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WICKPROOFING OF SYNTHETIC FABRIC

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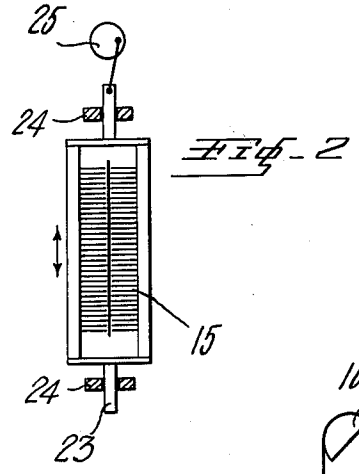


Fig. 2

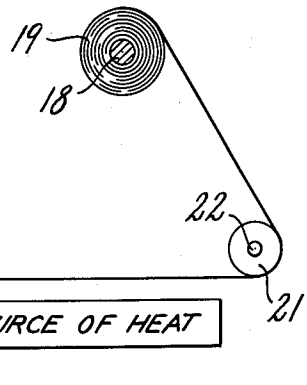


Fig. 1

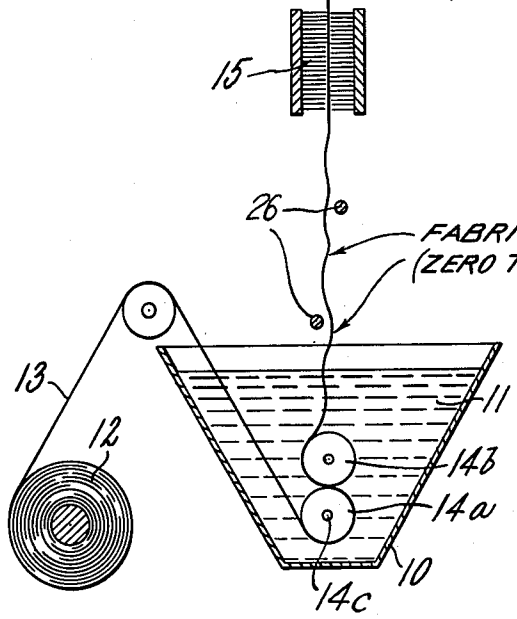
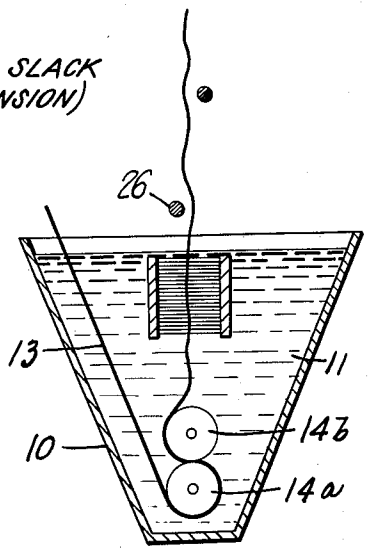


Fig. 3



INVENTOR.
EDOUARD A. BRODEUR
BY
Robert J. Patterson
ATTORNEY

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WICKPROOFING OF SYNTHETIC FABRIC

Edouard A. Brodeur, Summerville, Ga., assignor to United States Rubber Company, New York, N.Y., a corporation of New Jersey

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This invention relates to a method and apparatus for wickproofing woven synthetic fabrics which are employed in the manufacture of gas or air inflatable items and liquid containers. In particular, the invention relates to an improved method of effectuating complete impregnation of woven nylon fabric with liquid adhesive or bonding composition.

Considerable difficulty has been encountered in the production of gas or air inflatables and liquid containers, such as the fuel cells used extensively in the aircraft industry, because of a very undesirable property found in the finished item known as wicking. Said containers are made of fabric which has been coated and impregnated with a thin film of adhesive. A surface coat of elastomeric material or plastic is applied to the coated and impregnated fabric which is adapted to be formed into the shape of a liquid or gas container with highly impervious characteristics. If the fabric strands and fibers are not thoroughly impregnated with the bonding agent, residual air-containing areas will remain within. If the fabric is not completely coated with adhesive, the elastomeric surface coat may not adhere properly to the fabric. When fuel, for example, comes in contact with an incompletely coated area, frequently occasioned where there is a seam in the finished container, the wicking effect takes place. The fuel tends to diffuse into the plies of the container wall and find its way into the air-containing areas or voids by capillary action. This causes the container wall to become soft and weak. A weakening of the wall in any particular area will eventually render the entire container useless. It is desirable, therefore, to completely impregnate the fabric strands and fill the interstices between said strands with adhesive or bonding agent prior to the application of any surface coat of elastomeric or plastic material.

Heretofore, complete saturation of the inside of fibers has been attempted by passing the fabric through a dunking operation which consists of dragging the fabric through a low viscosity adhesive solution while under tension using conventional equipment developed originally for the processing of cotton fabric. The capillary action of cottom would draw the thin liquids into the fabric strands while under stress. The synthetic fibers are generally monofilament in nature and when under tension and in alignment one along or over the other, it becomes impossible to penetrate such strands by mere low viscosity, low interfacial tension, or capillary attraction. When it becomes desirable to coat fabrics with colloidal dispersions, such as a rubber latex, methods were proposed to accomplish impregnation by mechanical means, e.g., by bending and flexing the fabric as it is passed through the liquid impregnating composition under tension, such as the method disclosed by McGiehan in U.S. Patent No. 1,228,458, issued June 5, 1917, or by beating the tense fabric as it emerges from the adhesive bath, such as the method taught by Wilson in U.S. Patent No. 2,450,847, issued October 5, 1948. These methods were proposed to increase adhesion of the elastomer to the fabric and are apparently effective for that purpose. However, the fabric strands must be completely impregnated and coated in order to be wickproof. Complete impregnation is not possible when the fabric is maintained under tension throughout the process cycle as taught by the above methods. Cotton fiber is mechanically interlinked to the elastomeric coating because of its irregular surface and, hence, very little impregnation is required for adequate adhesion. Continuous film nylon, viscose, rayon acetate and other synthetic filaments lack the structural irregularities of cotton and must be impregnated at least partially by the rubbery adhesive before bonding will occur but partial impregnation will not be sufficient to wickproof these synthetic woven fabrics. The adhesive composition must surround all fibers of the strands and cables, and replace and exclude all air and voids present in the strands prior to impregnation, thus preventing subsequent wicking, absorption, or travelling of gases or liquids through the strands as a result of pneumatic or hydrostatic pressures applied against these fabric strands after incorporation in the finished item.

Complete wickproofing will make possible the production of light weight, lightly coated fabrics of impervious construction. Furthermore, it will make it possible to manufacture an infinite variety of gas or air inflatable and liquid retaining products by assembling the item prior to vulcanization without leaving raw edges and similar imperfections which, heretofore, afforded the liquids or gases contained therein a means of access to the plies of the container walls. Wickproofed constructions start their impermeability below the fabric surface, i.e., at the base of the weave, instead of at the fabric surface.

It is the principal object of this invention to provide a process and apparatus for wickproofing fabrics woven from synthetic continuous filaments by thoroughly impregnating and coating the fabric strands with an adhesive or bonding agent.

My invention also has for its object to provide a relatively simple means for continuously accomplishing the complete impregnation of the strands or fibers which is convenient, economical, and not readily subject to mechanical failure.

These objects are accomplished by removing the tension from the synthetic fabric, soaking the tensionless fabric in a liquid adhesive composition, opening the strands of fabric mechanically so as to allow the properly compounded and rheologically adjusted liquid adhesive composition to flow into the fabric strands and to fill the interstices between said strands, removing excess adhesive, replacing the tension on the fabric, and fusing the coated and impregnated fabric strands together by volatilizing the liquid component of said adhesive composition.

A preferred method of wickproofing fabric and a preferred form of apparatus therefor is illustrated in the accompanying drawings.

FIGURE 1 is a diagrammatic view;

FIGURE 2 is a plan view of the preferred brush actuating device; and

FIGURE 3 is a diagrammatic view similar to FIGURE 1 showing a different arrangement of one of the elements in the tank.

As shown in FIGURE 1, the apparatus is comprised of an immersion tank **10** containing a rheologically adjusted liquid adhesive composition **11**. A freed roll **12** directs the synthetic fabric **13** along a predetermined path and into an adhesive containing immersion tank **10** which is disposed along the path. A driven pair of counter-rotating cooperating rolls **14***a* and **14***b* are rotatably mounted within the tank **10** and beneath the surface of the adhesive composition **11**. These rolls are disposed in closely spaced relation to each other, the spacing of these elements being less than the normal thickness of the fabric that passes between them. The upper roll **14***b* rotates freely. The lower roll **14***a* is keyed on a drive shaft **14***c*. Cooperating rolls **14***a* and **14***b* must rotate at the same peripheral speed as guide roll **21** which is keyed on drive shaft **22**. Drive

shafts 14c and 22 are rotated by chain and sprocket drives from an external power source (not shown). Mounted generally above the immersion tank 10 in the path of the fabric as it passes upwardly from the tank are oppositely disposed pluralities of projecting yielding edges 15. Preferably these projecting yielding edges 15 are bristle brushes. Any other flexing means, such as rug material, rubber pads, wire, or plastic brushes can be conveniently substituted for the bristle brushes so as to accomplish the purpose of mechanically opening the relaxed fabric strands. These oppositely disposed pluralities of projecting yielding edges 15 are attached to a solid frame base of metal, plastic, or wood and are so arranged in relation to each other that each brush-like surface will make contact with the fabric surface as it passes between them. The brushes are made to reciprocate horizontally and any suitable non-electrical means may be employed to impart reciprocatory motion thereto. A spreader bar 16 to remove wrinkles from the fabric as it leaves the pluralities of projecting yielding edges 15 is mounted above and in a vertical plane with said edges. This grooved half round spreader bar 16 also directs the fabric between squeeze rolls 17 which rotate in opposite directions as shown. A clutched drive shaft 18 with a roll 19 keyed thereon takes up the processed fabric. Heating means 20 are disposed along the tense expanse of fabric between the squeeze rolls 17 and the driven guide roll 21 and generally in the same horizontal plane as these members. The heating means 20 preferably comprises steam heated pipes or platens as shown but may be batteries of oppositely disposed infrared lamps, or any other suitable heat source.

As shown in FIGURE 2, I prefer to make the projecting yielding edges reciprocate horizontally by placing the frame base ends 23 through a retaining fitting 24 of brass or other durable material and attaching one of the protruding ends of the frame base to an off center wheel 25 which is turned by air actuation. Air actuating means (not shown) are employed because electrical connectors constitute an explosion hazard in any solvent vapor atmosphere which may surround the brushes. Brushes sliding against the fabric with a stroke of one inch, and a frequency of 200 cycles per minute are suitable. However, this is a mechanically set pattern and will vary with the weave, the weight and/or gauge of the fabric, and the rate at which the fabric is fed to and carried away from the brushes.

In the operation of the apparatus the fabric 13 is continuously advanced from the feed roll 12 into the rheologically adjusted liquid adhesive composition 11 and thence is directed between cooperating rolls 14a and 14b. The tension is manually released from the fabric 13 in the area between cooperating rolls 14a and 14b and the oppositely disposed projecting yielding edges 15. The fabric is maintained at zero tension in all directions while in the critical zone by causing cooperating rolls 14a and 14b and guide roll 21 to rotate at the same peripheral speed. By zero tension I mean that the fabric is under no mechanical stress or strain. As more and more of the fabric is taken up by driven roll 19, the increase in diameter resulting therefrom could cause the moving fabric to be pulled taut. In order to prevent this undesirable occurrence, rotation of drive shaft 18 with roll 19 mounted thereon may be reduced proportionally by clutch and gear means (not shown). As it emerges from the enveloping liquid, guiding means in the form of spaced transverse stationary bars 26 direct the tensionless fabric 13 into a zone of contact between the oppositely disposed edges 15 wherein said edges mechanically open the coated and partially impregnated fabric strands by imparting oscillatory force tangentially to each surface of the moving fabric. It is understood that said projecting edges could be placed beneath the surface of the adhesive and the fabric strands mechanically opened while still submerged in the enveloping liquid. Thence, the fabric 13 is passed over the half-round spreader bar 16 and through the squeeze rolls 17 which remove any excess adhesive composition 11 which thereupon runs back into the immersion tank 10. The driven guide roll 21 replaces tension on the expanse of fabric between the projecting yielding edges 15 and said guide roll 21. The volatile liquid component of the adhesive composition on the fabric is volatilized by heating means 20 disposed along the expanse of tensioned fabric between the squeeze rolls 17 and the driven guide roll 21. The driven clutch actuated roll 19 takes up the processed fabric. The resulting rolled and wickproofed synthetic fabric has been completely impregnated and uniformly coated with the solid adhesive which has filled the interstices between the fabric strands so that the fabric is ready to be further processed by spreading or calendering, or other means, and subsequently, applying a surface coating of suitable gauge and weight.

The liquid adhesive compositions employed to impregnate and coat the synthetic fabric so as to enhance its adhesion to rubber are well known in the art. Such compositions may be comprised of natural or synthetic rubber latex containing in most cases antioxidants, curatives and accelerators admixed with compounds to promote adhesion including such compounds as are capable of reacting to form synthetic resins which act as cross-linking agents. A latex combined with a phenol, such as resorcinol, and an aldehyde, such as formaldehyde, is an example of this type of adhesive composition. Another type of adhesive is vulcanizing latex combined with borax and casein or a reclaim emulsion-latex-casein mix omitting vulcanizing ingredients. The latter will diffuse from the rubber body into the bonding layer during vulcanization. Aromatic isocyanate solutions constitute another class of known adhesive compositions. The isocyanates polymerize and form a network mutually linking the fabric to the rubber (see, e.g., the De Bruyne and Houwink volume, Adhesion and Adhesives, p. 420, published 1951 by Elsevier Publishing Co.). It is understood that other liquid adhesive compositions comprising rubbery material, whether compounded with any of the aforementioned rubber chemicals and adhesives or not, may also be used either as an aqueous suspension (latex), or dispersion, or in an organic solution (cement), as may any liquid adhesive composition which will improve the adheson between the synthetic fabric and the surface coat of elastomeric or plastic material. However, in the production of liquid containers, such as fuel cells, cements based on NBR rubbers are preferred and in the production of gas inflatable items cements based on Neoprene-type rubbers are preferred for attaching tank linings or inflatable coverings to nylon fabric. An example of a liquid cement for air inflatables in parts by weight is as follows:

Neoprene stock [1]	100
Cumar P–25 resin [2]	3
Amsco-Solv A [3]	376
Hylene M–50 [4]	17
Toluene	17

[1] Neoprene cement stock is prepared by admixing 100 parts by weight of polymerized chloro-2-butadiene-1,3 (Neoprene GN marketed by E. I. du Pont de Nemours & Co.) with 4 parts of magnesium oxide, 1 part of stearic acid, 0.5 part sodium acetate, and 3 parts of zinc oxide.

[2] A paracoumarone resin (marketed by Barrett Div., Allied Chemical & Dye Corp.) consisting of a mixture of polymerized coumarone and polymerized indene obtained from solvent-naphtha fractions of coal tar.

[3] An aromatic solvent of intermediate aromaticity (marketed by American Mineral Spirits Co.) comprised of 0.47% aromatics, 19% naphthalenes, and 34% paraffins.

[4] A 50% solution of methylene bis (4-phenylisocyanate) in ortho-dichlorobenzene (marketed by E. I. du Pont de Nemours & Co.)

Generally, the viscosity and surface tension of the liquid adhesive composition are controlled in order to enhance impregnation of the fabric. It has been possible to wickproof using an adhesive bath with a viscosity as low as 200 centipoises using a Brookfield Viscosimeter

control and as high as 100 centipoises. However, the preferred viscosity range is from 300 to 600 centipoises. The narrow range is particularly suited for adhesive compositions containing polymerized chloro-2-butadiene-1,3 rubber. Adhesive baths of low surface tension are desirable, and a surface tension of not more than 25 dynes per square centimeter is preferred. An adhesive bath with a minimum of color is often desirable as it permits a wide range of subsequent color coatings.

Any of numerous organic solvents can be employed to prepare the liquid adhesive composition as a cement. Toluene, xylene, and methyl ethyl ketone are but a few of the solvents that can be substituted for the Amsco-Solv A in the above working example in the amount shown, with satisfactory results. The selection of a solvent depends on its volatility, the physical and chemical characteristics of the adhesive or bonding material to be dissolved therein, and the cost in relation to other suitable solvents. The quantity of such solvent should be sufficient to yield a cement having a Brookfield viscosity of from 200 to 1000 centipoises and a surface tension of not more than 25 dynes per square centimeter.

When the fabric which has been impregnated and coated with liquid adhesive composition is subjected to heat, the liquid vehicle will volatilize and the bonding agent will set on the fabric. Generally a temperature of from 100° F. to 300° F. will suffice depending on the speed of the heating means.

A simple test for wickproofed fabric can be made by scratching both sides (not directly opposite) of a coated fabric and applying a force of air or gas under a cover of water. No air seepage indicates satisfactory wickproofness.

It is apparent that many details relating to my process and apparatus may be varied without departing from the principles of this invention. It is, therefore, not my purpose to limit the patent granted otherwise than necessitated by the scope of the appended claims.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. A process for wickproofing woven synthetic fabric which comprises partially impergnating the fabric by advancing the fabric under tension through a liquid adhesive composition comprised of a rubbery material in a volatile liquid medium, said liquid adhesive composition having a Brookfield viscosity of from 200 to 1000 centipoises and a surface tension of at most 25 dynes per square centimeter, releasing the tension on the advancing fabric while in said adhesive composition, brushing the opposite sides of the strands of the partially imtregnated fabric, removing the fabric from the liquid adhesive composition, then applying pressure to the fabric to remove excess liquid adhesive composition, replacing the tension on said fabric, and volatilizing the liquid component of the adhesive composition on the fabric.

2. A process for wickproofing woven synthetic fabric as in claim 1, wherein the partially impregnated fabric strands are mechanically opened while still submerged in the enveloping adhesive composition.

3. A process for wickproofing woven synthetic fabric as in claim 1, wherein heat is applied to the fabric after replacing the tension therein in order to volatilize the liquid component of the adhesive composition and set the rubbery material contained therein.

4. A process for wickproofing woven synthetic fabric as in claim 1, wherein the rubbery material used to make the liquid adhesive composition is comprised of an admixture of a major proportion of polymerized chloro-2-butadiene-1,3 with a minor proportion of a paracoumarone resin and an aromatic isocyanate.

5. A process for wickproofing woven synthetic fabric as in claim 1, wherein the fabric is woven from nylon yarns.

6. An apparatus for wickproofing fabric woven of synthetic yarn, comprising, in combination, means for continuously advancing the fabric along a predetermined path, an immersion tank for holding a supply of liquid adhesive composition, disposed along said path, a pair of counter-rotating cooperating rolls disposed within said immersion tank at a point beneath the surface of adhesive composition therein, said rolls being spaced apart a distance less than the normal thickness of the fabric, oppositely disposed pluralities of projecting yielding edges for mechanically opening the yarn strands in the fabric, said yielding edges being disposed above and in a vertical plane with said counter-rotating cooperating rolls, means for imparting horizontal reciprocatory motion to said edges, means for directing the fabric into said immersion tank and for maintaining tension on the fabric prior to entry thereof into said immersion tank, the construction and arrangement of said counter-rotating cooperating rolls and said edges being such that the fabric moving therebetween is not tensioned, squeeze rolls located in the path of the fabric emerging from said immersion tank, said squeeze rolls being in a position following said projecting yielding edges, a rotating guide roll to advance the fabric along a predetermined path and to replace the tension in the fabric between said guide roll and said projecting yielding edges, said guide roll being driven at the same peripheral speed as said pair of counter-rotating cooperating rolls in said immersion tank, heating means disposed along the expanse of fabric between said squeeze rolls and said rotating guide roll, and a take-up roll for the wickproofed fabric.

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