

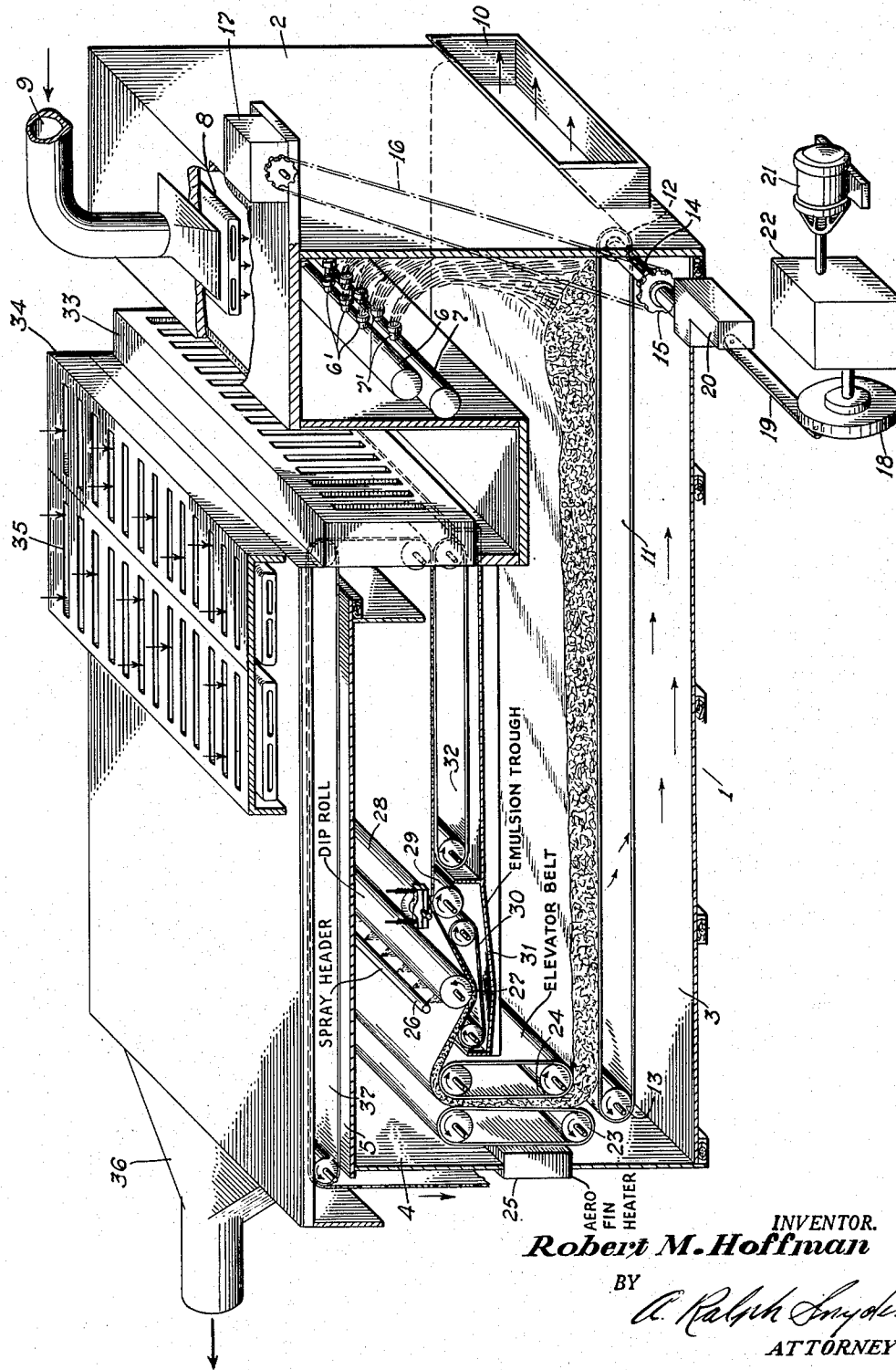
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SPINNING APPARATUS AND METHOD

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SPINNING APPARATUS AND METHOD

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This invention relates to improvements in the manufacture of masses of organic solvent-soluble thermoplastic filaments. More particularly it relates to an improved dry-spinning method and apparatus for producing organic solvent-soluble cellulose organic ester filamentous masses.

In copending application Serial No. 477,012 filed February 25, 1943 (Ira V. Hitt) there is disclosed the preparation of new continuous filaments of thermoplastic, organic solvent-soluble filament-forming organic material which filaments are characterized by having crimps lying at random in three directions, by a surface having deeply cut, irregular disconnected pits or channels and by having substantially no molecular orientation along the filament axis. These crimped or crinkled filaments, hereinafter termed "free-fall" filaments, are formed by extruding an organic solvent solution of the filament-forming material, e. g. an acetone solution of acetone-soluble cellulose acetate, in the form of fine streams into an evaporative atmosphere and under a jet velocity sufficiently high to maintain the extruded material under compressive force until the extruded material sets in the form of self-sustaining filaments.

When filaments from a plurality of spinnerets are collected as a continuous batting, the resulting product can be used to advantage in a variety of ways. For instance, it may be used as such in comforts, sleeping bags, as heat and sound insulations, for felting, etc., or it may be compacted under the influence of heat and pressure, with or without binding or adhesive agents, to form valuable structures of varying degrees of hardness, density, and toughness as set forth in copending application Serial No. 491,125 filed June 17, 1943 (Lawrence B. Steele, Jr.).

For most purposes it is desirable that the batting be uniform in thickness and density, and that the filaments be well interlocked. Additionally, when the batting is to be converted into pressed structures, it is desirable that the bulk of the batting be reduced to the point where the batting can be easily handled and economically shipped and stored, and that it be conditioned as by impregnation with a suitable binding or adhesive agent, or other agent, and/or dried to the proper moisture content for direct conversion to the pressed form.

An object of this invention, therefore, is to provide a composite method and means for continuously spinning, collecting, impregnating, debulking, and drying a filamentous mass comprised of free-fall filaments of organic solvent-soluble,

thermoplastic filament-forming material whereby to continuously form a coherent batting of uniform density which can be easily handled, shipped, stored, or directly used. A further object is to provide means for the efficient and thorough removal of solvent from freshly formed filamentous masses of free-fall filaments. A still further object is to provide means for producing a continuous batting of free-fall filaments which batting is of uniform density, substantially debulked, and impregnated with suitable agents to facilitate pressing or molding into dense fibrous panels and like structures. These and other objects will more clearly appear hereinafter.

From the following description and specific examples, in which are disclosed certain embodiments of the invention as well as details of what is believed to be the best mode for carrying out the invention, it will be apparent how the foregoing objects and related ends are accomplished. The description is to be read in connection with the accompanying drawing wherein the figure is a perspective view of a preferred construction embodying the principles of this invention. One side of the cabinet has been removed to better show the details and operation of the device.

Referring now to the drawing, machine cabinet 1 is divided into four main sections or chambers consisting of a spinning cell or chamber 2 disposed at one end of the cabinet; a conveyor section 3 disposed below the spinning cell and extending the full length of the cabinet, and arranged for the collection of the filaments in the form of a batting and adequate removal of solvent therefrom; an impregnating and debulking section 4 disposed in the other end of the cabinet and above the conveyor section; and a drier chamber 5 overlying the impregnating and debulking section. The spinning cell is open to the conveyor section immediately below but is substantially closed off from the remainder of the cabinet whereby to permit efficient solvent removal from the freshly formed filaments. A plurality of spinnerets 6' and 7' arranged in two banks one above and slightly offset from the other are located in the upper portion of cell 2. In the modification shown, the spinnerets direct the streams of filament-forming solution horizontally but they may be angled either upwardly or downwardly. The spinnerets are so spaced, one from the other, that there is no interlocking of the filaments from one spinneret with those of the adjacent position until the filaments have traveled at least two feet through the evaporative medium in the cell and

sufficient solvent removed to prevent the filaments from sticking to each other. The spinning solution is fed from a source of supply and through the conventional pumps and headers (not shown) to the spinning heads 6 and 7 to which spinnerets 6' and 7', respectively, are connected. Evaporative medium, e. g. air, heated to the proper temperature by means of a fin type heater 8 is introduced at the top of the cell from a duct 9 and the solvent laden evaporative medium is drawn from the cell at the bottom thereof through an aspiration duct 10 to be treated for solvent recovery. Evaporative medium from section 3 is likewise exhausted through duct 10 as indicated by the arrows.

A long endless belt 11 of porous material, preferably metal wire screen, suitably mounted at the cell end on a driven member 12 and at the opposite end on a free-running member 13 travels substantially the full length of section 3. Member 12 is fixed to a shaft 14 which in turn is keyed to a sprocket wheel 15 driven through an endless chain 16 and speed reducer box 17 by a suitable motor (not shown). Shaft 14 is freely journaled at either end to permit an endwise or traverse movement of said shaft, member 12 and conveyor belt 11. A crank arrangement 18, 19, 20 driven by motor 21 through speed reducer 22 is provided to impart the desired traverse motion to shaft 14. It will be appreciated, of course, that any other conventional mechanical expedient or arrangement ordinarily employed to obtain the desired simultaneous lengthwise and traverse motion of belt 11 may be substituted for the specific arrangement illustrated. The traverse motion of belt 11 at the spinning cell is uniform from side to side and the cycle is so adjusted that the falling filaments under any one spinneret are caused to overlap on to the piles on the belt which are produced under the two adjacent spinnerets.

A pair of vertically disposed, parallel, motor-driven endless belts 23 and 24 of porous material, e. g. canvas, are located at the end of belt 11 and cooperate to carry therebetween, and hence elevate the batting from section 3 to section 4 of the chamber. Belts 23 and 24 are so spaced from each other that the thickness of the batting as it leaves belt 11 is reduced by about $\frac{1}{2}$ in traveling between belts 23 and 24. A fin type heater 25 is placed adjacent belts 22 and 23 in order to provide a body of heated air in and about the batting at this point.

A spray header 26 (fed from a source of supply not shown) and a cooperating motor-driven dip roll 27 adapted to facilitate impregnation of the batting with a suitable liquid, are positioned in section 4 near the entrance thereto and are followed by a set of squeeze rolls 28 and 29. An endless belt conveyor 30 extending from the entrance to section 4 to the squeeze rolls is disposed so as to carry the batting under and in pressure contact with dip roll 27, and thence to the squeeze rolls. A trough 31 is placed below the elements 26, 27, 28, 29 and 30 to catch the excess impregnating fluid which is recycled for reuse by conventional means (not shown). A motor-driven endless belt conveyor 32 supports the batting for the remainder of its travel through section 4.

Chamber 5 at its inlet end is provided with fin type heaters 33, 34 and 35 adapted to effect final drying of the batting by radiation. An exhaust manifold 36 which is connected to an exhaust fan or pump (not shown) is provided to remove moist air from the drying chamber. Motor-driven endless belt conveyor 37, extending substantially the

full length of chamber 5 supports the batting in its travel through this final stage. The finished batting may be collected upon a roll or in any other suitable fashion or it may be subjected immediately to further processing.

Operation of the device above described will now be illustrated in the following specific example which is to be read with reference to the drawing but which is not to be construed in any way as a limitation upon the method or apparatus of this invention. Percentages are by weight unless otherwise stated.

Example

A spinning solution containing 25% of cellulose acetate (54.5% combined acetic acid) and having a viscosity of 350 poises when measured as a 24% solution in acetone containing 2% water, was extruded horizontally at a solution temperature of 59° C. and at a jet velocity of 30,000 inches per minute through spinneret groups 6' and 7' into air maintained at a temperature of about 45° C. There were six spinnerets in each group. Each spinneret had 36 holes, each hole being 0.04 millimeter in diameter and the spinnerets were spaced 4.5 inches from center to center. The filaments formed were allowed to fall freely onto belt 11 which was spaced 4 feet below spinnerets 6' and 3 feet 3 inches below the lower spinnerets 7'. The total traverse of belt 11 was 6 inches and it was driven at a linear speed of 0.27 foot per minute.

The speed and traverse of the belt was such as to cause the filaments to collect on the belt immediately below the spinnerets in overlapping piles having a uniform depth of about 9 inches. As the filamentous mass was carried along by belt 11, air at a temperature of about 40° C. was caused to circulate through the mass effecting further removal of acetone and the mass settled into a continuous batting having a uniform thickness of about 4 inches.

After traversing substantially the full length of the cabinet, the batting was picked up from the belt 11 by elevator belts 23 and 24 which were so spaced that the batting was squeezed to a thickness of about 2 inches.

From the elevator belts the batting was passed under the spray header 26 and dip roll 27 where it was thoroughly impregnated with a water emulsion of polyvinyl acetate containing about 12% solids. At this point the thickness of the batting was further reduced to approximately $\frac{1}{2}$ to $\frac{3}{4}$ of an inch, and a final reduction in thickness to about $\frac{1}{8}$ inch was effected when the batting was subjected to a total pressure of about 600 pounds between squeeze rolls 28 and 29.

After passing through the squeeze rolls where excess emulsion was removed, the batting was subjected to a preliminary drying with air maintained at about 45° C. Final drying was carried out in chamber 5, the air in this section being maintained at about 70° C.

A compact, well-adhered batting of uniform density throughout, particularly suited for immediate pressing into tough, dense, translucent panels, was formed.

It will be appreciated, of course, that the invention is not limited to the structural details or conditions hereinabove recited by way of example, but is susceptible rather to wide variation and to the substitution of a broad range of equivalents.

In the apparatus, for example, the number, disposition, spacing, and size of the spinnerets can be altered at will to suit particular requirements.

It is essential, however, that the spinnerets be spaced so there is no interlocking of the filaments until the yarn has traveled at least two feet through the spinning cell and sufficient solvent removed to prevent the filaments from sticking to each other. The spinnerets may be set at any desired angle above or below the horizontal provided the jet velocities are adjusted accordingly to insure the desired filament formation.

In general the speed of the collecting conveyor belt is dependent upon the thickness of batting required, i. e. the weight in pounds per square foot area. Taking into account the linear speed of the belt and thickness of batting being formed thereon, the length of travel of this belt must be such as to allow for air circulation through the batting for a period of time sufficiently long to obtain adequate solvent removal therefrom. The speed of the remaining belts in the system will, of course, be the same as that of the collecting belt save for belts beyond the squeeze rolls which must be speeded up slightly to compensate for stretch which occurs when the batting passes from the impregnating bath to the squeeze rolls.

As will be apparent to those skilled in the art, any suitable mechanism may be employed to impart traverse motion to the collecting conveyor belt. Alternatively, the spinning heads may be given a traverse motion to obtain the same result. A total traverse of 3 to 6 inches has proven satisfactory.

In order to facilitate solvent removal, impregnation, drying, etc., it is desirable to construct the endless belts of porous material. Metal screen belts are particularly effective for the horizontal runs, whereas it is preferred to use canvas for the vertically disposed elevator belts.

The particular spray and dip-roll combination shown herein may be replaced by any other suitable arrangement which operates to effect the rapid and thorough impregnation of the batting. The choice of liquid applying means will be dictated to a great extent by the nature of the impregnant to be applied.

Finally, it will be appreciated that while the arrangement of apparatus shown is preferred because of its compactness, simplicity and overall efficiency in operation, any other arrangement may be used so long as the essential characteristics of spinning, collecting, solvent removal, impregnating and drying herein disclosed are preserved, and carried out in the order named.

Although the invention has been described specifically with reference to the spinning of acetone-soluble cellulose acetate, it is applicable to the spinning of any thermoplastic filament-forming substance soluble in organic solvents, e. g. cellulose esters such as cellulose propionate, cellulose butyrate, cellulose aceto-propionate, cellulose aceto-butyrate or the like; organic solvent-soluble cellulose ethers such as methyl cellulose, ethyl cellulose, benzyl cellulose or the like; mixed cellulose ether-esters such as methyl cellulose acetate, ethyl cellulose propionate, etc.; vinyl polymers such as polyvinyl esters, for example, polyvinyl acetate; polyvinyl ethers such as polyvinyl acetal; copolymers of vinyl chloride and vinyl acetate, such as "Vinylite V"; copolymers of vinylidene chloride and vinyl chloride such as "Saran"; polystyrene; nylon; methacrylate polymers, and the like. Any suitable organic solvent or combination of solvents may be used depending, of course, upon the specific thermoplastic materials being spun.

The spinning solutions may contain, in addi-

tion to the filament-forming substance, a suitable modifying agent compatible therewith, for instance, a plasticizer. Also, the solution may contain modifying agents such as dyes, pigments, non-solvent diluents and the like.

In many instances it may be desirable to prepare battings of mixed synthetic filaments. This may easily be accomplished by spinning a mixture of filament-forming solutions whereby to form composite mixed filaments or a mixture of different filaments may be formed by using double spinnerets, i. e. spinnerets arranged for the extrusion of two different solutions simultaneously from one position; or two or more banks of spinnerets to which are fed different spinning solutions may be employed.

As suitable impregnants for pressing or molding purposes, any type of fusible heat-moldable (thermoplastic or thermo-setting) organic material may be used. Any of the thermoplastics recited above as filament-formers may be used. Some additional materials that are useful as impregnants are rosin and rosin derivatives, such as hydrogenated rosin and hydrogenated rosin esters; coumarone-indene-type resins; rubber and rubber-like polymers including synthetic rubber-like products, for example, chlorinated rubber, rubber hydrochloride and the like, or neoprene, polymerized butadiene compounds, such as the copolymers of butadiene and styrene, butadiene and acrylonitrile, and butadiene and isobutylene; urea-aldehyde resins, phenol (including polyphenols)-aldehyde resins, alkyl resins, melamine-aldehyde resins and "Columbian" resin which is the polymer from the reaction product of ethylene glycol, phosgene and allyl alcohol. The plastic impregnant chosen and the solvent or dispersion medium to be used therewith should have no dissolving action on the thermoplastic constituting the fibrous base material. Where the batting is to be used for purposes other than pressing, for example, where it is to be converted into wool-like yarns, used for heat or sound insulation, etc., the impregnant may be any of the well known lubricating and/or finish compositions, flame-proofing agents, and the like, or the impregnant may in many instances be dispensed with entirely.

A principal advantage of this invention is that it affords means for economically producing a well-adhered, debulked, uniformly dense, impregnated continuous batting of free-fall filaments of organic solvent soluble thermoplastic organic filament-forming substances. The batting produced is in condition for easy handling, storing and/or shipping. Probably the principal advantage, however, is that this invention makes possible the continuous commercial production of impregnated batting of a quality and uniformity in thickness and density which fits it for immediate conversion into dense fibrous structural panels of extremely wide utility.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not limited to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. Apparatus for producing continuous compacted batting of continuous crinkled filaments of organic solvent-soluble, thermoplastic organic filament-forming material which comprises in combination means for spinning a plurality of free-fall filaments of organic solvent-soluble, thermoplastic, organic, filament-forming material

in the form of a flat curtain-like mass, means for collecting said mass as a continuous batting of substantial thickness said means comprising a constantly traveling, horizontally disposed, endless belt conveyor provided with means for effecting a constant reciprocating transverse motion of that portion of the belt upon which said mass of filaments is first collected, means for removing residual solvent from the batting on the belt, means for thereafter compressing the batting to substantially reduce the thickness thereof, means for impregnating the compressed batting with a liquid impregnant, means for expressing excess impregnant and for further reducing the thickness of the batting and means for drying the batting to the desired degree.

2. Apparatus for producing continuous compacted batting of continuous crinkled filaments of organic solvent-soluble, thermoplastic organic filament-forming material which comprises in combination a vertical spinning chamber, means for extruding a plurality of fine streams of an organic solvent solution of a thermoplastic organic filament-forming material in said chamber said means comprising a plurality of spinnerets aligned in the upper end of said chamber so as to produce a flat, relatively wide, curtain-like mass of freely-falling filaments, means for maintaining an evaporative atmosphere in said chamber whereby said streams are converted into a plurality of self-sustaining, freely-falling filaments, means for continuously collecting and removing said freely-falling filaments from said chamber in the form of a continuous batting of substantial thickness which comprises a longitudinal, substantially horizontally disposed, endless belt conveyor extending into said chamber at the bottom thereof and in such a position that the curtain-like mass of filaments falls on the belt transversely of the longitudinal axis of the belt, means to impart continuous longitudinal travel to said belt, means to cause relative transverse movement between the spinnerets and that portion of the said belt in the chamber, means for removing residual solvent from the batting while on said belt, means for compressing the batting as it leaves the belt, means for impregnating the compressed batting with a liquid agent, means for pressing out excess liquid agent and further compressing said batting, and means for drying said batting to the desired degree.

3. Apparatus for producing continuous compacted batting of continuous crinkled filaments of organic solvent-soluble, thermoplastic organic filament-forming materials which comprises in combination a spinning chamber, filament-forming means including a plurality of spinnerets arranged at the upper end of the chamber in at

least two horizontal straight-line banks, the spinnerets of one bank being spaced above the spinnerets of the other bank and in offset relation thereto, all of said spinnerets being disposed so that the filament-forming solution extruded therefrom is projected in a horizontal direction to form a flat, curtain-like mass of free-falling continuous filaments; means for maintaining an evaporative atmosphere in said chamber; a horizontally disposed, longitudinal endless conveyor belt having one end extending into said spinning chamber at the bottom thereof a substantial distance below said spinnerets and arranged to receive and transport the filamentous mass in the form of a continuous batting, means to impart continuous longitudinal travel to said belt, means to impart a substantial reciprocating transverse motion to that portion of the belt extending within said spinning chamber; means for removing residual solvent from the batting as it is carried by said belt; positively driven parallel longitudinal belts arranged to receive therebetween the batting from said conveyor belt, said parallel belts being spaced sufficiently close together to effect a substantial reduction in the thickness of the batting received therebetween, means following said parallel belts for impregnating the batting with a liquid, positively driven squeeze rolls adapted to remove excess impregnating liquid from the batting and to further reduce the thickness of the batting, and means for drying said batting to the desired moisture content.

4. A method for producing continuous, compacted, impregnated batting of continuous crinkled filaments of organic solvent-soluble, thermoplastic, organic, filament-forming material which comprises the steps of extruding into an evaporative atmosphere a plurality of groups of fine streams of an organic solvent-solution of a thermoplastic, organic, filament-forming material in such fashion that the groups together form a flat, curtain-like mass, allowing said streams to fall freely through said evaporative atmosphere until they are converted into continuous self-sustaining filaments, collecting said filaments in a continuous wide batting of substantial thickness, causing adjacent groups of filaments to overlap as they are collected, removing residual solvent from said batting, compressing said batting whereby to substantially reduce the thickness thereof, impregnating said batting with a liquid impregnant, expressing excess impregnant and further compressing said batting, and drying said batting to the desired point.

5. The method of claim 4 wherein the thermoplastic organic filament-forming material is cellulose acetate and the organic solvent is acetone.

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