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FLOTATION EQUIPMENT  
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FIG-1-

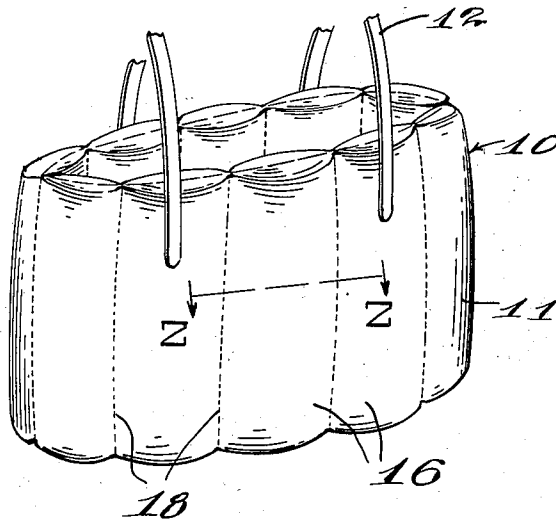


FIG-2 -

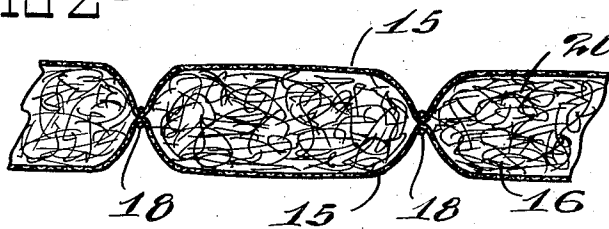
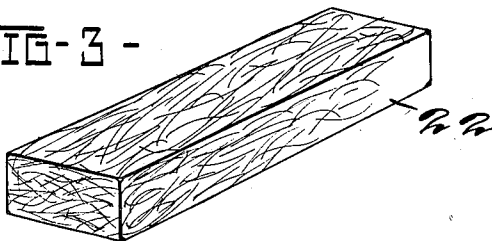


FIG-3 -



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## UNITED STATES PATENT OFFICE

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## FLOTATION EQUIPMENT

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8 Claims. (Cl. 9—17)

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This invention relates to flotation equipment and more particularly to life preservers, life jackets, floats, rafts, and similar articles. These usually embody a covering or container and a filling material having high buoyancy.

The commonly used buoyant materials are kapok and to lesser extent cork. Both these materials and in particular kapok, are affected by the atmosphere and deteriorate with passage of time. High humidities, changes in atmospheric conditions, subjecting the material to cleaning, and such things accelerate their deterioration. Kapok apparently contains certain oils which oxidize so that after a period of time the kapok loses such a large proportion of its original buoyancy that it is no longer satisfactory as a buoyant material.

Both kapok and cork are also inflammable so that their use on ships and aircraft where fires are of serious consequence is an ever present hazard but one which heretofore could not be avoided.

Various materials have been suggested as buoyant fillings for life preservers and jackets and other flotation equipment but none has proven to be practical. Materials such as foamed resin, for instance, are broken up if subjected to blows and to rough handling and when thus broken up lose some of their buoyancy and, what is more serious, may sift through openings in the covering or container and thus seriously impair the flotation equipment. Material such as sponge rubber or rubber foam owe a substantial amount of their buoyancy to a skin at the surface of a body of the material and once this skin is punctured the sponge or foam soaks up water and seriously lowers the buoyancy of the material. Like kapok and cork, these materials are also combustible and for this reason alone are unsatisfactory for flotation equipment.

It is the object of the present invention to provide flotation equipment that has a high degree of buoyancy relative to its weight and that retains its original buoyancy over long periods of time and when exposed to the atmosphere or subjected to handling, cleaning and other treatment in use.

It is a further object of the invention to provide flotation equipment having permanent buoyancy and that is not subject to mildew, rot or decay.

It is another object of the invention to provide a buoyant material that is fireproof.

It is another object of the invention to provide flotation equipment that is not injured by blows and impacts to which it may be subjected in use,

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and that is not seriously affected by breaks in or punctures of the container or covering.

It is a still further object of the invention to provide buoyant material in masses of high integrity usable as buoys or floats without containers or coverings.

The invention provides buoyant material comprising light weight, non-combustible, fibrous material that is unaffected by the crushing impacts to which such equipment is normally subjected in use and that has permanent high buoyancy. The buoyancy is not impaired by repeated wettings and dryings of the material, prolonged exposure to high relative humidities of the atmosphere, exposure to high temperatures, wetting with salt water, and repeated cleanings even with strong soap solutions.

In the drawings:

Figure 1 is a perspective view of an exemplary life jacket embodying the present invention;

Figure 2 is a cross-sectional view of the same taken on the line 2—2 of Figure 1; and

Figure 3 is a pad of buoyant material of the present invention.

The life preservers, life jackets, floats, and similar articles to which the invention is applicable may be of any suitable construction but for the purposes of illustration a conventional life jacket 10 is shown and described. This life jacket comprises a body-encircling portion 11 having straps 12 fastened thereto in suitable fashion. The straps are adapted to pass over the shoulders of the wearer and suspend the jacket about the upper portion of the body of the wearer.

The jacket comprises a covering 15 which may be of canvas, duck, or other cotton or other fabric. The fabric covering is divided into pockets 16 by spaced lines of quilting stitches 18. The covering 15 may be suitably treated to render it water resistant, fire resistant, and mildew resistant. Alternatively, the fabric covering may be of interwoven fibrous glass which will inherently provide fireproofness, resistance to attack by moisture, and resistance to mildew or other fungus attack.

The pockets 16 of the life jacket are filled with masses 20 of the fibrous material of the present invention. The fibrous material may be provided in a mass of loose, haphazardly arranged fibers which is divided into bodies of suitable size to be stuffed into the pockets 16. The fibrous material may also be in the form of integral bodies of fibers bonded together by an adhesive bonding

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agent, such as a synthetic resin, that is set or cured while the fibrous material is held to the desired density and shape. Bodies or pads of fibrous material formed in this way may be of the shape required to closely fit the pockets to assure the proper amount of fibrous material at the proper density being inserted in each pocket.

The buoyant material of the present invention comprises masses of glass fibers of diameters ranging from .00003 to .00015 inch. The fibers may be somewhat smaller, for instance, .00001 inch or slightly larger in diameter, say .00020 inch, but fibers of diameters within the ranges stated have been found most suitable. Where higher resistance to compression of the masses of fibers is desired, fibers of diameters in the neighborhood of the upper portion of the range, that is, from about .00006 to .00015 inch, have been found most suitable.

These fine glass fibers are provided in mats in which the fibers are haphazardly arranged and intertangled, the mats being of densities of about .3 to .6 pound per cubic foot. Fibers of the specified diameters thus arranged in mats or other bodies provide very small interstices between the fibers throughout the mats, the interstices in the most cases being smaller than the diameters of the fine fibers.

It has been found that when the surfaces of these very fine fibers are treated to render the surfaces non-water wettable, the mats are very resistant to penetration by water. Apparently, the fine interstices throughout the mat bounded as they are by non-wettable surfaces provide capillary passages of such small size that the pressure required to force water into the capillaries is in the order of hundreds of pounds per square inch. This high resistance to penetration by water makes the mats extremely valuable as buoyant material to be used in filling flotation devices.

The fibrous material of the present invention is preferably interbonded by a suitable adhesive or bonding agent, for instance, a synthetic resin such as an aldehyde condensation product, distributed throughout the mass of fibers. The bonding material is present in amounts of about 2 to 20% by weight of the fibers and its presence provides a body of fibrous material replete with voids but having a very high degree of integrity and one that retains its shape and that will readily return to original shape when it is deformed by being squeezed, folded, rolled, or otherwise manipulated.

The fine glass fibers are treated to make them non-water-wettable by having applied to their surfaces a material that will permanently bond to the surfaces of the fibers and that is highly water repellent. The coating material may be applied in any suitable way to the fibers as by dipping masses of loose fibers or bodies of interbonded fibers into solutions or dispersions of the coating material, or by spraying solutions or dispersions of the coating material onto masses or bodies of the fibers in amounts sufficient to cause the coating material to thoroughly impregnate the fibrous bodies.

Preferably, the coating materials are applied to the fibers as they are collected on a deposition surface such as a belt or conveyor to build up a web or mat. This permits application of the coating material to the individual fibers as they are suspended in the air or the gaseous blast used to deposit the fibers. This method of application of the coating material may be practiced in the

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process of forming the fibers, or mats of already formed fibers may be fed to a conventional picker or shredder and the separated fibers fed by the picker or shredder into a blast of air and by the blast carried to a conveyor upon which the fibers are deposited to build up into a mat. The coating materials may be sprayed onto the blast-borne fibers in the neighborhood of the deposition zone. Such a method of applying coating materials to fibers is well known in the art.

Where a bonding agent is to be applied to the fibers it may be sprayed onto the fibers in the same way as and simultaneously with the coating materials or it may be first applied to the fibers and then cured or set up and after this the coating materials may be applied to the masses of interbonded fibers by dipping or spraying.

According to the present invention, the fibers are coated with a material rendering the fiber surfaces permanently highly water repellent. The coating materials are the organo-silicon compounds which contain alkyl or aryl groups linked to the silicon atom through a carbon atom. These include the silanes of the formula  $R_nSiX_3$ ,  $RSiX_3$ ,  $RR'SiX_2$ , or  $RR'R''SiX$ , where R, R' and R'' may be the same or different, and each is either alkyl or aryl groups which are linked to the silicon atom through a carbon atom, and at least one X is a hydrolyzable group such as a halogen or an alkoxy group preferably ethoxy or methoxy. It will be apparent that such coating materials are represented by the generic formula  $R_nSiX_{4-n}$  where R and X have the meanings set forth, and n is a whole number between 1 and 3, inclusive. Also included are the polysiloxanes, which are the polymerized hydrolysis products of the hydrolyzable silanes.

Examples of the hydrolyzable silanes are: octadecyl trichlorosilane, phenyl trichlorosilane, dodecyl trichlorosilane, tetradecyl trichlorosilane, n-amyl trichlorosilane, diphenyl dichlorosilane, phenylethyl dichlorosilane, dodecylmethyl dichlorosilane, phenyldimethyl chlorosilane, and mixtures of these compounds, for example, a mixture of methyl trichlorosilane, dimethyl dichlorosilane and trimethyl chlorosilane. Representative compounds of the ethoxy derivatives found suitable in the present invention are: octadecyl triethoxy silane, dodecyl triethoxy silane, dodecylmethyl diethoxy silane, phenyl triethoxy silane. All of the halogen and ethoxy derivatives have been found to provide increased buoyancy as the length of the chain of the R groups increases. Thus, the buoyancy obtained by using octadecyl trichlorosilane has been found to substantially exceed the buoyancy resulting from use of methyl trichlorosilane. For this reason the long chain compounds such as octadecyl, tetradecyl, dodecyl trichlorosilanes and triethoxy silanes are preferred. Also, the alkyl derivatives have been found superior to the aryl derivatives.

Representative examples of the polymerized hydrolysis products of the hydrolyzable silanes are: dimethyl polysiloxane, diethyl polysiloxane, di-dodecyl polysiloxane, and copolymers of di-dodecyl polysiloxane and dimethyl polysiloxane. These compounds all have Si—O—Si— chains, the length of the chain being indicated by the viscosity of the material. In the present case compounds having chain lengths corresponding to about 100 to 2000 centistokes viscosity provide very favorable buoyancies. The compounds having straight chain R groups are preferable to those having ring type R groups in the present invention.

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To further illustrate the present invention the following examples are given.

#### Example I

Octadecyl trichlorosilane in a 1 to 5% solution of Stoddard solvent, a petroleum distillate, was sprayed onto the glass fibers as the loose fibers were deposited on a conveyor to build up a mat. The mats of coated fibers were then heated for about ½ hour at from 250° F. to 500° F. Temperatures much lower than this are ineffective to fix the organo-silicon compound onto the glass fiber surfaces while temperatures in excess of 500° F. seemingly impair the buoyancy of the finished material. The finished material displayed very good buoyancy of great permanency under very exhaustive tests.

The spray guns or other means for applying the material to the fibers were adjusted so that the amount of coating material on the fibers after evaporation of the solvent was about 1 to 3% by weight. It has been found that as little as .5% provides the desired buoyancy if it is evenly and uniformly distributed. For the sake of safety, however, it is preferable to employ at least 1% to obtain the necessary amount of coating material on all portions of the fiber surfaces. The buoyancy increases somewhat with increase of the amount of coating material up to the upper limit of 3%, indicating that polymolecular films of the coating on the fibers is more effective than monomolecular films, but increases in the amount of the coating material over 3% show no substantial increase in buoyancy.

In place of Stoddard solvent, any aromatic or hydrocarbon solvent or other solvent for the organo-silicon material, such as carbon tetrachloride or other chlorinated solvents, may be employed.

Other hydrolyzable silanes such as any of those previously mentioned, or diphenyl diol silane, phenyl dodecyl dichlorosilane, didodecyl diethoxy silane, tridodecyl ethoxy silane, may be substituted for octadecyl trichlorosilane. The temperatures required to fix the hydrolyzable silanes generally are in the neighborhood of 250° F. to 500° F. with the heat treatment lasting from about ¼ to ½ hour. The temperature necessary usually varies inversely with the ease of hydrolysis of the X group. For example, ethoxy silanes require somewhat higher temperatures than the chloro silanes to fix the materials on the fibers. The best temperature within the specified range for any particular material is readily determined by simple trial.

At the upper portions of the specified temperature range, that is, at about 400° F. to 500° F., the heat treatment of octadecyl trichlorosilane will cause some resinification of the material and provide a bonding agent for holding the fibers together in the mat. However, if substantial bonding of the fibers is desired without the addition of another bonding agent such as phenol formaldehyde, it is preferable to use a polymerizable long chain organo silicon compound such as the chain structure polysiloxanes of viscosities from about 100 to 2000 centistokes as in Example II.

#### Example II

Dimethyl polysiloxane of 100 centistokes viscosity was sprayed onto fine glass fibers as in Example I. The polysiloxane was a 3% solution in Stoddard solvent. The mats of coated fibers were then heated for ½ hour at 600° F. As in Example I the amount of coating material

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on the fibers was from about 1 to 3% by weight of the fibers.

The mats treated in this way had very good buoyancy and in addition the fibers were bonded together in the mat by the polymerized polysiloxane.

The time and temperature of treatment of dimethyl and other chain structure polysiloxanes may be varied somewhat from about ¼ to ½ hour at from 400° F. to 750° F. At these times and for temperatures below 550° F. no substantial gelation of the polysiloxane is obtained but the material is fixed to the glass fiber surfaces and provides a very favorable degree of buoyancy. At temperatures of 550° F. to 750° F. for these times gelation of the material takes place and the fibers are bonded together by the material. Temperatures much below about 400° F. do not fix the material to the fiber surfaces while temperatures in excess of about 750° F. apparently impair the buoyancy of the finished material.

Substantially the same results may be obtained by employing other chain structure polysiloxanes such as diethyl polysiloxanes of a viscosity of 100 to 2000 centistokes or dodecylmethyl polysiloxane (the copolymer of dodecyl polysiloxane and dimethyl polysiloxane) of similar viscosity. These viscosities are a measure of the length of the chain structure and in the present case are not critical since chain structure polysiloxanes of substantially lower viscosity and therefore shorter chain structures may also be employed. Generally, it has been found that the buoyancy does not vary substantially with the variation in chain length and that there is no apparent substantial difference in the buoyancy obtained when using polysiloxanes varying in viscosities from 100 to 2000 centistokes. Also very good buoyancy has been obtained by the use of polysiloxanes of less than 100, for instance 80, centistokes viscosity. Materials having chain lengths corresponding to viscosities very much less than 100 centistokes, say 20 centistokes, however, are not desirable since the buoyancy is not as good as the longer chain length materials.

The temperatures and times of treatments for these other polysiloxanes is approximately the same as those given in Example II for dimethyl polysiloxane. The times of treatment are from about ¼ to ½ hour, from about 350° to 750° F. with gelation of the material to form a bonding agent for the fibers at some intermediate temperature usually about 400° to 550° F. It is not believed necessary to go into greater detail in connection with these other similar materials since the optimum temperatures for each material are best selected on the basis of simple trial.

#### Example III

As in Example I the fibers as they were collected in a mat were sprayed with a treating material containing 3% dimethyl polysiloxane of about 500 centistokes viscosity and 3% to 6% "A" stage phenol formaldehyde, 10% isopropyl alcohol and 81 to 84% Stoddard solvent. The isopropyl alcohol may be replaced with other long chain alcohol compatible with the Stoddard solvent or other solvent such as those mentioned in Example I. This material was sprayed onto the fibers in such quantity as to provide coating material on the fibers of about 10% by weight of the fibers after evaporation of the solvent. The fibers are then heated for about ½ hour at 450° F. The mat made in this way had a high

degree of buoyancy and the fibers were well bonded together in the mat.

#### Example IV

As the fibers are collected in a mat they are sprayed with a 3% solution in Stoddard solvent of dimethyl polysiloxane of about 100 centistokes viscosity. Simultaneously a 10% aqueous solution of "A" stage phenol formaldehyde resin is sprayed on the fibers. The mat of collected fibers are then heated for ½ hour at 450° F. The amount of coating material on the fibers was about 7% by weight. This mat was well bonded together and displayed very good buoyancy.

Other resins may replace the phenol formaldehyde resin as binding agent. For instance, an aqueous emulsion of urea formaldehyde, furfural resin, coumar indene resin, polystyrene, polyvinyl chloride or polyvinyl acetate or other resin may be used.

#### Example V

A treating material for the fibers contained:

3% dimethyl polysiloxane (500 centistokes viscosity)  
3% paraffin wax  
3% Stoddard solvent  
3% oleic acid  
1% ammonium hydroxide  
89.7% water

These proportions may be varied substantially depending upon the concentration of the polysiloxane and wax found best handled by the spray guns or other means used for applying the emulsion to the fibers.

This treating material was prepared by dissolving the dimethyl polysiloxane, paraffin wax, and oleic acid in the Stoddard solvent heated to about 200° F. The ammonium hydroxide was mixed with 10% water and heated to 160° F. The Stoddard solvent solution was then added to the ammonium hydroxide and water mixture with agitation to form an emulsion and the balance of the water was then added. This emulsion was kept warm (about 90° F.) until it was applied to the fibers to prevent separation of the phases.

The emulsion was sprayed onto the fibers and the treated fibers were then heated for 15 minutes at about 600° F. At this temperature the paraffin wax burns and increases the temperature of the fibers in the mat to advance the gelation of the dimethyl polysiloxane and convert it to a bonding agent. The paraffin thus permits substantially complete gelation of the polysiloxane at somewhat lower oven temperatures.

The same emulsion may be employed without the paraffin for applying any of the polysiloxanes in an aqueous system. Also, in addition to or in place of the paraffin wax 3 to 9% "A" stage phenol formaldehyde may be added to the aqueous phase of the treating material to provide additional bonding agent.

#### Example VI

Glass fibers as they were collected in a mat were sprayed with a coal tar naphtha solvent solution of 3% dimethyl polysiloxane of 500 centistokes viscosity and 6% thermosetting polysiloxane resin. The mats were heated for ½ hour at 450° F. The amount of coating on the fibers was 10% by weight of the fibers. These mats displayed good buoyancy and the fibers were well bonded together in the mat.

#### Example VII

A mat of fine glass fibers bonded together by phenol formaldehyde resin present in amount of about 18% by weight of the fibers, was soaked in a 3% solution of octadecyl silicon trichloride in Stoddard solvent. The mat was squeezed to remove excess solution, then air dried and then heated for one hour at 225° F. This mat retained its original high integrity and displayed very favorable buoyancy.

#### Example VIII

The process of Example VII was carried out by employing in place of octadecyl silicon trichloride, dimethyl polysiloxane of 200 centistokes viscosity, and by heating the treated mat for one hour at 450° F. This mat also had very high buoyancy and retained its original high integrity.

#### Example IX

Glass fibers as they were deposited in a mat were sprayed with a Stoddard solvent solution of 9% phenyl silicon trichloride and 3% octadecyl silicon trichloride. Steam was sprayed onto the mat after the application of the solution. The mat was then heated for ½ hour at 450° F. The amount of coating on the fibers was 3% by weight of the fibers and the mat displayed good buoyancy and the fibers were well bonded together. The buoyancy was not as good as that obtained by using the chain structure organo-silicon compounds such as the polysiloxane.

These examples are given not by way of limitation since various other organo-silicon compounds may be employed either in solvent solutions or in aqueous emulsions and the temperatures and times of heat treatment may be varied depending upon the particular organo-silicon compound employed. The aim in each instance is to fix the organo-silicon compound securely to the glass while care is taken not to exceed the temperature at which the organo-silicon compound will be decomposed with a consequent impairment of the buoyancy.

When these compounds are applied in this way to glass fiber surfaces they, or at least the silicon atoms may combine, probably by chemical reaction with the surfaces of the fibers, explaining why the compounds become permanently attached to the surfaces. The resulting non-water wettable surface on the fibers provides a lightweight mass of fibrous material highly resistant to the penetration of water and having very high buoyancy.

Bonding the fibers together into an integral form-retaining mass by means of a synthetic resin or other binding agent forms a buoyant article usable as a float or buoy. The presence of the rigid binding agent resists compression of the mass and tends to retain the original volume of the mass and therefore the original total buoyancy. The presence of the rigid binding material is especially desirable where the buoyant material may be subjected to squeezing which might tend to reduce its volume as in the case of that portion of the buoyant material in a life jacket that is positioned between the body and the arms of the wearer.

The high degree of integrity attained by use of the binding agent makes bodies of the buoyant material usable as floats and buoys without the need of any covering material or containers. In Figure 3 is illustrated a body 22 of fine glass fibers interbonded by a binding agent distributed

throughout the body into a pad usable as a buoy or float.

Various modifications may be resorted to within the spirit of the invention and the scope of the claims.

I claim:

1. As an article of manufacture, a light-weight floatable body composed of haphazardly arranged, intertangled glass fibers and having buoyancy of such permanency and magnitude that the mass is usable as a filler for life jackets, the glass fibers being of from .00001 to .0002 inch in diameter and the surfaces of the fibers being coated with a water repellent substance selected from the group consisting of silanes and polymerized hydrolysis products thereof, the silanes having the general formula  $R_nSiX_{4-n}$  wherein R is an organic radical selected from the group consisting of alkyl and aryl, X is a hydrolyzable product selected from the group consisting of halogen and alkoxy, and n is a whole number between 1 and 3, and a binding material in the form of a resinous substance different from the water repellent substance distributed through the body at the junctures of the fibers and being present in an amount that bonds the fibers together into a body replete with voids of such size as to prevent the entry of water into the mass when it is submerged.

2. The article of manufacture of claim 1 wherein the binding material is phenol formaldehyde resin.

3. The article of manufacture of claim 1 wherein the water repellent substance is octadecyl silicon trichloride.

4. The article of manufacture of claim 1 wherein the water repellent substance is dimethyl polysiloxane of about 80 to 2000 centistokes viscosity.

5. The article of manufacture of claim 1 wherein the water repellent substance is diethyl polysiloxane of about 80 to 2000 centistokes viscosity.

6. The article of manufacture of claim 1 wherein the binding material is phenol formaldehyde resin and the water repellent substance is dimethyl polysiloxane.

7. Life preserving equipment comprising a casing having a plurality of compartments therein, each of said compartments containing a porous

mass of glass fibers replete with voids throughout the mass, a binding agent distributed through the mass and binding the fibers together at their junctures and holding the fibers in the relation to preserve the voids in the mass, and a water-repellent agent coating the surfaces of the fibers throughout the mass and preventing entry of water into the voids of the mass.

8. Life preserving equipment comprising a casing having a plurality of compartments therein, each of said compartments containing a porous mass of glass fibers replete with voids throughout the mass, a binding agent composed of phenol formaldehyde resin distributed through the mass and binding the fibers together at their junctures and holding the fibers in the relation to preserve the voids in the mass, and a water-repellent agent composed of dimethyl polysiloxane coating the surfaces of the fibers throughout the mass and preventing entry of water into the voids of the mass.

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