

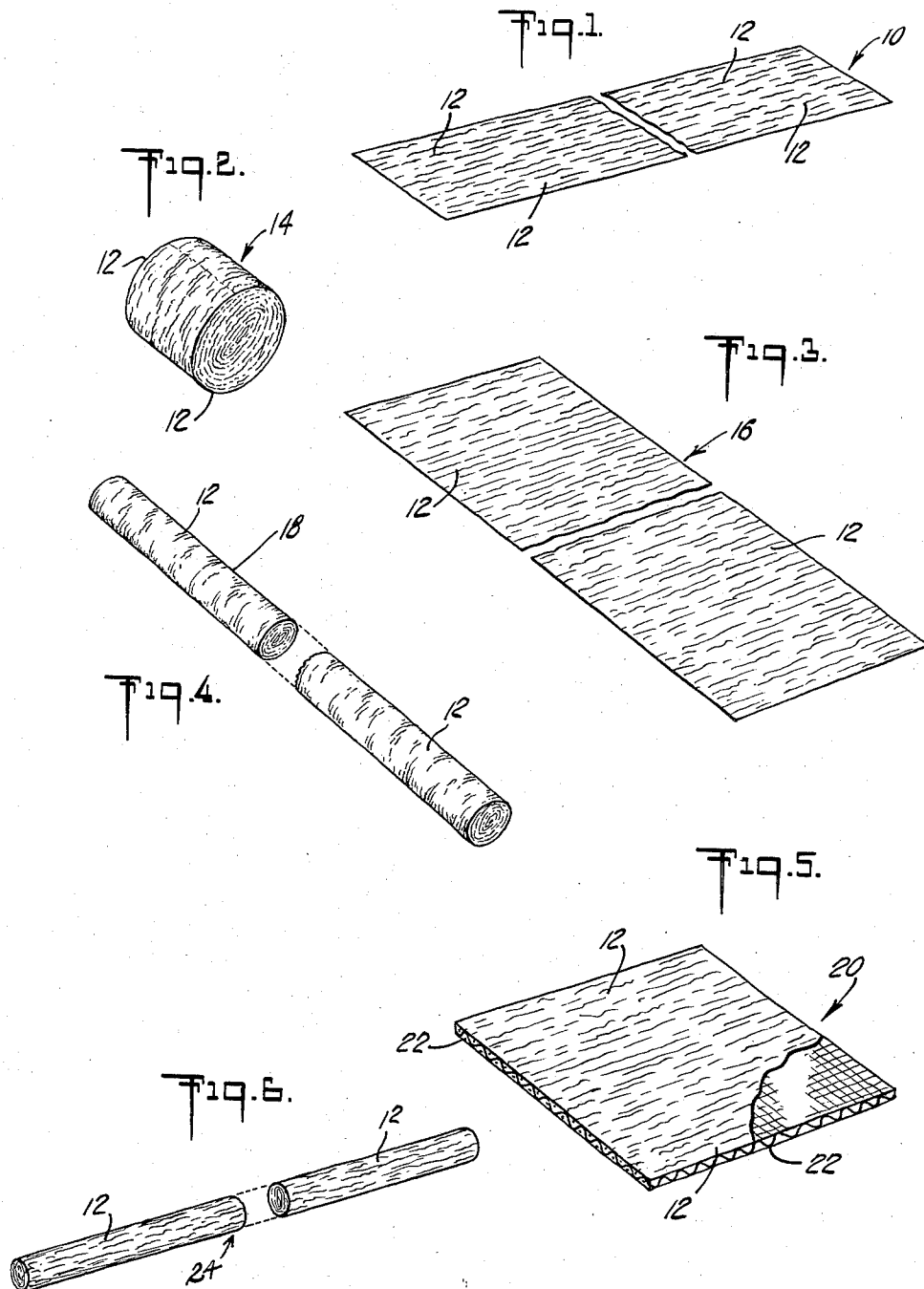
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F. C. BRENNER ET AL

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FIBROUS PRODUCTS

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1

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FIBROUS PRODUCTS

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6 Claims. (Cl. 28—78)

This invention relates to fiber systems in general containing highly crimped regenerated cellulose fibers to improve their physical properties and, more particularly, to fibrous absorbent surgical products.

Heretofore, fibrous absorbent surgical products have been comprised of assembled fibrous masses, normally of cotton fibers, which have been used, for example, to apply solutions or dressings on the body or for the removal of fluids or other materials from the body. Other uses have been as plugs or stoppers to cover the openings of test tubes and other similar vessels to prevent the contents thereof from becoming contaminated.

The replacement of cotton with regenerated cellulose fibers in surgical products and related materials has been proposed because of the controllability and greater uniformity of the staple regenerated cellulose fiber length, the lower cost thereof, the more constant supply and availability, and the fact that the regenerated cellulose fibers need not be subjected to cleaning operations or prior wet processing.

Unfortunately, regenerated cellulose fibers in ball or similar form are relatively not resilient and will tend to collapse and lose their shape, particularly when wetted with water. Various terms, such as "limp," "slick," and "greasy," have been used to describe the condition of such fiber assemblies in the wet state. Additionally, such fiber systems show little or no recovery after being wetted and/or compressed. The lack of such resiliency in both the wet and dry state has militated greatly against the more wide-spread use of regenerated cellulose for fibrous absorbent surgical products.

Additionally, it has been noted that the regenerated cellulose fibers, even though they can be manufactured in a more uniform length than cotton, have a tendency toward the loss of fibers and excessive shedding, especially when used to apply solutions or to absorb fluids on various parts of the body. This is obviously disadvantageous.

Furthermore, when regenerated cellulose fibers are used in the form of balls or similar shapes to plug test tubes and other vessels and are then exposed to heat and moisture, such as during steam sterilization, the plugs have a tendency to collapse and shrink in size and either fall out of, or to slip down into, the test tube or vessel. This, of course, is wholly undesirable and spoils that particular sample or specimen.

The principal object of the present invention is therefore to modify the physical properties of regenerated cellulose fibers so that the absorbency of products manufactured therefrom is enhanced, the fiber resiliency in the wet and dry state is improved, the tendency to collapse and mold in humid high temperature atmospheres is lessened, and the fiber loss or shedding of fiber assemblies in both the wet and dry state is reduced.

It has been found that these objects and others which will become clear from a further consideration of this disclosure may be obtained by using regenerated cellulose fibers having a specified length and denier and a total

2

number of crimps per inch which bears a very definite and critical relationship to the denier of the fibers.

The length of the fibers has been found to be advantageously within the range of from about 1/2 inch to about 7 inches and, within the more commercial aspects of the present invention, from about 1 inch to about 1 1/2 inches or even up to about 3 inches. It has been established that it is necessary to remain within the values of these ranges to provide the best carding and other manipulation of the fibers during manufacture of the absorbent product and to reduce fiber loss and shedding to a minimum while maintaining acceptable utilization of the fibrous product.

The denier of the fibers has been found to be advantageously within the range of from about 1 to about 9, and, within the more commercial aspects of the present invention, from about 1 1/4 to about 5 1/2, with optimum values being obtained in the range of from about 1 1/2 to about 3 1/2. Denier above 9 produce a product lacking in consumer acceptance in that it tends to abrade the skin, whereas denier less than 1 introduce production problems as well as a lack of "body" in the final product. As used herein, the term "denier" has its usual technical meaning, namely, in the case of regenerated cellulose or rayon, it is the weight in grams of 9000 meters of yarn.

With regard to the number of crimps per inch of the regenerated cellulose fibers, it is to be observed that not only is (1) the number of crimps per inch of importance, but (2) the ratio of the number of crimps per inch to the denier of the fiber is also critical. In this invention, crimp is a measure of the waviness, regular or irregular, of the regenerated cellulose fiber. The number of directional changes occurring per inch represents an estimate of the degree and extent of the crimp. In counting the crimps, care must be taken to include those which are three-dimensional as well as two-dimensional. The fibers are normally available in a bale, bundle, or blanket form and are mechanically opened, keeping the stretching of the fibers to a minimum. The closely grouped bundles of fibers which remain, the so-called "locks" or "noils," are used to measure the crimp. They are selected and are placed on a suitable flat surface and the crimps are then counted. A sufficient number of representative samples are taken in the usual fashion to increase the accuracy of the count. The number of crimps per inch is determined by counting the total number of directional changes in the particular fiber and dividing that number by the straightened fiber length in inches.

It has been found that if the number of crimps per inch is greater than twenty times the square root of the reciprocal of the denier, the desired objects indicated above are obtained. Within the more commercial aspects of the present invention, however, it has been established that a number of crimps equal to from about 25 times to about 50 times the square root of the reciprocal of the denier is preferred.

In the accompanying drawing and the following specification, there are illustrated and described preferred fibrous absorbent surgical products embodying the invention, but it is to be understood that the invention is not to be construed as limited to the constructions shown except as determined by the scope of the appended claims. Referring to the accompanying drawing:

Figure 1 is a perspective view of a fibrous web containing highly crimped regenerated cellulose fibers;

Figure 2 is a perspective view of a rayon ball containing highly crimped regenerated cellulose fibers;

Figure 3 is a perspective view of a fibrous web containing highly crimped regenerated cellulose fibers and having different proportions than the web of Figure 1 and intended for the manufacture of a different product;

Figure 4 is a perspective view of a roll containing highly crimped regenerated cellulose fibers;

Figure 5 is a perspective view of a fibrous web containing highly crimped regenerated cellulose fibers and reinforced with a supporting gauze layer; and

Figure 6 is a perspective view of still another form of an absorbent product of the present invention.

In the embodiment of the invention set forth in the drawing, Figure 1 illustrates a long, narrow fibrous web 10 comprising highly crimped regenerated cellulose fibers 12. This web may be used as it is for absorbent purposes, or it may be rolled into an approximately cylindrical shape, such as shown by the ball 14 shown in Figure 2.

Figure 3 shows a fibrous web 16 containing highly crimped regenerated cellulose fibers 12. This web is considerably shorter and wider than fibrous web 10 of Figure 1 and is used in the manufacture of the absorbent product 18 illustrated in Figure 4. The length of the absorbent product in Figure 4 is determined by the width of the fibrous web 16 and normally ranges from about an inch or less up to about 40 or 50 inches or more in width. If desired, the absorbent product 18, as well as the other absorbent products disclosed herein, may be lightly bonded with a suitable adhesive or other bonding agent.

It is occasionally desired to use these fibrous webs in a flat or opened-up position or in a singly or doubly folded condition. As such, if the grain weight per yard of the original web is very low, the strength of the resulting absorbent product is also very low and usually too low to handle manually. If desired, therefore, a product 20, as shown in Figure 5, may be manufactured by supporting the fibrous web in flat condition upon a backing gauze layer 22. If desired or required, additional materials may be added as a covering or the like to this composite product.

Figure 6 shows still another absorbent product 24 comprising highly crimped regenerated cellulose fibers. Such a product may be prepared by rolling up the web 10 of Figure 1, this time in the short direction, rather than in the long direction whereby the ball of Figure 2 may be obtained.

It is to be noted that in Figures 1, 3, and 5, the crimped fibers are in carded condition and assume an approximately straight over-all condition, ignoring the relatively small crimps and other irregularities. Additionally, the fibers are generally planar, that is, they lie in substantially one plane only and are practically uniformly arranged side by side in parallelism in that plane. It is believed that this carded relationship, in combination with the number of crimps per inch in the fiber, taken in conjunction with the denier of the fiber, leads to the advantageous properties and characteristics of the adsorbent products of the present invention.

In Figures 2, 6 and 4 are shown rolled or coiled absorbent products which can be made from the flat webs shown in Figures 1 and 3, respectively. Consideration of Figure 2, by way of example, specifically reveals more clearly that the fibers are generally in arcuate or curved over-all configuration, ignoring the relatively small crimps and other irregularities. Since the roll 14 was made from a product like the carded web 10, the fibers 12 are still substantially uniformly arranged in parallelism, that is, they are generally spaced evenly throughout the product and have approximately the same general inclination and direction. Thus, adjacent fibers lie side by side, each having a curved or arcuate configuration and not actually crossing each other. The curvature of the vast majority, perhaps over 80% by weight, of such fibers is such that their radius centers of curvature constitute a line passing approximately through the geometric center or axis of the rolled absorbent product.

It is not essential that all of the fibers in the absorbent product be highly crimped. The advantageous properties enumerated hereinbefore are still pronounced, although to a lesser degree, if other fibers are introduced

to form a substantially uniform blend with the crimped fibers. The additional materials, however, should not be incorporated in an amount substantially greater than 60% by weight inasmuch as the desirable effects of the crimped fibers become diluted too much if the other fibers are considerably in excess of 60% by weight.

The nature of the other fibers which may be included in the blend may be selected depending upon the particular purposes desired or the special effects required. Such other fibers would include, for example, wool, silk, cotton, commercial regenerated cellulose, cellulose acetate, nylon, polyester fibers, acrylic fibers, vinyl fibers, glass fibers, etc.

The term rayon or regenerated cellulose as used herein is intended to cover a cellulosic fiber which existed in cellulose form at one time and has gone through chemical manufacturing processing and is now reconstituted with substantially its original cellulose chemical structure. Such would include regenerated cellulose made by the viscose process, the cuprammonium process, the cellulose-acetate-saponification process, the cellulose nitrate-denitration process, etc. It is to be noted that these fibers are truly cellulosic, resembling cotton basically, and are not derivatives of cellulose, such as cellulose esters and ethers. Additionally, it is to be observed the crimps present are imparted by a chemical process and therefore permanently recoverable (rather than being imparted mechanically and therefore being temporary. Were this not so, the crimps would rapidly disappear when wet with water and the advantageous properties would be lost.

The invention will be further illustrated in greater detail by the following evaluations and specific examples. It should be understood, however, that although these evaluations and specific examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration and the invention in its broader aspects is not to be construed as limited thereto.

COMPRESSIONAL PROPERTIES

A quantitative procedure for measuring the compressional behavior of fibers, such as, for example, (1) cotton, (2) commercial rayon fibers, and (3) highly crimped rayon fibers in both the wet and dry state is employed. A cylindrical chamber of uniform cross section is used to hold the prepared fibrous test specimens. An amount of the carded web in grams equal to the specific gravity of the fibers therein is introduced into the cylindrical chamber so that, if all air space could be removed and the fibers had zero resilience and could be compressed together, approximately 1 cubic centimeter is occupied by the fibers.

A piston connected to a strain gauge is lowered into the cylinder until it gently contacts the fibers. Pressure is then applied to the fiber system by slowly raising the cylinder at a constant rate against the piston head, said cylinder movement being opposed during that time by the resilience of the fibers. In this manner, the relationship between the volume beneath the piston or the inter-fiber volume and the applied pressure under dynamic conditions is determined. This measurement of interfiber volume is made on a specific volume of the material in accordance with recognized procedures, e.g., the method described in the Gottlieb et al. article appearing in the Textile Research Journal, volume XXVIII, No. 1, page 43.

In the testing in the wet state, the fiber system is in contact with an excess of water added to the cylinder before the application of pressure by the piston. The amount of water added is sufficient to completely saturate the fibers and to provide an excess to form an external environment in which only water-fiber interfaces are present. During the application of compressional forces, the resistance is furnished by the resilience of the web fibers. The face of the piston is perforated to permit excess water to flow therethrough to the space above the piston head.

5

The following results are obtained:

Table 1

COMPRESSIONAL PROPERTIES OF ONE SPECIFIC VOLUME

Sample	Interfiber volume under a pressure of 0.5 p.s.i. (pounds per square inch)	
	Dry, cu. in.	Wet, cu. in.
Cotton-Virgin, strict middling, $1\frac{3}{16}$ " Micronaire value 5.....	1.438	1.041
Commercial Rayon, 1.5 denier, 15.1 crimps/inch.....	1.335	0.971
Commercial Rayon, 2.0 denier, 12.1 crimps/inch.....	1.370	0.964
High crimp rayon, 1.5 denier, 17.5 crimps/inch.....	1.803	1.057
High crimp rayon, 1.5 denier, 23.1 crimps/inch.....	2.534	1.023
High crimp rayon, 2.0 denier, 18.6 crimps/inch.....	2.261	1.031
High crimp rayon, 3.0 denier, 17.1 crimps/inch.....	2.243	1.078

Further compressional tests are made to determine the effect of the change of denier on the behavior of commercial rayon fiber systems during compression in the wet state.

Table 2

Sample	Wet interfiber volume under a pressure of 0.5 p.s.i.
Commercial Rayon, 1.5 denier, 15.1 crimps/inch.....	0.971 cu. in.
Commercial Rayon, 2.0 denier, 12.1 crimps/inch.....	0.964 cu. in.
Commercial Rayon, 3.0 denier, 9.1 crimps/inch.....	0.929 cu. in.
Commercial Rayon, 5.5 denier, 7.1 crimps/inch.....	0.934 cu. in.

Consideration of Tables 1 and 2 clearly shows the vast improvement resulting from the use of carded high crimp rayon, as compared with commercial rayon or cotton. The improvement in compressional properties is particularly notable in the dry state but marked improvement is also observed in the wet condition.

For the purposes of the invention, the interfiber volume at 0.5 p.s.i. should be at least 1.75 cu. inch for an article comprising one specific volume (i.e., an amount in grams equal to the specific gravity of the article). There is no upper limit, except that inherent in the article.

ABSORBENT CAPACITY

Measurements of the absorbent capacity of various fiber systems is made in accordance with methods specified for cotton in the U.S. Pharmacopoeia, vol. XV. The results are set forth in the following table which shows the fiber absorbent capacity (1) in a non-sterile absorbent capacity before steam sterilization and (2) in a sterile absorbent capacity after steam sterilization. The evaluation figures in the second and third columns represent the amount of fluid absorbed times the weight of the sample.

Table 3

ABSORBENT CAPACITY

Sample	Non-Sterile	Sterile
Commercial rayon, 1.5 denier, 15.1 crimps/inch.....	25.3	21.9
High crimp rayon, 1.5 denier, 23.1 crimps/inch.....	28.5	28.5
High crimp rayon, 2.0 denier, 18.6 crimps/inch.....	28.9	27.6
High crimp rayon, 3.0 denier, 17.1 crimps/inch.....	30.6	30.5

Consideration of Table 3 will clearly show the improvement in absorbent capacity obtained by the use of high crimp rayon. The improvement is more marked with the use of sterile absorbent materials.

ELONGATION AND SHEDDING

In surgical products, it is quite common to prepare the material in a ball or similar form. This is usually done by initially carding the fiber into a thin sliver, as shown in Figure 1, and rolling or otherwise forming it

6

into a ball as shown in Figure 2. These balls are used normally in the application of fluids or other materials to the body or to absorb fluids or other materials in the cleaning of the body. Excessive loss of fibers (shedding) by the balls is extremely disadvantageous. The following test for evaluating the quality and non-shedding characteristics of fiber systems in ball form is used. A ball is fastened to a spring paper clip. By means of a motor and a gear box, the assembly, suspended from a cord, is lowered into and then raised out of water. At the lowest point, the edges of the clip are about 1 centimeter below the surface of the water. The ball is dipped repeatedly ten times over a period of fifty seconds. As the test proceeds and as the ball is removed from the water, the ball body tends to elongate and to assume a cylindrical shape with an extended pointed lower end. The smaller the elongation of the ball, the better is its resistance to fiber loss and shedding. Using the above test method, measurements were made with the following results:

Table 4

RELATIVE INCREASE IN BODY LENGTH

Sample	Relative Elongation	
	Body	Overall
Commercial rayon, 1.5 denier, 15.1 crimps/inch.....	0.142	1.570
High crimp rayon, 1.5 denier, 23.1 crimps/inch.....	0.048	0.290
High crimp rayon, 3.0 denier, 17.1 crimps/inch.....	0.066	0.326

Consideration of Table 4 reveals the considerable improvement in the relative elongation obtained by the use of high crimp rayon. The improvement in both the body relative elongation and the overall relative elongation is extremely marked in both cases.

FIBER COLLAPSE OR MOLDING

In many instances, fibers in ball form are used by hospitals and research laboratories to plug test tubes or the opening of other vessels prior to sterilization. During sterilization, the fiber system is exposed to heat and moisture and, with some fibers, there is a tendency to contract and slip down into the tube, or at least to become loosened so that they will fall out later in the normal handling of the vessels. Evaluation of this property is carried out by measuring the forces required to dislodge the plugs after steam sterilization. The plug or ball is pushed gently into the neck of a constriction top without twisting until it is snugly in position. The results obtained are an average of 12 measurements for various fibers and are shown in the following table.

Table 5

REMOVAL FORCE

Sample:	Force in grams
Cotton	93
Commercial rayon, 1.5 denier, 5.1 crimps/inch ..	59
High crimp rayon, 1.5 denier, 20 crimps/inch.....	92
High crimp rayon, 1.5 denier, 23.1 crimps/inch ..	107

Consideration of Table 5 reveals the increase in the force in grams required to dislodge the high crimp rayon balls.

Further evaluations are made in a hospital wherein a total of 2000 balls made from 1.5 denier high crimp regenerated cellulose fibers having 23 crimps per inch are used. After sterilization and the usual handling in connection therewith, only four balls fall out of the test tubes. In a second test using 2000 balls comprising 3.0 denier high crimp regenerated cellulose fibers having 17 crimps per inch, no balls fall out of the test tubes. The test tubes used in these experiments are lipless and have internal diameters of approximately $\frac{7}{16}$ and $\frac{1}{2}$ inch. The rayon balls are pushed into the tubes until a depth of at least $\frac{1}{2}$ inch is obtained with the balance of the

ball extending over the top in the form of a mushroom. When these tests are repeated using commercial regenerated cellulose fibers, 1.5 denier, 15.1 crimps/inch, approximately 25% of all the test tube plugs were dislodged.

Evaluations are also made to determine differences between (1) cotton, (2) high crimp rayon, and (3) commercial rayon. The commercial rayon is 1.5 denier and averages 15.1 crimps per inch. The high crimp rayon is 2.0 denier and averages 18.6 crimps per inch. Samples are prepared in the form of balls suitable for applying fluids such as oils, alcohol, water, lotions, and the like. The results are as follows:

(1) The cotton balls absorb and hold the absorbed fluids very well. The fluids do not "seep through." The balls retain their shape and body, even when they are used in the strongest solutions. The "feel" is a little harsher than the other two groups.

(2) The high crimp rayon balls absorb and hold fluids in a satisfactory fashion. The balls do not become "slimy" and retain resilience and shape when wet. The "feel" of the balls is less harsh. Linting is low and the product does not fall apart in use.

(3) The commercial rayon balls do not absorb or hold moisture as well as the two preceding groups. The fluids tend to "seep through." The balls fall apart in use, especially when used in water. When the samples are allowed to stand or to soak in water for even a relatively short time, the balls stretch out into a long slimy string when removed from the water. Linting is excessive.

Although several evaluations and specific examples of the inventive concept have been described, the same should not be construed as limited thereby nor to the specific substances mentioned therein but to include various other compounds of equivalent constitution as set forth in the claims appended hereto. It is understood that any suitable changes, modifications and variations may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. As an article of manufacture, a fibrous absorbent product comprising carded, highly crimped staple fibers of regenerated cellulose, said fibers being substantially uniformly arranged in parallelism, the length of said fibers being at least about ½ inch, the denier of said fibers being from about 1 to about 9, and the number of crimps per inch being greater than 20 times the square root of the reciprocal of the denier, one specific volume of said article having an interfiber volume in a dry state under a pressure of 0.5 p.s.i. of at least 1.75 cu. in.

2. As an article of manufacture, a fibrous absorbent surgical product comprising carded, highly crimped fibers of regenerated cellulose, said fibers being substantially uniformly arranged in parallelism, the length of said fibers being from about 1 inch to about 1½ inches, the denier of said fibers being from about 1 to about 9, and the number

of crimps per inch being greater than 20 times the square root of the reciprocal of the denier, one specific volume of said article having an interfiber volume in a dry state under a pressure of 0.5 p.s.i. of at least 1.75 cu. in.

3. As an article of manufacture, a fibrous absorbent surgical product comprising carded, highly crimped fibers of regenerated cellulose, said fibers being substantially uniformly arranged in parallelism, the length of said fibers being from about ½ inch to about 3 inches, the denier of said fibers being from about 1½ to about 5½, and the number of crimps per inch being greater than 20 times the square root of the reciprocal of the denier, one specific volume of said article having an interfiber volume in a dry state under a pressure of 0.5 p.s.i. of at least 1.75 cu. in.

4. As an article of manufacture, a fibrous absorbent surgical product comprising carded, highly crimped fibers of regenerated cellulose, said fibers being generally arcuate and substantially uniformly arranged in parallelism with the radius-centers of curvature of said arcuate fibers falling upon a line passing approximately through the geometric center of said surgical product, the length of said fibers being from about ½ inch to about 3 inches, the denier of said fibers being from about 1 to about 9, and the number of crimps per inch being greater than 20 times the square root of the reciprocal of the denier, one specific volume of said article having an interfiber volume in a dry state under a pressure of 0.5 p.s.i. of at least 1.75 cu. in.

5. As an article of manufacture, a fibrous absorbent surgical product comprising carded, highly crimped fibers of regenerated cellulose, said fibers being approximately straight, generally planar and substantially uniformly arranged in parallelism, the length of said fibers being from about ½ inch to about 3 inches, the denier of said fibers being from about 1 to about 9, and the number of crimps per inch being greater than 20 times the square root of the reciprocal of the denier, one specific volume of said article having an interfiber volume in a dry state under a pressure of 0.5 p.s.i. of at least 2.2 cu. in.

6. An article of manufacture as defined in claim 1 wherein the fibrous absorbent surgical product comprises at least about 40% by weight of said highly crimped regenerated cellulose fibers and not more than about 60% by weight of other textile fibers having a crimp less than the crimp of said regenerated cellulose fibers.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,968,858

January 24, 1961

Fivel C. Brenner et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 58, for "5.1 crimps/inch" read
-- 15.1 crimps/inch --.

Signed and sealed this 5th day of September 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents

USCOMM-DC