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COMPRESSED FIBER ABSORPTION DEVICE AND METHOD OF MAKING

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Fig. 1.

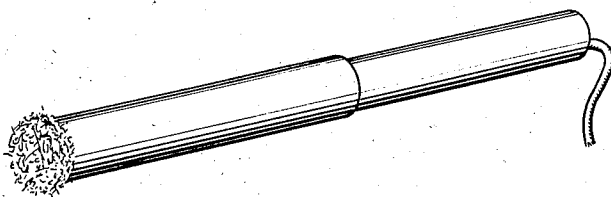
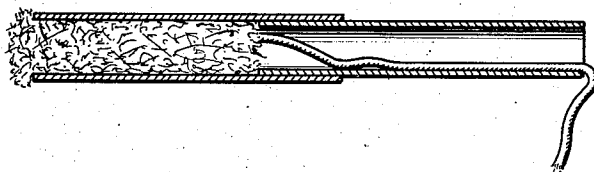


Fig. 2.



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COMPRESSED FIBER ABSORPTION DEVICE AND METHOD OF MAKING

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12 Claims. (Cl. 128—285)

This invention relates to devices adapted for fluid absorption and retention, and more particularly to such devices including a compressed mass of unspun cotton and like absorbent fibers such as surgical pads, dental rolls, catamenial pads, gun wadding, nasal and vaginal tampons, and the like (all of which will be referred to generally as "absorbent pads") in which the fluid absorbing medium comprises a shaped mass of absorbent cotton or like absorbent fibers. This application is a continuation in part of applications Serial Nos. 188,921 and 188,935, both filed October 7, 1950, and now abandoned.

With such absorbent pads, and especially with tampons, it is usually desirable that the pads be capable of absorbing as much fluid as possible for a given limited small bulk. I have found that there is a critical or optimum relation between the bulk or apparent density of the mass of absorbent fiber and the absorption capacity thereof. If, for a given size pad, too much fiber is compacted into its volume, much of the permeability of the pad to liquid is lost with a resulting decrease in absorbency. On the other hand, if such pad is not compressed or compacted, the amount of fiber in the mass may be too small to retain the required amount of fluid in the interstices thereof. Furthermore, in the case of such pads as may be used for nasal or vaginal tampons or dental rolls, it is desirable that the fibrous mass, before use, have a substantial rigidity to facilitate insertion of the tampon or roll and, in the case of such devices supplied originally in an enclosing tube, for example, such stability against expansion is desired to avoid excessive frictional resistance to ejection from the tube. It is difficult, however, to make an unspun mass of absorbent cotton hold just the degree of compression desired.

According to this invention an absorbent pad of predetermined size is produced with a particular density such that it is compacted yet readily permeable to fluid, by compressing a mass of absorbent fibers under conditions which produce a stable "set" in the fibers without destroying their elastic memory, whereby, when they are wet with fluid, the set is released and the fibers tend to return to the form which they had before compression. In order to facilitate setting of the fiber under compression to achieve the particular density or stably compressed state, the fiber is treated according to this invention with a compression stabilizing agent as set forth below. By this treatment the fibers are given a stable set in the absorbent mass, and this set can be controlled to give a retained density in the compressed mass which corresponds to a high degree of absorbency not obtainable with untreated fibers.

Accordingly, a principal object of this invention is to provide an improved absorbent pad of the character described having high absorption efficiency.

Another object of this invention is to provide an improved absorbent pad of treated fibers having a stable set under storage conditions.

Still another object of this invention is to provide an

improved method of producing an absorbent pad of the character described.

A still further object of this invention is to provide a method of improving the stability of form and dimensions in a compressed absorbent pad of the character described.

Still another object of this invention is to increase the absorption efficiency of absorbent pads of the character described.

A still further object of this invention is to provide an absorbent pad of the character described with increased absorption capacity for a given bulk of absorbent fiber.

Still a further object of this invention is to provide a method and materials for stabilizing the form of absorbent cotton and like fibers imparted thereto by compression of a mass of unspun fibers to a desired size and bulk or density.

A still further object of this invention is to simplify the manufacture of absorbent pads and thereby to reduce their cost.

Still another object of this invention is to provide compressed absorbent pads of the character described which will retain a predetermined stable density and degree of compression upon the release of compressing forces.

Other objects and advantages of this invention will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawing—

Fig. 1 is an isometric view of a vaginal tampon as illustrative of an absorbent device embodying this invention; and

Fig. 2 is a view partly in axial section and partly in plan of the tampon of Fig. 1.

Considering an absorbent pad comprising a compressed mass of unspun absorbent cotton fibers, it is possible with such compression to overcome the inherent resiliency of the fibers and produce a compressed mass which remains compressed after the compressing forces are released. It has been found, however, that the amount of compression of untreated fibers necessary to achieve such stability of form and dimensions (i. e., to overcome such inherent resiliency of the fibers tending to spring back to a larger loose mass after compression) may be so great that the density of the resulting compressed mass precludes maximum absorbency of the pad, i. e., because it is too tightly compressed, with too little air space between the individual fibers so that it actually absorbs less fluid than a smaller amount of fiber in a less dense mass.

Of course the appropriate size for an absorbent pad in compressed form is determined by its intended use. For example, the size of a vaginal tampon should be determined by how much fiber can be comfortably inserted and worn in the vaginal cavity. It is not true, however, that the more fiber which can be compressed into a tampon of given size, the more fluid it will absorb and retain. In fact I have discovered that there is a critical density of fiber for maximum absorption of fluid, and that this is not the same density which cotton assumes after conventional compression treatment.

It has been found that the problem is somewhat analogous to the creasing of textile fabrics, in that both involve the ability of the fibers to take a "set" in the bent form produced by pressure on the fibrous mass, and in both cases the resiliency of the fiber and permeability of the fibrous mass must not be destroyed. In the present case, there is no creasing of a fabric desired and the primary purpose is absorbency of the pad.

It has also been found that processes heretofore employed in manufacturing such absorbent pads have achieved a stable compression, although not necessarily at the optimum density for maximum absorption, by utilizing very high compressive forces. By use of the

compression stabilizing agents according to this invention, such compression stability can be produced with optimum density with a reasonable compression pressure. Also heretofore, it has been attempted to achieve a compression stability with such absorbent pads by conducting all or part of the manufacturing operations under rigidly controlled conditions of temperature and humidity and by maintaining both temperature and humidity at elevated levels. Such procedures are not only costly, but they necessarily involve an atmosphere which is uncomfortable for the workers and, in cases where large amounts of absorbent cotton are stored over substantial lengths of time at elevated temperature and humidity, mold growth, etc., are encouraged in the cotton. Producing absorbent pads according to this invention eliminates such difficulties.

Satisfactory results according to this invention have been produced by treating the fibers of an absorbent cotton mass before compression with compression stabilization agents as set forth below. Such treatment enables the production of compressed absorbent pads with the desired compression stability and optimum density for a given bulk or size of fiber mass. For example, a process according to this invention permits the production and commercial operations of a stable pad of desired size and optimum density containing, for example, in a standard size vaginal tampon, as little as 2.3 grams of absorbent cotton, whereas not less than three grams of cotton was formerly required to produce a tampon of the same size and comparable stability by compression pressure alone without the use of a stabilizing agent.

The surprising results in size stability and improvement in absorption capacity obtained by treating fibers according to this invention is evidently due to the use of compression stabilization agents in amount which allows the fibers to take a set and hold it with substantial stability, but with elastic memory, so that it is released upon wetting. The compression stabilization agents according to this invention are selected primarily for the plasticizing effect on the absorbent cotton to be treated. It is thus believed that the limited plasticizing effect on the cotton fibers, before pressing so far overcomes the inherent resiliency of the fibers that a set can be given thereto which is stably held but with elastic memory. It is also believed that such set is thereafter maintained, in a state of "elastic memory," upon the release of compressing force due to the presence in or on the fibers of the plasticizer in amount adapted to set as a compression stabilization agent. Without such agent, the fibers exhibit elasticity which prevents the desired set; and too much plasticizer would give elastomeric resiliency or even plasticity which would preclude the desired elastic memory.

Although I refer here to "stabilization" and "dimensional stability," it need not be absolute. Thus, for some time after compressing, the fibers may still undergo continued or repeated variations caused, for example, by varying moisture content picked up from or given off to the atmosphere under varying humidity conditions, but without such dimensional variations causing excessive fluffing out or essential lack of compression stability.

Accordingly, compression stabilization agents for this invention are selected primarily for plasticizing effects on the absorbent fiber. Advantageously, such agents should possess also surface wetting properties to facilitate wetting of the fiber to release its set and give effect to its "memory." This property also helps the plasticizing agent to penetrate the fibrous mass to effect plasticizing thereof.

Preferably, such compression stabilizing agents are, in addition, hydrophilic, fluid and water soluble. Especially when the absorbent pad is for body fluids, such as catamenial pads, vaginal tampons, dental rolls and the like, such agents should be aesthetically acceptable, compatible with living tissue which the device may contact in use, as well as being compatible with the fluid to be

absorbed. That is, the agent should not have properties (biological, chemical or aesthetic) which are inconsistent with its intended use. For example, one agent which might be considered too germicidal for a vaginal tampon would give completely satisfactory results in a dental roll or a compressed pad for nonphysiological use. Neither should such agents be adhesive, or at least, any adhesive effect should be promptly released upon contact with the fluid to be absorbed, in order that the maximum volume of interstices between fibers within the mass should be available for fluid absorption. In general, materials which are known to facilitate and stabilize creasing of cellulosic or other absorbent fibers can be regarded as suitable for this invention if they are hydrophilic and compatible with whatever fluid is to be absorbed and whatever tissue is to be subjected to contact with the treated cotton.

Such agent is employed to modify the resiliency of the fibers so that they will retain their compressed form after the compressing forces are released (e. g., during storage before use) and yet will retain a "memory" of their original loose form which will be released upon wetting so that the fibers can expand to take up fluid during use, thus providing maximum absorption capacity. The materials of this invention, however, apparently act upon the fibers themselves in a manner analogous to plasticizing to alter elastic characteristics thereof, and are to be distinguished from adhesives which merely bond or embed the fibers so as to restrain their elastic recovery.

Such compression stabilizing agents of this invention advantageously are distributed on the surface of the fiber and can be effective in minute amounts without leaving more than a microscopic or monomolecular film or deposit on the individual fibers. But this amount on the individual fibers should be strongly held or diffused into the fiber. To this end a working of the fibers, e. g., by carding and other processing steps and storage for sufficient time to allow substantial diffusion of the compression stabilization agent into the fiber after its application and before the pressing step is advantageous.

The class of materials which have been found satisfactory include fluid, water soluble, hydrophilic, plasticizers for cotton fiber. Some representative materials with which satisfactory results have been obtained are:

	Percent
Sodium lauryl sulfate (Duponol C).....	0.1-10
Diocetyl ester of sodium sulfo succinic acid (Aerosol OT).....	0.5-20
Alkyl aryl sulfonate (Nacconol LAL.).....	0.1-10
Benzyl trialkyl ammonium chloride (Roccal)---	0.1-10
Triethyl citrate.....	0.5
Polyoxyethylene scrubitol monolaurate (Tween-20)	0.5
Polyoxyethylene scrubitol lanolin derivative (Atlas G-1441)	0.1-0.5

As noted, it is preferred that such plasticizing compression stabilization agents also possess surface tension depressing, i. e., wetting agent properties; and some wetting agents which without water would not be plasticizers may, by wetting agent action, give a compression stabilization when used with water. Duponol, Nacconol, and Aerosol noted above are all well known anionic wetting agents, while Roccal is a cationic wetting agent and glycerol monostearate is a non-ionic wetting agent. Triethyl citrate is representative of a class of plasticizers which are not classified as wetting agents.

Satisfactory results have been achieved with the above agents applied to the cotton generally in the range of from 0.1% to 20% based on the dry weight of fiber (5% moisture content), although concentrations within the range of approximately 0.25% to 1% are most advantageous. In general, additional agent beyond 1% has not shown enough improvement to justify its cost. In some cases a maximum effect is reached in the range of

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from 0.25% to 1%, after which additional agent may actually impair the desired effect. One or more of such compounds may be used, the total concentration being, advantageously, within these percentage ranges.

There appears to be advantage in applying these materials during the final washing of the fiber, i. e., by washing with a solution of the agent. A substantial proportion of the agent will be lost in the wash water but a sufficient proportion is held on the fiber as a film and the subsequent treatment of the fiber distributes mechanically any unevenness in application and the heat involved in drying, etc., accelerates bonding of the agent to the fiber.

These materials are all water-soluble and substantially non-volatile, so that the properties of the treated material are not lost by evaporation. These materials are advantageously applied to the fibers in water solution, although other solvents may be used and in some instances direct application to the fibers without a solvent may be carried out as noted below.

For purposes of illustration, however, and without limiting the scope of this invention, one procedure will be described for forming a vaginal tampon embodying this invention and using Duponol C (sodium lauryl sulfate) as the compression stabilizing agent:

An aqueous solution of the Duponol was prepared in 0.2% concentration (although any other concentrations which are convenient for the application procedure may be used). This solution was sprayed or otherwise distributed over the absorbent fiber in such proportion that the Duponol so applied was within the range from 1.00-10% on the air dry weight of the cotton (i. e., weighed with, or weight corrected to, approximately 5% moisture in the cotton). After drying and usual processing of the absorbent fiber and storage of the air dry treated cotton for two days or more, this left a residue of approximately 0.20% to 2.0% of Duponol (on the air dry weight of the cotton) in the completed tampon blank when ready for compression.

The compression stability of the cotton so treated is increased significantly so that a compressed tampon made therefrom effectively holds its size.

The compression stabilizing material is advantageously applied to unspun, absorbent cotton fibers in sliver, bats or the like before the pads or tampons are cut, compressed, and formed into their final shape.

A solution of the agent is conveniently used as the final wash solution applied to the cotton immediately ahead of squeeze rolls through which the cotton passes as a final step prior to drying. It has been found that approximately 100 cc. of solution is retained by approximately 100 grams of absorbent cotton after squeezing; and the water is then evaporated from the retained solution.

Nacconol LAL (alkyl aryl sulfonate) used in place of the Duponol in this example gives almost identical results. Aerosol OT may be used in the same way but the concentration of the residue on the blank for the pad should be from 0.5-20% for best results.

In situations where the viscosity of the stabilizing material is sufficiently low to penetrate the mass of fibers satisfactorily (e. g., where the process is carried out at elevated temperatures) the compression stabilizing agent may be directly applied to the fibers, as by spraying; without dissolving in water or other diluent. Other solvents than water (e. g., alcohol) may satisfactorily be employed in the treating solution; but water is preferred because of its convenience and low cost and because it obviates many problems of solvent elimination or recovery.

After the solution of compression stabilizing agent is applied, the fiber mass is dried, e. g., in the usual manner as by passing the cotton on a conveyor through a drying tunnel with circulation of warm air. Satisfactory results are obtained with temperatures ranging from 240° F. at the wet end to approximately 212° F. at the dry end, with

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the cotton passing through this range of temperatures in approximately one-half hour.

It may often be advantageous to apply more of the agent than is needed and then remove some or all of the excess by evaporation or washing. It has been determined, for example, that some of the stabilizing agents which are satisfactory for use in this treatment have been applied in concentrations of 0.5% to 10% may lose a substantial proportion of the originally applied material, when dried at 240° F. for four hours. It appears, however, that the smaller amount of compression stabilizing agent necessary for this invention is quite stably held by the fibers so that, after an excess is evaporated, substantially no further noticeable loss occurs. Furthermore, normal storage of the product does not involve the high temperatures which may be used in the drying operation. It is probable that at least part of the agent is held in a monomolecular layer on the fiber surface, and when a surface-active agent is used, it aids the capillary absorbency of the compressed mass. It is also probable that a part enters the fiber by diffusion to modify its rigid elasticity so as to give it the ability to take a set with elastic memory to give compression stability at the desired density and consequent improved absorbency.

Evaporation losses, if any, should, of course, be considered in determining the amount of treating material applied to achieve the desired stabilizing agent concentration on the fibers of the finished absorbent pads.

After the uncut and unformed bats of absorbent cotton fibers are completely processed and treated with the compression stabilizing agent as noted above, the bats are cut into pads, e. g., tampon blanks, and compressively formed into a desired size and shape by conventional means—for example, between conventional compression dies by methods well known in the art. By way of illustration, a convenient method of forming absorbent cotton fibers into a compressed generally cylindrical tampon is indicated in the patents to Voss, No. 2,076,389, April 6, 1937, and McLaughlin No. 2,416,706, March 4, 1947. As shown by these patents, the loose cotton bats are fed in between compression dies which impart the desired shape and degree of compression (for the desired density of the compressed tampon).

While still under the compressing force of the dies, the tampon is ejected into a cylindrical chamber where the compression and shape of the tampon are maintained and where heat is applied to set the cotton fiber mass in compressed form. The compressive force used is preferably such that the finished tampon has a self-sustaining or unrestricted density of 0.3 to 0.7 gram per cubic centimeter.

As has been noted above, an absorbent cotton tampon made by mere compression and heating to the same degree without the treatment of this invention would have a tendency to expand to a size greatly in excess of the compressed size upon being ejected from the heated chamber mentioned above; and if it is held by a tubular container its pressure against the walls would make it difficult to eject. If such untreated cotton is compressed enough to hold its form it is too dense for the desired absorbency. Utilizing the principles of this invention; however, the inherent elasticity of cotton fibers of the tampon is overcome and the tampons are caused to retain their compressed configuration so that, upon ejection from the compressing apparatus and after compressing and retaining forces are removed, the tampon will still substantially retain its compressed condition without excessive pressure against the container. Yet, the effect of compression stabilizing materials of this invention is such that the compressed condition is released by wetting or direct contact of the fibers with body fluid, and such wetting or spreading of the fluid over the fibers is directly promoted by the surface-active compression stabilizing agent.

Although one example of the method of this invention

has been described in detail above using Duponol as illustrative of the various resiliency modifying and size stabilizing materials with which satisfactory results have been obtained, it will be understood that other materials or substances including those specifically set out above may also be advantageously used according to this invention. Similarly, compressing techniques other than that mentioned by way of illustration may be used in a process embodying this invention, which is not limited to the specific apparatus, techniques, concentrations, or materials set forth above.

Satisfactory results have been obtained using such other materials as compression stabilizing agents in concentrations of from 0.1% to 20%. If the fibers are plasticized to the point that they fuse or mold under compression or become rubbery or too resilient to take a set, the proportion of plasticizer should be reduced. Although the compression stabilization agents generally, such as these set forth above, have been found to give satisfactory results in the residue concentration ranges set forth, approximately 0.25% (based on air-dry weight of fiber treated) may be considered a satisfactory minimum concentration and approximately 2% a maximum concentration for general use in commercial operations.

It will also be understood that the compression stabilizing material may satisfactorily be applied to the cotton fibers at various stages in the processing thereof other than during the last washing step as described above. These agents, with or without dilution may be applied as a spray or vapor in conventional carding or other steps with the advantage that the fibers are subjected to rubbing along their surfaces which blends the agent with the fibers, and thus overcomes inequalities or non-uniformity in application.

It has been noted that chemical agents of the character set forth, when applied to cellulose fibers according to this invention apparently become more strongly held by the fibers the longer they remain in contact therewith; so that the treatment appears to be more than a mere temporary inter-fiber entrapment of treating material by the mass of fibers. The "setting" produced according to this invention suggests that some alteration of the fibers themselves, or at least an alteration in their inherent elastic properties takes place. But the fact that the fiber mass expands upon contact with body fluid indicates that any structural or chemical alteration or surface phenomenon that may occur as a result of the described treatment is a releasable one.

I claim:

1. The method of making an absorbent pad of absorbent cotton fibers, which comprises the steps of distributing onto the fibers a hydrophilic water soluble plasticizer therefor, working the fibers to distribute the plasticizer, storing the cotton for a substantial time, compressing a predetermined weight of said cotton into a predetermined volume and holding it under compression until the fibers are set in forms corresponding to a desired density.

2. The method of making an absorbent pad of cotton fibers, which comprises the steps of distributing onto such fibers at least about 0.1% of their weight of a hydrophilic water soluble plasticizer therefor, compressing a predetermined weight of said fibers into a predetermined volume and holding the resulting mass of fibers under said compression until set in forms corresponding to an apparent density, upon release of compression, approximately 0.3 to 0.7 gram per cubic centimeter.

3. The method of making a compressed absorption device of absorbent cotton fibers which comprises the steps of distributing onto said fibers a hydrophilic water soluble wetting agent plasticizer therefor as a compression stabilization agent effecting plasticizing of said fibers for modifying said inherent resiliency thereof, compressing a predetermined weight of said fibers to a predetermined volume, subjecting said fibers to heat during said com-

pression step rapidly driving moisture from said fibers, and maintaining said compressed fibers under compression until set.

4. The method of making a compressed absorption device of a mass of cotton fibers which comprises the steps of distributing onto said fibers throughout said mass a solution of a hydrophilic water soluble plasticizing wetting agent for said fibers, drying said fibers leaving deposited thereon said plasticizing wetting agent in an amount in the range 0.1% to 20% of the air dry weight of said fibers, compressing a predetermined weight of said fibers into a predetermined volume corresponding to a density which provides capillary porosity for ready absorption of fluid and holding the resulting mass of fibers under said compression until set in said compressed form.

5. The method of making a compressed absorption device of a mass of cotton fibers which comprises the steps of distributing onto said fibers throughout said mass a solution of a hydrophilic water soluble plasticizing wetting agent for said fibers, drying said fibers leaving deposited thereon said plasticizing wetting agent in an amount approximately 0.1% to 20% of the air dry weight of said fibers, compressing a predetermined weight of said fibers to a predetermined volume corresponding to a density which provides capillary porosity for absorption of liquid, subjecting said fibers to heat during said compression step, and maintaining said fibers under compression and heat until set in said compressed form.

6. The method of making a compressed absorption device of a mass of cotton fibers which comprises the steps of distributing onto said fibers throughout said mass a solution of a hydrophilic water soluble plasticizing wetting agent for said fibers, drying said fibers leaving deposited thereon said plasticizing wetting agent in an amount approximately 0.25% to 1% of the air dry weight of said fibers, compressing a predetermined weight of said fibers to a predetermined volume corresponding to a density which gives the mass a capillary porosity, subjecting said fibers to heat during said compression step, and maintaining said fibers under compression and heat until set in said compressed form.

7. The method of making a compressed absorption device of a mass of cotton fibers which comprises the steps of distributing onto said fibers throughout said mass a solution of a hydrophilic water soluble plasticizing wetting agent for said fibers, drying said fibers leaving deposited thereon said plasticizing wetting agent in an amount approximately 0.1% to 20% of the air dry weight of said fibers, compressing a predetermined weight of said fibers to a predetermined volume corresponding to a density which gives the mass a capillary porosity, subjecting said fibers to heat during said compression step, and maintaining said fibers under compression for approximately 20 to 40 seconds at about 70° to 90° C. to set them in said compressed form.

8. An absorption device of the character described for fluid absorption comprising as a fluid absorbing means a compressed mass of absorbent cotton fibers, said mass having a self-sustained density in the range of approximately 0.3 to 0.7 gram per cubic centimeter, and said fibers carrying at least 0.1% of a water soluble hydrophilic plasticizer therefor effecting stable compression at said density.

9. An absorption device of the character described for fluid absorption comprising as a fluid absorbing means a compressed mass of absorbent cotton fibers, said fibers carrying distributed thereon at least 0.1% of a water soluble hydrophilic plasticizer therefor, and said compressed mass having a self-sustaining density less than the self-sustaining density of said fibers without said plasticizer providing capillary porosity.

10. An absorption device of the character described for fluid absorption comprising as a fluid absorbing means a compressed mass of absorbent cotton fibers, said fibers

carrying thereon a water soluble fluid hydrophilic plasticizing wetting agent therefor and a minute layer of moisture effected by said wetting agent for temporarily plasticizing and decreasing said inherent elasticity of said fibers.

11. An absorption device of the character described for fluid absorption comprising as a fluid absorbing means a compressed layer of absorbent cotton fibers, said fibers holding thereon approximately 0.1% to 20% by weight of a water soluble, hydrophilic, plasticizing wetting agent therefor, and said compressed mass having a self-sustaining density of approximately 0.3 to 0.7%.

12. An absorption device of the character described for fluid absorption comprising as a fluid absorbing means a compressed mass of absorbent cotton fibers, said fibers

carrying firmly held thereon approximately 0.25% to 1% by weight of a water soluble, hydrophilic, plasticizing wetting agent therefor, and said compressed mass having a self-sustaining density of approximately 0.3 to 0.7%.

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