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H. L. HOOVER
UNWOVEN FILAMENTARY WEB AND
METHOD OF PRODUCING SAME
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Fig. 1

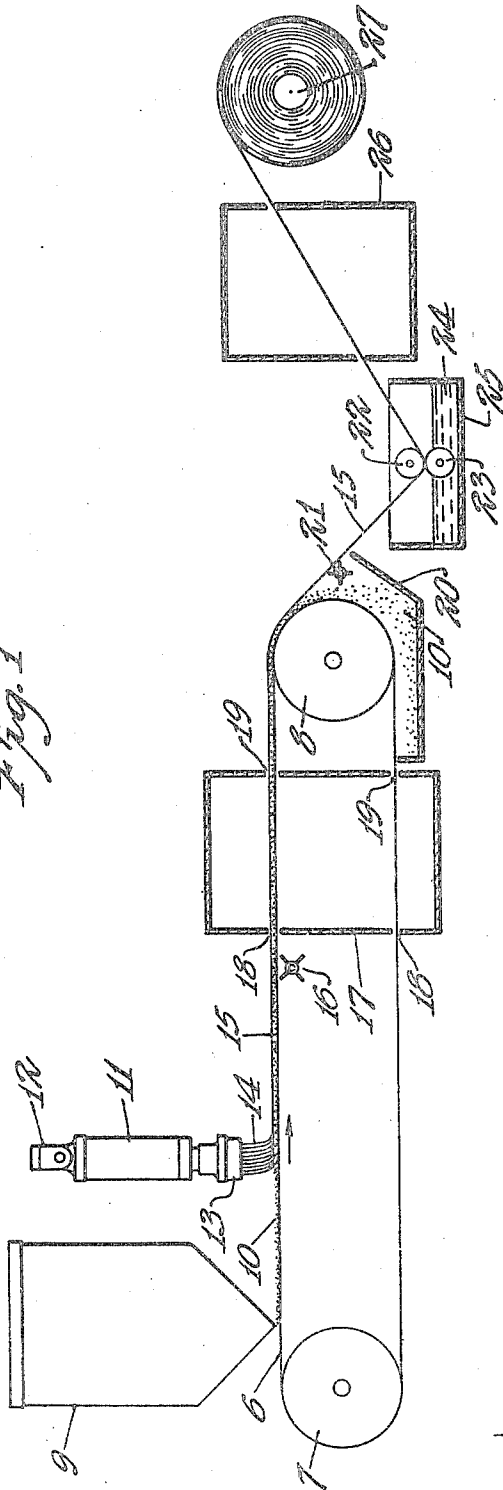


Fig. 4

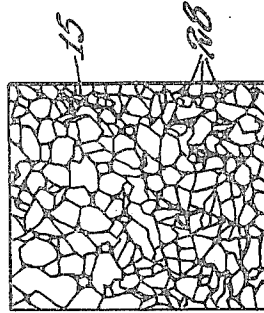


Fig. 3

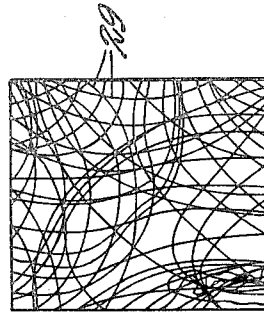
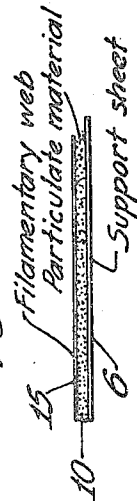


Fig. 2



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UNWOVEN FILAMENTARY WEB AND
METHOD OF PRODUCING SAME

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10 Claims. (Cl. 154—101)

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This invention relates to the production of un-
woven fabrics formed of overlaid and self-bonded
artificial filaments of cellulose esters, ethers, or
derivatives, such as cellulose acetate, and of other
synthetic plastic substances. Such fabrics may
be formed by forcing a solution of a cellulose de-
rivative, such as cellulose acetate, through one
or more spinnerets which contain a large num-
ber of minute orifices, and permitting the thus
formed filaments to drop vertically to the surface
of a support member such as a moving strip sheet.
The spinneret or plurality of spinnerets, are
moved in an overlapping rotary or oval pattern,
or in an overlapping eccentric pattern to cause
an irregular, overlapping deposition of unbroken
filaments which are bonded, upon evaporation of
the solvent, at the points of intersection to pro-
duce the desired fabric. The web is dried to
eliminate the solvent and is then removed from
the support or strip sheet. A fabric is thus pro-
duced without carding, calendering or weaving
and without fibre formation in the ordinary prac-
tices of fibre spinning.

The present invention is particularly concerned
with the production of tulles or other lace-like
fabrics which have considerable utility as decora-
tive materials in the millinery and lamp shade,
etc. fields. In depositing the filaments directly
upon a strip sheet, such as cellophane, the sol-
vent-laden filaments tend to film or flatten out,
are shiny on the side contacting the strip sheet,
and the web of overlapping and self-bonded fila-
ments does not have the desired lace-like charac-
teristics. The formation of a web of curly fila-
ments is inhibited since on deposition the individ-
ual filaments adhere lightly to the strip sheet and
their normal contraction between the points of
intersection of the filaments, as the solvent evap-
orates, is prevented by reason of their adherence
to the surface of the strip sheet.

It has been found that by dusting particulate
material upon the strip sheet prior to the deposi-
tion of the filaments that the tendency of the
filaments to "film" is substantially eliminated and
that a web of unusual delicacy and appearance
is formed. Various particulate substances, or
short lengths of fibrous materials, may be placed
upon the strip sheet in advance of the spinneret
with the result that some of the particles or flock
are bonded to the filaments while the filaments

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are still adhesive. Unique coloring effects can
thus be imparted to the lace-like material. Fur-
thermore, by depositing the freshly spun fila-
ments upon a powdered surface it has been found
that the dried web may be more readily removed
from the strip sheet than if the comminuted or
pulverized material is not employed.

It appears that the particulate material acts to
reduce friction between the filaments and the
strip sheet, permitting the filaments to move
slightly after deposition on the dusted strip sheet
or support and during evaporation of the solvent.
Some of the filaments are thus bonded to the
movable particles rather than to the support.
Thus normal surface tension controls the ulti-
mate disposition of the overlaid filaments and
permits the formation of a delicate lace-like web,
by the contraction of the portions of the fila-
ments between the points of intersection. The
desired lace-like web structure is not obtained
by deposition of filaments on an undusted strip
sheet or support, to which the filaments become
sufficiently bonded upon deposition to prohibit
drawing or sliding of the filaments on the strip
sheet during evaporation of the solvent. It is be-
lieved that the bonding of the particles to the ad-
hesive filaments and of the filaments at their
intersecting points provides a basis for the con-
tractile surface force of the solids component of
the filaments to produce the desired lacy effect.

As previously mentioned various cellulose de-
rivatives, such as cellulose acetate and ethyl cel-
lulose provide a satisfactory viscous spinning so-
lution for the present purposes. Other sub-
stances such as polymeric amide, protein-base
material, as soy bean and casein, polyacrylates,
rubber and modified rubber and vinyl polymers
and copolymers may be employed, modified or
unmodified by plasticizers and flame-proofing
agents, if the filaments are inflammable, to form
a viscous spinning solution. Glass and polymeric
amide, etc. may be also used and spun from a
molten state. Certain of the cellulosic deriva-
tives, such as cellulose xanthate, require a coagu-
lating solution. In this case the filaments are
cast on the strip sheet from the spinnerets and
are then coagulated in an acidic bath or spray
and are removed from the strip sheet and washed
and dried. Dyes or pigments may be dissolved
or suspended in the spinning solution to obtain

desired color effects in the web. Typical solutions suitable for spinning to provide a lacy web of synthetic filaments having the desired strength and elasticity and flame-proofness are presented in the following examples.

Example 1

Cellulose acetate-----gm--	2200
Acetone -----cc--	13200
Ethyl alcohol-----cc--	1470
Triphenyl phosphate-----gm--	715
Tricresyl phosphate-----gm--	80

Triphenyl phosphate and tricresyl phosphate are flame-proofing agents and may be omitted if that property is not required. Tricresyl phosphate acts to inhibit crystallization of the flame-proofing agent and both phosphate compounds have plasticizing properties.

Various types of cellulose acetate may be used. For example, cellulose acetate, of an acetyl content of 55.5 to 56.2 and a viscosity of 35 to 55 seconds as measured by the time of fall, in seconds of a $\frac{1}{16}$ inch steel ball through 10 inches of a 20% (by weight) solution of the cellulose acetate dissolved in a solvent composed of 9 parts (by weight) of acetone and one part of ethanol, has been found to be satisfactory.

To obtain a more pliable web, a spinning solution of ethyl cellulose may be used, as follows:

Example 2

Ethyl cellulose-----gm--	468
Xylol -----cc--	1260
Alcohol -----cc--	750
Tricresyl phosphate-----gm--	94

Flexible or pliable filaments may be obtained by adding plasticizers to the spinning solution. Methyl phthalyl ethyl glycolate is very satisfactory for cellulose acetate. Dibutyl phthalate may be employed in ethyl cellulose spinning solutions. Other commonly used plasticizers for cellulose acetate and ethyl cellulose may be employed. The plasticizer may be added in proportions ranging from approximately 5 to 40% of the solids content of the solution, depending upon the degree of pliability desired in the filaments.

The above formulae provides spinning solutions of approximately 20 to 30% solids content which may be spun into filaments satisfactory for the above described purposes. The solution of Example 1 has a viscosity of 1730 centipoises at 73° F. on a Brookfield viscosimeter. To obtain a relatively strong web, solvents that evaporate fairly rapidly should be employed. If the solvents evaporate slowly, a weak web is produced since, during evaporation, individual filamentary segments tend to draw toward the points of intersection with other filaments and present weakened, thin portions intermediate the intersecting areas. On the other hand it has been found, if acetone is the sole solvent or diluent, that it evaporates too rapidly and provides a spinning solution which is too viscous for many usages. For this reason it is preferred to employ a combination of solvents or a solvent and a diluent, as indicated in the examples.

Care should also be exercised to insure that the filaments are deposited upon the strip sheet in a tacky condition. The rate of evaporation of the solvents from the filamentary material should be controlled in order that the filaments when deposited upon the coated strip sheet, will be sufficiently tacky to adhere to each other. Accordingly it is desirable to position the spinnerets ad-

5 adjacent to the strip sheet or to spin the filaments into a solvent-containing atmosphere. In employing the spinning solutions previously set forth, the spinnerets are preferably disposed from $\frac{1}{2}$ inch to 6 inches above the strip sheet. If larger proportions of solvent or slower evaporating solvents are employed the spinnerets may be disposed at a greater distance from the strip sheet. Satisfactory results have been obtained by extruding the spinning solution under pressures of from 95 pounds to 125 pounds per square inch.

The particulate material to be dusted upon the strip sheet and partially bonded to the freshly deposited filaments may comprise water ground mica, glass beads, graphite powder, silica aerogel, such as described in U. S. Patent No. 2,093,454 to Kistler, starch, precipitated chalk, titanium oxides, zinc oxide, and colored aluminum or bronze or similar mineral or metallic powders. The particulate spacing material may be used singly or in combination, such as a mixture of a bronze powder and mica, or of mica and a powdered pigment or a dye. Traces of a dry dye may be applied to the powdered spacing material and are transferred to the filaments upon deposition of the filaments thereon.

The particle size of the comminuted material may vary considerably. Generally speaking the larger and heavier particles produce a web having smaller openings or interstices between the filaments forming the web than lighter, smaller particles. Water ground mica powder of a length of 2 to 40 microns and a thickness of 0.1 to 5 microns is very satisfactory. Aluminum and bronze powders may be somewhat larger and may have a particle size of approximately 30 to 40 microns. In general, the comminuted material should be of a size and nature that it is readily movable upon the surface of the strip sheet and upon lower layers of the comminuted material. Because of their leaf-like formation and relatively friction-free surfaces mica, graphite and the like are particularly suitable. The spherical shape of glass or metal beads enhances their utility for this purpose. Aerogel, described in the preceding paragraph, has a slippery surface and is used most satisfactorily when the solvent is removed rapidly after the web is formed. Powders having a low refractive index and which are good inert extenders, are preferred for most usages. Accordingly titanium oxides are not suitable for many decorative usages since, when bonded to the unwoven web, they cannot be readily covered or hidden by a subsequently applied film of the plastic solution.

As previously set forth, the strip sheet is completely covered with the comminuted material which is preferably deposited in at least a double layer on the strip sheet. The strip sheet may comprise a sheet of "cellophane," kraft paper, rubber or cloth, which may be pretreated, to present a non-absorbent surface. Upon deposition, the filaments are spaced from the strip sheet by the comminuted material, some of which is immediately bonded to the solvent-laden filaments. The filaments draw together and slide over other comminuted particles during evaporation of the solvent to form the desired lacy effect.

After deposition of the filaments the strip sheet may be vibrated to throw upwardly unbonded particles some of which in descending fall upon the upper surfaces of the filaments and are bonded thereto to present a web of filamentary material having color effect materials bonded at ir-

regular intervals. The same result may be obtained by sprinkling a powder of the type described on the upper surface of the freshly formed web. Natural or artificial flock, such as rayon, cotton or wool flock of $\frac{1}{4}$ inch to $\frac{1}{2}$ inch lengths, may be employed in place of or to supplement the comminuted materials previously described for decorative purposes. The lace-like web having a great number of particles bonded thereto may be subsequently dipped or sprayed on one or both sides with a diluted solution of the spinning material or of other material of the type described to provide a covering film for the particles, when it is desired that the particles be hidden somewhat.

For many usages it is desired that the bonding of comminuted material to the filaments during deposition be kept at a minimum and in some cases powdered material bonded to the filaments is removed therefrom after the web is removed from the supporting sheet. In these instances, water-soluble or acid-soluble particulate material may be used and, after the solvent-free web is removed from the support, it is briefly immersed in a bath of water or of an acid that does not attack the web. In these instances the steps of vibrating the strip sheet or sprinkling additional powder upon the freshly formed web are not practiced.

The invention will be readily understood from the following description in connection with the accompanying drawing in which a preferred form of apparatus on which the invention may be practiced is shown.

Figure 1 is a diagrammatic view in side elevation, of suitable apparatus for carrying out my invention;

Fig. 2—an enlarged, fragmentary, elevational view at an intermediate stage of the production of my improved lace-like web, showing the support, several layers of powder thereon and the filamentary web deposited on the powder;

Fig. 3—a plan view of a filamentary web produced by deposition directly upon a strip sheet; and

Fig. 4—a plan view of a lace-like web according to my invention and formed by depositing filaments upon a support of comminuted material.

Referring to Figures 1 and 2 of the drawing, the reference character 6 indicates a support or strip sheet in the form of an endless belt mounted upon rollers 7 and 8, one of which is a driven roller. The dimensions of the belt may obviously vary considerably, a belt 31 yards in length and approximately 4 feet in width is suitable. It preferably travels at a speed of 10 to 30 feet per minute. As previously mentioned the support 6 may be formed of kraft paper, "cellophane," rubber or cloth. A hopper 9 containing particulate material is mounted above the upper surface of the conveyor 6, adjacent to the roller 7, and is provided with a suitable gate adapted to distribute one or a plurality of layers of the comminuted material upon the upper surface of the support 6; this surface is preferably completely covered with the comminuted material 10. Also mounted above and adjacent to the upper surface of the support 6 are one or more spinnerets 11, eccentrically mounted, so that the spinnerets are moved in an overlapping pattern, laterally and longitudinally of the belt 6, in a horizontal plane, and thus the filaments are deposited, in an overlapping and intersecting pattern, upon the coating of particulate material 10 to form an unwoven web. If desired, the filaments may be

deposited to form a web of a plurality of piles of filamentary material. At the upper end of the spinneret 11 is a pipe 12 leading into a container (not shown) of a solution of the spinning material, which is preferably forced therefrom under pressure. The spinneret head 13 is of the conventional type and has a plurality of minute orifices. The spinneret may have twenty or more orifices arranged rectangularly or in a circle and the orifices are from 2.5 to 7 mills in diameter. The spinneret head is preferably disposed from $\frac{1}{2}$ to 6 inches above the flight of the conveyor 6 carrying the powder coating 10 and the extruded filaments 14 drop vertically onto the powder coating 10 to form an unwoven web 15 of overlaid and intersecting filaments.

A vibrator or beater 16 may be disposed below the upper level of the conveyor 5 and is adapted to vibrate the conveyor belt 6 to throw upwardly unbonded particles, some of which in descending fall upon the upper surface of the filamentary web 15 and are bonded thereto. The vibrator 16 may be omitted if a lace-like web having a minimum of bonded particles is desired.

An oven 17 having apertures 18 and 19 in its vertical walls to permit passage therethrough of the belt support 6, the newly-formed web 15 and the space coating 10 of particulate material, is adapted to heat the web to complete the evaporation of the solvent from the filamentary web. It may be heated to temperatures of the order of 125° F. If a long and slowly moving conveyor belt is employed and it is thus not necessary to hasten the drying of the filaments, the oven 17 may be omitted.

The solvent-free web 15 is led away from the conveyor belt 6 as it passes over the roller 8 and the unbonded particulate material falls into a trough 20 disposed below the roller 8. A second beater 21 is mounted above the trough 20 and is adapted to vibrate the web 15 lightly, as it leaves the roller 8, to remove therefrom any unbonded particles.

The freshly formed web 15 then passes between a pair of coating rolls 22 and 23. The lower roll 23 is partially immersed in a plastic or resinous solution 24 carried in the tray 25. The resinous solution may be of the same material as the solution from which the filaments 14 are spun or a different resinous solution of the types described may be used. A thin film of the solution 24 is applied to the web 15 by the rollers 23 and 22. Since the web is of an open or net-like construction some of the solution 24 is transferred through the web to the upper coating roller 22 and the filaments forming the web 15 are thus completely coated with a thin film of the solution. The web is led through a second oven 26, suitably apertured to permit passage of the web therethrough, to complete the removal of the volatile solvent of the bath 24 and is then wound upon a reel 27. If the wind-up reel 27 is placed at a distance from the vat 25 so that the solvent is evaporated from the web 15 without heating, the oven 26 may be omitted.

In like manner the resinous film may be applied to the unwoven web by spraying or the web may be dipped in a bath of the plastic solution. In either case the web is dried before it is wound upon the reel 27. For certain decorative uses, a web is preferred in which the bonded particles 28 are not film-coated and in these cases, the tray 25, bath 24 and oven 26 are omitted.

The marked difference in appearance between my improved lace-like web 15 of filamentary ma-

materials formed by depositing the freshly spun filaments in overlaid relation upon a layer of freely movable particulate material, as shown in Fig. 4, is well illustrated by comparing it with the web 29 shown in Fig. 3 in which the same filaments are deposited directly upon a conveyor sheet which is not provided with the intervening and supporting layer of particulate material.

As appears from the foregoing description the lacy web has a wide field of utility and may be satisfactorily employed as a millinery material, lamp shade material, curtain material, display and costuming material and for many other decorative uses. The web may be laminated to other webs, similarly formed, of contrasting or complementary colors, or to paper, films, cloth or to dry-laid tissue, and the like, to obtain striking color effects or greater strength.

Specific examples of suitable spinning solutions and of comminuted particles to be bonded to the sticky filaments have been given for the purpose of illustration only and other suitable solutions and spacing and coloring particles within the scope of the invention will be readily apparent to those skilled in the art.

What I claim is:

1. The method of producing a web of artificial filaments comprising extruding plastic spinning material into a plurality of filaments and depositing said filaments in overlapping relation, while still sufficiently plastic to adhere to one another and to particulate material, upon a support coated with said particulate material, whereby some of said particles becomes bonded to said filaments and said filaments are bonded to each other prior to the evaporation of said solvent.

2. The method of forming a lace-like web comprising extruding plastic filaments from a solution of plastic spinning material, moving the source of said extruded material so that said filaments are deposited upon a moving support coated with finely divided material in such manner as to cause the filaments to intersect promiscuously, said filaments being sufficiently plastic to adhere to one another at points of intersection and to said material to form a lacy web.

3. An unwoven web formed of a plurality of unbroken artificial filaments bonded to each other and to other filaments at closely spaced irregular intervals by reason of the adhesive condition of the filaments upon deposition, said web presenting a lacy appearance from deposition of said solvent-laden filaments upon a layer of particulate material.

4. The method of forming a lace-like web comprising forming a plastic spinning solution of filamentary producing material and a solvent, said solution containing from 20 to 30% solids content, extruding said solution under pressure to form artificial filaments and permitting said freshly spun filaments to drop in overlapping relation upon a spacing layer of finely divided material carried upon a supporting member, a portion of said finely divided material adhering to said filaments during evaporation of said solvent.

5. The method of producing a lace-like web of overlaid and irregularly bonded artificial filaments comprising depositing a thick layer of metallic powder upon a moving support and de-

positing freshly spun unbroken filaments in overlapping relation upon said layer of metallic powders prior to the evaporation of the solvent content of said filaments, whereby some of said metallic powder is bonded to said filaments and said filaments are spaced from said support and are free to curl and draw together to form a lace-like web.

6. The method of producing a lace-like web of overlaid and irregularly bonded artificial filaments comprising depositing a thick layer of mineral particles upon a moving support and depositing freshly spun unbroken filaments in overlapping relation upon said layer of mineral particles prior to the evaporation of the solvent content of said filaments, whereby some of said mineral particles are bonded to said filaments and said filaments are spaced from said support and are free to curl and draw together to form a lace-like web.

7. The method of claim 4 in which the freshly formed web is dipped into a dilute solution of spinning material.

8. The method of producing a web of artificial filaments comprising extruding plastic spinning material to form a plurality of filaments, depositing said solvent-containing filaments in overlapping relation upon a layer of finely divided material spacing said overlaid filaments from a moving support and vibrating said support during evaporation of the solvent content of said filaments to bond some of said finely divided material to all surfaces of said filaments at irregular points thereon.

9. The method of producing a web of artificial filaments comprising extruding plastic spinning material to form a plurality of filaments, depositing said solvent-containing filaments in overlapping relation upon a layer of finely divided material spacing said intersected filaments from a moving support and sprinkling finely divided material above the newly formed web during evaporation of the solvent content of said filaments.

10. An unwoven lace-like web comprising artificial filaments bonded at their points of intersection by reason of the adhesive condition of the filaments upon deposition, particulate material bonded to said filaments at irregular intervals during the deposition of said filaments upon a support coated with said material, and a plastic film thinly coating said bonded particulate material and said filaments.

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