

[54] **COMPLIANT CONFORMABLE TAMPON**

[75] **Inventor:** **Bernard A. Dulle**, Montgomery, Ohio

[73] **Assignee:** **The Proctor & Gamble Company**, Cincinnati, Ohio

[22] **Filed:** **Aug. 18, 1971**

[21] **Appl. No.:** **172,694**

[52] **U.S. Cl.** **128/285, 128/270**

[51] **Int. Cl.** **A61f 13/20**

[58] **Field of Search** **128/285, 270, 263, 153**

[56] **References Cited**

UNITED STATES PATENTS

2,884,925	5/1959	Meynier, Jr.	128/270
3,559,646	2/1971	Mullan	128/285
3,054,403	9/1962	Baker	128/285 X
2,330,257	9/1943	Bailey	128/285 X
3,229,690	1/1966	Scholl	128/153

FOREIGN PATENTS OR APPLICATIONS

1,592,445	6/1970	France
-----------	--------	--------

Primary Examiner—Lucie H. Laudenslager

Attorney, Agent, or Firm—David J. Richter; Fredrick H. Braun; Robert B. Aylor

[57]

ABSTRACT

An open celled mensesphilic polyurethane foam tampon having a transverse periphery large enough to substantially coincide with the periphery of the vagina and a shape modulus of compression which allows it to be deformed by the vertical pressures exerted by the vagina whereby the tampon spreads laterally to more completely establish contact with the walls of the vagina, and having a material modulus of compression such that surface irregularities on the vaginal wall compress the tampon slightly so that the tampon surface substantially conforms to the irregularities of the vaginal walls.

24 Claims, 6 Drawing Figures

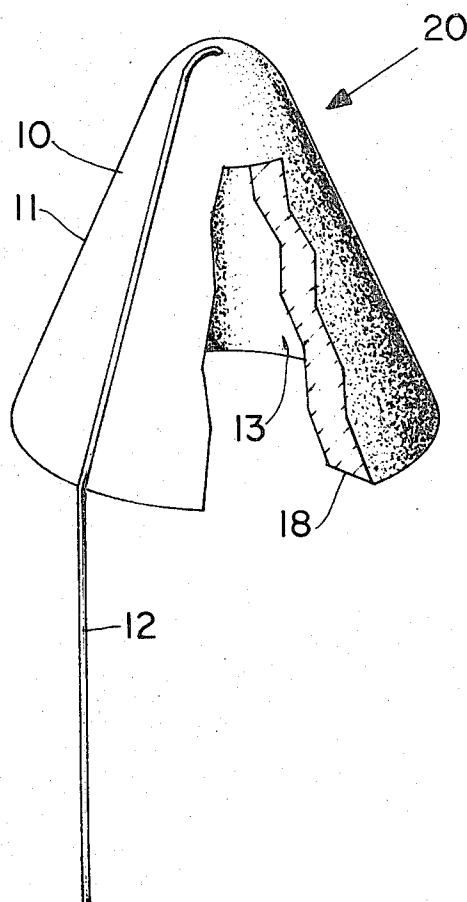


Fig. 1

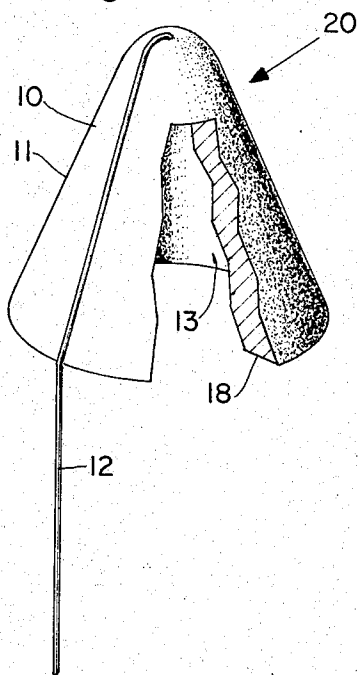


Fig. 2

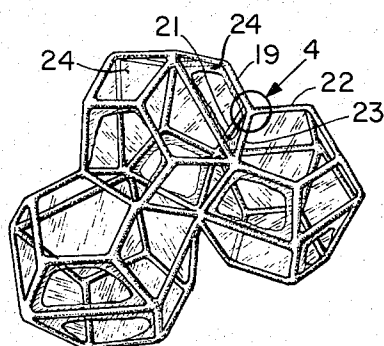


Fig. 3

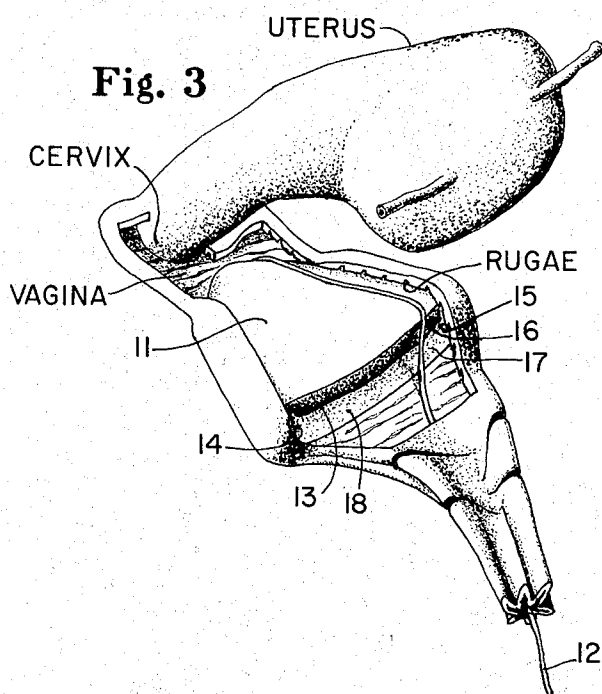
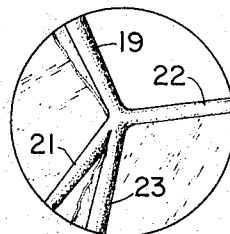


Fig. 4



INVENTOR.
Bernard A. Dulle

BY

John V. Egan
ATTORNEY

Fig. 5

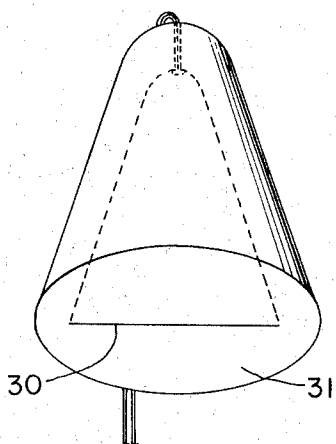
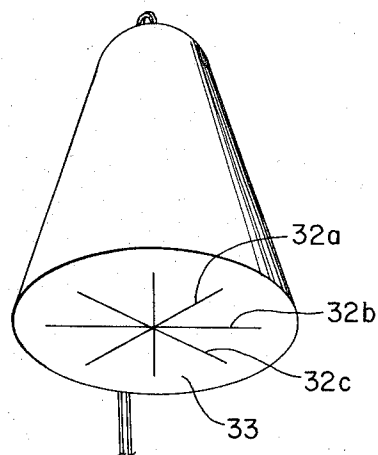


Fig. 6



COMPLIANT CONFORMABLE TAMPON

FIELD OF THE INVENTION

This invention relates generally to absorbent catamenial tampons and more particularly concerns tampons which, in a dry state, are compliant to and deformable by pressures exerted thereon by the vagina.

DESCRIPTION OF THE PRIOR ART

Anatomy references teach that the vaginal passage is a pocket irregular in shape, rather than a cylindrical tube. It is about 3 inches long, shorter on its anterior wall and longer on the posterior wall. It is collapsed to form a slit crosswise of the body, i.e., being wide but with little height. Distended, it forms a gourd-shaped or pear-shaped balloon, wider at the top, and possibly lopsided because of the greater size of one lateral pocket or fornix.

The anterior wall is more than about 3 inches long and the posterior wall is more than about 4 inches long. These lengths are measured from the hymen to the rear-most wall of the vagina. The distended width at the rearmost or upper end ranges from about 2 ½ inches to 3 inches and the circumference at that point is about 8 inches.

Menstrual fluid enters the vagina through the cervix which is located where the vagina is most distensible and therefore has its maximum potential cross sectional area. The vagina is least distensible near the introitus and therefore the potential cross section is reduced. The introital region of the vagina is more sensitive to outwardly directed pressures than the remainder of the vagina.

During the menstrual period an increased mucosal secretion is released by the vaginal walls and vaginal cervix surface. In the high-menstrual-flow woman, some discharge of whole blood mixed with menses is evidenced. These natural secretions, i.e., the mucoprotein and mucopolysaccharide solutions in vaginal mucus secretions and the clottable whole blood, frequently block the surface of current highly compressed textile tampons and hinder menses sorption. A greater surface area and porosity will form a coarse filter medium which is not readily blocked and which absorbs or entraps clots and mucus while continuing to sorb menses.

Methods of collecting the recurring menses which flow periodically from females during their child bearing years are many and varied and are generally well-known to those skilled in the art. Most methods proposed fall into one of the following two general classifications: retentive and absorptive means. Retentive means are those which form an impervious dam across an internal canal; these are generally in the form of a rubber cap or diaphragm which prevents flow from passing them, thereby damming up the menses using an internal organ as a reservoir. Retentive means generally fall into two main classes: devices which are intended to cover or contact the cervix and devices which are intended to lie in the vaginal canal below the position of the cervix.

Absorptive devices can also be placed into two broad categories, i.e., interior and exterior devices. Exterior devices are generally in the form of pads and probably are the most commonly used type of menstrual sanitary device, but they are unsatisfactory for a variety of reasons. Some of these reasons are physical discomfort

from the bulkiness of the pad, self-consciousness that its presence may be discerned by others, emotional discomfort because the bulk of the pad constantly reminds the user of its presence, and the odors which accompany the exposure of the menses to air.

Internal absorptive devices generally in use are fibrous assemblies which are highly compressed into 1 ½ inches - 2 inches long cylinders approximately one-half inch in diameter. These products do not expand in a cross sectional direction until contacted with body fluids. Prior art insertion techniques are designed to achieve placement of the tampon deep (2 ¼ inches - 2 ½ inches) in the vagina near the point of fluid entrance, i.e., near the cervix, and thereby avoid placement near the introitus to avoid wearing discomfort. Deep insertion to a position where the collapsed vaginal vault contains many folds and convolutions coupled with the small cross sectional area of the compressed tampon frequently results in bypass failures, i.e., the menses discharged from the cervix travels the length of the vagina without contacting the tampon and thereby escapes through the introitus without being absorbed. Bypass failures occur because the deeply inserted, compressed tampon cannot block the many folds and convolutions of the vagina in that deep region, but the menses can and does flow down through these folds and convolutions and ultimately through the introitus to soil the woman's clothing and possibly cause her embarrassment.

Each of the attributes associated with the generally available tampons, i.e., cylindrical shape, highly compressed material, deeply inserted, and expanded only by the menses, contributes towards lessening the effectiveness of these tampons in that (1) the cross section of the vagina is distensible and not circular; therefore, a small, rigid cylinder is not the best shape to use to block the vagina, (2) the high compression and resultant high density dictates that the tampon, upon insertion, is relatively small and has literally no inherent resiliency to immediately expand it, because the hydrogen bonding which accompanies the high compression precludes elastic response, (3) deep insertion locates the tampon in a part of the vagina where the potential vaginal cross section is the greatest, which means that a nondry-expanding tampon is in contact with a small percentage of the vaginal periphery whereby the probability of bypass increases, (4) since these tampons rely on fluid to expand and block a cross section of the vagina, if they are located so that bypass occurs, they are never wetted and consequently continue to fail, and (5) their limited surface area is readily blocked by blood clots and mucus secretions.

Some devices have been attempted which try to overcome one of several of these disadvantages, but they fail in that they do not overcome all of the disadvantages or that they have their own peculiar attendant disadvantages. Some tampons have noncircular cross sections, which is an attempt to conform the tampon to the shape of the vagina, but generally these tampons are highly compressed to facilitate insertion and thus have a high density, are inserted deep, and require moisture to break the hydrogen-bonded and friction-bonded structure before they can expand. Thus they do not alleviate the problem of bypass.

Some tampons attempt to solve the problem of bypass by being structured so that they assume arcuate form following ejection from the inserter and release in

the vagina. The theory is that they will arc across the vagina and thereby form a barrier from one wall to the other, but they do not solve the problem of bypass because they are highly compressed and deeply inserted; therefore, they can be inserted into one of the vaginal fornices and, figuratively, become lost. Since they do not actually span the vaginal passage, they do not solve the problem of bypass.

Another approach to solving the problem of bypass is shown in U.S. Pat. No. 3,512,538 which is an expandable catamenial tampon in the form of an elongate hollow shell of absorbent material with an inner sack which may be semi-permeable or impervious. The tampon is inserted into the vaginal canal in a collapsed condition and then expanded in place by an energy source exterior the vagina so as to form a flexible seal with the vaginal wall to prevent bypass of menses. The disadvantage of this approach is that expanding the tampon requires a secondary operation after the tampon is inserted which comprises manipulation of a pressure-creating device and a filler tube which interconnects the pressure-creating device and the inner sack of the tampon. This also has a serious psychological disadvantage because the user is inflating a device inside herself which could be extremely distasteful to many potential users.

An intravaginal device, for proper function per se, must satisfy mutually contradictory criteria, as indicated by the following anatomical facts. (1) The entrance (introitus) to the vagina is provided with a functional sphincter comprised of several muscles which form the main closure of the vagina. These muscles resist distension of the vaginal vestibule, hence, entry to and exit from the vagina proper. Consequently, the diameter of any intravaginal device should be small for easy, comfortable, and safe insertion. (2) Beyond this sphincter, the vagina per se is a flaccid organ, the walls of which are normally collapsed about a horizontal plane, touching one another, to give a cross section of roughly H-shape -- capable of relatively great lateral distension without appreciable resistance.

Therefore, an ideal catamenial tampon should be (1) capable of being easily made small enough in diameter to facilitate insertion into, and removal from the vaginal cavity; (2) thereafter, with minimum effort, being changed to a shape which is large enough in diameter to permit the tampon to substantially fill and conform to the cross section of the vagina; and (3) great enough in absorptive capacity to permit the tampon to be worn for an extended period of time during which it will accumulate the menses released and hold it without leakage. These contradictory requirements are difficult to reconcile.

Catamenial tampons are subject to four distinct kinds of failure: bypass, partitioning, compression and exceeding saturation capacity. Bypass failure occurs when the menses travels the length of the vagina without contacting the tampon, i.e., the tampon fails to intercept the flowing menses. This generally occurs because the tampon does not fill the cross section of the vagina. Partitioning failure occurs when the menses flow rate past a particular area of the tampon is greater than the absorption rate of the tampon in that area. Thus, although some of the menses is absorbed, that flow which is greater than the absorption rate of the tampon proceeds past the tampon and out the introitus. Compressive failure occurs when the user inad-

vertently brings pressure to bear on a tampon which has absorbed menses, and this pressure is great enough to "squeeze" the menses from the tampon. Exceeding the saturated capacity occurs when the tampon has absorbed all the fluid it can, and for every drop added thereafter, another drop must leave the tampon.

Hollow tampons are not unique. The prior art shows solid and hollowed out conical and cylindrical tampons made from polyurethane foams such as shown in U.S. Pat. No. 2,884,925 issued to Meynier, Jr. on May 5, 1959 and U.S. Pat. No. 3,559,646 issued to Mullan on Feb. 2, 1971. The device taught by the Meynier, Jr. patent is a truncated conical plug which can be hollowed out to some extent, has microscopic pores, and which is made of a deformable expansive material, preferably generated cellulose, but polyurethane foam will suffice. Although the Meynier, Jr. patent speaks of a deformable resilient material, it does not teach a tampon having a periphery large enough to substantially coincide with the periphery of the vaginal wall in a cross section perpendicular to the vagina's longitudinal axis, a tampon deformable under static pressures exerted by the vagina, a tampon conformable to vaginal surface irregularities, a tampon having an absorbent capacity sufficient to protect a user for a reasonable time span, or one having partially closed cells to produce a suction effect.

The Mullan patent teaches a tampon having a body of compressible spongy absorptive material, the body being hollow, closed at one end, and tapered inwardly toward the closed end. This patent has the same shortcomings as the Meynier, Jr. patent in that it does not teach a device having a periphery large enough to contact a substantial portion of the vaginal wall when inserted to the normal depth, one deformable by the static pressures exerted by the vagina, a tampon conformable to the irregularities in the walls of the vagina, or a tampon wherein the cells are only partially opened to form a structure similar to a syringe whereby a cell collapsed through compression will upon subsequent expansion draw fluid into the cell through the opened cell faces.

OBJECTS OF THE INVENTION

It is an object of this invention to provide a tampon which is easy and comfortable to insert.

It is another object of this invention to provide a tampon which is comfortable to wear during normal everyday activities.

A third object of this invention is to provide a tampon having a periphery substantially equal to the inside periphery of the vagina.

A more specific object of this invention is to provide a tampon with improved absorption and wicking properties.

Another object of this invention is to provide a tampon which is not blocked from sorbing menses by blood clots or thick vaginal mucosal secretions.

A further object of this invention is to provide a tampon having superior capacity properties.

A further object of this invention is to provide a tampon which distends laterally when it is deformed by the substantially vertical force exerted by the vagina thereon.

It is also an object of this invention to provide a tampon which substantially conforms to the irregularities of the vaginal walls.

Another object of this invention is to provide a tampon which is easy and comfortable to remove from the vagina.

SMMARY OF THE INVENTION

In accordance with the present invention, there is provided a tampon comprising a flexible, resilient, elastic, dry-expanding, absorbent body having a maximum periphery of at least about 5.5 inches in a plane transverse the longitudinal axis of the tampon. The absorbent body has an internal discontinuity and a shape which permits deformation of the tampon to its collapsed state wherein it has a distended lateral diameter. The shape modulus of compression is in the range of from about 0.05 pounds to about one pound and the distended lateral diameter is at least about 115 percent of that lateral diameter when the tampon is not deformed.

BRIEF DESCRIPTION OF THE DRAWINGS

While the Specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as forming the present invention, it is believed that the invention will be better understood from the following description taken in connection with the accompanying drawings, in which the thickness of some of the material are exaggerated for clarity and in which:

FIG. 1 is a fragmentary perspective view of a tampon of this invention;

FIG. 2 is an enlarged schematic perspective view of a series of individual polyurethane cells which form the absorbent material for the preferred embodiment of the tampon of this invention;

FIG. 3 is a perspective view of the uterus and vagina of a human female wherein the vagina is fragmented to show the tampon of this invention in place during use;

FIG. 4 is an enlarged view of a typical juncture of cellular structural elements within area 4 of FIG. 2;

FIG. 5 is a perspective view of an alternate embodiment of this invention showing a single slit into the interior of a tampon; and

FIG. 6 is a perspective view of an alternate embodiment of this invention showing a plurality of slits extending into the interior of the tampon.

DETAILED DESCRIPTION OF THE INVENTION

A tampon which is totally acceptable must be acceptable to the user in all its aspects. It must be acceptable from an aesthetic standpoint both before insertion and after removal. It must also be relatively easy and unobtrusive to carry, e.g., in a purse. In addition, the tampon must be acceptable from a performance standpoint wherein insertion must be both easy and comfortable, wearing must be comfortable, containment - including both bypass control and capacity - must be at least adequate and preferably superior, and removable must be both easy and comfortable. Since the superlatives of some of these aspects are mutually exclusive when using presently available materials and technology, a consumer acceptable tampon must be a balance of all these aspects.

The tampon of the present invention is intended to be inserted by the user and has deformability, distensibility and conformability. It is deformable under the substantially vertical forces exerted on it by the vagina

whereby it takes a shape similar to that shown in FIG. 3. It is distensible in that the lateral edges 14 and 15 of the absorbent body 10 of tampon 20 in FIG. 3 move horizontally as the tampon is deformed. It is conformable due to its material modulus, as defined hereinafter, so that it attempts to conform to the irregularities of the walls of the vagina. The tampon of this invention provides a means, e.g., dry expansion, of substantially filling the vaginal cross section to prevent menses bypass. Dry-expanding as used herein means a spreading from a compacted configuration, e.g., as when within an inserter, without relying on the actions of liquids to release compression set which may have taken place within the absorbent body while it was compacted. Much of the improved performance of this tampon is due to the increased periphery of the tampon which prevents menses bypass without causing wearing discomfort and the greater surface area and porosity of an uncompressed foam, when contrasted with a compressed textile, which minimizes surface blockage by clots and mucosal secretions.

Turning to FIG. 1, there is shown the structure of a preferred embodiment of this tampon. It is a tampon 20 cut from a block of foam. The tampon 20 has a conically shaped body 10 of flexible, resilient, absorbent material having a removal string 12 attached to its apex. The body 10 has a transverse periphery which is defined as the maximum periphery existing in a plane perpendicular to the longitudinal axis. In the illustrated preferred embodiment, the transverse periphery is the periphery around the base of the cone and the longitudinal axis is that axis which passes through the apex and the center of the base of the cone. The transverse periphery forms the primary seal between the absorbent body 10 and the vaginal walls; therefore, it should be large enough to contact the vaginal wall on all sides. A transverse periphery which is too small contacts only part of the vaginal wall in a large percentage of users and can result in bypass if the menses happens to flow down some part of the vaginal wall which is not contacted by the tampon. Therefore, the transverse periphery should approximate the inside periphery of the portion of the vagina with which it mates. Accordingly, the transverse periphery of the undeformed tampon is a minimum of about 5.5 inches and, preferably, about 7.0 inches. A smaller transverse periphery will not achieve bypass control in the majority of users because the reduction in perimeter resulting from deforming a tampon of this invention to its compressed state, hereinafter described, will reduce it to a size smaller than its mating vaginal periphery.

The interior of the absorbent body 10 is relieved so it has an internal discontinuity whereby diametrically opposed walls of the tampon have no interconnection across the diameter, thus little or no diametrical tensile strength remains to resist lateral spread when a force transverse the tampon's longitudinal axis is exerted on the tampon. The internal discontinuity allows the compressive forces generated within the absorbent body during deformation of the tampon to force the lateral edges 14 and 15, FIG. 3, outwardly toward the sides of the vagina. Without the internal discontinuity the outward movement (distension) is retarded by the external tensile strength of the absorbent body 10 associated with a continuous or solid interior. The internal discontinuity is instrumental in reducing the shrinkage of the transverse periphery which occurs when the tampon is

deformed to its collapsed state, i.e., the top and bottom surfaces of an interior surface are in contact, as shown in FIG. 3. The lateral edges distend because the vertical force exerted by the vagina is transmitted through the walls as compression forces which push outwardly on the lateral edges 14 and 15. With no diametrical tensile forces to restrain them, the lateral edges 14 and 15 move outwardly. The internal discontinuity of a tampon can take various forms, one of which is a single slit, such as slit 30 shown in the tampon of FIG. 5, extending from the base 31 of the tampon up through the interior, passing through its longitudinal axis or close thereto. If a single slit is used, it must be realized the tampon probably will have to be oriented during placement, i.e., the slit positioned vertically, because of the directionality inherent to a unidirectional internal discontinuity. A plurality of slits can also be used to relieve the tampon. In FIG. 6, a plurality of slits 32a, 32b, and 32c are shown radially dispersed on the tampon base 33. These slits extend up through the interior of the tampon, similar to that shown in dotted form for the slit in FIG. 5, to provide an internal discontinuity in such a tampon. Such a plurality of slits can also be parallel rather than radially dispersed. The preferred form for an internal discontinuity is a hollow or cavity, as shown in FIG. 1, which creates interior surface 13. A cavity as compared to a slit in addition to promoting greater lateral spread or distension, yields a tampon having a lower shape modulus of compression hereinafter described.

A solid tampon, i.e., one without an internal discontinuity, will distend and maintain periphery somewhat, but substantially less than a tampon of the preferred embodiment. The distension in the preferred embodiment when it is deformed by a vertical force to its collapsed state, i.e., whereby any interior cavity of a hollow tampon is substantially eliminated and the interior surface is reduced to line contact between opposing points such as is shown in FIG. 3, is about 200 percent of the distension of a similar solid tampon deformed to the same thickness. In the preferred embodiment, the distended diameter of the tampon base when the tampon is deformed to its collapsed state is 22 percent larger than that diameter when the tampon is not deformed. A minimum distension for that diameter of approximately 15 percent, i.e., the distended diameter is 115 percent of that diameter when the tampon is not deformed, is required so the lateral edges 14 and 15 will "reach out" and the tampon can fill the vaginal cross section. For a given transverse periphery, the greatest lateral distension and maintenance of the transverse periphery occurs when the tampon wall thickness around that periphery is approximately zero. A zero wall thickness is, of course, undesirable in a tampon because the tampon would have no absorptive capacity and, therefore, a balance must be made between lateral distensibility and absorptive properties desired.

The preferred embodiment when deformed to its collapsed state has a periphery maintenance of about 91 percent, i.e., the transverse periphery of the tampon when deformed to its collapsed state is 91 percent of the transverse periphery when the tampon is not deformed. A solid cone, without an interior discontinuity and having the same exterior dimensions as the preferred embodiment, deformed to the same thickness as the preferred embodiment has a periphery maintenance

of about 84 percent. A tampon having a 90 percent periphery maintenance, i.e., a 10 percent reduction in periphery, strikes an acceptable balance between absorptive properties, distensibility, and periphery maintenance.

The cavity can be of almost any shape such as spherical, cylindrical or rectangular, but the shape which seems to promote the best deformability and distensibility, and thus the greatest perimeter maintenance, is a shape essentially coaxial with and similar to the exterior surface 11 of the tampon, which in this case is generally conical. Also, a larger cavity will promote greater deformability, distensibility, and perimeter maintenance. The diameter of the cavity is about 61 percent of the transverse diameter in a preferred embodiment.

Therefore, a preferred embodiment of the tampon of this invention has an absorbent body 10 wherein the exterior shape is generally conical and the tampon has a hollow interior, the shape of which is also generally conical. It has an exterior height ranging from about 1.75 inches to about 3.0 inches, and an exterior base diameter of about 1.75 inches to about 3.00 inches, preferably about 2.1 inches. The wall thickness is a minimum of about 0.10 inches and preferably about 0.40 inches, which leaves the interior cavity with a base diameter of about 1.2 inches. The height of the interior cavity for this preferred embodiment is about 1.50 inches.

The absorbent body 10 of tampon 20 can be made from any materials having acceptable absorbency and modulus of elasticity properties. If a foam is used as the absorbent body of this tampon, it can be a flexible, resilient polyurethane foam. The preparation of flexible, resilient polyurethane foams is disclosed in general and in detail in the text entitled, *Polyurethanes: Chemistry and Technology*, Vol. XVI (in two parts) of the series entitled *High Polymers*, by J. H. Saunders and K. C. Frisch, copy-righted in 1962 and published by Interscience Publishers, said work being incorporated herein by reference. A similar disclosure of polyurethane technology can be found in *Polyurethane Technology*, edited by Paul F. Bruins, copyrighted in 1969 and published by Interscience Publishers, this work also being incorporated herein by reference.

Other disclosures of polyurethane foams can be found in the following patents, all of which are incorporated herein by reference. William J. Considine, et al, U.S. Pat. No. 3,391,091, patented July 2, 1968; William E. Erner, U.S. Pat. No. 3,376,236, patented Apr. 2, 1968; George T. Gmitter, et al, U.S. Pat. No. 3,341,482, patented Sept. 12, 1967; Robert A. Volz, U.S. Pat. No. 3,171,820, patented Mar. 2, 1965; Harlan B. Freyermuth, U.S. Pat. No. 3,148,163, patented Sept. 8, 1964; Robert P. Kane, U.S. Pat. No. 2,955,091, patented Oct. 4, 1960; Rudolf Bick, et al, U.S. Pat. No. 2,938,005, patented May 24, 1960; Newell R. Bender, et al, U.S. Pat. No. 2,888,409, patented May 26, 1959; and Andrew Mitchell III, U.S. Pat. No. 2,850,464, patented Sept. 2, 1958.

The absorbent body 10 of this invention should be mensesphilic, i.e., have surface characteristics such that the menstrual fluid tends to spread readily or spontaneously on the surface and in the capillaries. This spreading tendency is primarily a function of (1) the nature and packing of atoms or groups of atoms in the surface layer of the molecules of absorbent body 10 and (2) the affinity of the outermost groups of atoms

comprising these molecules for the molecules of the fluid. Secondary factors which modify the spreading tendency include roughness of the surface and the affinity for the menstrual fluid of the layers of atom groups just below the surface atoms.

Since the menstrual fluid is primarily an aqueous solution, materials onto and into which it spreads readily could be loosely described as hydrophilic. However, the state of the art respecting wetting of materials allows a more precise description in terms of contact angles and surface tensions of the fluids and solids involved. This description is disclosed in detail in the American Chemical Society publication entitled *Contact Angle, Wettability and Adhesion*, edited by Robert F. Gould, and copyrighted in 1964; said publication being incorporated herein by reference.

The contact angle is defined as the angle formed between two planes as measured in the liquid, i.e., the plane tangent to the liquid-air interface at the point of liquid-air-solid mutual contact and the plane of liquid-solid contact at the liquid-air-solid mutual contact. The smaller this angle is, the less is the force required to spread the liquid and at a contact angle of zero, the fluid tends to spread spontaneously and without limit on the surface of the solid. In general, materials having a contact angle between them of less than 90° can be described as -philic (attractive toward each other) and those having angles greater than 90° between them as -phobic (repellent toward each other). Therefore, a mensesphilic material can be definitely but broadly defined as one with which menstrual fluid makes a contact angle of less than 90°.

The contact angle between a fluid and a solid, and consequently the philicity or phobicity of the solid for the liquid, is related to the ratio between the surface tension of the fluid and the solid. In practice, the method for determining surface tension of the solid is to compare contact characteristics of the solid against various liquids. This method is more completely described on p. 12 et seq. of the above last mentioned publication. The value derived from this method is usually called the critical surface tension of the solid. If the ratio is greater than 1:1, i.e., the surface tension of the fluid is greater, the solid is -phobic. If the ratio is less than 1:1, i.e., the surface tension of the solid is greater, the solid is -philic. As the ratio becomes smaller, the solid is more and more -philic.

Menstrual fluid has a surface tension range of about 35 to 60 dynes per centimeter. It will have a contact angle of less than 90° and will tend to spread spontaneously on a solid which has a critical surface tension value greater than its surface tension.

Water has a high surface tension which is about 72 dynes per centimeter and would be apt to spread spontaneously only on solids with critical surface tensions higher than 72 dynes per centimeter unless the solid's surface had changed through an interaction with the water. Therefore, hydrophilicity is not a precise definition with respect to the affinity of a solid for menstrual fluid. The contact angle between menstrual fluid and a solid or the ratio between the surface tension of the menstrual fluid and the critical surface tension of the solid is definitive of their mutual affinity and tendency toward spontaneous wetting. Since the surface tension of water is higher than that of menstrual fluid, any solid which is hydrophilic is also usually mensesphilic.

Although flexible polyurethane foams in general can be used, there are drastic differences in tampon performance between tampons prepared from conventional mensesphobic flexible polyurethane foams and mensesphilic flexible polyurethane foams. The differences are sufficiently great that mensesphilic polyurethane foams are highly preferred. Even within mensesphilic polyurethane foams there is a wide variation in performance; and it is most preferred to use mensesphilic polyurethane foams having good wet swell properties since the total volume of menstrual fluids which can be contained by a tampon is related to its eventual size and yet one prefers to have a tampon of minimal size for ease of insertion. Minimal size is especially important where one uses an inserter of the type that requires the tampon to be pushed out through a cylindrical portion of the inserter. Another desirable quality is low compression set when radially compressed within an inserter since dry expansion after insertion provides better bypass control. It is, of course, desirable to use foams having a minimum content of extraneous soluble materials since the product may be retained in the body for a considerable period of time and retained soluble extraneous materials could cause a safety hazard if they are toxic.

In general, the flexible polyurethane foams used in the preferred embodiment of this invention will be prepared from a reaction mix comprising a polyhydroxy compound which will be, at least in part, a polyether but which may be also, in part, a polyester, and mixtures of polyester and polyether compounds. The following patents, all of which are incorporated herein by reference, disclose mensesphilic polyurethane foams which are especially desirable. Joerg Sambeth, et al, U.S. Pat. No. 3,586,648, patented June 22, 1971; Alexis Archipoff, et al, U.S. Pat. No. 3,573,234, patented Mar. 30, 1971; Joerg Sambeth, et al., U.S. Pat. No. 3,560,416, patented Feb. 2, 1971; Charles H. Hoffrichter, et al, U.S. Pat. No. 3,463,745, patented Aug. 26, 1969; Stanley I. Cohen, et al, U.S. Pat. No. 3,457,203, patented July 22, 1969; Joerg Sambeth, et al, U.S. Pat. No. 3,451,954, patented June 24, 1969; Joerg Sambeth, et al, U.S. Pat. No. 3,451,953, patented June 24, 1969; Joerg Sambeth, et al, U.S. Pat. No. 3,432,448, patented Mar. 11, 1969; Rudolf Merten, et al, U.S. Pat. No. 3,388,081, patented June 11, 1968; Bernard Rabussier, U.S. Pat. No. 3,385,803, patented May 28, 1968; James A. Calamari, U.S. Pat. No. 3,164,565, patented Jan. 5, 1965; Morris V. Shelanski, et al, U.S. Pat. No. 3,098,048, patented July 16, 1963; Carl V. Strandkov, U.S. Pat. No. 3,042,631, patented July 3, 1962; Fritz Schmidt, et al, U.S. Pat. No. 3,007,883, patented Nov. 7, 1961; Harold L. Elkin, U.S. Pat. No. 2,965,584, patented Dec. 20, 1960; Erwin Windemuth, et al, U.S. Pat. No. 2,948,691, patented Aug. 9, 1960; Elekal, British 1,180,316, patented Feb. 4, 1970; Vereinigt Papierwerke Schickedanz & Co., French 1,350,709, patented Dec. 23, 1963.

Other mensesphilic polyurethane foams can also be used, including the foams disclosed in the following patents which are also incorporated herein by reference. George Shkapenko, et al, U.S. Pat. No. 3,535,143, patented Oct. 20, 1970; John G. Simon, et al, U.S. Pat. No. 3,508,953, patented Apr. 28, 1970; Whitney R. Adams, et al, U.S. Pat. No. 3,458,338, patented July 29, 1969; John R. Caldwell, et al, U.S. Pat. No.

3,418,066, patented Dec. 24, 1968; Joerg Sambeth et al, U.S. Pat. No. 3,413,245, patented Nov. 26, 1968; Lyle W. Colburn, U.S. Pat. No. 3,404,095, patented Oct. 1, 1968; Fred W. Meisel, et al, U.S. Pat. No. 3,382,090, patented May 7, 1968; Yvan Landler, et al, U.S. Pat. No. 3,326,823, patented June 20, 1967; Ming Chih Chen, U.S. Pat. No. 3,249,465, patented May 3, 1966; Sotirios S. Beicos, U.S. Pat. No. 3,149,000, patented Sept. 15, 1964; John Bugosh, et al, U.S. Pat. No. 3,094,433, patented June 18, 1963; Karl Goldann, U.S. Pat. No. 2,998,295, patented Aug. 29, 1961; Marvin J. Hurwitz, et al, U.S. Pat. No. 2,990,378, patented June 27, 1961; John Bugosh, U.S. Pat. No. 2,920,983, patented Jan. 12, 1960; and William R. Powders, et al, U.S. Pat. No. 2,900,278, patented Aug. 18, 1959.

In general, it is preferred to have mensesphilic foam which is at least partially mensesphilic by virtue of the reactants; but is also desirable in many instances to add additional mensesphilic materials to the foam to increase either the mensesphilicity of the foam or the ability of the foam to hold liquid and resist compressive failure, i.e., squeeze out. A mensesphilic, polyurethane foam used should have a critical surface tension of at least about 60 dynes per centimeter and preferably greater than about 72 dynes per centimeter.

As shown in FIGS. 2 and 4, the structural members of the cells, e.g., 19, 21, 22, 23, form junctions between the faces or walls of the cells of the foam with thin membrane-like polymer forming faces or walls. A portion of the areas 24 between structural members contain no membrane-like materials and thus provide an open face to the cell. Membranes like 24 are ruptured during or after cell formation.

The material used as absorbent body 10 in the preferred embodiment of this invention has a property called wet swell or wet volume swell which results from the absorption of water into the actual molecular polymeric structure that forms the cell structure, as contrasted to the water that is taken into and held by the void areas in the polyhedral cells. The void-held water is water held by capillary action on the surfaces of the cell structure members, e.g., 19, 21, 22, 23; and cell walls; in the junctures between the cell structure members, 19, 21, 22, 23; and in the reservoir defined by the walls of a cell. This void-held water can be considered a free water, readily squeezeable from the foam by compression.

The water which causes wet swell is not the void-held water but that water absorbed into the polymeric structure. It is in intimate, strongly held, contact within the matrix of the polymer molecules. It is simplistic but not inaccurate to describe the expansion of the polymer by the absorption of water as being caused by the strong attraction of certain atomic groups of the polymer molecules for water so that water penetrates the polymer matrix and, loosening the bonds between polymer molecules, makes room for itself, thereby increasing the softness, compressibility, and volume of the polymer structure. This swelling of the structural material causes an increased cell size and a resultant increase in the overall bulk volume of the foam. A secondary effect of this swell is to increase the amount of water that can be held in the cells by reason of their increased size. The volume swell is usually measured and expressed as a percent increase in dry volume.

As stated before, it is especially desirable for the foam to have good wet swell properties, i.e., undergo

wet swell at one atmosphere of pressure, being at least about 25 percent and preferably about 100 percent. A minimum wet swell of about 25 percent is necessary to appreciate advantages of wet swell. Examples of polyurethane foams which have good wet swell properties include those disclosed in U.S. Pat. No. 3,164,565 referred to hereinbefore and Morris V. Shelanski, et al, U.S. Pat. No. 3,098,048, patented July 16, 1963; those disclosed hereinafter in FOAMS I, II, and III; and the product sold commercially as Scott Hydro-Foam™ by Scott Paper Company Foam Division, Eddystone, Pennsylvania. As discussed hereinbefore, it is desirable to remove extraneous materials from these foams, for example, by washing them with water, to avoid any irritant or toxicity problems that these extraneous materials may cause.

The cell count of a foam is an indication of the size of the cells composing that foam. The cell count is the average number of cells per linear distance, usually 1 inch. Thus a foam with a cell count of 10 has large cells in comparison to a foam having a cell count of 100. The cell count of a foam is one of the factors which controls the porosity of the foam.

A polyurethane foam used as absorbent body 10 should have a minimum cell count of about 20 cells per linear inch to a maximum cell count of about 100 cells per linear inch, preferably about 60 cells per linear inch. The porosity of this foam in the direction parallel to its rise as indicated by air flow through a 0.4 inch thick piece with a pressure differential of 0.5 inch of water across the foam thickness is a minimum of about 30 cubic feet per minute per square foot of foam and a maximum of about 200 cubic feet per minute per square foot of foam, preferably about 40 to 120 cubic feet per minute per square foot of foam. Its density should range between about 1.0 pound per cubic foot and about 3.0 pounds per cubic foot in an unstressed state, preferably about 2.0 cubic feet per square foot of foam. Foams are more porous in the direction of their rise during formation than in a direction transverse the rise. The cells within the foam are elongated somewhat in the direction of rise. It is preferable to orient the foam when making the tampon such that the direction of highest porosity is approximately transverse the longitudinal axis of the tampon and thus will effect greater efficiency in transporting fluids from exterior surface 11 to interior surface 13.

The tampon 20 should have a shape modulus of compression, i.e., the unidirectional pounds force required to deform the tampon to its collapsed state, i.e., it is collapsed so any interior cavity is substantially eliminated and the interior surface is reduced to line contact between opposing points such as is shown in FIG. 3, ranging from about 0.05 pound to about one pound, preferably about 0.20 to 0.40 pound. The shape modulus should be greater than about 0.05 pound so the tampon has some tendency to maintain its shape when compressed by intravaginal pressures. For example, a tampon "as limp as a dishrag" would not work well because it has essentially no shape modulus. The shape modulus should not be greater than about one pound because then the tampon becomes too difficult to deform and retains its round cross section which is not as good for tampon performance because the vaginal walls do have some strength and do not drape perfectly; therefore, if the vagina is not fully distended by a tampon, a greater percentage of the vaginal wall is in

contact with a collapsed, i.e., flattened tampon than is in contact with an uncollapsed, i.e., round tampon. The shape modulus is dependent upon the density and elasticity of the material and the shape of the tampon.

As a tampon is deformed, the exterior surface 11 and the interior surface 13 at the lateral edges 14 and 15 are respectively placed in tension and compression; the exterior surface 11 and the interior surface 13 of the top and bottom walls 16 and 17 are respectively put in compression and tension. The foam used as the absorbent body should have a dry modulus of compressibility as defined in ASTM Test D1564, Compression Load Deflection Test (Suffix D), of from about 0.2 pound per square inch to about 0.6 pound per square inch, preferably about 0.4 pound per square inch, and a wet modulus of compressibility to attain 75 percent of the original dry thickness ranging from about 0.1 to 0.3 psi, preferably about 0.2 psi. The ASTM Compression Load Deflection Test consists of measuring the load necessary to produce a 25 percent compression over the entire top area of the foam specimen.

The preferred embodiment of the tampon of this invention thus is a conical, mensesphilic, polyurethane, foam tampon 2.0 inches high, having a 2.1 inch base diameter and hollowed out to achieve a wall thickness of about 0.40 inch. It has a critical surface tension of greater than about 72 dynes per centimeter, a cell count of approximately 60 cells per linear inch, an air flow porosity of approximately 70 cubic feet per minute per square foot of foam as described above, a density of about 2.0 pounds per cubic foot, a shape modulus of compression of approximately 0.2 to 0.4 pounds, and a material dry modulus of compressibility of approximately 0.4 pounds per square inch. The material used as the absorbent body in this tampon preferably also has wet swellability. In its preferred embodiment, the tampon of this invention has a volume wet swellability of approximately 100 percent.

A tampon of this invention can be formed by cutting a hollow cone from a solid block of foam or by joining two superposed coextensive triangular or trapezoidal blanks along all edges but one of their periphery as disclosed and shown in the specification and drawing of the copending, commonly owned application by Bernard A. Dulle, Ser. No. 353,058. These blanks should be cut transverse the direction of foam rise so that any elongation of the foam cells associated with foam rise is parallel to the thickness of the blanks. Trapezoidal blanks which have worked well have an altitude of 2.25 inches, a long base of 3.75 inches, a short base of 1.06 inches, and a thickness of 0.40 inch. The superposed blanks were sewed together and the tampon was turned inside out to acquire a tampon having a generally conical shape or more specifically, a bell shape having the approximate dimensions as follows: altitude of 2.0 inches, exterior base diameter of 2.1 inches, interior base diameter of 1.3 inches. Turning the sewed blanks inside out imparts a bending moment to the blanks such that the tampon formed has a generally circular periphery in a plane transverse to the tampon's longitudinal axis. Also, this bending moment places the cells on the exterior surface in tension and the cells on the interior surface in compression whereby there is a gradient, between the exterior and interior surfaces 11 and 13, in the average diameter of the capillaries through the tampon walls and the gradient is substantially linear. The method of making tampons from flat blanks is ex-

plained in more detail in the copending, commonly owned application entitled, "Hollow Foam Tampons From Flat Blanks And Method of Making Same," by Bernard A. Dulle, Ser. No. 353,058. The average cell diameter on the exterior surface 11 is approximately 62 percent larger than the average cell diameter on the interior surface 13.

A gradient in capillary size as described above is advantageous because it promotes good wicking into the tampon from the exterior surface. Either a cut or a formed hollow cone takes on an acceptable capillary size gradient when deformed to its collapsed state. In a cut cone as deformed, the radius of curvature at the lateral edges is decreased, thereby imparting capillary size gradient to the folded lateral edges. The top and bottom walls 16 and 17 possibly acquire a reverse gradient, i.e., narrow at the exterior surface and larger at the interior surface. In a formed cone not deformed, the exterior surface is already in tension and thus has larger capillaries and the interior surface is in compression and thus has reduced capillaries. When the formed cone is deformed, the radius of curvature at the lateral edges 14 and 15 is decreased, effecting a greater capillary gradient, and the top and bottom walls 16 and 17 are returned to a substantially neutral state so there is essentially no capillary gradient therein. The capillary gradient established in either the cut or the formed hollow cone when deformed is acceptable and advantageous. The gradient is present and effectively works at the lateral edges 14 and 15 where the pressure between the vagina and the tampon is the least and the best fluid transport mechanism is needed to prevent partitioning. The gradient does not exist or it is reversed in the top and bottom walls 16 and 17 and thus the fluid transport mechanism is not enhanced at these points. But, since the maximum force exerted by the vagina on the tampon is vertical, contact between the vagina and the top and bottom walls of the tampon is good, and this good contact will prevent partitioning in those two areas even though the fluid transport mechanism is not enhanced.

In conjunction with the transverse periphery, a removal comfort modulus must also be considered. There is a maximum compressed cross sectional area which can be comfortably removed from the vagina through the introitus. This removal comfort modulus is dependent upon (1) the cross sectional area of the material in the absorbent body in a section through the transverse periphery and (2) the material modulus of compressibility at the time or removal. Thus for a larger transverse periphery, the tampon wall thickness must be thinner or have a lower material modulus of compressibility or both. Thus for removal comfort, the tampon when wetted should be compressible normal to the longitudinal axis by an encompassing compressive force to a maximum cross section perpendicular to the longitudinal axis of less than about one inch in diameter and preferably less than about 0.75 inch in diameter. The preferred embodiment of tampon 20 is compressible, either wet or dry, to a diameter of 0.75 inch by a 0.50 inch wide teflon band which encircles the tampon and is subjected to a tensile force of less than 600 grams and in the range of 350 to 600 grams, i.e., a tensile force is put on both ends of the encircling band and the tensile load imposed on the band is less than 600 grams.

The omnidirectional elastic and compression properties inherent in the foam used in the preferred embodiment, especially in a wetted, wet swellable absorbent foam, help increase removal comfort. When under compression by a band type constriction, the wetted foam tends to migrate from the area of constriction to the limit of its stretch or ultimate strain to relieve the compression. Under tension, as when pulled through a ring, the wetted foam stretches in the direction of pull and necks down to reduce its cross section transverse to the direction of pull. This behavior permits a larger than expected tampon to be removed through the ring-like band of the introitus. The omnidirectional properties are exhibited to a great degree by the material of the preferred embodiment in its wet swollen state.

The omnidirectional properties exhibit their advantage further in that a material having them can adjust to the cross section of a passageway during removal, such as the vaginal introitus, rather than make the passageway conform to the shape of the material. The greatest cross sectional area possible for a given perimeter is attained with a circular shape. If both the tampon and the wall of the introitus are completely flexible, the passageway will acquire the circular shape as the tampon passes through. If the tampon is not capable of deforming to the circular shape, that tampon having a given cross sectional area must encounter greater resistance to removal than a tampon of the same cross sectional area which will deform to the circular shape. Even if the introitus does not acquire the circular shape, but is of irregular shape when expanded by the tampon during removal, the omnidirectional properties of the preferred foam tampon allows it to conform to the irregular shape of the introitus and increase removal comfort. The tampon of this invention made from a compliant foam of the above specified material modulus of compressibility does adjust or conform to the cross section of the introitus to thereby increase removal comfort.

The tampon of this invention is flexible and resilient, and as it is deformed under the pressures exerted by the vagina, it takes the shape as shown in FIG. 3. The tampon is deformed to bring its top wall 16 into contact with the bottom wall 17. As it is deformed as above described, its lateral walls 14 and 15 are distended laterally, i.e., perpendicular to the direction of the force which deformed the tampon. This lateral distension enables the tampon to "reach out" for the side walls of the vagina to form a seal between the tampon and the vaginal walls against menses flow.

Absorbent body 10 being mensesphilic will absorb fluids and due to its large transverse periphery and deformability, distensibility and conformability, fills substantially the entire vaginal cross section. Thus tampon 20 blocks the flow of menses down the vagina as a result of the substantially continuous line of contact between the vagina walls and the tampon. The menses contacting the tampon is absorbed into the structure as well as both wetting the cell walls and filling the void cells.

The tampon of this invention is also preferably capable of volume wet swell which enhances its absorption and fluid capability. The wet swelling of the tampon of this invention causes it to expand as it is wetted, so that it fills any voids remaining after the tampon has completed its dry expansion, thereby possibly contributing to the prevention of bypass as the tampon approaches

its fluid retention capacity. Due to the increased volume and resiliency of a wet swelled tampon, the wet swell characteristic also enables the tampon to maintain contact with the vaginal walls as they move during the normal activity of a user and therefore helps to better maintain contact between the tampon and the vaginal walls.

The absorption characteristics of this tampon rely on at least two phenomena, i.e., capillarity and suction. Capillarity is the principal force moving the fluid from the exterior surface 11 of the tampon 20 toward the interior surface 13. Capillarity in a foam, such as used in the preferred embodiment of this tampon, is dependent upon several foam properties, two of them being cell size and porosity. It is dependent on cell size because the cells form the capillaries. A continuous string of cells form a channel through which the fluid can travel. Small cells form narrow capillaries and large cells form broad capillaries. The narrow capillaries will draw a fluid to greater depth than will the broad capillaries, but the broad capillaries will transport a greater volume of fluid or a higher viscosity fluid than will the narrow capillaries.

The capillary action for moving fluid into the tampon is enhanced if there is gradient from the exterior to the interior of the tampon in the average diameter of the cells whereby the average diameter on the exterior is larger than that on the interior. The smaller capillaries near the interior have a greater capillary attraction and pull the fluid deep into the tampon leaving the exterior relatively dry to absorb more menses. A capillary gradient which is linear from the exterior to the interior of tampon 20 is acceptable to provide the increased driving force on a liquid toward the tampon interior.

The porosity of a foam is determinative of the capillarity the foam exerts upon a fluid in that a foam with a low porosity does not have as many complete capillaries from the exterior to the interior as does a foam with a high porosity. Also any capillary from the exterior surface 11 to the interior surface 13 is probably longer in a low porosity foam than in a high porosity foam because the openings between cells, which give the foam porosity, are not in a direct line from the exterior to the interior but form a circuitous path. The route described by the capillaries in a less porous foam is more circuitous because fewer cell faces between cells are opened and communication between one cell and all of its adjacent cells is restricted. Therefore, porosity affects the capillarity of a foam in two ways, i.e., the lower the porosity the fewer continuous capillaries there are available from the exterior to the interior and the lower the porosity, the longer are any available capillaries from the exterior to the interior.

Directional porosity in a foam can also promote efficient capillarity in a foam. Partitioning failure, wherein the menses flow rate past a particular area of the tampon is greater than the absorption rate of the tampon in that area, is controllable by directional porosity. A foam tampon having the direction of highest porosity transverse to the longitudinal axis and the direction of lower porosity parallel to the longitudinal axis will absorb more menses, i.e., have less partitioning failure, before failure.

Another mechanism which operates to move fluid from the exterior to the interior of an absorbent body having a cellular structure is the suction developed by expanding cells which have most of their faces intact.

These relatively complete cells act as a syringe in that compression will expell the gas from their interior and upon re-expansion of the cells, any fluid in the vicinity of their opened faces will be drawn into the cell interior due to the suction developed by the expanding cell. A tampon in place in the vagina is constantly undergoing compression and expansion from the normal movements and body functions of the female. That is to say that the pressure exerted upon the vagina fluctuates. This change in pressure tends to compress and release the cells in a soft, resilient foam tampon which causes those cells which are relatively complete to act as a syringe and draw fluid into them.

A syringe effect can also occur when the tampon undergoes wet volume swell into an existing void within the vagina. As the cells are wetted the volume encompassed by a cell is increased and the pressure differential created by the increase in volume of the cell causes the cell to suck in fluid which is present at any of its ruptured faces. The syringe effect is particularly strong when a partially closed cell has only one or two faces open and these open faces lie at the end of a capillary within the foam. Thus we see that fluid movement within a cellular absorbent body is the result of two independent phenomena, capillarity and suction.

The following FOAMS I, II, and III are wet swellable mensesphilic foams which have been used in the preferred embodiment of this tampon. They were made from a polyether polyol having an appreciable level of polyethylene oxide built into the molecule. For this purpose, a polyether incorporating 40-60 Wt. % polyethylene oxide and 60-40% polypropylene oxide seems to be about optimum.

FOAM I

An intimate mixture of

INGREDIENT	PARTS BY WEIGHT	COMMENT
Polyether Polyol ¹	100.00	
Non-ionic Surfactant ²	15.00	wetting agent
n-ethyl Morpholine	0.10	foaming catalyst
Stannous Octoate (T-9)	0.40	polymerization catalyst
Silicone Surfactant ³	4.00	foam stabilizer
Water	4.50	blowing agent

¹Dow SA-1421 available from Dow Chemical Company, Midland, Michigan.

²Polyethylene glycol

³Silicone L-532 available from Union Carbide, Charleston, West Virginia.

was prepared at room temperature. These ingredients were mixed in a food type blender at high speed for about one minute. Then 48.3 parts by weight of toluene di-isocyanate (TDI), comprising 80% 2,4 and 20% 2,6 isomers, were quickly added and mixed at high speed in the blender for 2 to 5 seconds. The entire mixture was then poured quickly into a form wherein the foaming proceeded. Upon completion of the foaming, within 90 seconds, the gelled foam was further cured in an oven at 250°F. for 2 hours. This post cure is necessary for small batches but not for large batches.

The polyurethane foam thus formed was flexible, resilient, mensesphilic and wet swelling. It was made into a tampon as above described and performed well in a syngina, i.e., a simulated vagina comprising a flexible nonporous membrane having the dimensions of a vagina and subjected to 6 inches of water pressure and having an orifice for admitting simulated menses in the

area of the cervix, the simulated menses being similar to menses in salinity and viscosity.

FOAM II

A polyurethane foam was prepared using the procedure of FOAM I, but instead of 48.3 parts by weight of TDI, 38 parts by weight were used. The procedure used for pouring, foaming, and post-foaming cure was the same as in FOAM I.

The foam thus formed was flexible, resilient, mensesphilic, and wet swelling. It was made into a tampon as above described and performed well in a syngina.

FOAM III

A polyurethane foam was prepared using the procedure of FOAM I, but instead of 48.3 parts by weight of TDI, 52 parts by weight were used. The procedure used for pouring, foaming, and post-foaming cure was the same as in FOAM I.

The foam thus formed was flexible, resilient, mensesphilic, and wet swelling. It was made into a tampon as above described and performed well in a syngina.

In addition to the above formulations, acceptable foam for use as the absorbent body 11 can be made in the complete absence of the non-ionic surfactant, n-ethyl morpholine, and silicone surfactant. By the same token, the levels of foaming catalyst, polymerization catalyst, and foam stabilizer may be increased to several times the values stated while still producing a wet swellable mensesphilic foam. The amount of water may be varied from zero to nine parts per hundred as a method of varying the density of the foam. Similarly, an organic blowing agent such as Freon-11 may be used instead of water/TDI yielding CO₂ as the blowing agent.

EXAMPLE I

To 50 grams of a polyol prepared by sequentially condensing propylene oxide-ethylene oxide with propylene glycol to give a polymer having an average molecular weight of approximately 8,000 and containing approximately 80 percent ethylene oxide, is added 2 milliliters of a 65:35 mixture of 2,4-tolylene diisocyanate and the corresponding 2,6-isomer. The mixture is stirred for about 2 hours at approximately 120°C. in a system open via a capillary. An additional 12 milliliters of the 65:35 mixture of 2,4- and 2,6-tolylene diisocyanates is added and then the mixture is cooled to room temperature to form a solid prepolymer. Twenty-five grams of this prepolymer is melted. To the melted prepolymer is added 0.895 milliliters of a catalyst mixture (which contains 10 parts N-methyl morpholine, 2 parts triethylamine, 3 parts of a propylene glycol-propylene oxide-ethylene oxide block copolymer containing 20 percent ethylene oxide, having an average molecular weight of about 6,000 and 35 grams of water) with constant stirring. The foam is allowed to stand at room temperature for about 1 hour. The foam is then cured by drying at 70°C. for approximately 24 hours.

From this foam is cut a tampon in the shape of a truncated cone having a large base diameter of approximately 2 ¼ inches and a small base diameter of about ½ inch. The cone is hollowed out by cutting from its center a cone having a base of 1 ½ inches, the base of the removed cone being coplanar with the large base of the tampon. The walls of the removed cone are parallel to the outside walls of the tampon. The height of the

tampon between the two bases is approximately 2 inches. A cotton string having a tensile strength of approximately 9 pounds and long enough to function as a withdrawal string is attached to the small base of the tampon.

This tampon, when compressed and placed in a tubular inserter having an outside diameter of approximately one-half inch, can be used as a tampon for collecting the menses. The tampon is mensesphilic, water-swallowable, flexible, soft, and white in color.

The Scott Hydro-FoamTM previously mentioned, also a mensesphilic, wet swellable, polyurethane foam, was made into tampons as above described. These tampons gave superior bypass control and weight gain, i.e., menses absorbed, when placed in the vagina of menstruating women.

When the specific foams disclosed in the following U.S. patents are substituted for the foam in Example I, substantially equivalent results will be obtained in that a useful tampon is formed. Alexis Archipoff, et al. U.S. Pat. No. 3,573,234, patented Mar. 30, 1971; Joerg Sambeth, et al, U.S. Pat. No. 3,560,416, patented Feb. 2, 1971; Charles H. Hofrichter, et al, U.S. Pat. No. 3,463,745, patented Aug. 26, 1969; Stanley I. Cohen, et al, U.S. Pat. No. 3,457,203, patented July 22, 1969; Joerg Sambeth, et al, U.S. Pat. No. 3,451,954, patented June 24, 1969; Joerg Sambeth, et al, U.S. Pat. No. 3,451,953, patented June 24, 1969; Joerg Sambeth, et al, U.S. Pat. No. 3,432,448, patented Mar. 11, 1969; Rudolf Merten, et al, U.S. Pat. No. 3,388,081, patented June 11, 1968; Bernard Rabussier, U.S. Pat. No. 3,385,803, patented May 28, 1968; James A. Calamari, U.S. Pat. No. 3,164,565, patented Jan. 5, 1965; Morris V. Shelanski, et al, U.S. Pat. No. 3,098,048, patented July 16, 1963; Carl V. Strandkov, U.S. Pat. No. 3,042,631, patented July 3, 1962; Fritz Schmidt, et al, U.S. Pat. No. 3,007,883, patented Nov. 7, 1961; Harold L. Elkin, U.S. Pat. No. 2,965,584, patented Dec. 20, 1960; Erwin Windemuth, et al, U.S. Pat. No. 2,948,691, patented Aug. 9, 1960; Elekal, British Pat. No. 1,180,316, patented Feb. 4, 1970; Vereinigte Papierwerke Schickedanz & Co., French Pat. No. 1,350,709, patented Dec. 23, 1963; George Shkapenko, et al, U.S. Pat. No. 3,535,143, patented Oct. 20, 1970; John G. Simon, et al, U.S. Pat. No. 3,508,953, patented Apr. 28, 1970; Whitney R. Adams, et al, U.S. Pat. No. 3,458,338, patented July 29, 1969; John R. Caldwell, et al, U.S. Pat. No. 3,418,066, patented Dec. 24, 1968; Joerg Sambeth, et al, U.S. Pat. No. 3,413,245, patented Nov. 26, 1968; Lyle W. Colburn, U.S. Pat. No. 3,404,095, patented Oct. 1, 1968; Fred W. Meisel, et al, U.S. Pat. No. 3,382,090, patented May 7, 1968; Yvan Landler, et al, U.S. Pat. No. 3,326,823, patented June 20, 1967; Ming Chih Chen, U.S. Pat. No. 3,249,465, patented May 3, 1966; Sotirios S. Beicos, U.S. Pat. No. 3,149,000, patented Sept. 15, 1964; John Bugosh, et al, U.S. Pat. No. 3,094,433, patented June 18, 1963; Karl Goldann, U.S. Pat. No. 2,998,295, patented Aug. 29, 1961; Marvin J. Hurwitz, et al, U.S. Pat. No. 2,990,378, patented June 27, 1961; John Bugosh, U.S. Pat. No. 2,920,983, patented Jan. 12, 1960; and William R. Powers, et al, U.S. Pat. No. 2,900,278, patented Aug. 18, 1959.

Thus it is apparent that there has been provided, in accordance with the invention, a tampon that fully satisfies the objects, aims, and advantages set forth above. While the invention has been described in conjunction

with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations as follows in the spirit and broad scope of the appended claims.

What is claimed is:

1. A tampon, comprising: a flexible, resilient, dry-expanding, absorbent body; said absorbent body having an uncompacted transverse periphery of at least about 5.5 inches; said periphery being in a plane transverse the longitudinal axis of the tampon; and said absorbent body having an internal discontinuity.

2. The tampon of Claim 1 wherein the internal discontinuity is a slit in the interior of the absorbent body.

3. The tampon of Claim 1 wherein the absorbent body has a material modulus of compressibility for a 25 percent compression deflection of less than 0.6 pound per square inch so that it conforms to irregularities in the vaginal walls.

4. The tampon of Claim 1 wherein the absorbent body is generally conically shaped.

5. The tampon of Claim 4 wherein said absorbent body is an open celled, polyurethane foam, said body having a generally conical exterior surface with the longitudinal axis passing through the cone apex and the center of its base, the base diameter of said cone being greater than about 1.75 inches and less than about 3.00 inches, the height of said cone being greater than about 1.75 inches and less than 3.00 inches, the internal discontinuity being an internal cavity which is coaxial with and similar in shape to the tampon exterior, the cavity base being approximately 61 percent of said absorbent body base, said cavity propagating from the base of said absorbent body, said absorbent body having a shape modulus of compression of less than approximately 1 pound, said body having a maximum periphery around its base diameter, said periphery being reduced no more than 10 percent when said body is deformed to its collapsed state, said body having a material modulus of compressibility in the dry state of less than 0.6 pound per square inch, said polyurethane foam having a critical surface tension greater than about 60 dynes per centimeter, said dry tampon having a cell count on its exterior of greater than approximately 20 cells per linear inch and less than approximately 100 cells per linear inch, and said absorbent body being open celled to the extent that the air flow through a 0.4 inch thick dry foam is a minimum of about 30 and a maximum of about 200 cubic feet per minute per square foot of foam with a pressure differential of 0.5 inch of water across the foam, said absorbent body being wet-swallowable at least about 25 percent of its original volume at one atmosphere of pressure, and said absorbent body upon being wetted having a maximum cross sectional area perpendicular to the longitudinal axis of less than about one inch in diameter when compressed by an encircling one-half inch wide teflon band, said band subjected to a tensile force of less than about 600 grams.

6. The tampon of claim 4 wherein the internal discontinuity is a hollow cavity within the body.

7. The tampon of claim 6 wherein said body is a mensesphilic foam.

8. The tampon of claim 1 wherein said body is a mensesphilic foam.

21

9. The tampon of claim 8 wherein said foam is a polyurethane.

10. The tampon of claim 9 wherein the absorbent body is generally conically shaped.

11. The tampon of claim 9 wherein the absorbent body is generally conically shaped and the internal discontinuity is a hollow cavity.

12. The tampon of claim 9 wherein the absorbent body is generally conically shaped, the internal discontinuity is a hollow cavity and the direction of foam rise in the polyurethane is substantially transverse the longitudinal axis of the tampon.

13. The tampon of claim 9 wherein the cell count of said absorbent body is greater than approximately 20 cells per linear inch and less than approximately 100 cells per linear inch.

14. The tampon of claim 9 wherein the cell count of said absorbent body is greater than approximately 20 cells per linear inch and less than approximately 100 cells per linear inch and the polyurethane foam absorbent body is open celled to the extent that the air flow through 0.4 inch thick dry foam is a minimum of about 30 and a maximum of about 200 cubic feet per minute per square foot of foam with a pressure differential of 0.5 inch of water across the foam.

15. The tampon of claim 9 wherein the foam rise direction is substantially transverse the longitudinal axis of the tampon.

16. The tampon of claim 9 wherein the structural members of the cells in said mensesphilic polyurethane foam absorbent body absorb water and thereby cause said absorbent body to swell in volume at least about

22

25 percent at one atmosphere of pressure.

17. The tampon of claim 16 wherein the tampon is generally conically shaped.

18. The tampon of claim 16 wherein the tampon is generally conically shaped and the internal discontinuity is a hollow cavity.

19. The tampon of claim 16 wherein the cell count of said absorbent body is greater than approximately 20 cells per linear inch and less than approximately 100 cells per linear inch.

20. The tampon of claim 19 wherein the polyurethane foam absorbent body is open celled to the extent that the air flow through 0.4 inch thick dry foam is a minimum of about 30 and a maximum of about 200 cubic feet per minute per square foot of foam with a pressure differential of 0.5 inch of water across the foam.

21. The tampon of claim 1 wherein said body after being wetted has a maximum cross section perpendicular to the longitudinal axis of less than about one inch in diameter when compressed by an encircling one-half inch wide teflon band, said band subjected to a tensile force of less than about 600 grams.

22. The tampon of claim 21 wherein the internal discontinuity is a hollow cavity within the body.

23. The tampon of claim 1 wherein the uncompacted transverse periphery is at least about 6.6 inches.

24. The tampon of claim 6 wherein the wall thickness of the absorbent body is at least about 6 percent of the uncompacted transverse periphery.

* * * * *

35

40

45

50

55

60

65

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,794,029

Dated February 26, 1974

Inventor(s) Bernard A. Dulle

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

Assignee: "The Proctor & Gamble Company" should read
--The Procter & Gamble Company--.

Column 2, line 6, "internal" should read --Internal--.

Column 2, line 9, "do not" should read --do not--.

Column 5, line 5, "SMMARY" should read --SUMMARY--.

Column 6, line 64, "onternal" should read --internal--.

Signed and sealed this 16th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents