constituents of the diaper to maintain their strength and resist shredding when wet.

Thus, although the absorbent article depicted in FIG. 1 is an improvement over the conventional absorbent

articles, with respect to one or more of the above qualities, nevertheless, as mentioned previously, certain draw-backs are encountered. For example, with respect to item (a), although the valvular openings in the topsheet have the ability to pass at least 20 milliliters of liquid within 10 seconds when an area of 20 square inches is wetted, the initial wicking time, i.e., the commencement of absorption of the liquid into the absorbent material is still not of optimum standards. Stated another way, the residence time of the liquid (urine in the case of diapers) prior to initiation of wicking is of a duration such that discomfort could result.

With respect to item (c) above, it has been found that the absorbent article depicted in FIG. **1**, does not have the dimensional or relative stability which would be characterized as significantly superior to conventional articles. This is probably atrributable to the fact that the absorbent material is sandwiched between the topsheet and the backing sheet in non-adhering relation thereto, and consequently, there is a tendency for the absorbent material to "migrate" or shift with respect to its relation to the edges of the top and backing sheets. In addition, the vertically aligned valvular openings (slits) although providing the proper valvular action as heretofore described, nevertheless are subject to "zippering," i.e., the tendency to tear from one vertically disposed slit to the other corresponding upper or lower disposed vertical slit.

With respect to item (d), I have found that aesthetic qualities of the absorbent article are not entirely satisfactory from a commercial standpoint since the topsheet upon visual observation, lacks a warm appearance.

Various techniques were tried in an effort to minimize or eliminate one or more of the disadvantages incident to the absorbent product depicted in FIG. **1**. Initially, in order to preserve the relative stability of the topsheet with respect to the absorbent material, I tried adhering the topsheet to the absorbent layer with an adhesive, but found however that improved dimensional stability is achieved at the sacrifice of absorption qualities and loss of a soft hand to the article. In order to eliminate the disadvantage of "zippering," the vertically aligned slits were eliminated and curved and V-shaped slits were substituted.

However, these design variations, substantiated previous observations that curved or V-shaped slits formed flaps in the surface of the topsheet which were too easily opened and which tended to remain open thereby permitting the liquid to exude back through them in contact with the skin.

Various other techniques were considered including, for example, needle punching the absorbent article to firmly fix the absorbent material with respect to its relation to the topsheet, but I found, however, that the additional cost of processing in addition to the contemplated loss of absorption and strength qualities created additional disadvantages that far outweighed the problems sought to be solved.

During the course of development, I tried a procedure whereby the topsheet was adhered to the absorbent layer at various points along the lower surface of the topsheet. The adhesion was accomplished by contacting the absorbent article with a roller containing a system of probes, and with the aid of heat and pressure, I was able to depress and soften the topsheet (which is thermoplastic) at the points of contact with the probes so that the fibers of the absorbent layer immediately below the probes intermingled with the softened depressed thermoplastic topsheet. Upon cooling of the thermoplastic material, the intermingled fibers became permanently embedded in the topsheet thereby reducing migration of the absorbent material.

As mentioned previously however, the absorption of liquid takes place through the valvular slits which must permit the passage of the liquid to the absorgent layer. It would appear obvious, therefore, that if the probes are to depress and soften the thermoplastic material sufficient to "embed" the absorbent fibers thereto, that any slits in contact with the probes would fuse thereby decreasing the openings through which the liquid can pass resulting in poor initial wicking and total absorption of the liquid. In other words it would appear again that the solution of one problem (dimensional stability) would be accomplished at the sacrifice of another quality (good absorption characteristics).

When the resultant absorbent material was analyzed with respect to absorption qualities, however, it was found surprisingly and contrary to normal expectations that the absorption and more significantly the wicking action was improved dramatically. It was indeed surprising to find that this technique would provide an absorbent article having outstanding absorption and wicking qualities since, as mentioned previously, it appears logical and obvious that if the thermoplastic material is to be selectively treated with a hot probe, in the manner described, that there would be a loss of absorption by fusion of those slits in contact with the hot probe. I am of course aware of the disclosure in U.S. Pat. No. 3,221,738 issued to G. E. Ekberg et al. on Dec. 7, 1965. The diaper according to the patent disclosure consists of a core of moisture-absorbing material, which is completely enclosed by a liquid-insulating, thin plastic foil, and its main feature is that the plastic foil on one of the core sides inside its confining edges is heat-treated in such a way that the liquid insulating property of the foil is completely or partially neutralized, so that liquid reaching the heat-treated foil surface is automatically sucked in through the foil and absorbed by the core. The method is further characterized in that the foil layer is heated by means of a number of heated metal bodies placed at a short distance from each other, so that the foil layer forms a net-like pattern of liquid-insulating foil.

According to the disclosure, therefore, liquid transfer is provided through the throughgoing pores formed by heating the foil layer in the manner described in the patent.

This teaching is diametrically opposed to what is desired by the instant invention. According to the instant invention the bulk of absorption of the liquid must be accomplished through the valvular slits as contrasted to absorption through the thermoplastic topsheet in the depressed areas. In this way, the valvular action (as previously explained and as will be more fully explained) will regulate the desired ingress of liquid. Thus, the depressed areas in the instant invention (hereinafter referred to as "dimples"), are for the purposes of providing dimensional stability, improving the aesthetic appearance of the material and as an aid in absorption in the manner as will be described with reference to the drawings.

Referring to FIG. **2** of the drawings where like parts are designated by like reference numerals (compared

to FIG. 1), the improved disposable diaper **10**, includes the rectangular absorbent pad **12**, the flexible backing sheet **14** of liquid impermeable material and the flexible topsheet **16** also of a normally liquid impermeable material. The techniques of fabrication, the properties, and the choice of the materials and characteristics of the improved diaper depicted in FIG. **2** are identical to the diaper depicted in FIG. **1** except for differences specifically provided for hereinafter. Situated across the surface of topsheet **16** is a system of valvular openings (slits), identified by reference numeral **18***a* and a system of depressed areas **22** (dimples). The slits **18***a* are arranged in longitudinal rows in a manner such that each row constitutes a longitudinal array of substantially parallel straight slits each angularly disposed with respect to the longitudinal axis of the row. Adjacent rows are similarly disposed except that the slits are arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in the adjacent alternate rows. The slits useful in the present invention must be substantially straight since, if they are curved, V-shaped or of any other configuration, they will form flaps in the surface of the film which are too easily opened and tend to remain opened. Moreover, the angular placement of the slits as described previously, prevents "zippering" thereby eliminating one of the major disadvantages of the absorbent articles depicted in FIG. **1**. The slits should each be from about 0.030 to about 0.25 inch in length. Preferably there are from about 30 to about 150 slits per square inch, each of such slits being from about 0.07 to about 0.2 inch in length. The most preferred film contains about 81 slits per square inch, each about 0.1 inch in length.

The slits can be formed according to the methods employed in connection with the absorbent diaper depicted in FIG. **1**. However, the preferred method for forming the slits in the topsheet according to the present invention is described in the co-pending application, Ser. No. 190,908 filed Oct. 20, 1971 and entitled "Method and Apparatus for Piercing Thin Sheet Material." Briefly, there is disclosed therein a method and apparatus for piercing thin sheet material, such as plastic film, wherein the sheet material is passed between a piercing member having a plurality of independently resilient protrusions extending therefrom and a backing member having a retiform exterior surface. The piercing member or backup member is moved relative to the other member, thereby causing the resilient protrusions to follow the retiform surface and selectively pierce the film. The piercing member can be a metal comb, a wire brush or a metal strip having a plurality of substantially parallel slits extending from the edge thereof in the direction of the opposite edge defining the resilient protrusions. The backing member can be a wire screen, a perforated metal sheet, an engraved metal roll or an endless belt which is driven longitudinally with respect to the piercing member.

The depressed areas **22** (dimples) are distributed across the surface of the topsheet in the manner shown in FIGS. **2–5**. Thus, it will be seen that the topsheet **16** contains a plurality of dimples arranged in staggered parallel rows along the surface of the topsheet (FIG. **2**) and which extend below the plane of the topsheet (FIGS. **3** and **4**). The configuration of these dimples can be circular, eliptical, rectangular, diamond shaped, and the like, the important criteria being that they be formed in a manner such that there is substantially no breaking or cutting of the topsheet during or after fabrication.

I have found that the full advantages of the present invention are not achieved if, during fabrication of the dimples, the topsheet is broken, cut, or melted to an extent which would hinder the controlled passage of liquid to the absorbent pad (which as explained previously, is the function of the valvular openings). It will be evident that if cutting or breaking of the topsheet occurs during fabrication of the dimples, that the liquid will pass through these cuts or breaks when the absorbent pad is unsaturated and once the absorbent pad is saturated or even partially saturated, that these entry points will also serve as points or sites through which the liquid exudes back through the topsheet in contact with, for example, a baby's skin.

For these reasons and furthermore in view of the ease and simplicity of fabrication, I have found that the preferred form of the dimple is circular as shown in FIGS. **2–4**.

The dimples can be formed in the topsheet in a variety of ways. The easiest and therefore the most preferred method involves the use of a roller equipped with heating means and having a number of spikes or probes extending therefrom across the width of the roller and around its circumference. The spikes, pins, or probes, which have smooth, rounded end points, can be spaced as desired on the roller in order to provide the desired number of dimples to the absorbent article. The dimples are provided on the absorbent article preferably after the valvular openings, but prior to complete fabrication of the absorbent article, and this operation can be effected by passing the absorbent article containing the valvular openings in contact with the heated roller. In this technique, the absorbent pad is supported on a resilient back-up member, such as an endless conveyor belt, or a resilient back-up roller. The depth of the dimple can be controlled by limiting the depth to which the probes depress the film. If desired, portions of the topsheet may be retained in their untreated (without the dimples) condition. This can be accomplished, for example, along a strip about one inch wide near the periphery of the topsheet. Since the topsheet is thermoplastic, the amount of heat and pressure applied to the areas to be treated should be strictly controlled in order to avoid substantially puncturing the topsheet. As a general rule, the amount of heat required should be enough to soften the film, and the amount of pressure should be sufficient to plastically distort the film to the general contour of the probe. It will, of course, be understood that the current heat and pressure conditions will depend (among other variables) upon the residence time of the treated absorbent pad, i.e., the length of time the topsheet is in contact with the roller; the thickness of the absorbent pad, etc. The correct conditions, however, can be easily ascertained by one skilled in the art and hence no further detailed description of the conditions appears necessary.

Referring specifically to FIGS. **3** and **4**, it will be seen that the dimples **22** extend below the plane of the topsheet **16** a short distance, and that the absorbent material **12a**, immediately below the dimples, is in a compressed state. At the site where a dimple is formed over a portion of the slit **18***a*, it will be seen that the slit is opened to a much greater degree than corresponding

slits situated remote from the dimples **22.** However, because of the placement of the dimples, the slits disposed between corresponding dimples are opened to a greater extent than would be the case if no dimples were present. This is attributed to the fact that the pressure exerted on the surface of the topsheet by the dimples causes the slits to open slightly under the influence of the stretching of the topsheet. Portions of the compressed absorbent pad are associated with these opened slits, and because of this association, wicking is achieved at a degree never heretofore achieved. As a matter of fact, in most cases, wicking is instantaneous. As the liquid is transferred to the absorbent pad **12,** the absorbent pad absorbs the liquid throughout its entire area until either partial or full saturation. As will be seen in FIG. **5,** (which depicts a saturated absorbent pad), the compressed material **12**a has expanded and urges the dimple **22** upward, closer to the plane of the topsheet **16.** This action serves to close the previously opened slits, thereby trapping the bulk of the liquid in the absorbent pad.

Thus, advantageously, according to the present invention, maximum wicking and absorption is achieved during the critical period when flooding, (such as by urination and the like) is experienced, whereas transfer of the liquid from the absorbent pad back through the same slit opening is substantially reduced by virtue of the combination of the valvular action of the slit and the dimple.

The dimples can be arranged on the absorbent article in a variety of patterns. Thus, the overall design effect can be diamond shaped, curvilinear, herringbone and the like. The preferred design configuration is a system of substantially straight staggered, parallel rows along the surface of the topsheet. The number of dimples per square inch of absorbent pad area can be varied over a relatively wide range. Improvements have been noted utilizing as little as one dimple (having a diameter of 0.05 inch) per square inch of absorbent pad. I have further observed that good results are obtained when as many as 100 dimples (0.05 inch diameter) per square inch of absorbent pad area are utilized. It will of course be understood that the number of dimples per square inch of absorbent pad area depends on the dimple size. As a general rule, the total area occupied by dimples should not exceed more than 20 per cent of the area of the absorbent material. Excellent results are achieved when the total dimple area is from 4 to 12 per cent of the area of the absorbent material. Preferably there are from about 3 to about 25 dimples (0.10 inch diameter) per square inch of absorbent material area, and most preferably from about 6 to about 15 per square inch of absorbent pad area.

As a general rule, dimple size can be in the range of about 0.025 to about 0.250 inch diameter. From the standpoint of functional and aesthetic qualities, it is preferred that the dimple size range from about 0.075 to about 0.150 inch diameter.

In still another, but less preferred embodiment, the dimples are associated with the absorbent pad depicted in FIG. **1,** as shown in FIG. **6.**

Thus, referring to FIG. **6,** the slits **18** are substantially straight and arranged in staggered parallel rows, and are shown as being associated with dimples **22.** Although, according to this embodiment of the invention, improved wicking, dimensional stability and absorbency is obtained over conventional prior art material, the problem of "zippering," although improved substantially, is nevertheless not entirely eliminated.

In the following examples, a different test procedure than described with reference to Examples 1–3 was employed. According to the procedure employed in the following examples, a four inch inside diameter open cylinder is placed over a section of the absorbent article. 30 CC's of a liquid such as water, or a saline solution is poured into the cylinder and the time required for the 30 CC's of liquid (maintained at a temperature of 95°–100°F.) to be absorbed through the hydrophobic film is recorded.

EXAMPLE 4

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches × 16 inches × 3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by feeding it through the nip of a roller having a plurality of small blades spaced around its circumference in staggered parallel rows and a resilient backup roller. The perforating roller has a blade density of about 125 blades per square inch and the resulting perforated film had about 125 parallel slits per square inch each measuring about 0.1 inch in length.

The perforated film was cut to approximately 12¼ inches × 16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the sandwiched material were then heat sealed.

The assembly was then placed under the cylinder and tested for wicking characteristics. 30 cc's of liquid i.e., a saline solution comprising 0.3N-sodium chloride at body temperature (simulated urine) was poured into the cylinder. The liquid was fully absorbed through the top sheet and into the absorbent material in 74 seconds.

The topsheet was thereafter carefully removed and superimposed on an identical absorbent material and the edges were sealed.

The absorbent article was then passed in contact with a roller equipped with heating means and having about 10 pins per square inch extending across the width of the roller and around its circumference. The diameter of the pin was seven sixty-fourths inch and the endpoint of the pin had a spherical configuration of about 0.0547 inch radius. The absorbent article was supported by a resilient back-up roller. The pins were heated to a temperature of about 300°F. by a circulating hot oil system wherein the temperature of the oil was maintained at 350°F. The resultant absorbent product had about 10 dimples per square inch disposed along the topsheet of the absorbent article. The absorbent article was then tested for initial wicking and absorbency according to the procedure explained previously. The following results were obtained: The liquid was fully absorbed through the topsheet and into the absorbent material in 14 seconds.

EXAMPLE 5

This example demonstrates that without valvular openings little or no liquid passes through the dimples in the topsheet.

An absorbent article substantially identical to the one described in Example 4 was fabricated except that the slitting procedure was omitted. Thus, the absorbent article was identical to the article of Example 4 except that the topsheet did not contain the valvular openings (slits). The absorbent article was tested for water absorption according to the procedure of Example 4. After a period of 3 minutes, no discernible absorption of the liquid had been observed in the absorbent material. The liquid remained as a pool on the surface of the topsheet. Thus, substantially no liquid passed through the dimples of the topsheet.

EXAMPLE 6

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches × 16 inches × 3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by feeding it in contact with a reciprocating bar having a plurality of small blades spaced to an inch across the surface of the reciprocating bar. The resulting perforated film had about 72 parallel slits per square inch each measuring about 0.08 inch in length.

The perforated film was cut to approximately 12¼ inches × 16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the sandwiched material were then heat sealed.

The assembly was then placed under the 4 inch diameter cylinder and tested for absorption characteristics 30 cc's of liquid (simulated urine). The liquid was fully absorbed through the topsheet and into the absorbent pad in 57 seconds.

The topsheet was thereafter carefully removed and superimposed on an identical absorbent material and the edges were sealed.

The absorbent article was then passed in contact with a roller equipped with heating means and having about 10 pins per square inch extending across the width of the roller and around its circumference. The diameter of the pin was seven sixty-fourths inch and the endpoint of the pin had a spherical configuration of about 0.0547 inch radius. The absorbent article was supported by a resilient back-up roller. The pins were heated to a temperature of about 300° F. by a circulating hot oil system wherein the temperature of the oil was maintained at 350°F. The resultant absorbent product had about 10 dimples per square inch disposed along the topsheet of the absorbent article. The absorbent article was then tested for absorbency according to the procedure explained previously and the liquid was fully absorbed through the topsheet and into the absorbent material in 4 seconds.

EXAMPLE 7

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches × 16 inches × 3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by feeding it in contact with a reciprocating bar having a plurality of small blades spaced 8 to an inch across the surface of the reciprocating bar. The resulting perforated film had about 65 parallel slits per square inch each measuring about 0.1 inch in length.

The perforated film was cut to approximately 12¼ inches × 16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the sandwiched material were then heat sealed.

The assembly was then placed under the 4 inch diameter cylinder and tested for wicking characteristics. The liquid was fully absorbed through the topsheet and into the absorbent material in 36 seconds.

The topsheet was thereafter carefully removed and superimposed on an identical absorbent material and the edges were sealed.

The absorbent article was then passed in contact with a roller equipped with heating means and having about 10 pins per square inch extending across the width of the roller and around its circumference. The diameter of the pin was seven sixty-fourths inch, and the endpoint of the pin had a spherical configuration of about 0.0547 inch radius. The absorbent article was supported by a resilient back-up roller. The pins were heated to a temperature of about 300°F. by a circulating hot oil system wherein the temperature of the oil was maintained at 350°F. The resultant absorbent product had about 10 dimples per square inch disposed along the topsheet of the absorbent article. The absorbent article was then tested for absorbency according to the procedure explained previously and the liquid (simulated urine) was fully absorbed through the topsheet and into the absorbent material in 3 seconds.

EXAMPLE 8

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches × 16 inches × 3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by feeding it in contact with a reciprocating bar having a plurality of small blades spaced 9 to an inch across the surface of the reciprocating bar. The resulting perforated film had about 78 parallel slits per square inch each measuring about 0.07 inch in length.

The perforated film was cut to approximately 12¼ inches × 16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the sandwiched material were then heat sealed.

The assembly was then placed under the 4 inch diameter cylinder and tested for wicking characteristics. The liquid (simulated urine) was fully absorbed through the topsheet and into the absorbent material in 87 seconds.

The topsheet was thereafter carefully removed and superimposed on an identical absorbent material and the edges were sealed.

The absorbent article was then passed in contact with a roller equipped with heating means and having about 10 pins per square inch extending across the width of the roller and around its circumference. The diameter of the pin was seven sixty-fourths inch and the endpoint of the pin had a spherical configuration of about 0.0547 inch radius. The absorbent article was supported by a resilient back-up roller. The pins were heated to a temperature of about 300°F. by a circulating hot oil system wherein the temperature of the oil was maintained at 350°F. The resultant absorbent product had about 10 dimples per square inch disposed along the topsheet of the absorbent article. The absorbent article was then tested for absorbency according to the procedure explained previously and the liquid (simulated urine) was fully absorbed through the topsheet and into the absorbent material in 5 seconds.

EXAMPLE 9

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches × 16 inches ×3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by passing the film through the apparatus disclosed in co-pending application, Ser. No. 190,908 filed Oct. 20, 1971. The backing member was a 9 mesh wire screen and the piercing member was a metal comb. The resulting perforated film had the appearance as shown in FIG. 2 and contained 81 slits per square inch each measuring about 0.1 inch in length.

The perforated film was cut to approximately 12¼ inches × 16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the sandwiched material were then heat sealed.

The assembly was then placed under the cylinder and tested for absorbing characteristics. The liquid was fully absorbed through the topsheet and into the absorbent material in 4 seconds.

The topsheet was thereafter carefully removed and superimposed on an identical absorbent material and backsheet and the edges were sealed.

The absorbent article was then passed in contact with a roller equipped with heating means and having about 10 pins per square inch extending across the width of the roller and around its circumference. The diameter of the pin was seven sixty-fourths inch and the endpoint of the pin had a spherical configuration of about 0.0547 inch radius. The absorbent article was supported by a resilient back-up roller. The pins were heated to a temperature of about 300°F. by a circulating hot oil system. The resultant absorbent product had about 10 dimples per square inch disposed along the topsheet of the absorbent article. The absorbent article was then tested for absorbency according to the procedure explained previously. The following results were obtained: The liquid was fully absorbed through the topsheet and into the absorbent material in 3.2 seconds.

EXAMPLE 10

The procedure of Example 9 was repeated except that the size of the slits measured about 0.07 inch in length. All the other conditions remained the same. The results are as follows:

Time for Absorption

Before dimpling	After dimpling
80 seconds	3 seconds

The following examples 11–15 will demonstrate that the amount of absorbency in the baby diapers of the present invention is affected by the number of dimples per square inch of topsheet surface. In previous test procedures, the liquid was poured onto the fabricated diapers while the portion of the diaper treated with the liquid was in a horizontal position. In order to more closely simulate actual wicking characteristics while the diaper is worn by a baby, the following test procedure was devised:

The diapers to be tested were each placed and clamped to a 45 degree angled board. A separatory funnel with a delivery rate of 40 ml./30 seconds was placed above the board so that the tip of the funnel was one inch above the topsheet of the diaper. The funnel was adjusted so that liquid leaving the tip of the funnel would fall on the topsheet of the diaper and would travel an eleven inch linear path across the width of the diaper. The liquid was a water solution (0.3N NaCl) which was maintained at room temperature. The forty milliliters were emptied from the funnel over a 30 second period, and the amount of liquid run-off, i.e., the amount not absorbed by the diaper, was measured.

The diapers to be tested were fabricated from the same roll of wadding and the same roll of topsheet material (ethylene-ethyl acrylate). They were fabricated according to the technique described in Example 6 except that the number of dimples per square inch varied as indicated below:

Three runs under each example were conducted (using separate diapers), and the average of the results are indicated in Table I.

TABLE I

Water Delivery Speed Test

Example	Dimples per square inch	Amount of water run-off (milliliters)
11	0	31
12	2.5	6
13	4.9	2
14	7.2	0
15	9.8	0

The procedure of Examples 16–20 is identical to the procedure of Examples 11–15 except that the angle of the board was adjusted to 60 degrees. The results are indicated in Table II below:

TABLE II

Water Delivery Speed Test

Example	Dimples per square inch	Amount of water run-off (milliliters)
16	0	33
17	2.5	10.8
18	4.9	4.3
19	7.2	0
20	9.8	0

The following Example 21 demonstrates the increase of wet integrity strength of a diaper which has been dimpled according to the present invention. A wood pulp fluff was used as the absorbent pad since the fluff

is more drastically effected by loss of wet integrity strength than wadding.

The test procedure was as follows:

A test apparatus was employed wherein a 4 by 4 inch sample of the composite pad, as prepared for test by wetting with 2 times its dry weight with water and allowing it to sit or equilibrate for 1 minute, was restrained in compression between two annular, flat metal rings of aluminum with an internal opening diameter of 3.5 inches. The bottom center of the 3.5 inch diameter sample thus restrained rested on a 1.5 inch diameter first plate covered with one-sixteenth inch polyurethane foam. A second 1 inch diameter plate covered with one-sixteenth polyurethane foam was centered and pressed down on the top of the sample, disposed on the first or bottom plate, with a pressure of 12.7 lb. per sq. in. and the test sample was additionally wetted with 2 times its dry weight of water and allowed to equilibrate for 1 minute. The first plate, pressing on the bottom surface of the sample under test, was free to rotate in the plane of the sample while the second plate pressing against the top surface was articulated so that it could be rotated within an arc of 45° at a frequency of 55 times per minute. The rotary movement of the first and second plates tended to tear out the restrained test sample in a circle around the articulated 1 inch diameter central pressure plate. A test period in this simulated test with the described rotary articulation was 4 minutes, and the test results were recorded as tear grades from 0 to 3 by inspection, with tear grades greater than 1 equated to unsatisfactory performance in actual use. The tear grades assigned to the individual test samples had the following meanings:

Tear grade 1 — tearing in less than a total of 10° around the compressed area

Tear grade 2 — tearing in a total of 10° to 90° around the compressed area

Tear grade 3 — tearing greater than a total of 90° around the compressed area

EXAMPLE 21

An absorbent pad consisting of 30 grams of cellulose of which 22 grams were wood pulp fluff and measuring approximately 12 inches × 16 inches × 3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12¼ inches × 16¼ inches × 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by passing the film through the apparatus disclosed in co-pending application, Ser. No. 190,908 filed Oct. 20, 1971. The backing member was a 9 mesh wire screen and the piercing member was a metal comb. The resulting perforated film had the appearance as shown in FIG. 2 and contained 81 slits per square inch each measuring about 0.1 inch in length.

The perforated film was cut to approximately 12¼ inches × 16¼ inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the sandwiched material were then heat sealed. The resulting diaper was thereafter tested for wet integrity according to the procedure described previously and the result was a tear grade reading of 2.

Another diaper was fabricated identical to that described above. The diaper was then passed in contact with a roller equipped with heating means and having about 10 pins per square inch extending across the width of the roller and arounds its circumference. The diameter of the pin was seven sixty-fourths inch and the endpoint of the pin had a spherical configuration of about 0.0547 inch radius. The absorbent article was supported by a resilient back-up roller. The pins were heated to a temperature of about 300° F. by a circulating hot oil system. The resultant absorbent product had about 10 dimples per square inch disposed along the topsheet of the absorbent article. The absorbent article was then tested for wet integrity and resulted in a tear grade reading of 1.

EXAMPLE 22

A diaper was constructed using the materials and procedure of Example 9 except the slits measured 0.07 inch in length and the dimple size was 0.094 inch radius. The diaper was tested for absorbency according to the procedure of Example 9, with the following results:

Before dimpling	After dimpling
80 seconds	4 seconds

As will be evident from the foregoing examples and description of the invention, the absorbent product of the instant invention has outstanding qualities with respect to the characteristics enumerated (a) through (d). Variations of the invention are possible particularly the elimination of features which although not providing an optimum product as explained previously, would nevertheless provide an improved product with respect to conventional products. Thus for example, the fibers in the absorbent pad need not be adhered to the lowest portions of the depressed areas. There would be some sacrifice of the dimensional stability, however the other advantages would not be materially affected. Thus, rather than passing the absorbent product through the dimpling process, the topsheet can be pretreated so as to provide the depressed areas and thereafter the topsheet joined to form the final product.

In the claims which follow, the term "dimples" are employed to characterize the depressed areas. As used in the claims therefore, the term "dimples" shall mean the depressed areas across the surface of the topsheet which extend below the plane of the topsheet and which are fabricated in a manner such that there is substantially no breaking, melting or cutting of the topsheet during or after fabrication in a manner which would hinder the controlled passage of liquid to the absorbent pad. Thus the dimples are also substantially liquid impermeable.

It will be obvious that while the present invention has been set forth in some detail and described with particularity it is susceptible to changes, modifications and alterations without departing from the scope and spirit of the invention as defined in the appended claims.

What is claimed is:

1. A disposable absorbent article comprising a hydrophobic topsheet for placement adjacent to the body and having a plurality of valvular openings therein, a substantially liquid impermeable backing sheet, an absorbent pad disposed between said topsheet and backing sheet and being characterized by

its ability to absorb liquid passed through said valvular openings, said valvular openings being substantially closable to prevent contact of said absorbent material with the body and to retard backflow of liquid absorbed by said absorbent pad, and a system of dimples disposed on said topsheet, said dimples having a frequency of at least 1 per square inch of absorbent pad area.

2. An absorbent article in accordance with claim 1 wherein said plurality of valvular openings are substantially straight slits arranged in parallel rows, each slit being disposed parallel to the longitudinal axis of said rows.

3. An absorbent article in accordance with claim 2 wherein each slit is from 0.07 to 0.2 inch in length and wherein said slits are present in said topsheet in an amount of about 30 to 150 per square inch of topsheet.

4. An absorbent article according to claim 1 wherein said dimples are disposed on said topsheet in an amount of about 1 to about 100 dimples per square inch of absorbent pad area.

5. An absorbent article according to claim 1 wherein said dimples are disposed on said topsheet in an amount of about 3 to about 25 dimples per square inch of absorbent pad area.

6. An absorbent article according to claim 1 wherein said dimples are disposed on said topsheet in an amount of about 6 to about 15 dimples per square inch of absorbent pad area.

7. An absorbent article in accordance with claim 2 wherein the total area of said dimples does not exceed more than 20 percent of the area of said absorbent pad.

8. An absorbent article in accordance with claim 1 wherein the total area of said dimples is from 4 to 12 percent of the area of said absorbent pad.

9. An absorbent article in accordance with claim 1 wherein said dimples have a circular configuration with a diameter of from about 0.025 to about 0.250 inch.

10. An absorbent article in accordance with claim 1 wherein said dimples have a circular configuration with a diameter of from about 0.075 to about 0.150 inch.

11. An absorbent article in accordance with claim 1 wherein said plurality of valvular openings are substantially parallel straight slits disposed in longitudinal rows, each slit being angularly disposed with respect to the longitudinal axis of said row and being arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows.

12. An absorbent article in accordance with claim 11 wherein said slits are from about 0.030 to about 0.250 inch in length.

13. An absorbent article in accordance with claim 11 wherein said slits are from about 0.07 to about 0.2 inch in length.

14. An absorbent article in accordance with claim 11 wherein said slits are present in said topsheet in an amount of 30 to 150 per square inch.

15. An absorbent article according to claim 11 wherein said dimples are disposed on said topsheet in an amount of about 1 to about 100 dimples per square inch of absorbent pad area.

16. An absorbent article according to claim 11 wherein said dimples are disposed on said topsheet in an amount of about 3 to about 25 dimples per square inch of absorbent pad area.

17. An absorbent article according to claim 11 wherein said dimples are disposed on said topsheet in an amount of about 6 to about 15 dimples per square inch of absorbent pad area.

18. An absorbent article in accordance with claim 11 wherein the total area of said dimples does not exceed more than 20 percent of the area of said absorbent pad.

19. An absorbent article in accordance with claim 11 wherein the total area of said dimples is from 4 to 12 percent of the area of said absorbent pad.

20. An absorbent article in accordance with claim 11 wherein said dimples have a circular configuration with a diameter of from about 0.025 to about 0.250 inch.

21. An absorbent article in accordance with claim 11 wherein said dimples have a circular configuration with a diameter of from about 0.075 to about 0.150 inch.

22. A disposable baby diaper comprising in combination, the hydrophobic topsheet, the substantially liquid impermeable backing sheet, the absorbent pad and the dimples as defined in claim 1 wherein the topsheet and backing sheet are each 0.5 to 2.0 mil thick and of substantially the same dimensions and being at least partially adhered to each other around their periphery to form an integrated diaper structure having the absorbent pad substantially enclosed and sandwiched between the topsheet and the backing sheet, and wherein the valvular openings are substantially straight slits arranged in parallel rows, each slit being disposed parallel to the longitudinal axis of said rows.

23. A disposable baby diaper in accordance with claim 22 wherein each slit is from about 0.030 to about 0.250 inch in length and wherein said slits are present in said topsheet in an amount of about 30 to 150 per square inch of topsheet.

24. A disposable baby diaper in accordance with claim 23 wherein the hydrophobic topsheet is an ethylene-ethyl acrylate film and wherein the absorbent pad is a stack of layers of absorbent wadding.

25. A disposable baby diaper in accordance with claim 22 wherein said dimples are disposed on said hydrophobic topsheet in an amount of about 1 to about 100 dimples per square inch of absorbent pad area.

26. A disposable baby diaper in accordance with claim 22 wherein said dimples are disposed on said topsheet in an amount of from about 3 to about 25 dimples per square inch of absorbent pad area.

27. A disposable baby diaper in accordance with claim 22 wherein said dimples are disposed on said topsheet in an amount of from about 6 to about 15 dimples per square inch of absorbent pad area.

28. A disposable baby diaper in accordance with claim 23 wherein the total area of said dimples does not exceed more than 20 percent of the area of said absorbent pad.

29. A disposable baby diaper in accordance with claim 22 wherein the total area of said dimples is from 4 to 12 percent of the area of said absorbent pad.

30. A disposable baby diaper in accordance with claim 22 wherein said dimples have a circular configu-

ration with a diameter of from about 0.025 to about 0.250 inch.

31. A disposable baby diaper in accordance with claim 22 wherein said dimples have a circular configuration with a diameter of from about 0.075 to about 0.150 inch.

32. A disposable baby diaper according to claim 22 wherein said topsheet and backing sheet are heat sealed to each other around their periphery.

34. A disposable baby diaper which comprises in combination:

a hydrophobic topsheet, for placement adjacent to the body, having a plurality of valvular openings therein, said openings being substantially parallel straight slits disposed in longitudinal rows, each slit being angularly disposed with respect to the longitudinal axis of each row;

at least one absorbent pad adjacent to said topsheet characterized by its ability to absorb and retain liquid passed through said openings;

a substantially liquid impermeable backing sheet adjacent to the absorbent layer on the side opposite the topsheet, the openings in said topsheet being substantially closable to prevent contact of said absorbent pad with the body and to retard backflow of liquid from said absorbent pad, and said topsheet and said backing sheet being of substantially the same dimensions and being at least partially adhered to each other around their periphery to form an integral diaper structure having the absorbent pad substantially enclosed and sandwiched between the topsheet and backing sheet; and

a system of dimples disposed on said topsheet, said dimples having a frequency of at least 1 per square inch of absorbent pad area.

34. A disposable baby diaper in accordance with claim 33 wherein said slits are further characterized in that they are arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows and are from about 0.030 to about 0.250 inch in length.

35. A disposable baby diaper in accordance with claim 33 wherein said dimples have a frequency of about 1 to about 100 dimples per square inch of absorbent pad area, and wherein said topsheet and bottom sheet are adhered by heat sealing said topsheet to said backing sheet.

36. A disposable baby diaper which comprises in combination:

a hydrophobic topsheet, for placement adjacent to the body, having a plurality of valvular openings therein, said openings being substantially parallel straight slits disposed in longitudinal rows, each slit being angularly disposed with respect to the longitudinal axis of each row and being arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows and are from about 0.030 to about 0.250 inch in length;

at least one absorbent pad adjacent to said topsheet characterized by its ability to absorb and retain liquid passed through said openings;

a substantially liquid impermeable backing sheet adjacent to the absorbent layer on the side opposite the topsheet, the openings in said topsheet being substantially closable to prevent contact of said absorbent pad with the body and to retard backflow of liquid from said absorbent pad, and said topsheet and said backing sheet being of substantially the same dimensions and being at least partially heat sealed to each other around their periphery to form an integral diaper structure having the absorbent pad substantially enclosed and sandwiched between the topsheet and backing sheet; and

a system of dimples disposed on said topsheet, said dimples having a frequency of about 1 to about 100 dimples per square inch of absorbent pad area.

37. A disposable baby diaper in accordance with claim 36 wherein said dimples are disposed on said topsheet in an amount of about 3 to about 25 dimples per square inch of absorbent pad area.

38. A disposable baby diaper in accordance with claim 36 wherein said slits are from about 0.07 to about 0.2 inch in length.

39. A disposable baby diaper in accordance with claim 37 wherein the slits closest to said dimples are opened to a greater extent than slits situated further from said dimples.

40. A disposable baby diaper which comprises in combination:

a hydrophobic topsheet, for placement adjacent to the body, having a plurality of valvular openings therein, said openings being substantially parallel straight slits disposed in longitudinal rows, each slit being angularly disposed with respect to the longitudinal axis of each row and being arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows and are from about 0.07 to about 0.2 inch in length;

at least one absorbent pad adjacent to said topsheet characterized by its ability to absorb and retain liquid passed through said openings;

a system of dimples disposed on said topsheet, said dimples having a frequency of about 3 to about 25 dimples per square inch of absorbent pad area; and

a substantially liquid impermeable backing sheet adjacent to the absorbent layer on the side opposite the topsheet, the slits in said topsheet closest to said dimples being opened to a greater extent than slits situated further from said dimples, said slits being substantially closable to prevent contact of said absorbent pad with the body and to retard backflow of liquid from said absorbent pad and said topsheet and said backing sheet being of substantially the same dimensions and being at least partially heat sealed to each other around their periphery to form an integral diaper structure having the absorbent pad substantially enclosed and sandwiched between the topsheet and backing sheet.

41. A disposable baby diaper according to claim 40 wherein said dimples have a frequency of about 6 to about 15 per square inch of absorbent pad area.

42. A disposable baby diaper according to claim 36 wherein the total area of said dimples does not exceed more than 20 percent of the area of said absorbent pad.

43. A disposable baby diaper according to claim 36 wherein the total area of said dimples is from 4 to 12 percent of the area of said absorbent pad.

44. A disposable baby diaper according to claim 36 wherein said dimples have a circular configuration and are from about 0.025 to about 0.250 inch diameter.

45. A disposable baby diaper according to claim 36 wherein said dimples have a circular configuration and are from about 0.075 to about 0.150 inch diameter.

46. A disposable baby diaper according to claim 36 wherein said slits are disposed in said topsheet in an amount of about 30 to about 150 per square inch.

47. A disposable baby diaper which comprises in combination:

a non-fibrous hydrophobic topsheet, for placement adjacent to the body, having a plurality of valvular openings therein, said openings being substantially parallel straight slits disposed in longitudinal rows, each slit being angularly disposed with respect to the longitudinal axis of each row and being arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows and are from about 0.07 to about 0.2 inch in length and having a frequency of about 30 to 150 per square inch of topsheet;

at least one absorbent pad adjacent to said topsheet characterized by its ability to absorb and retain liquid passed through said openings; and

a system of dimples disposed on said topsheet, said dimples having a circular configuration and being about from 0.25 to about 0.250 inch diameter, and wherein the total area of said dimples does not exceed more than 20 percent of the area of said absorbent pad.

48. A disposable baby diaper according to claim 47 wherein the total area of said dimples is from 4 to 12 percent of the area of said absorbent pad.

49. A disposable baby diaper according to claim 47 wherein said non-fibrous hydrophobic topsheet is a film of ethylene-ethyl acrylate and wherein said absorbent pad is a stack of layers of absorbent wadding.

50. A disposable baby diaper according to claim 49 wherein said ethylene-ethyl acrylate film is from 0.5 to 2.0 mil thick.

51. A disposable baby diaper according to claim 47 wherein the slit size is 0.1 inch and wherein there is present about 81 slits per square inch of topsheet.

52. A disposable baby diaper according to claim 47 wherein the slits closest to said dimples are opened to a greater degree than slits situated further from said dimples.

53. A disposable baby diaper according to claim 47 wherein said dimples are from about 0.075 to about 0.150 inch diameter.

54. A disposable baby diaper which comprises in combination:

an ethylene-ethyl acrylate film of 0.5 to 2.0 mil thickness as topsheet, for placement adjacent to the body, having a plurality of valvular openings therein, said openings being substantially parallel straight slits disposed in longitudinal rows, each slit being angularly disposed with respect to the longitudinal axis of each row and being arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows and are about 0.1 inch in length and of a frequency of about 81 per square inch of topsheet;

at least one absorbent pad comprising a stack of layers of absorbent wadding adjacent to said topsheet characterized by its ability to absorb and retain liquid passed through said openings; and

a system of dimples disposed on said topsheet, said dimples having a circular configuration and being about from 0.25 to about 0.250 inch diameter, and wherein the total area of said dimples does not exceed more than 20 percent of the area of said absorbent pad, said diaper being further characterized in that the slits closest to said dimples are opened to a greater degree than slits situated further from said dimples.

55. A disposable baby diaper according to claim 54 wherein the dimples have a frequency of about 1 to about 100 per square inch of absorbent pad area.

56. A disposable baby diaper according to claim 54 wherein the dimples have a frequency of about 3 to about 25 per square inch of absorbent pad area.

57. A disposable baby diaper according to claim 54 wherein the dimples have a frequency of about 6 to about 15 per square inch of absorbent pad area.

58. A disposable baby diaper which comprises in combination:

a hydrophobic topsheet, for placement adjacent to the body, having a plurality of valvular openings therein, said openings being substantially parallel straight slits disposed in longitudinal rows;

at least one absorbent pad adjacent to said topsheet characterized by its ability to absorb and retain liquid passed through said openings;

a substantially liquid impermeable backing sheet adjacent to the absorbent layer on the side opposite the topsheet, the openings in said topsheet being substantially closable to prevent contact of said absorbent pad with the body and to retard backflow of liquid from said absorbent pad, and said topsheet and said backing sheet being of substantially the same dimensions and being at least partially adhered to each other around their periphery to form an integral diaper structure having the absorbent pad substantially enclosed and sandwiched between the topsheet and backing sheet; and

a system of depressed areas disposed on said topsheet the lower portion of said depressed areas extending below the plane of said topsheet and being substantially liquid impermeable and in nonadhering relation with said absorbent pad, said depressed areas having a frequency of at least 1 per square inch of absorbent pad area.

59. A disposable baby diaper according to claim 58 further characterized in that the slits are angularly disposed with respect to the longitudinal axis of each row and are arranged in a manner such that the end points of each slit lie in a line substantially between the end points of corresponding slits in adjacent rows.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,814,101 Dated June 4, 1974

Inventor(s) Theodore F. Kozak

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 27; "whereby" should read --wherein--

Column 5, line 65; "advantage" should read --disadvantage--

Column 11, line 17; "atrributable" should read --attributable--

Column 16, line 25; "has" should read --had--

Column 12, line 9; "absorgent" should read --absorbent--

Column 23, line 34; "2" should read --1--

Column 24, line 60; "23" should read --22--

Column 25, line 10; "34" should read --33--

Column 26, line 19; "37" should read --36--

Signed and sealed this 11th day of February 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
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