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METHOD FOR THE PRODUCTION OF RETICULATED WEBS

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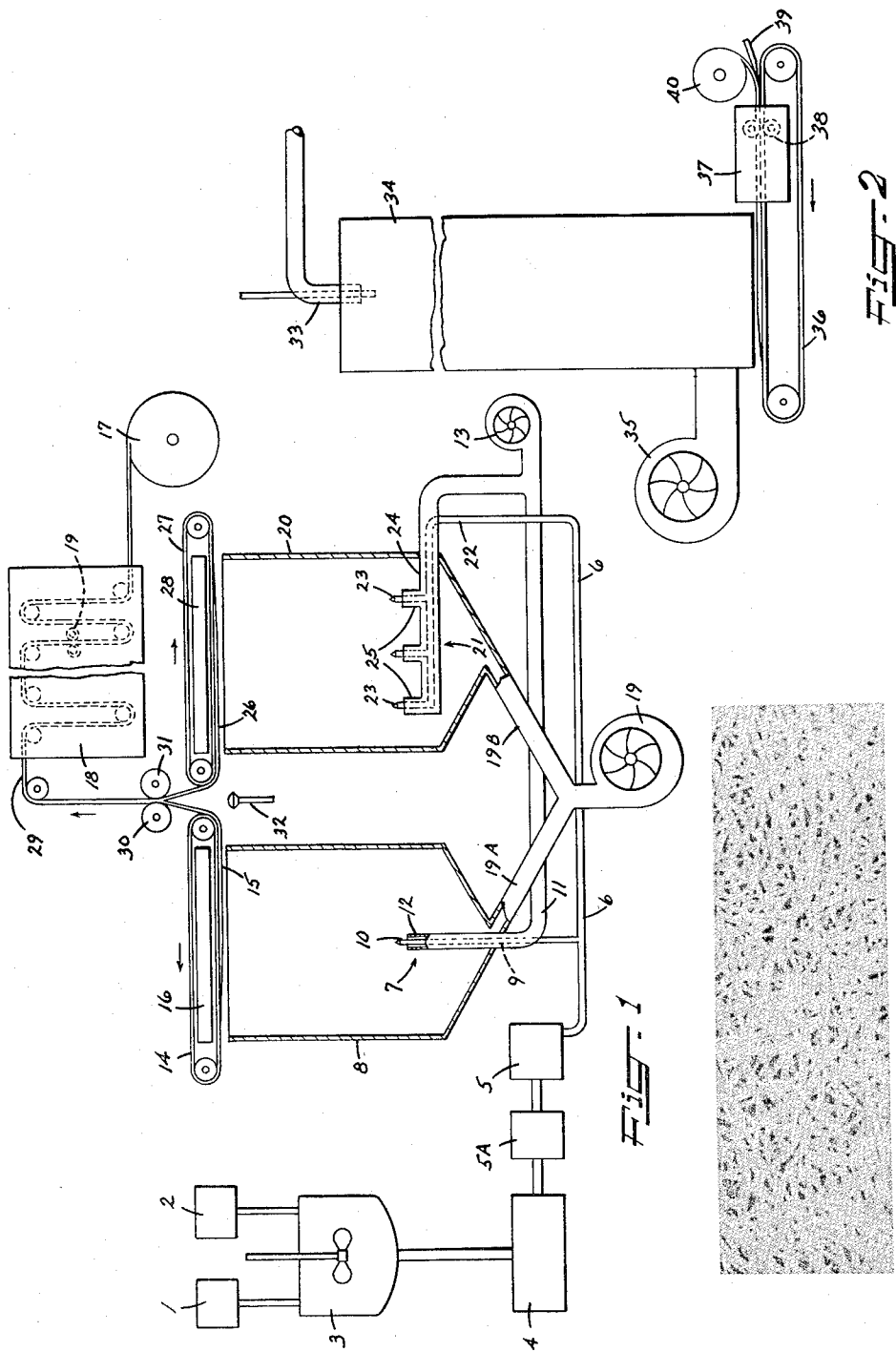


Fig. 3

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METHOD FOR THE PRODUCTION OF RETICULATED WEBS

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This invention relates to fibrous bodies and more particularly to a method of preparing shot-free reticulated webs or structures formed of fibrous materials.

Fibrous bodies or structures of fiber-forming organic substances are generally formed from filaments prepared by either extruding a filament-forming organic substance through an orifice or by spraying the organic substance by the use of spray guns and the like. Methods which involve the extrusion of the filament-forming substance through orifices are limited to the use of certain substances which may be filtered and which possess certain other characteristics, including wet and dry tensile strengths, necessary for the spinning operations. The filaments produced by conventional extrusion methods are continuous filaments and the size or denier is limited by the extrusion characteristics of the substances or of the spinning solutions of the particular substance. In many instances, it is desirable to incorporate various solid materials, such as fillers, into the fibers or filaments. However, it is not practical to do so when the material is to be extruded through fine orifices and the amount of foreign material which may be incorporated in the fiber or filament is strictly limited. In the production of sheet material or padding from such filamentary materials, it is necessary to collect the filaments and cut them to staple lengths. The staple is subsequently processed on conventional textile and felting equipment to form a woven sheet or felted layer or mat. Where the filament is formed of a potentially adhesive substance and it is desired to produce a product, with or without non-adhesive fibers, wherein the fibers are bonded together at their points of contact, it is necessary to subject the sheet or mat, as formed, to an activating treatment whereby the potentially adhesive filaments become tacky or adhesive and are capable of bonding to other fibers at their points of contact and then deactivate the fibers.

As an alternative, fibers or filaments may be formed from a wide range of substances by the use of various types of spray guns. Because of the relatively large size of the spray gun orifices as compared to extrusion orifices such as those of a rayon type spinneret, for example, the limitations with respect to the characteristics of the spinning liquid are far less exacting than for the extrusion methods. Various materials such as fillers, hardening agents, plasticizing agents and the like may be incorporated in the spinning liquids. If it is desired to form a product of potentially adhesive fibers and non-adhesive fibers, the potentially adhesive fibers may be produced by spraying into the air stream containing air-borne non-adhesive fibers and collecting the mixed fibers, for example, as shown in the patent to Carleton S. Francis, Jr., No. 2,357,392. In the use of spray guns, the liquid material upon extrusion is disintegrated or disrupted into minute droplets by a rapidly diverging stream of gas. The droplets when flung through the atmosphere by the gas stream become attenuated to form fibers but a substantial number of the droplets are not given a sufficient velocity to be attenuated and solidify to form what is commonly termed "shot."

The principal purpose of the present invention is to provide a method for the preparation of shot-free, re-

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ticated, fibrous webs or structures formed of discontinuous fibers or fibrils in random distribution.

A further purpose of this invention is to provide a method for the production of shot-free, reticulated, fibrous webs or structures formed of at least two types of fibrous materials.

Another purpose of this invention is to provide an inexpensive method for the production of shot-free, reticulated, fibrous webs or structures formed of relatively long, fine fibers or fibrils.

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

In the drawings,

FIGURE 1 is a diagrammatical, elevational view, partly in section, of one form of apparatus for the practice of the method of this invention;

FIGURE 2 is a diagrammatical, elevational view, partly in section, of another form of apparatus for the practice of the method of this invention; and,

FIGURE 3 is a photograph, at an enlarged scale, of a reticulated, fibrous web formed in accordance with this invention.

The present invention contemplates the production of relatively long, discontinuous fine fibers of non-elastomeric, fiber-forming thermoplasts by a spraying technique wherein a fiber-forming spraying liquid is extruded into a high velocity unidirectional, free-flowing jet stream of gas which in unconfined and unrestricted within the atmosphere as in a tower, spray chamber or the like as an initial, relatively large-diameter uninterrupted stream of plastic which stream is attenuated without the formation of shot, and possibly fibrillated into a multiplicity of fibers and fibrils before being deposited on a collector. Unlike dry spinning, as performed in the rayon and synthetic fiber industries, in which a spinneret with multiple minute holes (generally about 2 to 4 mils in diameter) 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 spraying process of the present invention utilizes a single relatively large extrusion orifice (at least about 10 mils in diameter) producing a single large-diameter, uninterrupted plastic stream which is attenuated and possibly fibrillated into a multiplicity of fibers and fibrils without the formation of shot, the diameters of which fibers and fibrils are small fractions of the orifice diameter, there being no continuous filament running between the orifice and the collector. Generally, the filaments produced by the conventional synthetic fiber industry methods have diameters of at least about 10 microns whereas filaments having diameters as low as 1 micron may be formed by the present method although the extrusion orifice may have a diameter as great as about 42 mils (1067 microns).

The velocity of the gas into which the spraying liquid is extruded is appreciably higher than the velocity of extrusion of the spraying liquid and the direction of extrusion is coincident with the direction of the gas flow. The high velocity free-flowing, jet stream of gas thereby attenuates and possibly fibrillates the uninterrupted stream of spraying liquid without disintegrating or atomizing the liquid, that is, the stream of liquid is highly attenuated and may be split lengthwise into two or more thinner fibers or fibrils and is broken up into discontinuous fibers or fibrils of varying length by the high velocity gas. The jet stream of gas partially or substantially completely sets the fiber-forming thermoplast due to a partial or substantially complete vaporization of the solvent or to a partial cooling of the spraying liquid to form the discontinuous, attenuated fibers or fibrils. The gas also carries,

supports or floats the fibers or fibrils and finally deposits them or allows them to deposit upon a suitable collecting surface. Alternatively, a low velocity or secondary stream of gas such as the ambient atmosphere in the tower or chamber may be moved at a velocity lower than that of the high velocity jet stream or primary stream of gas but having a sufficiently high velocity so as to carry, support or float the fibers and fibrils and finally deposit them or allow them to deposit upon a suitable collecting surface. The fibers may be collected in any desired condition depending upon the proportion of solvent removed and/or by the degree of cooling between the point of extrusion and the point of collection.

The fiber-forming thermoplasts utilized in the practice of this invention are primarily synthetic, non-elastomeric polymers capable of forming fibers from volatile organic solvent solutions or from hot melts or both, and are thermoplastic or may exist in a thermoplastic state. The spraying liquids comprised of the solvent solutions of the synthetic polymers or the hot melts of the polymers or both are capable of being attenuated and fibrillated to form the fibers. The fibers of the polymer are capable of being rendered adhesive, sticky, cementitious, agglutinous or tacky by heating to temperatures elevated with respect to normal or room temperatures or by treatment with a solvent or both, and the polymers and fibers formed therefrom may therefore be termed "potentially adhesive materials."

The non-elastomeric thermoplasts satisfactory for the purposes of this invention consist of a wide variety of substances selected generally from the classes or groups consisting of organic cellulose derivatives, thermoplastic resins and thermosetting resins in their thermoplastic state. These thermoplasts include organic solvent soluble cellulose esters such as cellulose acetate, cellulose acetate-butyrate and the like; organic solvent soluble cellulose ethers such as ethyl cellulose, and the like; water-soluble cellulose ethers, such as hydroxyethyl cellulose and the like; vinyl resins, which may be defined as solid, thermoplastic, saturated synthetic resins resulting from the polymerization of compounds containing the vinyl group such as polyvinylchloride, copolymers of vinyl chloride and vinyl acetate (Vinyon), copolymers of vinyl chloride and acrylonitrile (Dynel), polyacrylonitrile and copolymers of polyacrylonitrile containing a predominant proportion of acrylonitrile (Acrilan, Orlon), polystyrene, polyacrylates such as ethyl acrylate polymers, methyl acrylate polymers and the like; polyesters (Dacron); polyamides (nylon), including alcohol soluble nylon, organic solvent soluble thermosetting resins of the types which are capable of existing in a thermoplastic state such, for example, as urea-formaldehyde, melamine-formaldehyde, thiourea-formaldehyde, glyptals, silicones and the like, which resins are attenuated and fibrillated while they are in their thermoplastic state and which, if desired, may be converted subsequently to the thermoset state while in fiber form; and the like. Mixtures of specific thermoplasts may be utilized to provide fibers and structures of desired characteristics. The specific thermoplasts are enumerated merely as illustrative and are not intended as limitations of the invention.

The spraying liquid may be formed by dissolving the fiber-forming thermoplastic in a suitable organic solvent which may be volatilized at moderately elevated temperatures, or the spraying liquid may comprise a hot melt or molten mass of the thermoplastic. For example, a spinning liquid may comprise a solution of Vinyon in tetrahydrofuran and methyl isobutyl ketone, or an alcohol solution of alcohol soluble nylon, or a hot melt of nylon. Where the spinning liquid comprises a solution of a thermoplastic, the solution may contain from about 10% to about 55% of the fiber-forming thermoplastic, the specific solids content varying with the different types of fiber-forming materials.

The properties and characteristics of the fibers formed

from the thermoplasts may be varied as desired by incorporating additives in the spraying liquid. For example, fillers, coloring agents such as dyes and pigments, plasticizers and the like may be incorporated in the solution of the thermoplastic or in the hot melt. By varying the relative proportions of solvent, thermoplastic and additive substance, the viscosity of the spraying liquid may be varied over a wide range. It is possible to utilize spraying liquids in forming the products of this invention which are totally unsuited for use in the usual or conventional spinning methods.

The gas streams may be at normal atmospheric temperature or at any other desired temperature. For example, the temperature may be elevated so as to increase the rate of volatilization of the solvent. Any desired gas may be employed such as air, nitrogen, carbon dioxide, steam and the like.

The thermoplasts are potentially adhesive materials, as described hereinbefore. Since the fibers as they are formed are adhesive or tacky, a reticulated web or structure can be produced by collecting them on a surface, or a composite reticulated web or structure can be produced by collecting them in combination with other particulate material such as preformed fibers and/or discrete particles, preferably of a non-adhesive, non-elastomeric material, which may be introduced into the streams of gas. The preformed fibers or discrete particles are thereby brought into contact with the potentially adhesive fibers while the latter are in a tacky or cementitious condition and the preformed particulate material adheres to the newly formed fibers. The fibers may be collected while they are in an adhesive condition or afterwards. The fibers as collected are deposited in a completely random distribution or haphazard manner to produce a reticulated, web or structure. Where the fibers are collected while they are in a tacky condition, the fibers will stick together where they contact each other and where they contact preformed particulate material, if such material is present. The fibers may be collected after complete removal of the solvent or a cooling of the fibers to a temperature at which they are not tacky in which case they will not stick together. The degree of bonding of the fibers in the reticulated web may be thus controlled as desired. Conventional methods of handling staple fibers, even though elaborate carding equipment is employed, do not produce webs having the totally random distribution of fibers as formed by this method. This method also eliminates the activating procedure required where conventional methods are utilized in forming the mixed fiber or composite bodies.

The term "particulate non-adhesive material" is used to designate preformed fibers and/or discrete particles of a material which is not rendered adhesive or tacky under the conditions at which the thermoplasts are adhesive.

Among the non-adhesive substances or materials which may be employed in forming the composite bodies are natural fibers, such for example as wood fibers, cotton, flax, jute, sisal, kapok, wool, hair, and silk, other natural substances such as leather and cork; synthetic fibers, for example, cellulosic fibers such as cellulose hydrate, cellulose derivatives such as cellulose esters, mixed cellulose esters, cellulose ethers, mixed cellulose ester-ethers, mixed cellulose ethers, cellulose hydroxyalkyl ethers, cellulose carboxyalkyl 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 thermoplastic fibers or 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 in lieu of the preformed fibers, preformed discrete particles of natural and synthetic materials may be introduced into one or both of the streams of gas; for example, cork dust, leather dust,

wood flour, flake particles, fibers of flock length and the like. Two or more different non-adhesive materials may be introduced into the gas streams and the different materials may be of different physical form; for example, one may be in fiber form and another in powdered form, depending upon the nature and characteristics desired in the final product. In producing composite webs or structures including preformed non-adhesive fibers, it is preferable to employ both the primary and secondary streams of gas and introduce the preformed fibers into the secondary air stream. Preformed discrete particles may be introduced into either gas stream. Where the composite body is to include both preformed fibers and discrete particles, the discrete particles, for example, cork dust or wood flour, may be introduced into the primary stream of gas and the preformed fibers, for example, wood fibers, rayon staple or mineral wool fibers, may be introduced into the secondary stream of gas. Both types of preformed non-adhesive material, however, may be introduced into the primary or high velocity stream of gas or into the secondary stream of gas. In contradistinction to the shot of the fiber-forming material, the discrete particles intentionally added are employed to impart desired characteristics.

The present fiber-forming process can be practiced by utilizing apparatus as illustrated more or less diagrammatically in FIGURE 1. The fiber-forming thermoplast is supplied from a suitable storage vessel 1 and the solvent is supplied from a suitable tank 2 to a mixer 3. Desired additives such as pigments, dyes, plasticizers and the like may be introduced with the thermoplast or with the solvent. Where the thermoplast is utilized as a hot melt, the thermoplast may be heated to the desired temperature in the mixer and the succeeding apparatus will be provided with suitable means to maintain the liquid at the required temperature. After forming the spraying liquid, it may be transferred to a storage tank 4 from which it passes to a pump 5. A strainer or filter 5A may be interposed between the storage tank and the pump. The spraying liquid is supplied continuously to a conduit 6 which communicates with the spraying unit 7 which is preferably mounted concentrically with a cylindrical tower 8. The spraying unit comprises a conduit 9 which communicates with the liquid conduit 6 and which terminates in an upwardly directed spray tip 10 having a suitable extrusion orifice at its upper end, and a gas conduit 11 which terminates in upwardly directed gas nozzle 12. The spray tip 10 is preferably located concentrically within and extends above or beyond the terminus of the gas nozzle 12. A high velocity stream of gas is supplied continuously to conduit 11 and the gas nozzle 12 by means of a blower 13. The velocity of the gas emerging from the nozzle 12 is appreciably higher than the velocity of the spraying liquid emerging from the spray tip 10.

The diameter of the gas nozzle 12 is insignificant with respect to the diameter of the tower 8 or with respect to the dimensions of the space into which the gas is projected from the nozzle. The gas issuing from the nozzle is therefore a unidirectional, high velocity, free-flowing jet stream of gas which is unconfined and unrestricted within the ambient atmosphere into which it is projected. The stream of gas is comparable to the naturally occurring jet air streams in the earth's upper atmosphere and to the ocean currents such as the Gulf Stream in the Atlantic Ocean. The jet stream continues for some distance as a unidirectional flowing stream of gas which after attenuating the plastic, then gradually diverges. It is also comparable to a stream of water issuing from a hose nozzle adjusted to deliver the water at a maximum distance from the nozzle in contradistinction to water issuing from a nozzle adjusted to provide a spreading mist.

The spraying liquid is extruded into the high velocity free-flowing, unidirectional, jet stream of gas in the form of a single, relatively large-diameter stream of plastic.

The high velocity jet stream of gas draws or attenuates the spraying liquid stream without atomizing the liquid and may possibly fibrillate the spraying liquid, that is, split the stream lengthwise into two or more thinner streams or fibers, and after attenuating the liquid stream, breaks the stream or streams transversely into discontinuous lengths to form fibers or fibrils of varying length. The velocity of extrusion of the spraying liquid and the velocity of the stream of gas may be varied so as to regulate the amount of attenuation, hence, the diameter of the fibers and to regulate the length of the fibers. In general, for a given spraying liquid, the greater the velocity of the stream of gas with respect to the velocity of extrusion, the finer the fibers or fibrils. Solvent is evaporated simultaneously with the attenuation action so as to partially set or harden the fiber-forming material, or if the spraying liquid comprises a hot melt, the liquid becomes partially cooled.

It has been discovered that the nature of the high velocity jet stream of gas, the direction of extrusion of the liquid with respect to the direction of the gas flow and the point or position at which the plastic liquid is extruded into the gas stream are critical in order to eliminate the formation of shot. A rapidly diverging gas flow as in spray guns and nozzles results in a disruption or atomization of the liquid with consequent formation of shot. The high velocity, unconfined and unrestricted jet stream of gas must be a more or less unidirectionally flowing mass of gas or column of gas particularly in the vicinity of the position at which the liquid is introduced. If the liquid stream is introduced at any appreciable angle with respect to the direction of the gas flow, the liquid is disintegrated with the resulting formation of shot. The action of the jet stream of gas is restricted to attenuating the liquid stream only when the direction of travel of the gas and liquid streams is coincident, and this direction of both may be at any desired angle to the horizon, and then only when the point of extrusion is within certain limits. When the extrusion orifice is placed in the plane of the terminus of the gas nozzle, there is a sufficient convergence of the gas toward the axis to disrupt the liquid into droplets similar to an atomizing of a spray gun. This disrupting action continues as the extrusion orifice is moved outwardly beyond the gas nozzle and the size of the droplets formed gradually increases until a point is reached, for a given spraying liquid, velocity of extrusion and gas velocity, at which the sole action is an attenuation of the extruded liquid. This attenuating action continues as the orifice is further advanced until a point is reached where the gas no longer attenuates the liquid. As will be pointed out hereinafter, for practical operation, satisfactory spacing of the orifice is from about 1/4 inch to about 1 inch beyond the terminus of the gas nozzle. The precise optimum spacing is dependent upon the nature of the spraying liquid, the relative spacing between the extrusion orifice and gas nozzle and the relative velocity of extrusion and velocity of the gas and may be readily determined by simple adjustment beginning with a spacing between the extrusion orifice and nozzle of about 1/4 inch.

The most surprising discovery upon which this invention is founded is the fact that fibers may be formed having diameters as small as 1 micron although the diameter of the extrusion orifice through which the fiber-forming liquid is extruded exceeds 1000 microns, Example 5. This is all the more surprising when it is considered that in Example 5 which follows the liquid contained 15% fiber-forming material whereas in the production of viscose rayon, for example, the filaments have diameters of at least 10 microns, usually 12 to 15 microns, utilizing orifices having diameters between about 2 to 4 mils (50 to 100 microns) and viscose solutions containing 4% to 8% cellulose.

The fibers or fibrils are carried or floated in the air or gas stream while the solvent continues to volatilize, or the

cooling of the molten fiber continues, and the fibers are finally deposited on a suitable collecting surface such as a conveyor screen 14 supported at the top of the tower 8. As the fibers or fibrils collect on the screen or other porous surface, the resistance of the reticulated mat or web 15 to the flow of gas increases and for the production of thicker mats or webs, a suction chest 16 may be provided above the collector. The suction chest may also be employed to aid in the recover of the solvent, if desired. The reticulated mat or web can be stripped or removed from the conveyor screen 14 and collected on a take-up roll or drum 17. A heating chamber 18 may be interposed between the collector and the take-up roll through which the web is passed to complete the solvent removal, or where the fiber-forming material is a thermosetting material utilized in a thermoplastic state for the production of the fibers, the web or mat may be passed through the heating chamber 18 to convert the fibers into a thermoset state.

The characteristics of the reticulated mat or web may be varied by altering the positioning of the collecting surface with respect to the spraying unit. By decreasing the distance between the collecting surface and the spraying unit, the distance through which the fibers travel before being collected is also decreased. The fibers have had a shorter period to become set and are accordingly deposited in a more tacky condition to form a more thoroughly bonded mass. The velocity of the fibers at the instant of deposition is higher the shorter the distance of travel and, hence, the mat or web will be of higher density. By increasing the distance between the collecting surface and the spraying unit, the fibers will be in a less tacky condition and will be deposited at a lower velocity and the web or mat is lower in density and the fibers are less firmly bonded together. In either case, the heating chamber 18 may be utilized to raise the temperature of the mat so as to increase the bonding between the fibers. For the production of thin sheet-like bodies, the web or mat upon activation of the thermoplastic fibers may be passed between pressure rolls 19 to provide a hot-calendered product, or the pressure rolls may be provided with desired protuberances whereby the additional bonding is confined to localized areas. If desired, the heater may be replaced with heated pressure rolls. After deactivation of the thermoplastic fibers, the web or mat is collected as upon the take-up roll or drum 17.

If desired, a second upwardly moving stream of gas such as the ambient air in the tower 8 may be moved or passed upwardly by means of a blower 19 and surrounds the first stream of gas. This secondary stream of gas is passed upwardly at a velocity lower than that of the primary stream of gas which is supplied through nozzle 12. As the extruded liquid is attenuated and the velocity of the gas from nozzle 12 approaches the velocity of the secondary stream of gas, the attenuated fibers are then carried upwardly by the secondary stream of gas. In order to increase the drying or setting rate of the fibers, the temperature of the secondary stream of gas may be elevated, if desired. The velocity and temperature of the secondary stream of gas through the tower may be controlled to deposit the fibers on the screen 14 in a desired condition. The temperature of the gas stream may be varied so as to control the evaporation of solvent or cooling of the thermoplastic and deposit the fibers in either a desired adhesive or a non-adhesive condition. Where the fibers are to be utilized in forming a more or less coherent reticulate mat, the temperature and velocity of the secondary stream of gas are so controlled that the fibers are deposited on the conveyor screen 14 in a somewhat tacky condition whereby the fibers become bonded together at their points of contact.

For the production of low density and loosely bonded webs or mats wherein the fibers are not bonded together, the temperature and velocity of the secondary stream of gas are controlled so that the fibers are deposited in a

loose, non-adhesive condition. Thus, the properties and characteristics of the fibers and of the deposited web may be varied over a wide range by a control of the gas velocities and temperatures.

Relatively thick bodies or structures can be produced by a laminating technique. The web or mat can be stripped from the collecting screen and folded upon itself to provide the desired thickness. As alternatives, the web may be cut to a desired size and a plurality of such cut webs assembled, or a plurality of uncut webs of desired length may be assembled while the thermoplastic fibers are in an adhesive condition, the fibers on contiguous surfaces adhere to each other upon contact so as to bond the adjacent layers into a unitary structure. Additional bonding between adjacent layers may be obtained by the application of pressure to the assembly whereby the exposed fibers lying beneath the plane of the surface fibers of adjacent layers are brought into contact. The exposed fibers may be activated by the application of a solvent, as by spraying a solvent on the surfaces, before assembling the plies, or by heating the assembly to a temperature at which the fibers are activated, that is, rendered sticky or tacky.

In the production of fibrous bodies comprising preformed non-adhesive fibers and/or discrete particles and the potentially adhesive, thermoplastic fibers formed as described, the preformed non-adhesive fibers and/or discrete particles are preferably carried in the secondary stream of gas and may be introduced through the blower 19. The non-adhesive fibers or particles are thereby carried or blown into contact with the fibers while these latter fibers are in a partially set and tacky or cementitious condition and thereby become firmly attached to the sprayed fibers. The spraying conditions are maintained so that the sprayed fibers are still in a somewhat tacky condition when they are collected on the conveyor screen 14.

Although the chamber or tower 8 is shown as being provided with a spraying unit consisting of a single spray tip and nozzle, it is to be understood that such illustration is merely for purposes of simplifying the drawing and the foregoing discussion. A plurality of spaced spraying units may be mounted within a large tower.

A product of uniform thickness over the width of the web can be produced by utilizing a tower 20 having a square or rectangular section. A plurality of spraying units 21 are positioned in spaced relationship at or adjacent the base of the tower. Each spraying unit comprises a liquid conduit 22 provided with a plurality of spaced, upwardly projecting spray tips 23 and a gas conduit 24 provided with a plurality of spaced, upwardly projecting gas nozzles 25 surrounding the spray tips. The conduit 22 communicates with the spraying liquid conduit 6 and the gas conduit 24 communicates with the blower 13. The production of the fibers is as described hereinbefore.

The sprayed fibers or fibrils are carried by the primary or high velocity, jet streams of gas issuing from the nozzles 25 or may be carried by a secondary stream of gas provided by the blower 19. The fibers are collected as a reticulated web 26 on the collecting screen 27 mounted at the top of the tower 20. A suction chest 28 may be mounted above the collecting screen, as described hereinbefore. The web may be stripped from the conveyor screen and accumulated on the take-up roll 17. As described, the web may be passed through a heating chamber 18 and/or between pressure rolls 19 before being accumulated on the take-up roll, if desired.

As illustrated in FIGURE 1, a laminated product 29 can be produced by bringing together two or more webs from different chambers or towers between squeeze rolls 30 and 31 while the thermoplastic fibers are in an activated tacky or adhesive state. The fibers on contiguous surfaces of the webs 15 and 26 may be activated by spraying the surfaces with a solvent as by means of a spray

nozzle 32 at a position immediately preceding the squeeze rolls. Alternatively, the fibers may be activated by heating in the chamber 18 and employing the rolls 19 as squeeze rolls.

Fibrous products comprising the potentially adhesive thermoplast fibers and preformed non-adhesive particulate material can be produced by introducing the preformed fibers or particles into the blower 19. Plies or layers of different characteristics may be prepared by introducing different particulate materials into the ducts 19A and 19B through which the secondary gas streams are supplied to the separate towers. If desired, one of the webs may be formed without introducing a particulate material and the other web formed with any desired added particulate material or different particulate materials may be introduced into the separate towers.

Where a plurality of spraying units are positioned within a tower, all of the spraying units may be provided with the same spraying liquid and each nozzle may supply the primary gas at the same velocity. The resulting reticulated web thus consists of a single composition and the fibers will be of a length and size within a certain range. If desired, the relative velocities of extrusion of the spraying liquid and of the primary gas stream may be varied for different spraying units to provide fibers of a length and size within a greater range. Products containing fibers of two or more different thermoplasts or different compositions may be formed by supplying spraying liquids of different thermoplasts or of different composition to separate spraying units. For example, products having color blends may be prepared by supplying spraying liquids containing different coloring agents to separate spraying units.

Laminated, reticulated products wherein the outer plies are of different characteristics or properties may be prepared by providing different spraying liquids to spraying units in the separate towers and by maintaining different conditions of spraying in the separate towers. For example, one web may be formed of one type of thermoplast and the spraying and fibrillating conditions maintained so as to form a reticulated web of relatively coarse long fibers and the other web may be formed of another thermoplast composition having a different coloring agent and the spraying conditions maintained so as to form a web of relatively fine and short fibers. The webs are subsequently laminated as described. By applying a stencil over a first formed web, a layer of the same or different thermoplast fibers may be formed on the first web at predetermined areas.

The method may also be practiced by passing the secondary or low velocity stream of gas in a direction countercurrent to the primary or high velocity jet stream of gas, as illustrated in Figure 2. A spraying unit 33 consisting of a spray tip and nozzle, as described hereinbefore, is mounted at the top of tower 34, preferably concentrically with respect to the walls of the tower. The primary or high velocity jet stream of gas is supplied to the nozzle by suitable means and the spraying liquid is extruded through the spray tip by suitable means, not shown. The direction of travel of the primary or high velocity jet stream of gas and the direction of extrusion are downwardly. The attenuation of the spraying solution and the fiber formation by evaporation of the solvent is identical to that described hereinbefore.

The secondary or low velocity stream of gas is passed upwardly through the tower as by means of a blower 35. The secondary stream of gas is passed at a velocity sufficient to support or retard the fall of the attenuated fibers and permit the fibers to deposit on the collecting screen 36 in any desired condition. The fibers may be deposited in a tacky or cementitious condition to cause them to effect an immediate bonding at their points of contact or they may be supported until they are in a substantially non-adhesive condition before being allowed to deposit.

The reticulated web or mat may be passed through a

suitable heating chamber 37 wherein the thermoplast fibers are activated and the bonding between the fibers increased. The heating chamber may be employed to complete the removal of solvent, or, where the fiber-forming material is a thermosetting material utilized in a thermoplastic state for the production of the fibers, the web or mat may be passed through the heating chamber to convert the fibers into a thermoset state. For the production of thin sheet-like bodies, the web or mat upon activation of the thermoplast fibers may be passed between the pressure rolls 38 to provide a hot-calendered product, or the heating chamber may be replaced by heated pressure rolls. If desired, the additional bonding may be confined to localized areas by providing the pressure rolls with protuberances. After deactivating the thermoplast, as by cooling, the web or mat is finally stripped from the conveyor screen as by means of a doctor blade 39 and the web collected on a take-up roll or drum 40.

Reticulated webs or mats comprising preformed particulate material such as preformed fibers and/or discrete particles, preferably of a non-adhesive material may be formed by introducing the particulate material into the secondary stream of gas.

The spraying and fiber-forming method herein described has been found to be particularly satisfactory and inexpensive for the production of reticulated webs and mats consisting of very fine fibers of the thermoplast materials. It has been found that by the use of this method, fine fibers may be formed from spraying liquids having a wide range of viscosity and that the viscosity and the apparent stringiness of the spraying liquid is not a measure of its fiber-forming characteristics. The size of the fibers may be controlled by varying the concentration of the liquids containing the thermoplast. For a given spraying liquid including a hot melt, the size of the fiber may be controlled by varying the relative velocity of the high velocity jet stream of gas from nozzle 12 with respect to the velocity of extrusion of the spraying liquid as well as by varying the size of the orifice in the spray tip 10. For a given set of spraying conditions, the characteristics of the deposited web may be varied by altering the spacing between the spraying unit and the collector. The shorter the distance between the spraying unit and the collector, the greater the density of the web and the greater the bonding between contacting fibers. With fixed spraying conditions and a fixed spacing between the spraying unit and collector, a secondary stream of gas may be utilized to vary the time between the formation of the fibers and the deposition of the fibers, and the velocity at the instant of deposition. The thickness of the web or mat may be regulated by controlling the speed of the collector surface.

FIGURE 3 is a photograph, at an enlarged scale of a representative mat or web of thermoplast fibers made in accordance with the method of this invention. As shown by the photograph, the product is a lacy, fibrous reticulated web wherein the fibers are in a totally and completely random or haphazard distribution. Although there is little or substantially no coalescence of fibers, the fibers are bonded together at their points and areas of contact. Where the fibers come into contact with each other longitudinally while they are tacky, they become bonded together to form a bundle of fibers and the reticulated web includes such bundles as well as individual, discontinuous fibers.

It is well known that for certain types of gas filters, it is essential to employ fine fibers, that is, fibers having a diameter of the order of 2 to 3 microns and lower. Considerable difficulty is encountered in preparing filter media from such fine fibers because they cannot be handled by conventional commercial fiber and textile equipment thus rendering such media quite costly. The only known materials commercially available are certain grades of glass fibers and imported asbestos. No comparable organic fibers, either natural or synthetic, are available.

The present method provides an inexpensive reticulated filter medium of very fine fibers which is admirably suited

for both gas and liquid filters, gas masks, and the like. The reticulated, fibrous bodies are also very highly effective as thermal and sound insulating materials. Because of the relatively light weight of the webs or mats, the bodies or structures are especially well suited for such uses as thermal and sound insulation for aircraft, thermal insulation for arctic clothing and the like.

In a small scale production of fibrous, reticulated mats or webs of this invention, a tower may be employed having a diameter of four feet and a height of about twenty-five feet. The spraying unit 7 consisting of a spinning tip 10 and a nozzle 12 is mounted concentrically within the tower at a point from about 5 or 6 feet to about 15 feet from the collecting screen. If the filament-forming material is to be extruded downwardly, the spraying unit may be mounted adjacent or at the top of the tower. A plurality of spaced spraying units may be employed if desired.

A blower may be provided to introduce an inert gas such as air at the bottom of the tower and suitable heating means may be provided to permit regulation of the temperature of the air stream if a secondary stream of gas is employed. The collecting conveyor may consist of a suitable screen such as a screen formed of Saran. The spray or extrusion orifice for the thermoplasts may be varied. Orifices between about 0.01 inch and about 0.05 inch in diameter have been satisfactory. The primary gas stream or high velocity gas stream may be provided through a nozzle having an internal diameter of from about 0.25 inch to about 0.75 inch. The extrusion orifice is positioned from about 0.25 inch to 1 inch beyond the terminus of the nozzle. The thickness of the reticulated web or mat is controlled by regulating the speed of the collecting conveyor.

The following specific examples are set forth herein merely to illustrate the production of reticulate filamentary webs formed of various thermoplasts. The tower dimensions were as set forth above. The viscosities of the various spinning liquids to which specific reference is made were measured at room temperatures. The internal diameter of the nozzle was 0.493 inch and the external diameter of the spinning tip was 0.165 inch.

It is to be understood that the foregoing specific dimensions are merely illustrative. The orifice size for any specific thermoplast may be varied depending upon the size of fiber desired and upon the viscosity of the spraying liquid. Similarly, the specific size of the gas nozzle may be varied depending upon the specific thermoplast and the characteristics of the spraying liquid. Where multiple spraying orifices or units are employed, a spacing between the orifices of at least about 1.5 inches is satisfactory when the nozzle diameter is about 0.25 inch and the orifice has a diameter of about 0.010 inch.

Example 1

A spraying liquid was formed by dissolving 100 parts of a commercial, high viscosity type cellulose acetate in 800 parts of a solvent consisting of acetone and ethyl alcohol in the proportion of 9 parts of acetone to 1 part of ethyl alcohol. A commercial plasticizer was added to the liquid. Other types of solvents are also satisfactory for the production of reticulated, fibrous webs of cellulose acetate. The fiber-forming liquid was extruded downwardly through an orifice having a diameter of 0.018 inch at the rate of from 15 to 30 cc. per minute or at a velocity of from 300 to 600 feet per minute. Air was supplied to the nozzle at a rate of 3 c.f.m. or at a velocity of about 2500 feet per minute. Air was passed upwardly through the tower at the rate of 3000 c.f.m. or at a velocity of about 240 feet per minute and at a temperature of about 50° C.

The fibers formed under these conditions were rather coarse and were deposited in a tacky condition and the fibers were bonded together at their points of contact. The product had the appearance of a closely matted mass

of long fibers which were bonded together into a coherent but permeable, reticulated mat.

Cellulose acetate, of the thermoplasts investigated, was the most sensitive material with respect to the spraying conditions, probably due to the relatively high volatility of the solvents. As the attenuating jet air stream approaches a rate of about 15 c.f.m. or a velocity of about 9000 feet per minute at the gas nozzle exit, the solvent appears to be vaporized sufficiently rapidly so as to produce nodular bodies or "shot" in place of the desired fibers, and hence, in producing fibers from this substance a lower gas velocity should be employed to eliminate the formation of shot.

Example 2

A spraying liquid was formed consisting of a 25% solution of an ethyl cellulose polymer, the polymer having a viscosity of 22 cps. in a solvent consisting of toluene and ethanol in the ratio of 4 parts of toluene to 1 part of ethanol.

The spraying liquid was extruded downwardly through an orifice having a diameter of 0.018 inch at a rate of about 10 cc. per minute or at a velocity of about 200 feet per minute. Air was supplied to the nozzle at the rate of 5 c.f.m. or at a velocity of about 4250 feet per minute. Air was passed upwardly through the tower at a rate of 2000 c.f.m. or at a velocity of about 160 feet per minute and at a temperature of about 120° F.

The mat or web formed consisted of long separable fibers or filaments, curly in character. By the application of heat and a slight pressure, the fibers may be bonded together at their points of contact into a coherent, reticulated, fibrous mat or web.

Example 3

A spraying liquid was prepared of a copolymer of vinyl chloride and vinyl acetate, known commercially as Vinylite VYHH, by forming a solution containing 25% of the resin in a solvent consisting of 9 parts tetrahydrofuran to 1 part of methyl isobutyl ketone. The viscosity of this solution was 300 cps. The spraying or fiber-forming liquid was extruded upwardly through an orifice having a diameter of 0.025 inch at a rate of about 9 cc. per minute or at a velocity of about 93 feet per minute. Air was supplied to the nozzle at the rate of 30 c.f.m. or at a velocity of about 25,500 feet per minute. Air was passed through the tower at a rate of from 3700 to 5000 c.f.m. or at a velocity of from 300 to 400 feet per minute and at a temperature of about 11° C.

The fibers formed under these conditions had a diameter of between 1 and 5 microns. The collected product was light in weight and fluffy and had the appearance of a reticulated web formed of a mass of long fibers very loosely bonded together at their points of contact and had a very warm feel.

The temperature of the secondary or low velocity stream of air has a decided effect upon the size of the fibers produced from this group of vinyl resins. For the production of fine fibers, the viscosity of the spinning solution, hence, the resin content of the solution, must be reduced as the temperature of the secondary stream of air is increased. The table which follows illustrates the variations in viscosity and solids content necessary to produce a light, fluffy product having fibers of the diameter set forth in the foregoing example as the temperature of the low velocity or secondary stream of air is varied.

Temperature	Solids, percent	Viscosity, cps.
0-6° C.....	30	260
8° C.....	28.5	600-700
11° C.....	25	300
17° C.....	22	190

Example 4

A spraying liquid was formed of a commercial copolymer of vinyl chloride and acrylonitrile, known as Dynel. The spraying liquid was a 21% solution of the resin in a solvent consisting of equal parts of dimethylformamide and acetone. The viscosity of the solution was 3860 cps.

The spraying liquid was extruded upwardly through an orifice having a diameter of 0.025 inch at a rate of 12 cc. per minute or at a velocity of about 120 feet per minute. Air was supplied to the nozzle at the rate of 20 c.f.m. or at a velocity of about 17,000 feet per minute. Air was passed upwardly through the tower at a rate of 5000 c.f.m. or at a velocity of about 400 feet per minute and at a temperature of 71° C.

The fibers formed under these conditions varied from 4 to 10 microns in diameter. The product had the appearance of a very closely matted mass of fine fibers loosely bonded together at their points of contact. The reticulate web had much the same feel as a mat of cotton batting but had a very warm feel.

Example 5

A spraying liquid was prepared consisting of a 15% solution of a polyacrylonitrile in dimethylformamide. The solution had a viscosity of 9,300 cps.

The fiber-forming liquid was extruded upwardly through an orifice having a diameter of 0.042 inch at a rate of 8 to 15 cc. per minute or at a velocity of 30 to 55 feet per minute. Air was supplied to the nozzle at the rate of 35 c.f.m. or at a velocity of about 30,000 feet per minute. Air was passed upwardly through the tower at a velocity of 3000 c.f.m. or at a velocity of about 240 feet per minute and at a temperature of about 100° F.

The fibers formed under these conditions had a diameter of between 1 and 2 microns. The product formed was a reticulated web wherein the fibers were bonded together at their points of contact. The web was a very lightweight, fluffy product.

Example 6

Spraying liquids were formed from polystyrenes over a wide viscosity range. Of the various thermoplasts which have been investigated, polystyrene appears to be the least sensitive to spraying conditions and to the viscosity of the spraying liquid. Satisfactory products have been prepared from spraying liquids having a viscosity of 500 cps. and lower, extruded through the orifice at rates as high as about 50 cc. per minute.

A commercial polystyrene preparation known as Whiz Webbing Agent consists of a 28.6% solution of polystyrene in toluene. The solution had a viscosity of 488 cps.

This spraying liquid was extruded upwardly through an orifice having a diameter of 0.042 inch at the rate of 51 cc. per minute or at a velocity of about 190 feet per minute. Air was supplied to the nozzle at a rate of 25 c.f.m. or at a velocity of about 21,000 feet per minute. Air was passed upwardly through the tower at a rate of 3000 c.f.m. or at a velocity of about 240 feet per minute and at a temperature of 29° C.

It will be noted from the foregoing examples that the relative velocities of extrusion and of the gas streams differ depending upon the direction of extrusion or spraying and upon the specific thermoplast and spraying liquid. When spraying upwardly, the velocity of the secondary or tower gas stream is intermediate between the velocity of extrusion and the velocity of the primary or high velocity jet stream of gas. In spraying upwardly, the tower or secondary gas stream not only supports but must also carry the fibers to the collecting conveyor and its velocity must be sufficient to overcome the force of gravity exerted upon the fibers. When spraying downwardly, the force of gravity and the nozzle gas are sufficient to deposit the fibers upon the collecting conveyor at the bottom of the tower. Thus, the velocity of the tower or

secondary gas stream in spraying downwardly only need be sufficient to support or float the fibers or retard the deposition of the fibers until the desired drying and/or setting of the fibers has been effected. In both types of spraying, the secondary gas stream continues the vaporization of solvent and/or cooling so that the fibers are in the desired condition of tackiness or non-tackiness at the time they are deposited.

Although the foregoing examples illustrate the production of fibrous products by the use of a secondary stream of gas to carry or float the fibers before they are deposited, it is not essential to employ such a secondary gas stream. Satisfactory fibers and fibrous webs have been formed without employing a secondary gas stream by extruding or spraying the fiber-forming liquids upwardly and positioning the collecting screen from about 3 feet to about 10 feet from the spraying units. The linear velocities of extrusion and the velocities of the attenuating gas have been of the same order as in the foregoing examples and gas velocities have been used as high as 85,000 feet per minute. For example, fibrous webs have been thus prepared from a Dynel spraying solution as described in Example 4 and from polyacrylonitrile solutions containing 10% of the resin in dimethylformamide. Extrusion orifices having a diameter of 0.010 inch and a primary gas nozzle having an internal diameter of 0.25 inch have been satisfactory. When utilizing multiple spraying units, a spacing of at least about 1.5 inches has been found to be satisfactory. Fibers formed without utilizing a secondary gas stream have been of the size range as those of the previous examples, namely, from less than 1 micron to 10 microns. The size and length of the fibers and the nature of the webs may be varied by altering the extrusion velocity, the velocity of the attenuating gas stream and the spacing between the spraying unit and the collector as described hereinbefore.

Surface-active agents may be incorporated in the spraying liquids so as to improve the fiber-forming characteristics of the liquids. The addition of surface-active agents in amounts of about 0.1% and lower, based upon the weight of the fiber-forming material results in the production of substantially longer fibers or filaments. For example, the addition of 0.1% of a commercial surface-active agent known as Amine 220 to a 21% solution of Dynel in a solvent consisting of equal parts of dimethylformamide and acetone produces what appears to be a continuous filament.

If desired, preformed particulate material such as non-adhesive fibers may be embodied in the reticulated web or mat by introducing the non-adhesive fibers into the tower air stream. For example, staple fibers having a length of from 1/2 inch to 1 1/2 inches, such as rayon staple, cotton staple, or other desired fiber such as kapok, asbestos, or other particulate material such as ground cork or leather dust may be introduced into the air stream in the blower. The individual preformed, particulate materials as they contact the undried, tacky fibers of the thermoplast material adhere to the tacky fibers and the fibers and attached non-adhesive materials are deposited on the collecting means in a random or haphazard distribution. By a control of the spraying conditions, the thermoplast fibers may be in a tacky condition upon deposition and as the tacky fibers contact the fibers and particulate material previously deposited on the collecting means, additional bonding points are produced. The soft, fluffy mat or web may be utilized, for example, as a filter medium or for thermal or sound insulation or vibration dampening material in the form in which the web is collected. The amount of preformed particulate material incorporated in the mat may be varied over a wide range, for example, from about 20% to about 80%, depending upon the characteristics desired and the purposes for which the product is intended, the preformed fibers or discrete particles being added to contribute desired characteristics.

If desired, the web may be subjected to heat and pressure at predetermined localized areas whereby the potentially adhesive thermoplast fibers become activated to bond the treated areas into relatively thin, compact sheet-like areas. That portion of the web or mat intermediate the treated areas remains soft and fluffy. Thin, porous sheet-like structures may be formed by calendaring the soft fluffy webs or mats under conditions whereby the potentially adhesive fibers are activated. Such sheet-like structures are particularly well suited for use as fluid filter media, surgical dressings and the like. Sheet-like structures of greater thickness may be formed by folding the loose, fluffy mat or web upon itself or by stacking a desired number of layers of the mat and activating the potentially adhesive thermoplast fibers.

Example 7

A composite mat was prepared by utilizing a spraying liquid containing Dynel as described in Example 4 and 1/2 inch rayon staple.

The spraying liquid was extruded upwardly through an orifice having a diameter of 0.025 inch at a rate of 15 cc. per minute or at a velocity of about 155 feet per minute. Air was supplied to the nozzle at the rate of 42.5 c.f.m. or at a velocity of about 36,000 feet per minute. Air was passed upwardly through the tower at the rate of 3,400 c.f.m. or at a velocity of about 270 feet per minute and at a temperature of 60° C. The 1/2 inch rayon staple fibers were manually introduced into the blower intake which supplied the tower air stream and at a rate sufficient to form a mat containing approximately equal parts by weight of Dynel and rayon.

The rayon staple fibers had a diameter of about 9.6 microns and the Dynel fibers formed under these operating conditions had a diameter of about 4.8 microns. The sheet-like body had the appearance of a closely matted mass of fine fibers, had a very soft feel and was a very lightweight, somewhat fluffy product.

A thin sheet-like material was formed by activating the thermoplast fibers by the application of heat and pressure. Sheet-like structures were also formed by stacking several layers of the mat and applying heat and pressure. As the number of plies is increased, the stiffness and harshness to touch also increases. Such hot calendared products are well suited for use as filter media.

As an alternative, mixed fiber products may be prepared by simultaneously forming fibers from a plurality of fiber-forming liquids. For example, a plurality of spraying units may be provided and spraying liquids of different fiber-forming materials supplied to different spraying units. Thus, two or more vinyl resins, such as copolymers of vinyl chloride-vinyl acetate and vinyl chloride-acrylonitrile may be simultaneously extruded. The extrusion orifices and conditions may be maintained so as to produce fibers of the same diameter, or the orifices for one material may be selected so as to provide fibers of different diameters. The relative proportions of the two materials may be varied by the number of spraying units supplied with the specific spraying liquids. If desired, modified fibers may be produced by employing spraying liquids formed of a mixture of two or more compatible fiber-forming materials.

This application is a continuation-in-part of my co-pending application Serial No. 400,239, filed December 24, 1953, entitled Reticulated Webs and Method for Their Production, now abandoned.

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. The method of producing a shot-free, reticulated, fibrous body which comprises providing a fiber-forming liquid containing a potentially adhesive, fiber-forming

thermoplast; creating a high velocity, unidirectional, free-flowing, unconfined and unrestricted jet stream of gas by discharging a high velocity stream of gas into the atmosphere within a chamber, the diameter of the jet stream of gas at the point of discharge being insignificant with respect to the dimensions of the chamber into which the gas is discharged; extruding the fiber-forming liquid into and within the jet stream of gas at a point beyond the point in the jet stream at which the liquid is disrupted, the direction of extrusion being coincident with the direction of the gas flow; attenuating the extruded fiber-forming liquid, then breaking the attenuated fiber-forming liquid into discontinuous lengths and at least partially setting the fiber-forming liquid to form discontinuous fibers by maintaining the velocity of the jet stream of gas at the point of discharge at a value greater than the velocity of extrusion of the fiber-forming liquid; and collecting the discontinuous fibers in random distribution to form a shot-free, reticulated, sheet-like fibrous body.

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

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

4. The method of producing a shot-free, reticulated, fibrous body which comprises providing a fiber-forming liquid containing a potentially adhesive, fiber-forming thermoplast; creating a high velocity, unidirectional, free-flowing, unconfined and unrestricted jet stream of gas by discharging a high velocity stream of gas into the atmosphere within a chamber, the diameter of the jet stream of gas at the point of discharge being insignificant with respect to the dimensions of the chamber into which the gas is discharged; extruding the fiber-forming liquid into and within the jet stream of gas at a point beyond the point in the jet stream at which the liquid is disrupted, the direction of extrusion being coincident with the direction of the gas flow; attenuating the extruded fiber-forming liquid, then breaking the attenuated fiber-forming liquid into discontinuous lengths and at least partially setting the fiber-forming liquid to form discontinuous fibers by maintaining the velocity of the jet stream of gas at the point of discharge at a value greater than the velocity of extrusion of the fiber-forming liquid; and suspending the attenuated fibers, completing the setting thereof and collecting the discontinuous fibers in random distribution to form a shot-free, reticulated, sheet-like, fibrous body by passing the atmosphere within the chamber upwardly at a velocity lower than the velocity of the jet stream of gas.

5. The method as defined in claim 4, wherein the fiber-forming liquid comprises a solution of a thermoplast.

6. The method as defined in claim 4, wherein the fiber-forming liquid comprises a solution of a vinyl resin.

7. The method of producing a shot-free reticulated, fibrous body which comprises providing a fiber-forming liquid containing a potentially adhesive, fiber-forming thermoplast; creating an upwardly moving high velocity, unidirectional, free-flowing, unconfined, unrestricted, jet stream of gas by discharging a high velocity stream of gas upwardly into the atmosphere within a chamber, the diameter of the jet stream of gas at the point of discharge being insignificant with respect to the dimensions of the chamber into which the gas is discharged; extruding the fiber-forming liquid into and within the jet stream of gas at a point beyond the point in the jet stream at which the liquid is disrupted, the direction of extrusion being coincident with the direction of the gas flow; attenuating the extruded fiber-forming liquid, then breaking the attenuated fiber-forming liquid into discontinuous lengths and at least partially setting the fiber-forming liquid to form discontinuous fibers by maintaining the velocity of the jet stream of gas at the point of discharge at a value greater than the velocity of extrusion of the fiber-forming liquid; and suspending the attenuated fibers, completing the setting thereof and collecting the

discontinuous fibers in random distribution to form a shot-free, reticulated, sheet-like, fibrous body by passing the atmosphere within the chamber upwardly at a velocity greater than the velocity of extrusion of the fiber-forming liquid but lower than the velocity of the jet stream of gas.

8. The method of producing a shot-free, reticulated, fibrous body which comprises forming a fiber-forming liquid containing a potentially adhesive, fiber-forming thermoplast; creating an upwardly moving high velocity, unidirectional, free-flowing, unconfined, unrestricted, jet stream of gas by discharging a high velocity stream of gas upwardly into the atmosphere within a chamber, the diameter of the jet stream of gas at the point of discharge being insignificant with respect to the dimensions of the chamber into which the gas is discharged; extruding the fiber-forming liquid into and within the jet stream of gas at a point beyond the point in the jet stream at which the liquid is disrupted, the direction of extrusion being coincident with the direction of the gas flow; attenuating the extruded fiber-forming liquid, then breaking the attenuated fiber-forming liquid into discontinuous lengths and at least partially setting the fiber-forming liquid to form discontinuous fibers by maintaining the velocity of the jet stream of gas at the point of discharge at a value greater than the velocity of extrusion of the fiber-forming liquid; passing the atmosphere within the chamber upwardly; introducing preformed, non-adhesive particulate material into the atmosphere; and suspending the attenuated fibers, completing the setting thereof and collect-

ing the discontinuous fibers and the performed, non-adhesive particulate material in random distribution to form a shot-free, reticulated, sheet-like, fibrous body by maintaining the moving atmosphere within the chamber at a velocity greater than the velocity of extrusion of the fiber-forming liquid but lower than the velocity of the jet stream of gas.

9. The method as defined in claim 8, wherein the fiber-forming liquid comprises a solution of a thermoplast.

10. The method as defined in claim 8 wherein the fiber-forming liquid comprises a solution of a vinyl resin and the particulate material consists of preformed fibers.

11. A method as defined in claim 1 wherein the diameter of the jet stream of gas at its point of discharge is from about 0.25 inch to 0.75 inch, the velocity of the jet stream of gas at its point of discharge is at least about 2,500 feet per minute, the diameter of the fiber-forming liquid at its point of extrusion is from about 0.01 inch to 0.05 inch and the point of extrusion of the fiber-forming liquid is about 0.25 inch to 1 inch beyond the point of discharge of the jet stream of gas.

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