

March 15, 1949.

C. S. FRANCIS, JR
TEXTILE FIBROUS PRODUCT

2,464,301

Filed Dec. 18, 1943

2 Sheets-Sheet 1

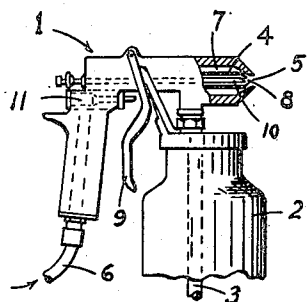


Fig. 1

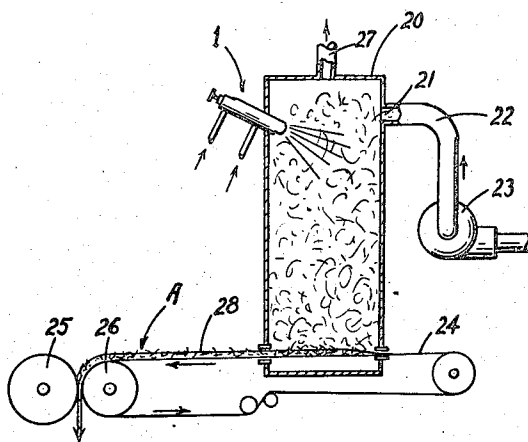


Fig. 2

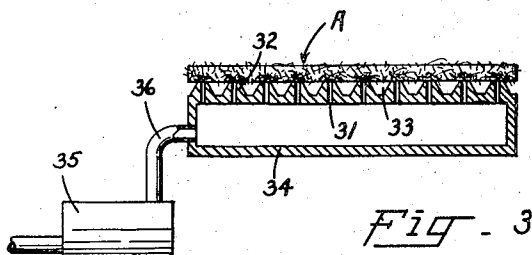


Fig. 3

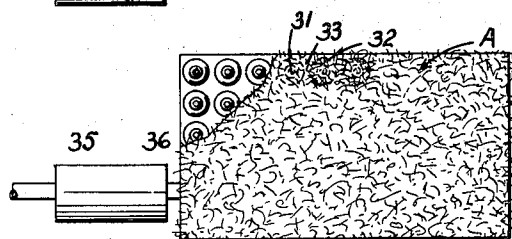


Fig. 4

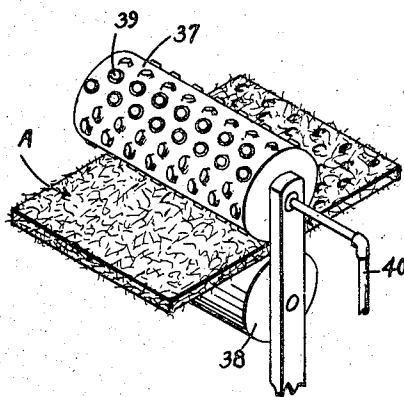


Fig. 5

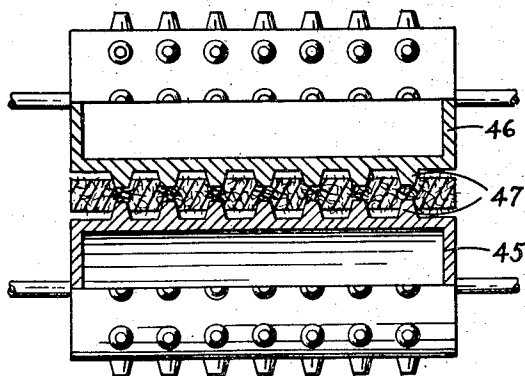


Fig. 6

INVENTOR.
CARLETON S. FRANCIS JR.
BY *Carl A. Castellon*
ATTORNEY

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C. S. FRANCIS, JR

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2 Sheets-Sheet 2

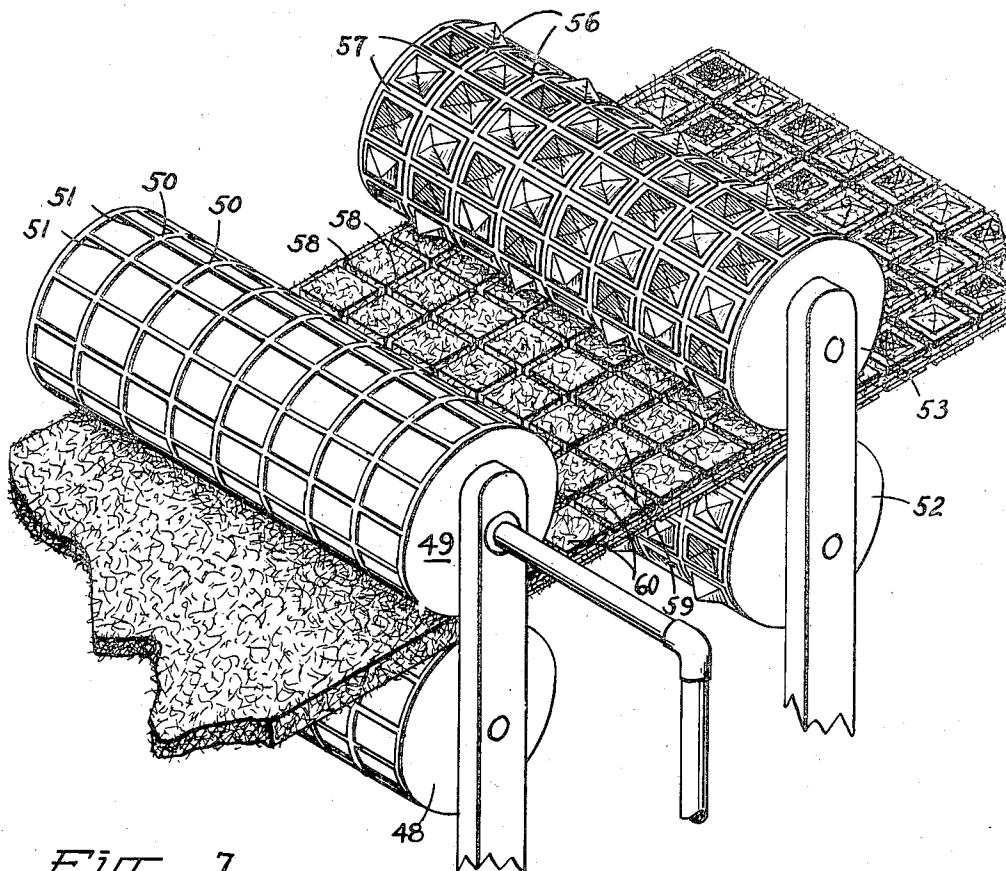


Fig. 7

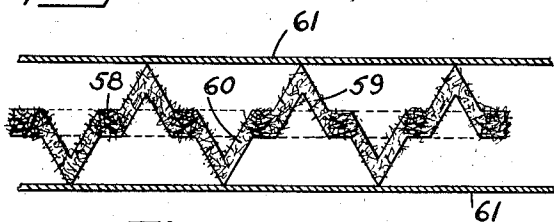


Fig. 8

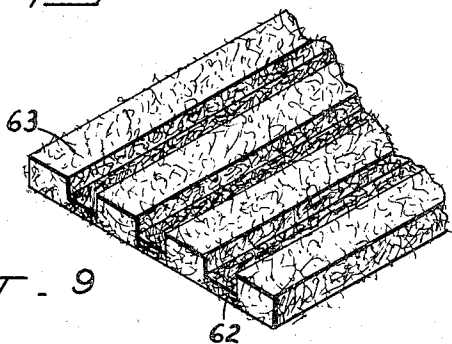


Fig. 9

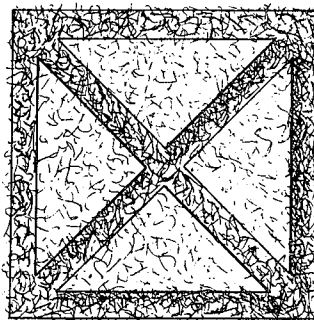


Fig. 10

INVENTOR.

CARLETON S. FRANCIS JR.

BY *Carl A. Castellon*

ATTORNEY

UNITED STATES PATENT OFFICE

2,464,301

TEXTILE FIBROUS PRODUCT

Carleton S. Francis, Jr., West Harwich, Mass.,
 assignor to American Viscose Corporation,
 Wilmington, Del., a corporation of Delaware

Application December 18, 1943, Serial No. 514,750

4 Claims. (Cl. 154—46)

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This invention relates in general to fibrous products and to processes of producing fibrous products, particularly of the class of textiles, felts and papers, and to correlated improvements therein designed to enhance the structure, properties and uses of the fibrous products. This application is a continuation-in-part of my pending applications Serial Nos. 381,292, March 1, 1941, and 405,102, August 1, 1941, which latter application is in turn a continuation-in-part of my co-pending applications Serial Nos. 300,876, October 23, 1939, now Patent No. 2,459,803, and 381,292, March 1, 1941, now Patent No. 2,357,392.

In my prior applications there are disclosed various fibrous products, such as felts, papers, and pile fabrics formed from a mixture of at least two types of fibers, one of the fibers being potentially adhesive, and processes of forming such products by rendering the potentially adhesive fibers in the mixture tacky at some stage of the process, to bind fibers in the product.

It is a general object of the present invention to provide fibrous products consisting entirely of potentially adhesive fibers or comprising such fibers in admixture with other fibers in which novel and improved structural characteristics are obtained and if desired, such characteristics may be accompanied by decorative effects. Further objects and advantages will be apparent from the description hereinafter.

In accordance with this invention, fibrous products comprising potentially adhesive fibers are fabricated in the same general manner as in my prior applications, with the exception that the activation or the step of rendering the potentially adhesive fibers tacky is effected at preselected points or areas of the products or differentially therein. Thus, in one embodiment of my invention, a pile fabric is formed by depositing a flock comprising a mixture of potentially adhesive fibers with others of different nature upon a base fabric carrying an adhesive coating. Subsequent to the setting of such adhesive, the pile fabric thus formed may be subjected to an activating agent and pressure to impart novel decorative effects resulting from the adhesion of fibers in the pile.

In another embodiment of the invention a mass of fibers comprising the potentially adhesive fibers may be formed by carding or by deposition from a fluid suspension thereof onto a moving band, or by any other system into felt-like or paper-like structures, and thereafter such structures may be activated in selected portions thereof to render the potentially adhesive fibers tacky

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or adhesive in those areas. Such activation may be accompanied by pressure, preferably applied at the portions in which activation is effected. Besides the possibility of obtaining decorative effects when pressure is utilized, the utilization of selective activation, with or without pressure is accompanied by valuable advantages in respect to the structure of the products.

For example, when it is desired to use such felt-like products for filtration purposes, the selective activation to "spot-weld" the structure, as it were, or to activate a grid of two sets of parallel lines intersecting at any desired angle to increase its structural stability can be applied without appreciable loss in porosity. It is not possible to obtain an equivalent porosity when the felt-like mass is activated uniformly throughout its area to obtain a given structural stability as determined by rigidity and freedom from crushing at the edges when allowed to stand upright.

In the following specification and in the claims, the term "fiber" or "fibers" when used in reference to the potentially adhesive material is intended to include any fibril, fiber, filament or filamentary structure, regardless of length or diameter, and whether independent of one another or adhered together at spaced points to form a web of reticulated structure. The expression "matted fibrous structure" includes webs, mats, bats, pile fabrics, and other interfelted products. The term "adhesive" includes sticky, cementitious, agglutinous, or tacky conditions. The term "non-adhesive fibers" includes those fibers which, although they may be rendered adhesive by some treatment, are not rendered adhesive under the conditions used to activate the potentially adhesive fibers associated therewith.

In the drawing illustrative of the invention—
 Figure 1 is a side elevation, partly in section of one embodiment of suitable means for forming the potentially adhesive fibers used in the invention;

Figure 2 is a side elevation, partly in section, of one embodiment of means for carrying out the invention in the fabrication of felts and papers;

Figure 3 is a side elevation, partly in section, of another embodiment for carrying out the invention;

Figure 4 is a plan view of the modification of Figure 3;

Figure 5 is a perspective view of another embodiment for carrying out the invention;

Figure 6 is an elevation, partly in section, show-

ing another embodiment for carrying out the invention;

Figure 7 is a perspective of still another embodiment for carrying out the invention;

Figure 8 is a cross-section of a product constituting one form of the invention;

Figure 9 is a perspective of another such product; and

Figure 10 is a face view of still another such product.

The potentially adhesive fibers may be a cellulose derivative, a resin or rubber. Among the cellulose derivatives which are suitable are, for example, cellulose esters, cellulose ethers, mixed cellulose ester-ethers, mixed cellulose esters, mixed cellulose ethers, and mixtures of cellulose derivatives. Among the resins which may be employed for forming the potentially adhesive fibers are, for example, cheap natural resins, such as shellac, damar, copal, and the like, and synthetic resins formed by the polymerization of various organic compounds, such as coumarone, indene hydrocarbons, vinyl esters and ethers, styrene, sterols, phenol-aldehyde resins, either unmodified or modified with oils, urea-aldehyde resins, sulfonamide-aldehyde resins, polyhydric alcohol-polybasic acid resins, drying oil-modified alkyd resins, resins formed from acrylic acid, its homologues and their derivatives, sulfur-olefine resins, resins formed from dicarboxylic acids and diamines (nylon type); synthetic rubbers and rubber substitutes, herein called "resins," such for example as polymerized butadiene, olefine polysulfides, isobutylene polymers, chloroprene polymers; and fibers formed from a resin comprising the product of copolymerizing two or more resins, such as copolymers of vinyl halide and vinyl acetate, copolymers of vinyl halide and an acrylic acid derivative; and also a mixture of resins, such as a mixture of vinyl resins and acrylic acid resins or methacrylic acid resins, a mixture of polyolefine resins and phenol-aldehyde resins, or a mixture of two or more resins from the different classes just named. There may be employed also fibers made from rubber latex, crepe rubber, gutta percha, balata, and the like.

Further, the potentially adhesive fibers may be mixtures of the cellulose derivatives with resins or rubber, such for example, as a mixture of cellulose nitrate and an acrylic acid resin, or a mixture of benzyl cellulose and a vinyl resin, or a mixture of ethyl cellulose and shellac.

The resins above mentioned may be classified as:

(a) Heat-non-convertible resins such as glycol polybasic acid resins, vinyl resins and the acid type phenol-aldehyde resins, and the like.

(b) Heat-convertible (or thermosetting) resins, such as a glycerol-polybasic acid resin, polyolefine resins, phenol aldehyde resins and the like.

(c) An element-convertible resin (which becomes infusible through the action of certain elements, such as oxygen and sulfur) such as glycerol-polybasic acid-drying oil, resins and olefine sulfur resins.

Among the non-adhesive fibers which may be employed are natural fibers, such as wood pulp fibers, cotton, flax, jute, kapok, wool, hair and silk; and synthetic fibers, such as cellulosic fibers, such as cellulose hydrate, or cellulose derivatives, as cellulose esters, mixed cellulose esters, cellulose ethers, mixed cellulose ester-ethers, mixed cellulose ethers, cellulose hydroxy-alkyl ethers, cellulose carboxyl alkyl ethers, cellulose

ether-xanthates, cellulose xantho-fatty acids, cellulose thiourethanes, natural and synthetic rubber and derivatives thereof; fibers made of alginic acid, gelatine, casein; and 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 resin fibers are rendered tacky; also fibers and filaments made by slitting, cutting or shredding non-fibrous films, such as waste cellophane.

The potentially adhesive fibers may be pre-formed, for example, by extrusion, or they may be made by dispersing into a fluid, a potentially adhesive fiber-forming material, as described in my Patent No. 2,357,392. By the latter procedure, such materials as are not adapted to the forming of fibers by extrusion may be utilized, since such factors as filtering characteristics, solution viscosity and fiber tenacity are not critical in that process. In order to disperse the fiber-forming material into the fluid in accordance with my copending application, the material is rendered flowable, i. e., plastic or molten or dissolved in a volatile solvent. To the fiber-forming material or solution thereof, there may be added suitable plasticizers, hardening agents for the resins, latent activating agents, dyes, pigments, moth-proofing agents, fire-proofing agents, water-proofing agents, and the like.

The fiber-forming material or solution thereof may be handled in a conventional type of spray gun, shown in Figure 1 and hereafter designated generally by the reference character 1, and comprising essentially a container 2 adapted to hold the fiber-forming composition from which it is forced by air pressure through the supply line 3 to the chamber 4 from which the composition is discharged through the orifice 5. The air is supplied through the line 6 to the air chamber 7 which surrounds the chamber 4 and terminates in a plurality of orifices 8 positioned adjacent the orifice 5. The trigger or handle 9 is adapted to operate the pin valve 10 which opens the orifice 5 and the air valve 11 which opens the air line 6. As the stream of fiber-forming composition is discharged from the orifice 5, it is disrupted into fibers by the force of the tangential streams of air discharged through the orifices 8.

The above-described fiber-forming processes may be employed for producing the non-adhesive textile or felt fibers as well as the potentially adhesive fibers.

In Figure 2 there is shown one embodiment of suitable apparatus for forming felt-like mats of the invention. A composition suitable for forming potentially adhesive fibers is dispersed by means of the spray gun 1 into a heated gaseous atmosphere contained in the chamber 20, into which may be simultaneously blown non-adhesive fibers 21 through conduit 22 by means of a blower 23. The fibers fall downwardly in the chamber and come to rest on the surface of an endless belt 24 made of porous or perforated flexible material such as textile, metal, leather or the like, which is positioned in a horizontal plane at the base of the chamber 20. The mat of fibers 28 is carried on the belt from the chamber and through pinch rolls 25 and 26 which compress the mat and enable it to be removed from the belt for activating or finishing operations to be hereinafter described. The solvent evaporated from the fiber-forming composition may be withdrawn from the chamber 20 through exhaust pipe 27 and wasted or recovered in a known manner. A suction pump

(not shown) is connected to the apparatus below chamber 20 to create a downward draft through endless belt 24 as it passes under chamber 20. In the manufacture of paper tissues, the belt 24 may be considered as comprising the wire screen of the paper-making machine and the fibers may be deposited from an aqueous suspension. Thus, the fiber-forming and felting steps in making the felts and papers are carried out concurrently and continuously, that is, in immediate sequence in a simple and economical manner. In making an interfelted web containing only potentially adhesive fibers in an apparatus such as shown in Figure 2, the conduit 22 and the blower 23 are omitted. If a felt of greater thickness than can be obtained with a single deposition of fibers is desired, the bat may be built up to the desired thickness by repeated passages thereof under chamber 20.

When preformed potentially adhesive fibers are employed in the production of the fibrous product, the fibers (cut into suitable length for carding), may be handled in the conventional manner and with the well-known equipment employed in the production of felt, wherein the fibers are fed into a card and deposited in the form of a web on an endless belt. As is customary, fibers are fed from the card onto the belt in layers until the desired thickness has been obtained. The bat so formed may be compacted by pressure rolls in order to make the bat self-supporting and susceptible to handling. In one embodiment, a minor proportion of non-thermoplastic fibers is blended with the thermoplastic fibers during the carding operation. If, however, it is desirable to utilize non-thermoplastic fibers in conjunction with fibers obtained by dispersion with a fluid of a potentially adhesive fiber-forming material, this may be accomplished by forming a carded web of the non-thermoplastic fibers, and during the formation of the bat, the potentially adhesive fibers may be formed as previously described and commingled with the other fibers as the layers of the web are built up on the endless belt.

In order to facilitate handling of the bat of fibers without damaging it, the potentially adhesive fibers are rendered adhesive in selected areas by heat or solvent to cause at least a partial adhesion between the fibers. Among the methods which may be used for activation are the following, taken singly or together in appropriate combinations.

1. When the potentially adhesive fibers are thermoplastic, they may be activated by heat applied locally, with or without pressure, as by use of hot water, steam or a blast of dry hot gas, or heated surfaces.

2. They may be activated by applying locally to the fibrous mixture a solvent or swelling agent, or mixtures thereof with diluents, under such conditions of concentration and temperature as to render the potentially adhesive fibers tacky. For example, fibers of organic cellulose derivatives, such as cellulose esters, may be rendered adhesive by solvents, such as acetone, ethyl acetate, butyl acetate, and the like.

3. A latent activating agent may be combined with the potentially adhesive fibers and/or with the non-adhesive fibers. Such agent may be rendered active by a subsequent treatment applied locally, such as chemical agents, heat or irradiation, thus producing a simultaneous activation of the potentially adhesive fibers in selected areas. For example, fibers may be impregnated with a liquid which, at room temperature, is a non-sol-

vent therefor but which, at a higher or lower temperature is a solvent sufficiently active to render the potentially adhesive fibers adhesive.

A plasticizer may be applied to the fibers and/or to the product before activation. The plasticizer may function to increase the flexibility of the fibers and, when employed with thermoplastic fibers, the plasticizer may serve, in addition, to lower the thermal softening point. The plasticized thermoplastic fibers can be rendered adhesive by heating to a temperature below that at which the non-thermoplastic textile fibers associated therewith would be detrimentally affected by such heating. The plasticizer may be allowed to remain in the product, or it may be removed by suitable means, such as washing and extraction, thus again elevating the thermal softening point of the thermoplastic material and preventing reactivation upon ironing.

While the fibers are in an adhesive condition, the fibers are preferably subjected locally to a compacting treatment to promote adhesion of the associated fibers at their points of contact and the term "compacting" includes pressing, squeezing and tension. For example, mechanically applied pressure may be exerted on the activated material during and/or after activation, and/or during calendering, embossing, printing, drying and other operations involving the use of rollers.

After activation, the fibrous material is treated to deactivate the adhesive, that is, to render the adhesive non-tacky so as to fix the new relationship of the fibers. The nature and extent of the deactivation treatment will depend, inter alia, upon the nature and extent of the activating treatment and upon the proportion and kind of potentially adhesive fibers used. If activation has been accomplished by heat, deactivation may be accomplished by cooling or, in the case of thermosetting resin fibers, by heating to a higher temperature; if activation is by means of a solvent, deactivation may involve extraction of the solvent by washing, evaporation, decomposition. The removal of the activating agent depends upon whether its presence in the product is desirable or objectionable.

The activating, compacting and deactivating treatments herein described may be carried out independently of, or simultaneously with, various treatments common to the fabrication and finishing of textiles and felts or the laminating and sealing of sheet materials.

The properties of the finished product depend upon various factors, such as the nature and proportion of potentially adhesive fibers; the area of activation; the extent of the activation thereof; the adhesive condition of the fibers during compacting; and the nature of the deactivation. The extent of activation, compacting and deactivation may be varied considerably, depending upon the relative proportions of the types of fibers, the properties of the potentially adhesive fibers and the effect desired in the product. The potentially adhesive fibers may be rendered superficially tacky; or made adhesive without losing their fibrous form; or rendered sufficiently fluid to spread under pressure to form a film in which the other fibers are embedded. If the potentially adhesive fibers are rendered only slightly tacky, the frictional resistance between fibers will be increased and the strength improved. If the potentially adhesive fibers are rendered substantially adhesive, they will cohere to each other and adhere to the other fibers to fix the position thereof to give a product having increased tensile

strength, structural stability, and lower stretch and shrinkage. As stated, the amount of potentially adhesive fibers present will depend on the characteristics desired in the product. The product may comprise 100% potentially adhesive fibers or the proportions may range from as low as about 50% up to 95% or more of the total weight of the fabric.

The fibrous product, whether a pile fabric or of felt-like or paper-like nature, may be subjected to activation in numerous ways. For example, in Figures 3 and 4, the product is treated locally with an activating agent in fluid state adapted to render the potentially adhesive fibers tacky or adhesive. As shown, the product A is laid upon the openings 31 in the tops of the hollow conically shaped projections 32 formed on the upper surface 33 of a container 34 supplied by pump 35 connected to it by the conduit 36. The product A may be held in place merely by gravity, but holding means may be provided for this purpose and any desired pressure may be applied, if desired. The pump may be operated by hand or automatically to force a given amount of solvent or stream or dry hot air through the regions of the product above the areas adjacent the openings 31. Thus, a gear pump of known capacity can be given a definite number of rotations to accomplish this result. If steam is employed, it may be supplied under pressure and thus forced through product A. After removal, deactivation occurs by evaporation of solvent, cooling, etc.

Another arrangement for selective activation of thermoplastic fibers is shown in Figure 5. As shown, the product A is passed through a pair of rolls 37 and 38. Roll 38 has a smooth surface but roll 37 is provided with evenly spaced projections 39 of round cross-section and is heated by steam introduced by an axial pipe 40 of conventional construction. The projections preferably are of sufficient height that the peripheral surface proper of roll 37 does not contact the product A when the projections 39 are pressed into the mass of the product to the extent desired. The rolls may be adjusted so that the projections just make contact with the surface of the fibrous product A or so that they make any predetermined pressure upon and penetration into such product.

When a fibrous product of felt-like character is produced in accordance with the system illustrated in Figure 2, one of the rolls 25 and 26 may be provided with a suitable pattern in relief and may be heated internally to effect activation of the fibrous web in the regions adjacent the areas corresponding to the elevated lands of the roll in a manner similar to that performed in Figure 5.

Figure 6 shows a modification in which the fibrous product, especially one having a felt-like structure is pressed between a pair of rolls 45 and 46 each having a truncated pyramidal projections 47 having a square base and arranged with their centers disposed on a system of squares. The heights of the projections are such that the surfaces of the fibrous web do not come into contact with the peripheral surfaces proper of the rolls. Both rolls may be, and preferably are, heated in this embodiment, so that activation of the thermoplastic fibers is effected in the regions pressed between the pyramidal projections.

Figure 7 illustrates another embodiment which is particularly useful for the production of heat and sound insulating structures. As shown, the fibrous web passes first between a pair of rolls 48

and 49. Rolls 48 and 49 each have a projecting network comprising two sets of parallel ridges 50 and 51 intersecting at right angles. However they may be arranged to intersect at any desired angle to provide diamond-shaped instead of square or oblong interstices. Roll 49 is also provided with heating means so that activation of the thermoplastic fibers in the web is effected by such ridges thereby providing the web with a supporting skeletal structure for imparting any predetermined stiffness and rigidity to the web. From rolls 48 and 49, the web passes into the nip between rolls 52 and 53. These rolls are provided with complementary surfaces each comprising pyramidal points 54 in relief on a square base alternating with similar pyramidal depressions 55 in intaglio and a network of rectangularly intersecting lines 56 and 57 disposed between the pyramids in an intermediate plane. The rolls are so disposed that the network of lines 56 and 57 register substantially with the activated areas 58 of the web produced by passage through rolls 48 and 49 and so that the points in relief on roll 52 deform the adjacent unactivated areas 59 into the intaglio portions of roll 53 while the relief points in roll 53 deform alternate unactivated areas 60 into the intaglio areas of roll 52. The resulting product may be sandwiched between covering sheets 61 of paper, felt or impermeable material, such as cellulose acetate, Vinylite, and the like to produce a sturdy self-supporting structure having numerous voids, such as is shown in Figure 8. This deformed structure is also useful for liquid and gaseous filters for obtaining a more highly extended filtration area within a given amount of space.

Activating rolls may have various forms and arrangements of projections and certain forms may be especially suitable for particular purposes. For example, the roll 37 in Figure 5 may be replaced with one having a set of parallel peripheral rings to produce a ribbed battery separator the structure of which is represented diagrammatically in Figure 9 in which the activated regions comprise narrow strips 62 between the highly porous inactivated regions 63. In making a battery separator, the fibers employed will of course be of the types that are inert to the acid of the battery; for example the non-adhesive fibers are advantageously mineral fibers, such as spun glass fibers.

Again, the roll 37 of Figure 5 may be replaced by a roll which is embossed with a design to be impressed upon a pile fabric or a felt like structure not merely to increase the rigidity of the structure but also to impart a decorative effect. Figure 10 illustrates such an embodiment in plan view wherein a design in the form of an activated cross is arranged within an activated border around all four edges of the piece of material.

It is to be understood that the areas which are not subjected to pressure may be activated without pressure as by use of a solvent, steam or dry hot gases, so that such regions have internal strength but a higher porosity than the compacted areas.

While the drawing illustrates embodiments in which activation is effected in regions bounded by spaced circular or square areas or a network of rectangularly intersecting lines, activation may be performed in regions bounded by areas in the lateral faces of the product of any desired shape and size. Such regions may be spaced and entirely separate or they may consist of an

intricate pattern or network. In either case, they may be simply decorative or functional in purpose or they may serve both purposes. Again, they may be irregular or regular in size, shape, and arrangement.

The improvement in strength and structural stability imparted by selective activation in accordance with the present invention depends upon the extent of activation, the proportion of potentially adhesive fibers in the mass and the activation pattern. A preferred embodiment insofar as the tensile strength obtainable is concerned involves the activation along a set of parallel lines which are spaced apart a distance less than the average fiber length in the mass. Improvement in the tensile strength in two dimensions can be accomplished by activation along two sets of parallel lines intersecting at right angles and spaced in the manner just described. Instead of activating along lines, an improvement in strength can be obtained by activating at spots or distinct areas which are arranged in parallel rows and are spaced apart by a distance less than the average fiber length. When such spots are arranged at the corners of a network of squares, the diagonal distance is also preferably made less than the average fiber length.

In making laminated structures comprising as one layer a fibrous web containing potentially adhesive fibers activated locally, advantage may be taken of the adhesive potentialities of such web in forming a bond at any selected portions of the area of contact or over the entire area of contact between such web and the layers adjacent thereto. The bonds between laminations may be formed simultaneously with the selective activation of the fibrous web or they may be formed subsequently thereto.

In the description hereinabove, activation of potentially adhesive fibers in a fibrous web containing them is effected at selected areas only and substantially not at all in the other areas. However, for certain purposes it is advantageous to effect different degrees of activation in the different areas. Thus while a high degree of activation and/or compaction is effected in selected areas of the web, none or a lesser but appreciable degree of activation and/or compaction is effected in some or all of the remaining areas. The difference in activation may result from the application of different heating effects, different amounts or concentrations of solvents, different pressure, or two or more of these factors combined. For example, the projections of Figure 6 may be made of such height that the peripheral surfaces proper of the heated rolls 45 and 46 exert some pressure upon the surfaces of the web when the projections reach their position of maximum penetration into the web. In this manner, the highly activated areas produced by the projections are surrounded by the highly porous remaining areas in which a minor but appreciable degree of activation has been produced by the contact with the peripheral surfaces proper of the heated rolls.

The fibrous products of this invention may be colored before, during, or after activation, compaction and/or deactivation, for example, by dyeing, or printing, with inks containing pigments of dyestuffs which are resistant to such treatments. If desired, the activating agent may be added to the printing ink. For example, in the embodiment of Figures 3 and 4, a printing ink comprising a solvent capable of rendering the

potentially adhesive fibers tacky or adhesive may be applied.

The felt-like or paper-like fibrous webs of the present invention may be used for many purposes in both the textile and miscellaneous industrial arts. In the latter, particularly, they may be used as battery separators, heat insulation, sound insulation, vibration damping material, gaskets, packings, wicks for coating, lubricating, and like purposes, and filter materials for gaseous as well as liquid suspensions.

Since certain changes in carrying out the above process, and certain modifications in the article which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim each and every novel and inventive feature shown and described herein including particularly:

1. As an article of manufacture, a fibrous product comprising potentially adhesive fibers substantially uniformly distributed therethrough, said product being bonded by fiber-to-fiber adhesion in a group of predetermined areas to thereby reinforce the product as a whole and a second group of areas in the product being bonded to a lesser extent to provide greater porosity than that of the first-mentioned areas, the density and porosity in the second group of areas being substantially uniform throughout the entire thickness of the product at such areas.

2. As an article of manufacture, a fibrous product comprising potentially adhesive fibers substantially uniformly distributed therethrough, said product being bonded by fiber-to-fiber adhesion in a group of predetermined areas to thereby reinforce the product as a whole and a second group of areas in the product being bonded to a lesser extent to provide greater porosity than that of the first-mentioned areas, said product having a different density in the first-mentioned areas than in the second group of areas, the density and porosity in the second group of areas being substantially uniform throughout the entire thickness of the product at such areas.

3. As an article of manufacture, a fibrous product comprising potentially adhesive fibers substantially uniformly distributed therethrough, said product being bonded by fiber-to-fiber adhesion in a group of predetermined areas to thereby reinforce the product as a whole and a second group of areas in the product being bonded to a lesser extent to provide greater porosity than that of the first-mentioned areas, the density of the product in the first-mentioned areas being greater than in the second group of areas, the density and porosity in the second group of areas being substantially uniform throughout the entire thickness of the product at such areas.

4. As an article of manufacture, a fibrous product comprising potentially adhesive fibers substantially uniformly distributed therethrough, said product being bonded by fiber-to-fiber adhesion in a group of predetermined areas to thereby reinforce the product as a whole and the fibers in a second group of areas in the product being substantially free of bonds to provide greater porosity than that of the first-mentioned areas, the density and porosity in the second group of

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areas being substantially uniform throughout the entire thickness of the product at such areas.

CARLETON S. FRANCIS, JR.

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