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FIBROUS WEBS AND METHOD FOR THEIR PRODUCTION

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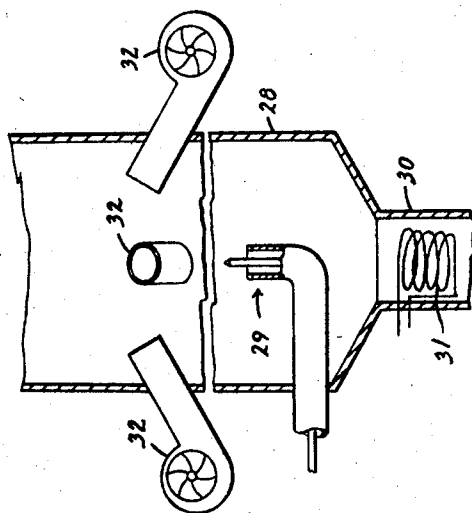
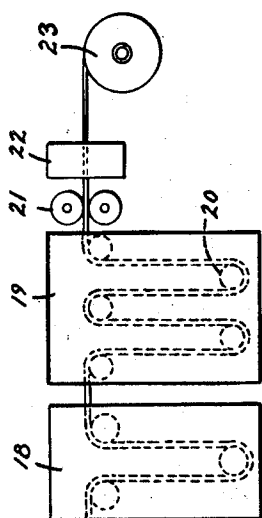


Fig. 1

Fig. 2

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FIBROUS WEBS AND METHOD FOR THEIR PRODUCTION

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15 Claims. (Cl. 154—101)

This invention relates to a method for the preparation of hollow or tubular fibrous elastomeric materials and of fibrous bodies and more particularly to reticulated webs or structures formed therefrom.

In the copending application of Howard O. McMahon and Paul C. Watson entitled "Reticulate Webs and Method for Their Production," Serial No. 400,240, filed December 24, 1953, there are disclosed and claimed permeable, reticulated, fibrous webs of elastomeric materials and a method for their production. As disclosed in that application, a liquid dispersion containing an elastomeric fiber-forming material is extruded into and within a concurrent primary high velocity stream of gas as a relatively large-diameter stream of plastic. The high velocity stream of gas attenuates and breaks transversely the stream of plastic to form a multiplicity of discontinuous fibers or fibrils, partially removes the solvent and partially sets the elastomeric material. A secondary stream of gas surrounding the primary stream of gas may be employed to carry the attenuated fibers and fibrils and deposit them at a point spaced from the point of formation. The attenuated fibers and fibrils are collected on a suitable collecting means and the fibrils become bonded together at their points of contact to provide a reticulated web and the web is then cured or vulcanized. The fibers are deposited in a completely and totally random or haphazard manner thereby forming a closely matted, but permeable sheet. The cured or vulcanized web has a substantially uniform elasticity and strength in all directions in the plane of the sheet.

However, because the fibers are solid, the product has a relatively high density.

Therefore, one of the principal purposes of this invention is to provide such elastomeric fibers and reticulated, fibrous webs containing elastomeric fibers which have all the desirable properties of the above described product but which have in addition a relatively low density, increased softness and increased bulk.

A further purpose of this invention is to provide a reticulated fibrous web or structure formed of discontinuous tubular or hollow fibers of elastomeric material and having a low density.

Another purpose of this invention is to provide a method for the production of low density, soft reticulated fibrous webs or structures formed of discontinuous hollow or tubular fibers of elastomeric material.

Other objects and advantages of this invention will become apparent from the description and claims which follow.

In the drawings,

Figure 1 is a schematic diagram of production apparatus for the practice of the method of this invention;

Figure 2 is a sectional view, at an enlarged scale, of a portion of a typical fiber as formed in accordance with this invention;

Figure 3 is a diagrammatical, elevational view, partly in section, of another form of apparatus for the practice of the method of this invention.

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The present invention contemplates or comprises, in a process for producing fibrous elastomeric material, the steps of extruding a stream of a fiber-forming liquid containing an elastomeric material and a latent gas-forming agent into and within a concurrent high velocity stream of a gas to form a multiplicity of elastomeric fibers and activating the latent gas-forming agent after the formation of the fibers but before the completion of the curing of the elastomeric material in the fibers. In its preferred embodiment, the process includes subjecting the freshly formed fibers to a preliminary cure or vulcanization at a relatively low temperature, that is, a temperature which does not activate the blowing agent for the purpose of forming a cured skin on the fiber. The partially cured fibers are then subjected to a more elevated temperature at which the gas-forming agent is activated to form hollow or tubular fibers, and finally, the hollow fibers are subjected to a more elevated temperature to complete the cure or vulcanization of the elastomer.

The fibrous product of this invention is characterized by the fact that in the form of a web the product consists of a multiplicity of elastomeric fibers tacked or bonded together at their points of contact and has substantially uniform elasticity and strength characteristics in all directions in the plane of the web. Each of the individual fibers differs from other fibers in length and diameter and also has a non-uniform cross-section or diameter along its length. The fibers are also characterized by having tapered ends, a relatively thick wall and a substantially hollow interior. The hollow spaces in some of the fibers may be a continuous void running substantially the full length of the fiber, but in some of the fibers the hollows may be elongated voids or bubbles spaced from each other by walls extending transverse of the fiber so that voids do not communicate lengthwise with one another. The fibers are substantially free of craters or blow holes in the surface.

Unlike dry spinning, as performed in the rayon and synthetic fiber industries, in which a spinneret with multiple minute holes is used to produce a predetermined number of filaments each substantially of the same size as the holes and in which the continuous filaments are pulled continuously from the face of the spinneret to a moving collector, the fiber-forming process of the present invention utilizes a single relatively large extrusion orifice producing a single large-diameter plastic stream which is attenuated and broken transversely into a plurality of fibers, the number of which is always greater than one and the diameters of which fibers are small fractions of the orifice diameter, there being no continuous filament running between the orifice and the collector.

The velocity of the gas is appreciably higher than the velocity of extrusion of the spraying liquid and the direction of extrusion is coincident or concurrent with the direction of the gas flow. The high velocity stream of gas attenuates the sprayed liquid, breaks the attenuated plastic stream transversely and partially sets the elastomeric material due to the partial evaporation of solvent to form a plurality of fibers having diameters smaller than the orifice. A secondary or low velocity stream of gas may be provided which has a velocity lower than that of the primary stream of gas but greater than that of extrusion of the fiber-forming liquid. The secondary stream of gas carries, supports or floats the attenuated fibers or fibrils and deposits the fibrils or allows the fibrils to deposit upon a suitable collecting surface at a distance from the extrusion orifice.

The elastomeric material contemplated by my invention is rubber, both natural rubbers and synthetic rubbers or rubber substitutes. Such elastomeric materials or rubbers, both natural and synthetic, which are soluble in inexpensive, volatile organic solvents are well suited

for the production of the reticulated mats or webs of this invention. Elastomeric materials satisfactory for use in the herein described method include natural rubbers such as crepe rubber and synthetic rubbers or rubber substitutes such as chloroprene polymers, for example, neoprenes, butadiene-acrylonitrile copolymers known as Buna-N, for example, Butaprene, Paracril, Ameripol-D, Perbunan, Chemigum, and Hycar-OR; butadiene-styrene copolymers, for example, Ameripol-F, Hycar-OS and GR-S; isoprene-isobutylene copolymers, for example, GR-I and butyl; elastomeric silicones or silicone rubbers; polyurethanes; and organic polysulfides, for example, Thiokol. Mixtures of specific elastomeric materials may be utilized to provide desired characteristics. The specific elastomers are enumerated merely as illustrative and are not intended as limitations of the invention.

The spraying or fiber-forming liquid may be formed by dissolving the fiber-forming elastomeric material in a satisfactory organic solvent such as aliphatic and aromatic hydrocarbons, chlorinated hydrocarbons, aralkyl hydrocarbons and the like, those being preferred which will volatilize readily at moderately elevated temperatures. The solvent utilized in forming the spraying liquid will be dependent upon the specific elastomer and upon characteristics desired in the spraying liquid such as volatility of the solvent. For example, solvents which are satisfactory include benzene, naphtha, toluene, xylene cyclohexanone, ethylene chloride, methylene chloride, carbon tetrachloride, nitroparaffins, ketones and the like. Such inexpensive volatile organic solvents as benzene and naphtha are entirely satisfactory for use in fiber-forming liquids containing natural rubber. The spraying liquids may contain from about 5% to about 50% or more of the fiber-forming elastomeric material and preferably contain between about 10% and about 45% rubber or rubber substitute.

Latent blowing agents or gas-forming agents are added to the spraying liquid either in the form of a solution or in the form of finely divided particles. These agents are thoroughly and uniformly distributed throughout the spraying liquid as by adding the agent to the various ingredients and milling in the usual manner. It is contemplated that activating agents for the blowing agent either in solution or in the form of finely divided particles may be simultaneously incorporated in the spraying liquid where the particular blowing agent requires such material. Care must be exercised during the milling operation and in other stages in the production of the fibers and reticulated webs or bodies to maintain the temperature below the temperature at which the blowing agent becomes activated. Blowing agents or gas-forming agents which are satisfactory for the purposes of this invention include ammonium carbonate, sodium acid carbonate, diazoaminobenzene such as the commercially available material marketed as Unicel, dinitroso pentamethylene tetramine, such as the commercially available material marketed as Unicel ND which consists of about 40% of the tetramine and 60% of an inert organic filler, and the like. These substances are adapted to release or form a gas such as ammonia, carbon dioxide, nitrogen or other inert gas at elevated temperatures.

The fibers are subjected to an elevated temperature after they are formed and before the completion of the curing or vulcanization of the elastomeric material. Several alternative methods of activating the blowing agent and curing or vulcanizing the elastomeric material may be employed depending upon the specific elastomer, the specific blowing or gas-forming agent, the amount of gas-forming agent employed, etc. For example, the fibers may be subjected to a temperature sufficiently high so as to effect a cure or vulcanization of the elastomer and an activation of the latent gas-forming agent. Such treatment first activates the blowing agent and initiates the cure and upon maintaining the fibers at such temperature finally completes the cure. Alternatively, the fibers may

be subjected to a temperature sufficiently high so as to activate the gas-forming agent but below the temperature necessary to cure the elastomer and subsequently subjected to a temperature sufficiently high so as to cure or vulcanize the elastomer. The preferred method includes subjecting the freshly formed fibers to three successive heat treatments. In the first stage, the fibers are subjected to a temperature lower than that required to activate the gas-forming agent but sufficiently high to provide the fibers with a cured skin. The temperature is then elevated to a value sufficiently high so as to activate the gas-forming agent. A more elevated temperature is subsequently employed so as to complete the curing or vulcanization of the elastomer.

Other properties and characteristics of the fibers formed from the elastomeric materials may be varied as desired by incorporating additives in the spraying liquid such, for example, as carbon black, curing or vulcanizing agents such as sulfur, accelerators, antioxidants, plasticizers, detackifying agents, such as paraffin wax, stearic acid and coloring agents, such as dyes and pigments. Abrasive particles such as emery dust, carborundum, silica, etc., may be incorporated in the spraying liquid to provide products having abrasive properties. Fillers such as clay, whiting, kaolin, French chalk and the like may be added to impart desired characteristics and to reduce the cost of the fibers. The amount of the additive may be varied over a wide range as desired. In the case of solid fillers, from about 50% to about 150% filler, such as clay, finely divided pigments and the like, based upon the weight of the elastomer, may be incorporated in the spraying liquid.

By varying the amount of solvent and the amount of additive substances and the degree of milling, the viscosity of the spraying liquid may be varied over a wide range. The apparent viscosity of the spraying liquid may be reduced by the addition of methanol and such commercial materials as Butyl "8" which also accelerates the cure. For example, solutions containing about 30% solids consisting of about equal parts of natural rubber and filler dissolved and dispersed in solvent naphtha may have their apparent viscosity reduced about 50% by incorporating in the solution about 2% Butyl "8" or methanol. It is possible to utilize spraying liquids containing elastomers which are totally unsuited for use in the conventional spinning methods.

The primary gas stream may be at atmospheric temperature or any other desired temperature providing it is below that which activates the gas-forming agent. The gas may consist of a chemically reactive gas, steam, air or other inert gas such as nitrogen, carbon dioxide and the like.

Similarly, the secondary gas stream may be used at atmospheric temperature or at any desired temperature providing it is below that which activates the gas-forming agent and the secondary gas may consist of a chemically reactive gas, steam, air, or other inert gas such as nitrogen, carbon dioxide and the like.

Preformed fibers and/or discrete particles, preferably of a non-adhesive, non-elastomeric material may be introduced into the secondary gas stream. The preformed particulate non-adhesive materials are thereby brought into contact with the potentially adhesive, elastomeric fibers while the latter are in a tacky or cementitious condition and the preformed fibers or discrete particles adhere to the elastomeric fibers. The fibers as collected are deposited in a completely random distribution or haphazard manner to form a reticulated web or structure.

Among the non-adhesive non-elastomeric fibers which may be employed in forming the composite bodies are natural fibers, such for example as wood or pulp fibers, cotton, flax, jute, kapok, wool, hair and silk, other natural substances such as leather and cork; and synthetic fibers, for example, cellulosic fibers such as cellulose hydrate, cellulosic derivatives such as cellulosic esters, mixed cellu-

lose esters, cellulose ethers, mixed cellulose ester-ethers, mixed cellulose ethers, cellulose hydroxy-alkyl ethers, cellulose carboxy-alkyl ethers, cellulose ether xanthates, cellulose xantho-fatty acids, cellulose thiourethanes; fibers made of alginic acid, gelatine, casein; mineral fibers such as spun glass, asbestos, mineral wool and the like; and fibers made of natural and synthetic resins which are not rendered tacky when the potentially adhesive fibrils are rendered tacky; also fibers and filaments made by slitting, cutting or shredding non-fibrous films, such as waste cellophane.

In addition to or as a substitute for such non-elastomeric fibers, particles of various classes may be introduced through the primary or secondary air stream, such for example as cork dust, wood flour, leather dust, or flake particles, or fibers of flock length.

In Figure 1 there is illustrated schematically and in flow diagram fashion, a method for commercially producing hollow fibers and a laminated, reticulated, fibrous web in accordance with this invention. The elastomeric material, the blowing agent and the desired additives such as fillers, vulcanizing agents, accelerators, anti-oxidants and the like are thoroughly mixed in a conventional type rubber mill 1. After the required milling period, the elastomeric composition is transferred to a conventional jacketed rubber mixer 2 and dissolved in the solvent, supplied from a suitable tank 3, to form the spraying liquid.

The spraying liquid is then transferred to a suitable storage tank 4 from which it passes to a pump 5. A strainer or filter 6 may be interposed between the storage tank and the pump. From the pump 5, the spraying liquid passes to the spray tips 7 mounted in adjacent towers 8. The primary gas stream is supplied to the nozzles 9 by means of a blower 10. The secondary gas streams are supplied to the bottom of towers 8 by means of a blower 11. The temperatures of the gas streams must be below that at which the gas-forming agent is activated. The spraying liquid is attenuated and the discontinuous elastomeric fibers are formed in the towers as described hereinbefore.

The fibers are collected on endless conveyor screens 12 which are disposed at the top of the towers and the vaporized solvent and gases supplied to the towers are removed through suction chests 13. The reticulated webs are stripped from the collector screens 12 and are brought together under pressure between squeeze rolls 14. The laminated sheet may then be passed through a dusting chamber 15 wherein a detackifier such as talc is applied to the outer surfaces to reduce the tackiness of the surfaces.

The sheet may then be passed between another pair of rolls 16 from which it is passed through a pre-curing or pre-vulcanizing chamber 17. The collected, freshly-formed fibers are subjected in chamber 17 to a temperature which is sufficiently high so as to pre-cure or pre-vulcanize the elastomer and only for such period as is necessary to provide the fibers with a partially cured skin. The temperature should be maintained below the activating temperature of the blowing agent. For example, where the elastomeric material consists of natural smoked sheet rubber, Unicel ND is employed as the latent gas-forming agent and urea is added as an activator for the Unicel ND, the temperature of chamber 17 may be maintained at about 90° C.

The sheet is then passed through chamber 18 wherein the fibers are brought to a higher temperature so as to activate the latent blowing or gas-forming agent thereby converting the substantially solid fibers into hollow or tubular fibers. For example, where the elastomer and latent gas-forming agent are as set forth above, the temperature of chamber 18 may be of the order of about 110° C. The sheet then passes to a curing chamber 19 where it travels over heated rolls 20. The temperature of the fibers is raised to the required curing or vulcanizing tem-

perature and maintained at such temperature for a sufficient period so as to cure or vulcanize the elastomeric material. For example, in the specific example set forth above, the temperature may be of the order of about 125° C.

The cured vulcanized sheet may then be passed through a suitable trimming device 21 to cut the sheet to a desired width. The finished sheet is then dusted with talc in a dusting chamber 22 and collected on a suitable wind-up roll 23.

If desired, the heat treating chambers may be consolidated into a single chamber divided by walls into three sections or zones and the sections may be provided with separate means for regulating the temperature within each section. Where the steps of pre-curing and of activation of the gas-forming action are combined, the pre-curing chamber or section may be eliminated.

The fibers as thus formed are of a structure as shown in Figure 2. The individual fibers, one end of a fiber 24 being depicted in the drawing, have relatively thick walls 25 with respect to the diameter of the fibers and elongated voids or bubbles 26. The voids extend longitudinally within the fiber and are separated by transverse walls 27. The voids are of different length and in some locations two or more longitudinal voids may be located at a single position along the fiber. In some instances, the void may extend substantially the length of the fiber. The fibers vary in diameter along their lengths and in general have tapered ends. Where the heat treatment is employed to provide the fiber with a partially cured skin of elastomeric material, the surfaces of the fiber are relatively smooth and are free of craters and blow holes as shown in Figure 2.

Relatively thick bodies or structures may be produced by laminating a single uncured web to itself, or by laminating a laminated web, as formed in the apparatus described, to itself or the webs may be laminated to another substance and then activating the blowing agent and finally curing or vulcanizing the elastomer.

The fibrous, reticulated web or mat of elastomeric material has a unique soft feel, is easily compressed, is highly porous and of very low density. However, because of the completely random or haphazard arrangement of the hollow fibers and due to the fibrous structure of these webs or mats as compared to the cellular structure of foam and sponge rubber, the permeability of the mats is substantially greater per unit of thickness than foam and sponge rubber. The tear strength and tensile strength of the webs and mats are also substantially greater per unit of thickness than foam and sponge rubber although the permeability is greater.

The following table includes representative data on various properties of the types of structures as discussed hereinbefore:

TABLE

Sample (Natural Rubber)	Density (lbs./cu. ft.)	Tensile Strength (p.s.i.)	Permeability to air
Solid fibrous mat.....	35	85	4
Tubular fibrous mat.....	15.2	44	4
Sponge.....	20.6	21	291
Foam.....	5.4	11	6.1

The permeability to air was measured by a modification of the method described in Bulletin T460, M49 of the Technical Association of the Pulp and Paper Industry using the Gurley Densometer. The sample was clamped to the top of a cylinder having an open bottom and an orifice in the top. The normal orifice (1 square inch) was reduced to an orifice having a diameter of 0.136 inch or an area of about 0.0145 square inch. The time elapsed for the cylinder to fall under its own weight into a slightly larger diameter cylinder

filled with oil is measured to determine the permeability to air.

It is well known that calendered rubber exhibits an appreciably different elasticity and strength in the direction of calendering as compared to the elasticity and strength in a direction transverse to the direction of calendering. It is also well known that fibrous products wherein the fibers and filaments are more or less oriented and as formed by conventional textile equipment exhibit different elasticities and strengths in the direction of orientation and in a direction transverse to the direction of orientation. The products of this invention possess substantially the same elasticity and strength characteristics in all directions in the plane of the sheet or web. Upon flexing or bending a corner of a mat releasing the force, the corner portion returns to its original position with much more of a brisk action or snap than a sponge or foam rubber pad of the same thickness. It is also well known that upon puncturing rubber sheet, foam and sponge rubber, the rubber tears or rips readily. The totally random arrangement of the fibers in the webs and mats of this invention results in an apparent localization of any puncture, hole or abrasion and the web or sheet does not rip or tear upon stretching of the punctured web.

The fibrous, reticulated webs or sheets are entirely unique in the field of elastomeric sheets in this respect and may be sewed, tacked or nailed by conventional means without tearing.

If it is desired to produce a mat or layer of loose separable fibers which are not bonded together, then the collector is spaced further away from the tip or nozzle and a detackifier such as talc is incorporated in the spraying liquid and another detackifier such as talc is blown in with the primary or secondary gas stream. Also, the temperature of the gas is elevated somewhat but is maintained below the activating temperature of the blowing agent to evaporate more of the solvent from the fibers before they are deposited or collected.

Although the chamber or tower 1 is shown as being provided with a single spray tip 7 and nozzle 9, it is to be understood that such illustration is merely for purposes of simplifying the drawing and the foregoing discussion. A plurality of spaced spray tips are preferably mounted within the chamber, the chamber being provided with a single secondary gas blower. In a preferred embodiment of the apparatus, a plurality of chambers are employed as shown in Figure 1, each containing a number of spaced spray tips and nozzles. Each spray tip is provided with a separate primary gas nozzle surrounding it. If desired, the relative velocities of extrusion of the spraying liquid and of the primary gas stream may be varied in different spraying units to provide fibers of different size and length. Products containing fibers of two or more different elastomers or different elastomeric compositions may be formed by supplying spraying liquids of the different elastomers or of different composition to separate spraying units. Products having color blends may be prepared by supplying spraying liquids containing different coloring agents to separate spraying units. Alternatively, the spraying liquid supplied to some of the spraying tips or to the spraying units of one tower may be free of the blowing agent to provide bodies comprising hollow or tubular fibers and solid fibers. The two webs are subsequently laminated and heated to activate the blowing agent and to cure or vulcanize the elastomer. By applying a stencil over a first formed web a layer of the same or different elastomer fibers may be formed on the first web in predetermined areas.

My method may also be practiced by passing the secondary or low velocity gas stream in a direction counter-current to the primary or high velocity gas stream; that is, the spray tip and nozzle are mounted at the top of the tower. The direction of travel of the primary gas

stream and the direction of extrusion are downwardly. The secondary or low velocity gas stream is passed upwardly through the tower at a velocity sufficient to support or retard the fall of the attenuated fibers so as to deposit the fibers on the collecting screen in any desired condition.

In the production of composite sheets or webs, preformed non-adhesive fibers or particles may be introduced into either gas stream. As shown in Figure 3, the tower 28 may be provided with the desired spinning unit 29 and a duct 30 through which the secondary gas stream is supplied to the tower. Suitable heating means 31 may be mounted in the duct so as to permit a control of the temperature of the secondary gas stream. A tertiary gas supply may be introduced by positioning suitable blowers 32, preferably above the point at which the fibers are formed. Preformed non-adhesive fibers or particles may be introduced by means of any or all of the gas streams.

The fibers may be deposited on a shaped collecting surface, if desired. For example, a tubular collector as of a girdle shape, may be rotatably supported at the top of the tower in place of the endless screen and provided with suitable means for rotation. The fibers are thereby deposited in the form of the desired article and a desired thickness is obtained by slowly rotating the shaped collector or by rotating the collector a sufficient number of times until a body of the desired thickness is formed. The fibers may be deposited directly upon a previously shaped article, the article itself serving as the collecting means to provide a layer of a reticulated, fibrous elastomeric web.

The following specific example is set forth to illustrate the invention and is not intended as a limitation of the invention. Other and different elastomeric materials and other and different blowing agents with or without desired additives are equally satisfactory:

Example

A rubber mix was prepared containing whiting and McNamee clay as fillers, zinc oxide as an activator, Ethyl Tuads and Captax as accelerators, sulfur as a vulcanizer, Agerite White as an antioxidant, Unicel ND as a blowing agent and urea as an activator for the Unicel ND. The composition was as follows:

Parts by weight	
Elastomer—#2 smoked sheet	100
Filler:	
Whiting	60
McNamee clay	40
Activator—Zinc oxide	5
Accelerator:	
Ethyl tuads	0.5
Captax	1.0
Vulcanizer—Sulfur	2.5
Antioxidant—Agerite white	1.0
Blowing agent—Unicel ND	7.5
Activator therefor—Urea	3.7

A spraying liquid was formed containing 40% of the rubber composition dissolved and dispersed in a commercial naphtha or petroleum hydrocarbon marketed as Amisco rubber solvent. The apparent viscosity of the liquid as measured by the shearing disc viscosimeter was between 10,000 cps. and 12,000 cps. The spraying liquid was extruded through an orifice having a diameter of 0.06 inch at a uniform rate of about 42 cc. per minute or at a velocity of about 75 feet per minute. The primary air stream was supplied to the nozzle at the rate of about 25 c.f.m. or at a velocity of about 21,200 feet per minute, the nozzle having a diameter of 0.493 inch and the orifice $\frac{3}{4}$ inch beyond the nozzle. The secondary air stream was passed through the tower (4 feet in diameter) at the rate of about 6,300 c.f.m. or at a velocity of about 500 feet per minute and at a tempera-

ture of about 60° C. The collecting screen was about 10 feet from the orifice.

The web was subjected to heat treatment at about 90° C. so as to form a partially cured skin on the fibers. The temperature was then raised to about 110° C. so as to activate the unicele ND and thereby convert the solid fibers to hollow fibers. The mat was subsequently subjected to heat treatment at about 125° C. so as to vulcanize the rubber. The hollow fibers and the reticulated, fibrous mat had the characteristics and properties as described hereinbefore.

The high degree of resiliency, softness, resistance to abrasion and permeability of the products of this invention render these products particularly suitable for such uses as inner soles and midsoles, for footwear, rug cushions, upholstery padding, mattresses, pillows, etc. For some of these purposes foam and sponge rubber must be reinforced with a textile fabric such as cotton duck, however, the mats of this invention have sufficient resistance to abrasion to allow their use without such reinforcement. Because of the fibrous structure and high degree of resiliency, the products are also highly satisfactory for such uses as sound absorption and deadening and sound and vibration dampening. The bodies are also highly satisfactory for the manufacture of life preservers, life jackets, and the like because of their low density and the hollow nature of the fibers. The mats may be provided with waterproof coverings to also utilize the permeable nature of the mats for added buoyancy. Other uses will suggest themselves to those skilled in the art.

Since variations and modifications may be made in carrying out the invention, without departing from its spirit and scope, it is to be understood that the invention is not to be limited except as defined in the appended claims.

I claim:

1. In a method for producing fibrous elastomeric products, the steps which comprise extruding a fiber-forming liquid containing between about 5% and about 50% of a fiber-forming elastomeric material and a latent gas-forming agent into a high velocity, non-turbulent, uni-directional, unconfined stream of gas to form a multiplicity of solid fibers, heating the solid fibers to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time so as to form a partially cured skin on the solid fibers and then heating the partially cured, solid fibers to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers.

2. The steps in a method as defined in claim 1, wherein the fiber-forming liquid comprises a solution of natural rubber.

3. The steps in a method as defined in claim 1, wherein the fiber-forming liquid comprises a solution of a synthetic rubber.

4. The steps in a method as defined in claim 1, wherein the blowing agent comprises diazoaminobenzene.

5. The steps in a method as defined in claim 1, wherein the blowing agent comprises dinitroso pentamethylene tetramine.

6. In a method for producing fibrous elastomeric products, the steps which comprise extruding a fiber-forming liquid containing between about 5% and about 50% of a fiber-forming elastomeric material and a latent gas-forming material into a high velocity, non-turbulent, uni-directional, unconfined stream of gas to form a multiplicity of solid fibers, heating the solid fibers to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time so as to form a partially cured skin on the solid fibers, and then heating the partially cured, solid fibers to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers and maintaining the hollow fibers at such

elevated temperature for a sufficient period of time to cure the elastomeric material.

7. In a method for producing fibrous elastomeric products, the steps which comprise extruding a fiber-forming liquid containing between about 5% and about 50% of a fiber-forming elastomeric material and a latent gas-forming material into a high velocity, non-turbulent, uni-directional, unconfined stream of gas to form a multiplicity of solid fibers, heating the solid fibers to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time so as to form a partially cured skin on the solid fibers, heating the partially cured, solid fibers to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers and then heating the hollow fibers to a more elevated temperature for a sufficient period of time to cure the elastomeric material.

8. In a method for producing fibrous elastomeric products, the steps which comprise extruding a fiber-forming liquid containing between about 5% and about 50% of a fiber-forming elastomeric material and a latent gas-forming liquid into and within a high velocity, non-turbulent, uni-directional, unconfined stream of gas to form a multiplicity of solid fibers, the direction of extrusion being coincident with the direction of the gas flow, collecting the solid fibers, heating the solid fibers to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time to form a partially cured skin on the solid fibers and then heating the partially cured, solid fibers to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers.

9. In a method for producing fibrous elastomeric products, the steps which comprise extruding a fiber-forming liquid containing between about 5% and about 50% of a fiber-forming elastomeric material and a latent gas-forming liquid into and within a high velocity, non-turbulent, uni-directional, unconfined stream of gas to form a multiplicity of solid fibers, the direction of extrusion being coincident with the direction of the gas flow, collecting the solid fibers, heating the solid fibers to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time to form a partially cured skin on the solid fibers, then heating the partially cured, solid fibers to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers and then heating the hollow fibers to a more elevated temperature for a sufficient period of time to cure the elastomeric material.

10. In a method for producing fibrous elastomeric products, the steps which comprise extruding a fiber-forming liquid containing between about 5% and about 50% of a fiber-forming elastomeric material and a latent gas-forming agent into and within a high velocity, non-turbulent, uni-directional, unconfined stream of gas to form a multiplicity of solid fibers, the direction of extrusion being coincident with the direction of the gas flow, suspending the fibers with a secondary stream of gas flowing concurrently with the primary stream of gas and at a velocity greater than the velocity of extrusion of the fiber-forming liquid but lower than the velocity of the primary stream of gas, heating the solid fibers to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time so as to form a partially cured skin on the solid fibers and then heating the partially cured, solid fibers to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers.

11. In a method for producing laminated products, the steps which comprise collecting at least two reticulated sheets of solid fibers, the fibers of at least one sheet com-

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prising an elastomeric material and a latent gas-forming agent, laminating the reticulated sheets to one another to form a laminated structure, heating the laminated structure to a temperature below the activation temperature of the gas-forming agent for a sufficient period of time so as to form a partially cured skin on the solid fibers and then heating the laminated structure to a more elevated temperature to activate the gas-forming agent thereby converting the partially cured, solid fibers to substantially hollow fibers.

12. As an article of manufacture, a body comprising a reticulated, permeable, fibrous sheet of tubular fibers comprising an elastomeric material, each of the fibers differing from other fibers in length and diameter and having a varying diameter along its length, tapered ends, relatively thick walls with respect to its diameter and its surface substantially free of craters, the fibers being arranged in the sheet in random distribution and bonded together at their points of contact, the sheet having substantially uniform elasticity and strength characteristics, per unit of thickness, in all directions in the plane of the sheet.

13. An article of manufacture as defined in claim 12, wherein the elastomeric material is natural rubber.

14. An article of manufacture as defined in claim 12, wherein the elastomeric material is synthetic rubber.

15. As an article of manufacture, a laminated body

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comprising at least one reticulated, permeable, fibrous sheet of tubular fibers comprising an elastomeric material, each of the fibers differing from other fibers in length and diameter and having a varying diameter along its length, tapered ends, relatively thick walls with respect to its diameter and its surface substantially free of craters, the fibers being arranged in the sheet in random distribution and bonded together at their points of contact, the sheet having substantially uniform elasticity and strength characteristics, per unit of thickness, in all directions in the plane of the sheet.

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