July 2, 1940. H. A. SHEESLEY 2,206,056

METHOD AND APPARATUS FOR MAKING FIBROUS SHEETINGS

Filed Oct. 30, 1935 4 Sheets-Sheet 1

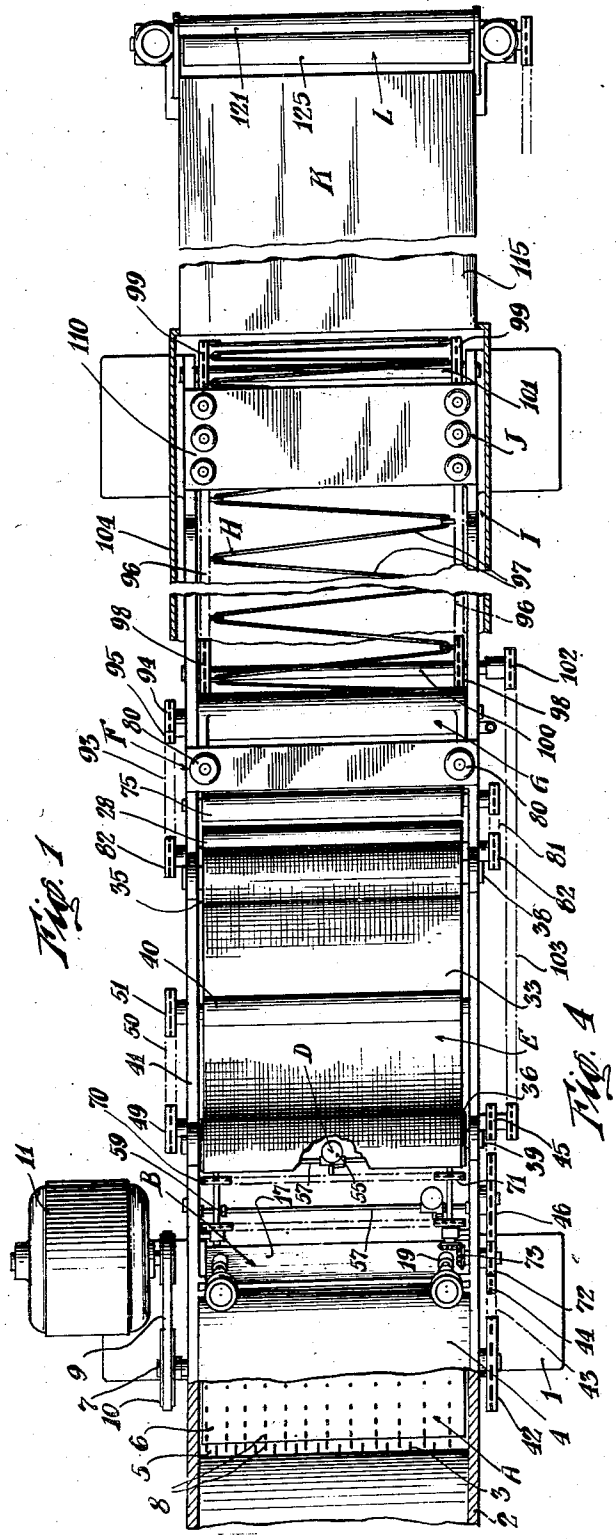


Fig. 1

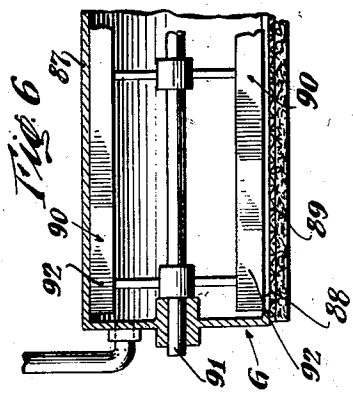


Fig. 6

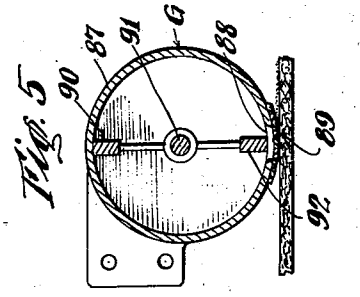


Fig. 5

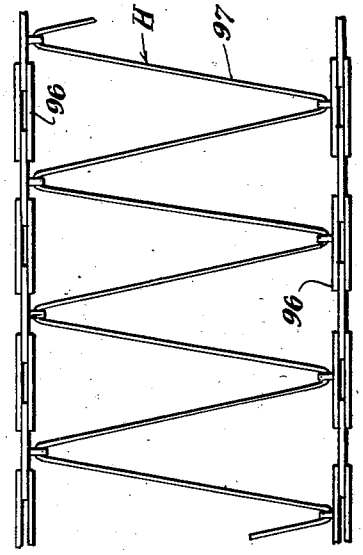


Fig. 4

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METHOD AND APPARATUS FOR MAKING FIBROUS SHEETINGS

Filed Oct. 30, 1935 4 Sheets-Sheet 2

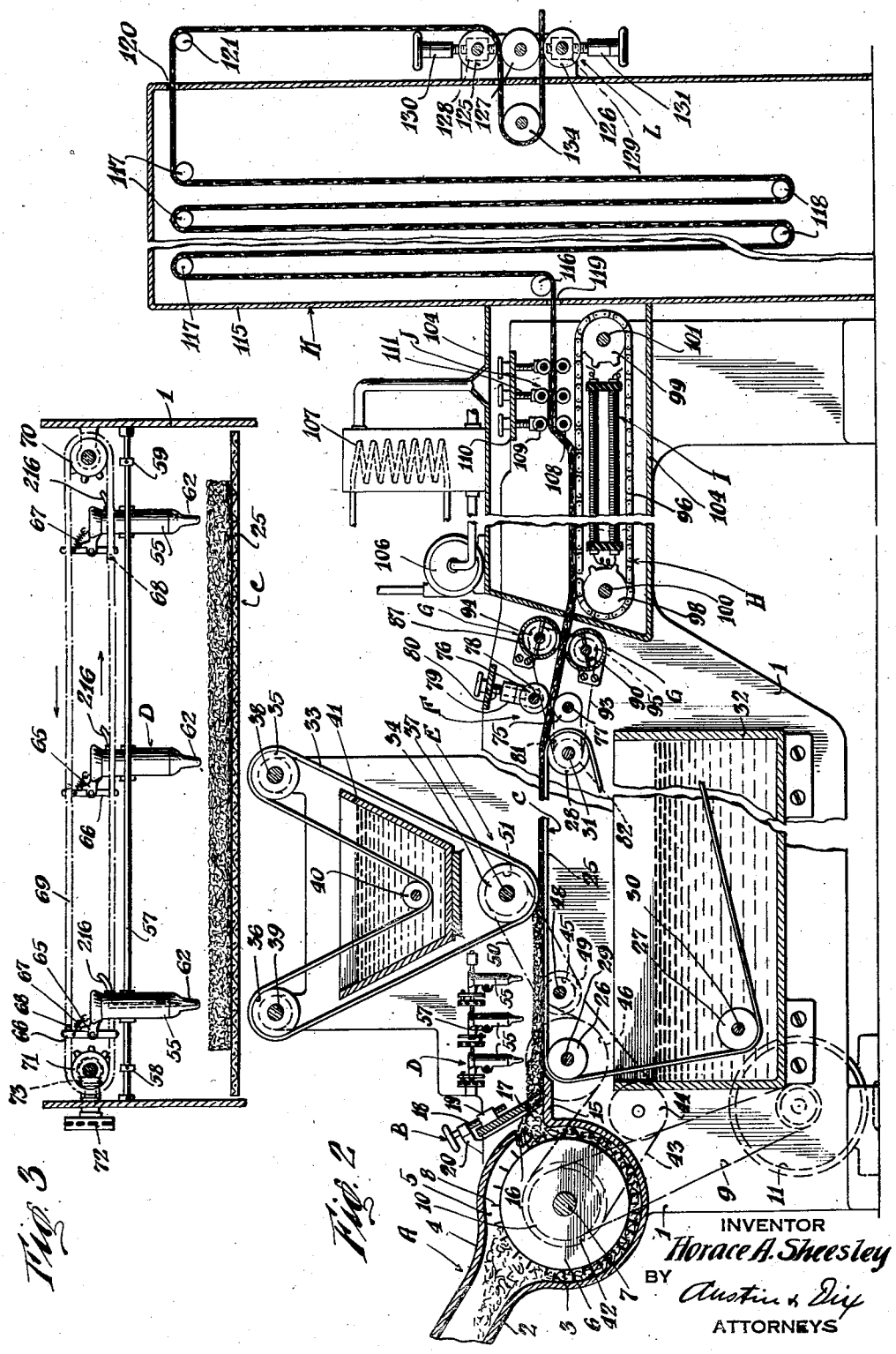


Fig. 2

Fig. 3

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METHOD AND APPARATUS FOR MAKING FIBROUS SHEETINGS

Filed Oct. 30, 1935 4 Sheets-Sheet 3

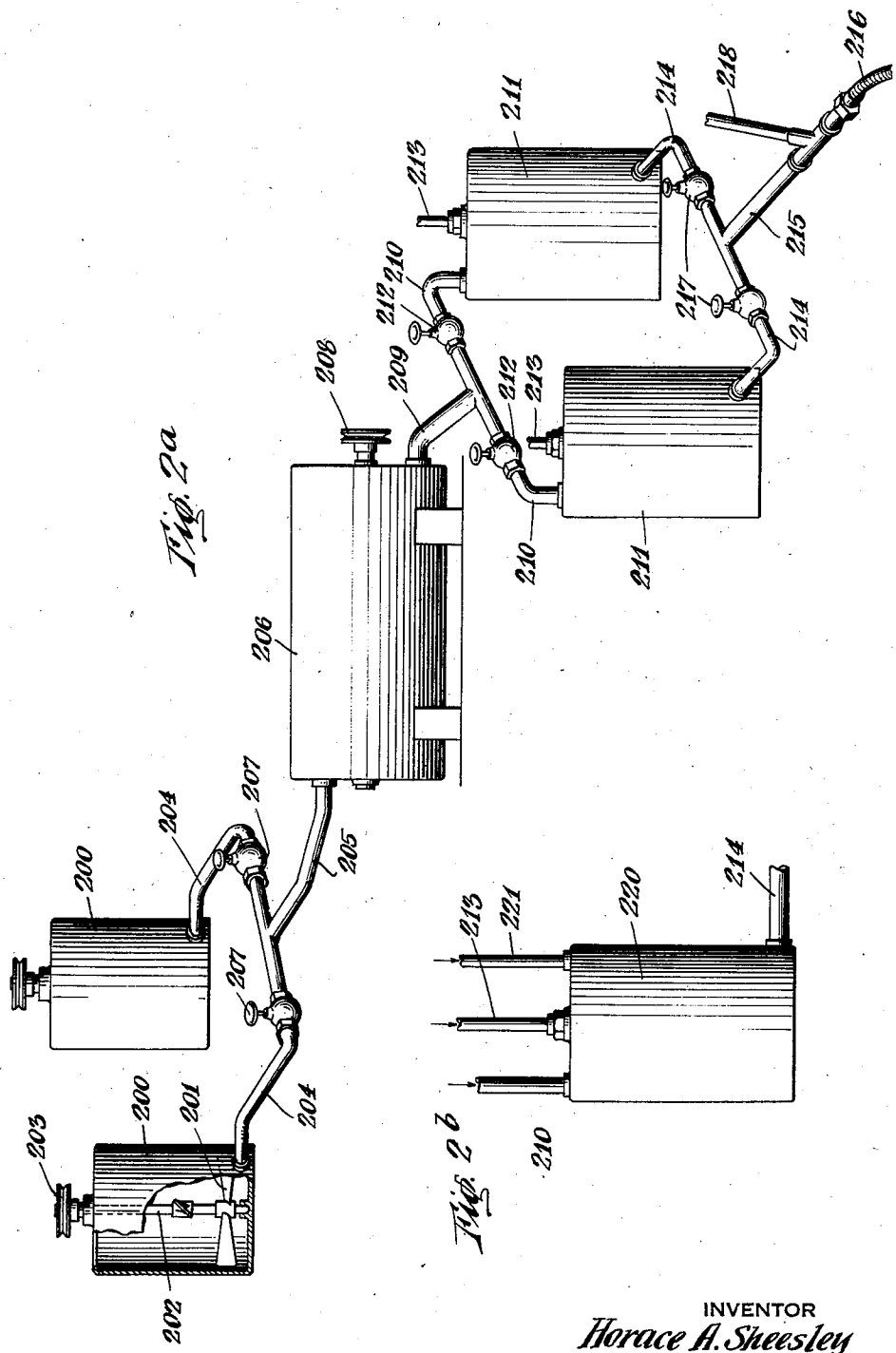


Fig. 2a

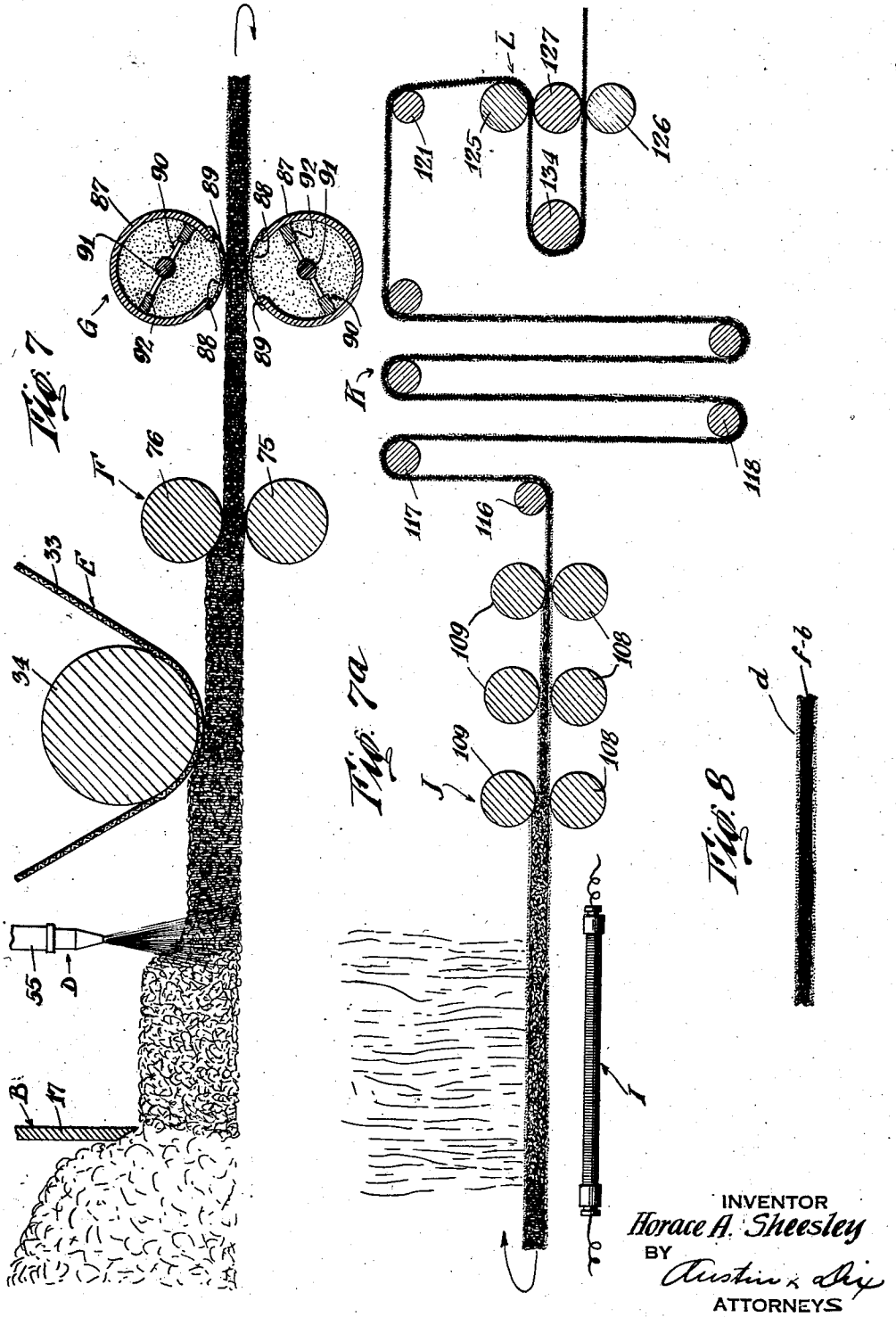
Fig. 2b

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METHOD AND APPARATUS FOR MAKING FIBROUS SHEETINGS

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UNITED STATES PATENT OFFICE

2,206,056

METHOD AND APPARATUS FOR MAKING FIBROUS SHEETINGS

Horace A. Sheesley, Portland, Maine, assignor to Tufide Products Corporation, Portland, Maine, a corporation of Maine

Application October 30, 1935, Serial No. 47,513

37 Claims. (Cl. 91—18)

This invention relates to method and apparatus for making fibrous sheetings and more particularly to an improved method and apparatus for making a composition comprising a mixture of fibres and a binder which can be economically and effectively used as a leather substitute.

It has heretofore been proposed in the manufacture of artificial leather compositions, to mix liquid latex with the fibre either in the beater or following the beater operation. The latex when so treated is inclined to coagulate and gum, resulting in an uneven dispersion of the binding material through the fibres when the sheet is formed.

It has also been proposed to form artificial leather compositions by providing multi-ply sheets of pulp tissue, each separate sheet being coated with a binding material before pressing the several sheets together. Another method proposes to puncture the superimposed tissue sheets by needle holes through which it has been attempted to force the latex binding material. The products formed by these known processes are not satisfactory since the binding medium is not uniformly dispersed in and through the fibres, with the result that the material presents areas of weakness where it can be torn or broken under test or in service. The composition thus formed also readily splits into layers which is most undesirable.

In processes heretofore practiced, the coagulating and/or vulcanizing ingredients have been introduced in such a manner that the binder solids have a tendency to coagulate or congeal before the binder solids have been completely dispersed in and through the fibres.

Latex-fibre leather substitutes as heretofore made, have a rubbery surface characteristic which is very unlike the surface of real leather and immediately identifies it as a leather substitute. The rubbery surface characteristic results from the concentration of excessive amounts of rubber solids by deposition upon the outer surface of the material. The latex solids covering the surfaces of the composition become sticky under pressure and especially so in damp warm weather. This sticky surface characteristic is especially undesirable where the latex pulp material is to be used for the inner soles of shoes. The body weight on the foot exerts pressure on these inner sole materials causing the feet or stockings to stick to the latex coating with resulting discomfort to the wearer. This sticky surface characteristic is also undesirable in other articles or leather products as will be evident to those skilled in the art.

Fibre-latex composition materials made under present known processes lack breathing qualities and are inclined to sweat the feet of the wearer. Such compositions also have a tendency to peel or rub off at the surface, leaving exposed unbound fibres beneath, which in turn will rub off even more rapidly. This further characteristic makes fibre-latex composition materials as heretofore manufactured undesirable for inner soles, causing discomfort to the foot and undue wear on the hose. Washing will not remove latex deposited on clothing or hosiery and for this reason latex pulp compositions heretofore manufactured have not found a ready use where the composition would come into frictional contact with clothing or other washable fabrics.

According to my invention substantially dry fibres of the group comprising wood fibres, linen, cotton, hemp, sisal, henequen, jute and the like vegetable fibres are fluffed in a suitable manner to interlace the fibres in a loosely piled condition so that the fluffed layer is of substantially uniform consistency and free from lumps. The fluffing operation can be performed on a so-called shredding machine of well-known construction which breaks up the lumps and delivers a uniform layer of the fibres on to a continuous belt conveyor, preferably a continuous Fourdrinier paper making screen. Adjusting means are provided for regulating the thickness of the fibre layer placed on the conveyor.

The binding material is forcibly driven into and through the loosely piled fibrous layer preferably by spray guns movably mounted and so arranged as to uniformly spray the entire layer with the binder material. The binder material and the method and apparatus for introducing the same into and through the fibres forms an important feature of this invention. Rubber latex and animal glue gel in suitable proportions are placed in an agitator or mixer and these components slowly stirred so as not to coagulate the latex but nevertheless mix the components. The mixer is connected to a paint mill in which the latex and glue component are ground together to provide a homogeneous mixture. The mixture flows from the paint mill into a compression tank or container where it is stored under pressure. The pressure tank is connected to the spray guns which preferably travel at a rather rapid rate transversely across the loosely piled and fluffed layer of fibres. The guns are so arranged as to thoroughly impregnate the fibres with

the binder material. The spray guns are operated under sufficient pressure to thoroughly impregnate the fibres, the pressure used varying with the consistency and character of the binder as well as the impregnable characteristics of the fibre layer.

The spray guns can be arranged to project the binder into opposite sides of the felted layer simultaneously, and the invention further contemplates establishing an atmosphere of reduced pressure or partial vacuum around the fibre layer at the point of impregnation to facilitate and assist the impregnating action. It is important that the fibres be thoroughly impregnated and coated with the solid constituents of the binder. A further important feature of the invention resides in the introduction of a coagulating material into the binder stream flowing into the spray guns, the introduction of the coagulating agent taking place at such point and under such conditions that no appreciable coagulating action has an opportunity to take place until the fibres have been thoroughly impregnated. In processes heretofore practiced congealing and vulcanizing agents added to the binder or other treatments given the binder, have produced lumps or clots of partially congealed binder solids prior to the introduction of the binder into the fibrous layer, with the result that a thorough impregnation of the fibres throughout the mass has not been obtained. The binder solids are thus concentrated on the outer surface of the sheeting, which has given the sheeting an undesirable rubbery feel and texture and in addition has produced a sheeting which is nonporous, weak and will readily split. My improved process as herein described results in the thorough impregnation of the fibres and in addition the fibres are interlaced and intertwined in a felted mass which produces a sheeting having a high and substantially uniform strength in all directions. In present processes wherein the sheeting is formed from a plurality of tissue layers, the sheeting so produced does not possess uniform strength in all directions which may be explained by the fact that each layer of tissue is formed on a Fourdrinier screen by the usual paper making processes, which gives the tissue greater strength in one direction than the other. The tissue sheets are superimposed one upon the other with the fibres in the sheet generally running in the same direction. By means of my novel felting process, the fibres are intertwined and run in all directions which, when thoroughly impregnated with the binder produces a tougher, stronger and more durable sheeting than has heretofore been made by present known processes.

A further improved feature of my process and apparatus for making fibre compositions comprises the use of an initial compression device which travels in the direction of and at substantially the same speeds as the impregnated fibrous layer. This device operates to initially compress the fibres into a web-forming mass without disturbing or disarranging the interlocked and interfelted relationship of the fibres.

The impregnated fibrous layer is supported on a continuous belting, preferably a Fourdrinier paper screen until the impregnated web has taken an initial set. The screen may be run through a suitable solvent bath to remove any stickiness which might result from binder deposits thereon.

The fibrous web is further compressed between compression rollers and then dusted with suitable surfacing material to remove surface stickiness and give the material the desired surface texture. I have found that wood flour placed within a dusting sieve so as to evenly dust the flour on to the web surface produces an excellent leather-like finish and feel to the product. Where imitation suede leather is to be made the web can be dusted with ground cotton, hemp linters or other animal, vegetable or earthy materials. The binder is not completely congealed and hardened at the point of application of the dusted materials so that the following compression rollers will roll the dusted materials into intimate adhering contact with the web. The web then passes through a drying tunnel to facilitate and hasten the escape of the volatile constituents in the web. A suitable conveyor carries the web through the drying tunnel which may be heated at temperatures ranging from room temperature to 250° F., and if desired, a vacuum pump may be connected to the tunnel to speed up the drying action. Suitable condensing equipment can also be attached to the tunnel to recover the valuable binder liquids which escape, such as for example, the alcohol constituent. The web passes through further compression rollers which apply progressively increasing compressive pressure to the web as the drying continues. The compression pressure exerted on the web at various points through the machine while the drying action continues produces a finished sheeting which is of substantially uniform texture throughout and substantially free from concentrated deposits of binder solids, particularly on the outer surface thereof. The web is given a final drying treatment in a festoon dryer where it remains for several hours. The web can then be run through a so-called leather machine to either calender the surface or emboss the surface to resemble any selected leather. The finished web can then be wound into rolls or cut into sheets of desirable shape and size. The process as herein disclosed permits the production of a finished fibrous sheeting in one continuous process at a great saving in cost.

An object of this invention is to provide an improved process and apparatus for making fibrous sheetings of the type known as artificial leather, which is strong, flexible and durable, which will not readily split, crack, tear or break, which has the surface characteristics and feel of genuine leather.

Another object of this invention is to provide a method and apparatus for making fibre-binder sheetings of a tough flexible nature, which will not disintegrate or become sticky under normal conditions of use.

Another object of this invention is to provide an improved method and apparatus for preparing binder materials including a method and means for impregnating a fibrous layer therewith.

Another object of this invention is to provide an improved method and apparatus for manufacturing fibrous compositions by continuous process, which is economical to perform and operate, which requires a relatively few attendants and which produces a highly satisfactory commercial article.

Another object of this invention is to provide artificial leather compositions in which the fibres are felted and interlaced and homogeneously saturated with an improved binder, includ-

ing an improved process and apparatus for manufacturing such materials.

Other objects of this invention will become apparent as the disclosure proceeds.

In order that this invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the accompanying drawings, illustrating by way of example, one embodiment of the invention, in which:

Fig. 1 is a top plan view showing the apparatus suitable for carrying out the process disclosed herein;

Fig. 2 is a longitudinal vertical cross-sectional view of the apparatus, this view being taken on line 2—2 of Fig. 1;

Fig. 2A is a diagrammatic view illustrating the apparatus which may be used in mixing and preparing the binder used in the process;

Fig. 2B is a fragmentary diagrammatic illustration of modified compression tank used in preparing the binder;

Fig. 3 is an enlarged fragmentary view of a spray device which may be used for forcibly injecting the binder into and through the fibrous layer;

Fig. 4 is an enlarged fragmentary view of one form of conveyor which may be used in carrying out the process;

Fig. 5 is a transverse cross-sectional view of the dusting devices by means of which a surface coating is dusted on the fibrous web during the process of manufacture;

Fig. 6 is a longitudinal cross-sectional view through the dusting devices, this view being taken on line 6—6 of Fig. 5;

Figs. 7 and 7A are continuous diagrammatic views illustrating the process as it may be carried out by the apparatus constructed in accordance with the present invention; and

Fig. 8 is a transverse cross-sectional view illustrating diagrammatically the nature of the material formed by the process of the present invention.

Similar reference characters refer to similar parts throughout the specification and drawings.

The fibres forming a part of my improved artificial leather composition may comprise either cotton, linen, henequen, sisal, hemp, and wood pulp fibres or a mixture of one or more of these. The well known varieties of wood pulp, such as Mitscherlich (sulphite) pulp, soda pulp, bleached sulphite pulp, sulphate (kraft) pulp, may all be used. Old rope and rag pulp also make an excellent material if the fibres still retain their normal tensile strength. It is, of course, necessary to beat and wash the rope or rag fibre material so as to remove all dirt and decayed fibres. It is evident that the stronger and tougher the fibre used the tougher and stronger will be the finished material.

The binder with which the fibres are saturated preferably contains liquid latex as an ingredient. A high grade glue may be added to the liquid latex along with a small amount of ammonia and formaldehyde, and a highly volatile organic liquid. Glue of the blood albumin type is preferably used but fish glues, hide glues, egg albumin, and other fat free animal glues may also be used. Casein glue may be used, but it is not usually recommended due to the fact that it has a tendency to decompose in warm and moist weather. The compound should be free from zince oxide which unfavorably affects the desired binding action of the latex or glue constituents.

The volatile organic liquids preferably used contain alcohol as the principal constituent. A liquid should be selected which is highly volatile, which will readily escape from the fibres and which will preferably aid in removing the less volatile liquid materials, such as water, from the composition during manufacture. A very satisfactory volatile liquid has been made from approximately 85 to 90% ethyl alcohol and approximately 10% of a mixture of methyl alcohol, acetone, ethyl acetate and aviation gasoline. The cheaper alcohols, such as wood alcohol or cheap-grain alcohol, preferably 170 proof, and upwards, can be used.

A small amount of liquid ammonia is added to stabilize the latex in solution and prevent a premature precipitation of the latex solids. A small amount of formaldehyde may also be added to assist in tanning the glue and prevent odors from the resultant product.

By way of example, the following formula has been found satisfactory for the purpose of this invention. To 8½ pounds of liquid latex of good commercial grade is added 6 pounds of blood albumin glue which comprises approximately 1 pound of solid blood albumin and 5 pounds of water. The quantities above referred to are representative and of course will vary within fairly wide limits since liquid latex from various sources may vary in amount of solid constituents and various sources of blood glue also vary in water absorbtive qualities. A liquid latex containing approximately 40% rubber solids provides a desirable material. Sufficient water should be added to the solid blood albumin to reduce the same to a soft but non-flowing gel.

For blending purposes approximately ½ to 2 pounds of a readily volatile liquid comprising a major portion of ethyl alcohol is added. The escape of the liquid constituents of the binder from the fibres may be facilitated by increasing the quantity of alcohol added. The proportion of aqueous ammonia which is added will depend upon the amount of ammonia contained in the commercial liquid latex. As a general rule, however, most commercial grades of latex will require the addition of from ½ to 2 pounds of liquid ammonia to every 8½ pounds of latex. Approximately ½ ounce of formaldehyde added to the above constituents is sufficient to remove any odors from the material and exert the desired tanning and hardening action on the blood albumin glue. A binder material containing approximately the above proportion of ingredients is liquid and free flowing and can be readily incorporated into the fibrous mass to homogeneously coat the fibres and bind them into a solid mass.

In summarizing the effective formula above referred to, the binder may contain approximately 18 to 22% rubber solids from latex, 4 to 7% of blood albumin, giving a solid constituent of approximately 25%, a liquid constituent of 70 to 74%, and a gaseous constituent of 1 to 4%. The normally liquid and gaseous constituents would comprise approximately 60 to 65% water, 6 to 8% ethyl alcohol (which might also contain approximately 1% or less of methyl alcohol), ethyl acetate and aviation gasoline, together with approximately $\frac{1}{10}$ to 1% of formaldehyde and from 1 to 3% ammonia.

The above formula is given by way of example only. The amount of liquid latex used may vary

within wide limits depending upon the type of material desired. A strong, tough and flexible material results when liquid latex in the approximate proportions above given are used. If a considerable increase in liquid latex is made the material will begin to have a rubbery feel and will be inclined to sweat the feet when used as an inner sole.

Commercial latex varies in solid latex constituents anywhere from 25 to 60%. Since the solid constituent is the important component it is always desirable to test each batch of latex for rubber solids before combining the same into the mixture. Different types of albumin blood glue will also absorb different quantities of water varying from 1 part dry glue to 4 to 7 parts water, depending upon the source of the albumin which varies in different animals. Sufficient water should be added to the dry glue to produce a soft but non-flowing gel. A composition comprising approximately 1 part latex solid to 1 part glue gel will produce a material which possesses hardness and considerable stiffness. A composition containing approximately 4 parts latex solid to 1 part glue gel makes an excellent leather substitute, highly adaptable for inner soles and quarter linings for shoes. The percentages used may thus be varied from approximately 1 part latex solid to 1 part glue gel (producing a relatively hard stiff material) to approximately 9 parts latex solids to 1 part glue gel (producing a highly flexible tough and strong material). From 2 to 20% of highly volatile liquids such as alcohol may be used, depending upon the hardening and drying speed desired.

In carrying out the process, the proper proportion of liquid latex and albumin glue gel is placed in an agitator or a mixer **200**, as shown in Fig. 2A, and slowly but thoroughly mixed for approximately thirty minutes. The ingredients are mixed within the mixer tank **200** by means of suitable paddles **201**, fixed to rotate on a rotatable shaft **202** suitably driven from a power source connected to the pulley **203**. The proper amount of ammonia should be added to the mixing tank **200** to prevent the latex from congealing during mixing. When the mixing has been completed, the mixture flows from the agitator tank **200** through the discharge pipe **204** and **205** to a paint mill **206** of well known construction. The paint mill thoroughly mixes the latex and albumin gel components into a homogeneous mass. A suitable power source connected to the pulley wheel **208** of the paint mill drives the apparatus. The flow from the mixer tank **200** to the paint mill may be regulated by means of a suitable valve **207**.

From the paint mill the homogenized latex albumin gel constituents flow through the discharge pipe **209** and **210** into a compression tank **211** where the binder may be stored until ready for use. Flow from the paint mill to the pressure tank **211** may be regulated by means of a suitable valve **212**. Air is introduced to the compression tank through the pipe **213** and the binder therein is held at a pressure of from 25 to 125 pounds per square inch. The binder flows under pressure through the discharge pipe **214** and **215** and into the flexible hose **216**, leading to the spray guns **55**, which will hereafter be described. The flow into the spray guns may be regulated by a suitable valve **217**.

In order to provide for a continuous flow of binder into the spray gun it is preferable to provide two mixers or agitators **200** so that when the material is being mixed in one mixer, the mixed contents can be removed from the other mixer by suitably manipulating the valves **207** and thus provide a continuous flow of mixed material into the paint mill **206**. The material is continuously mixed in the paint mill from which it preferably flows to either one of two compression tanks **211** so that while one tank **211** is being emptied by the action of the spray guns, the other tank may be filled and placed in readiness for discharge of the contents.

It is well known that concentrated alcohols exert a setting, cooking or congealing action on albumin glue and also operate to congeal the latex. Formaldehyde also operates to congeal the latex. It is of the utmost importance that no congealing action of the latex or glue gel mixture takes place until the fibres have been thoroughly impregnated and saturated with the binding material. I overcome this congealing action by feeding the alcohol and formaldehyde or other congealing constituent into the pressure feed line **215** through the introducing pipe **218**. The alcohol, formaldehyde or other congealing constituent mixes with the latex glue gel material as it passes through the spray gun at great speed and it is therefore given no appreciable time or opportunity to effect congealing action of the latex or glue gel until the fibres have been uniformly coated therewith.

There is shown in Fig. 2B a diagrammatic view of a modified compression tank **220** having the pressure air inlet **213**, the latex-glue inlet **210**, and the latex-glue outlet **214**. A feed line for introducing the alcohol and formaldehyde or other congealing agent is connected directly to the tank. Where the pressure is sufficiently high or the congealing action relatively slow, the congealing components of the binder may thus be introduced directly into the tank, although it is generally preferably to introduce the congealing components immediately prior to discharge from the spray apparatus.

The apparatus for forming the fibrous layer comprises generally a shredder A, a gate-gauge B which controls and regulates the depth of the material delivered by the shredder A onto the continuous belt conveyor C, spraying apparatus D arranged to project the binder liquid into and through the fluffed fibres as they are carried along on conveyor C, and a felter E operative to initially compress the layer, and a web-forming mechanism to compact the impregnated fibrous layer into a continuous web. A duster mechanism G is provided for dusting the surfaces of the web with a suitable surfacing material. A wire conveyor H conveys the web through a tunnel dryer I, having heating coils and other drying apparatus associated therewith. A series of compression rolls J progressively compress the web, which then passes through a festoon dryer K in which the drying is completed. A suitable finishing device L is provided for calendering, embossing or otherwise finishing the surface of the finished web.

The fibres comprising cotton, linen, hemp, sisal, henequen or wood pulp, or a mixture of one or more of these are fed in substantially dry condition into the shredding machine A.. The shredder comprises generally an arcuate lower housing **2** supported upon suitable frame **1**. The housing **2** is provided on its inner surface with a series of upstanding teeth **3** and an arcuate upper housing **4** covers the shredder and defines with the lower housing **2** a substantially cylin-

drical chamber 5. Disposed in the chamber 5 is a rotatable drum 6 carried on a shaft 7 and provided with a series of teeth 8 arranged in staggered relationship with respect to the teeth 3 extending from the lower housing. The drum 6 is driven by a pulley wheel 10 operably connected by the belt 9 to the main driving motor 11. The shredder acts to thoroughly mingle and intertwine the various fibres in a loose felted mass, removing all lumping material so that the fibrous mass has a uniform consistency.

The lower housing 2 may be provided with a horizontal lip or apron 15 and the upper housing 4 terminates short of this lip to provide a discharge opening 16 whereby the material discharged from the shredder passes through the opening 16 and is pushed across the lip 15 onto the continuous conveyor belt 25. The amount of fluffed fibrous material passing through the discharge opening 16 may be regulated by an inclined gate 17 which may be vertically adjusted by means of a suitable device such as screws 18 threaded into a threaded lug 19 fixed to the gate 17 and through an opening in a bracket 20 fixed to the frame 1.

The continuous conveyor C preferably comprising a Fourdrinier or paper making wire 25, is trained to rotate over drums 26, 27 and 28 carried on the shafts 29, 30 and 31 respectively. The drum 29 is positioned in and hence causes the Fourdrinier wire 25 to pass through a tank 32 containing water, ammonia or other suitable solvent for removing any congealed binder gummed on the wire from contact with the binder discharged from the sprayer D. A traveling belt conveyor may be substituted for the Fourdrinier wire but it has been found that the latter is generally the most satisfactory form for carrying out the present process.

The loosely piled mass of fibres evenly distributed in a layer of proper thickness on the Fourdrinier wire 25 is subjected to the action of the sprayer which preferably comprises spray nozzles which project the liquid binder into the loosely felted mass of dry fibre so that all the fibres are then uniformly impregnated and coated with the liquid binder. The spray nozzles 55 are disposed above the conveyor C so as to direct the binder into the felted mass. It is understood however that spray nozzles can be arranged both above and below the Fourdrinier wire 25 so as to direct and project the binder into the felted mass from both sides thereof. When the felted mass is rather dense or when other difficulties are encountered, a partial vacuum arrangement may be provided to assist by sucking or drawing the liquid binder into and through the fibres. The sprayer D may comprise a plurality of transversely reciprocable spray nozzles 55 having suitable lugs or other means slidable along transverse rods 57 fixedly supported in the frame 1. The reciprocal movement of the nozzles 55 may be limited by means of collars 58 and 59 adjustably fixed on each of the rods 57. Each nozzle or spray gun 55 is provided with a binder supply conduit 216 and a discharge outlet 62. The spray nozzles may be of any known construction, such, for example, as those used in spraying paint under pressure. Each spray nozzle may be provided with an outstanding arm 65 to which is pivoted a rock-lever 66 normally held in vertical position by a spring 67 adapted to lie in the path of a pin 68 carried on an endless chain 69, trained over sprockets 70 and 71, mounted on the sides of the frame 1. A sprocket 72 suitably connected to the motor 11 drives the sprocket 70 through gear 73 to reciprocate the spray gun.

When the sprocket 72 is rotated to drive the sprocket 71, the chain 69 is carried along to move the pin 68 in the direction of the arrows. When the pin is moved along by the upper carry of the endless chain it bears against the rock-lever 66 to move the nozzle 55 from right to left (as seen in Fig. 3). The nozzle 55 engages the collar 58 when the pin 68 reaches the end of the upper carry, and the pin then rocks the rock-lever 66 in a counter-clockwise direction, and rides off the lever and around the turn of the chain 69. The pin 68 engages the lower end of the rock-lever 66 as it enters the path of the lower carry of the chain 69, and then drives the nozzle 55 from left to right until the nozzle engages the collar 59. The pin 68 then rides off the rock-lever 66 and around the turn, and again engages the upper end of the rock-lever 66 to move the nozzle 55 again from right to left. This operation is carried out continuously to separately reciprocate the nozzles 55 across the path of the fibre layer on the conveyor C. Preferably the pins 68 are arranged in staggered relation so that they follow one another across the path of the material on the conveyor. A sufficient number of supporting nozzles 55 is pivoted to fully impregnate the fibre web as it moves along the conveyor C.

Disposed above and cooperating with the conveyor C is the felter mechanism E which preferably takes the form of a Fourdrinier or paper making wire 33 trained over rolls 34, 35 and 36 mounted respectively on shafts 37, 38 and 39. The wire 33 also is trained over a roll 40 positioned in a tank 41, containing a bath of suitable binder solvent to maintain the wire 33 in clean condition and free from any gummy or sticky binder where it contacts the web. The roll 34 is positioned to maintain the lowermost portion of the wire 33 at a predetermined distance above the wire 25 in order to effect a matting of the layer of fibres as the layer passes between the wires, after having been saturated by the liquid binder material projected by the spray nozzles 55. The felter E is arranged and constructed so as not to disturb the interlocked relationships of the fibres. A suitable liquid absorbent belting or an absorbent roller might also he used in place of the wire 33.

Carried on the shaft 7 is a sprocket 42 over which is trained a chain 43 which is trained around a guide sprocket 44, a sprocket 45 and a sprocket 46. The sprocket 46 is carried on a shaft 29 and drives the conveyor C. The sprocket 45 is carried on a shaft 48 which carries a sprocket 49 guiding a chain 50 which is trained over a sprocket 51 carried on a shaft 37 and which drives the felter mechanism E. Preferably all of the various portions of the mechanism which rotate are driven from the motor 10, in order that the operation of all of these portions be synchronized. However, it is within the contemplation of the invention to provide individual, but suitably synchronized, drives for the various portions of the apparatus.

Disposed beyond the end of the conveyor C is the web-forming mechanism F including a pair of cooperating web-forming rolls 75 and 76 carried respectively on shafts 77 and 78. Roll 76 is supported in a frame 79 and it may be adjusted toward or away from the roll 75 by means of an adjusting screw 80 secured in the frame 1. The

roll 76 is driven by a chain 81 trained over a sprocket 82 carried on a shaft 31.

The alcohol or highly volatile material quickly escapes from the fibres by evaporation and carries with it a considerable quantity of aqueous material contained therein. Before escaping, however, the alcohol as well as the formaldehyde exerts a setting and hardening action on the latex solids and glue binders with the result that the saturated web quickly assumes a self-sustaining tensile strength.

When the saturated web has assumed an initial set a powdered material is dusted uniformly over the surfaces of the web to give the finished material the desired leathery feel and remove surface stickiness. Wood flour provides a satisfactory surfacing material, although other powdered materials, either of animal, vegetable or earthy origin may be used.

One or more dusters G adapted to dust pulverulent material, such as wood flour or ground linters upon one or both sides of the web, is provided. Each duster consists of a cylindrical housing 87 having a longitudinal opening 88 covered by a fine screen 89. Within the housing 87 is an agitator 90 which may consist of a rotatable shaft 91 carrying a plurality of blades or paddles 92 having their edges adjacent the inner surface of the housing 87. The paddles serve to eject the pulverulent material through the screen-covered opening 88 against the surface of the web.

The dusters G are actuated by a chain 93 passing around the sprocket 82 and sprockets 94 and 95, fixed to the shafts 91.

After passing through the dusters G the web moves into a drying tunnel where it is heated to approximately 212 deg. F. and upwards to 250 deg. F. more or less. The greater portion of the volatile liquid constituents, particularly water, are driven off and evaporated from the felted web in the drying tunnel. The web is partially self-sustaining by the time it reaches the drying tunnel and may be carried therethrough on a relatively simple inexpensive conveyor, which has a minimum of contact with the web and leaves as much of the web surface exposed for drying as possible. The conveyor may comprise a pair of spaced endless chains 96 having threaded therebetween in serpentine form one or more wires 97 adapted to support the web with a minimum of contact therewith. The endless chain 96 may be trained over sprockets 98 and 99 carried on shafts 100 and 101 which sprockets are suitably driven by a sprocket 102 carried on a shaft 100 and connected to suitable driving mechanism by chain 103.

A suitable heater I is provided within the drying tunnel capable of heating the tunnel from 112 deg. F. to 250 deg. F. and upwards. The heat is maintained within the tunnel by a suitable housing 104. For purposes of illustration I have shown the heater I as consisting of a plurality of elongated parallel electric heating coils preferably disposed below the upper carry of the conveyor H so as not to obstruct the evaporation of the liquid. Any other well known form of heater can be used, however, within the contemplation of this invention. To hasten the drying action the pressure in the drying tunnel enclosure 104 may be reduced to a partial vacuum by means of a vacuum pump 106 and suitable means, such as condensing apparatus 107, may be provided to recover the valuable volatile material, such as alcohol, used in the process.

During the travel of the web through the tunnel dryer or immediately following its travel through the tunnel dryer, the web may pass through one or more sets of compression rollers J to progressively compact and compress the web together into a homogeneous sheet. The compression rolls may consist of a plurality of sets of rolls, each consisting of a lower roll 108 and an upper roll 109. The upper roll 109 is carried on a frame 110 and is vertically adjustable by means of an adjusting screw 111 mounted on the frame 1. Each set of rolls has progressively smaller clearances than the preceding roll in order to provide a progressive compacting action on the web. The sets of rolls may be driven from the motor 10 by any suitable mechanism.

Adjacent the end of the drying tunnel H is a festoon dryer K consisting of a housing 115, containing a direction roll 116 and a series of upper and lower supporting rolls 117 and 118. The housing is provided with entrance and exit openings 119 and 120 to permit the passage of the web into and out of the housing. The temperature of the festoon dryer is preferably kept between 80° F. and 100° F. and the humidity controlled so that drying may be facilitated. The web preferably passes continuously through the festoon dryer, remaining in the dryer a sufficient number of hours to properly dry the sheeting. Disposed adjacent the exit opening 120 is a direction roll 121, which permits the web to be turned from a horizontal to a vertical direction.

As the web leaves or is about to leave the festoon dryer it is preferably given a finishing treatment so as to either calender the surface or emboss the surface to imitate the particular type of leather or material desired. This may be accomplished by a leather finishing device which may comprise rolls 125, 126 and 127 between which the web moves. The rolls 125 and 126 are preferably adjustably mounted on supports 128 and 129 so that the relative spacing between the rolls may be controlled by adjustment of the screws 130 and 131.

To facilitate the leathering treatment, the web may be returned to the festoon dryer during its passage through the leather finishing device by passing the web around a roller 134, positioned within the festoon enclosure.

A layer of carded felted fibres approximately two inches in thickness will reduce down to a completed artificial leather composition approximately $\frac{1}{8}$ of an inch thick. The looseness of the felted layer through which the binding solution is sprayed can thus be readily understood. In addition, the felted condition of the fibrous constituent gives a finished material of uniform strength in all directions.

An unusually tough and strong material having the desirable characteristics of genuine leather may be formed by combining approximately one gallon of the liquid latex glue binder with approximately 5 pounds of wood pulp. The finished artificial leather product preferably contains from 50 to 65% substantially dry pulp and from 35 to 50% solid binder material. These proportions of course can be varied to give materials having a more fibre-like composition by reducing the binder constituent to 20 or 30% and increasing the fibre material to 70 or 80%. To make a material having more rubber-like characteristics the binder material can be increased to 60 or 65% of the total composition. If strength and toughness is not of prime impor-

tance, the liquid latex can be materially decreased and the glue component proportionately increased to produce a product which is stiffer and yet is strong and porous and possesses a leathery feel. Respirability or "breathing" of natural rubber is thus readily simulated in varying degrees, in the products of the present invention.

The albumin glue increases the resistance of the resultant product to water and heat and increases its firmness and hardness. The glue constituent appears to assist thorough penetration of the fibres and a complete dispersion of the solid particles of the binder among the fibres. The volatile solvents, as above described also greatly assist in the driving off or removal of the water constituent, thus shorting the time for drying of the finished material and furthermore assists in making the product homogeneous. While the above binder compound flows readily and appears to be even more liquid than the latex constituent, it nevertheless has the unusual and desirable characteristics of drying out with greater rapidity than latex compounds heretofore used, and at the same time obtaining a more thorough penetration and a more uniform dispersion of the solid binding material in the fibres. The raw materials can be prepared and fed into suitable apparatus which carries the material progressively during manufacture until the finished product is obtained in one continuous process thus effecting great saving in cost of manufacture over processes heretofore used. The wood flour is relatively inexpensive and is applied and rolled into the surface of the material while the web of saturated fibres moves through the apparatus, effecting further saving in cost of manufacture. Thus a product which has superior qualities over artificial leather compositions heretofore made is produced at a great saving in cost. The product is especially adapted for shoe manufacture and particularly inner soles. Actual tests of the material in use as inner soles have demonstrated that my artificial leather composition is comfortable to the feet, substantially respirable and waterproof, prevents the entray of moisture through the shoe and yet does not draw the feet nor cause the feet to sweat or heat.

The web of sheet material as it comes from the leather finishing device L is suitable for use without further treatment, the product having a flexible, tough and reasonably hard, leathery texture which renders it particularly adaptable for use as a leather substitute. It should particularly be noted that no vulcanizing or other equivalent treatment is necessary to render the product suitable for the desired uses.

The use of substantially dry fibres which are thoroughly fluffed and felted in the shredder and the use of a liquid binder material which is projected under pressure into and through the fibre layer before coagulating action has set in insures that the fibres will be intimately and thoroughly impregnated and coated with the binder, producing a material which is respirable, of high uniform strength in all directions and is free from binder clots and stratified layers.

The product has an unusually uniform texture and a high degree of resistance to deterioration due to abrasion and to splitting or tearing.

The preliminary matting or felting of the saturated layer, prior to formation of the web, without disturbing the inner felted position of the fibres, further serves to provide an interior structure in which the fibres are securely interlocked with each other, producing a finished product having a relatively high tensile strength in all directions.

The application of the powdered surfacing material to the saturated web, before complete solidification of the solid constituents of the binder, provides a novel surface texture not hitherto obtainable in prior processes. The powdered surfacing material such as wood flour does not affect the respiratory character of the product.

It is particularly to be noted that the process is a continuous one and that the web is progressively formed from a very loosely piled layer and progressively compacted between successive compacting and web-forming devices whereby the original interlacing of the fibres is not materially altered but the fibres are merely compressed into a more compact form without separation or stratification. It will be noted also that the apparatus is relatively simple and compact having in mind the complex nature of the operations to be carried out in forming the product and further that the series of operations are themselves relatively few and simple in view of the wide difference between the starting ingredients and the finished material.

The product resulting from the process above described may have widely varying appearances and characteristics depending upon the nature of the products employed and the details of the operations. However, the preferred material is one which is generally similar in nature and appearance to leather and which has a relatively high and uniform tensile strength, which is flexible, tough, non-splitting and waterproof and has a sufficiently stiff and hard surface to permit use in cases where leather is now employed. Not only is this product suitable as a leather substitute but by reason of its waterproof nature it is suitable in many applications where leather is unsuitable and rubberized material must be used, and furthermore is suitable for use where no hitherto known material was fully suitable for the reason that the present material has many of the characteristics of both leather and pure rubber, or rubber-containing material, and characteristics not possessed by either.

My artificial leather composition may be given a surface appearance closely resembling suede leather by dusting suitably dyed ground cotton, hemp or sisal linters over the surface of the material. Highly desirable wall and floor coverings of great strength and wearing qualities can also be made by using rope or hemp fibres in the composition. The finished material may be made of any desired thickness ranging from two irons to twenty-four irons.

The invention further consists in the new and novel compositions and in the constituents as set forth in the specification and all equivalents thereof, including the new and useful arrangement and combination of steps in the process and apparatus herein described and more particularly set forth in the claims annexed hereto.

What I claim is:

1. The process of making a leather-like composition including, in combination, establishing a substantially dry loosely piled layer of cellulose fibres, forcibly impregnating said substantially dry loosely piled layer of fibres with a binder, subjecting the impregnated fibrous layer to pressure, and removing the liquid fugitive components from the body under treatment.

2. The process of making artificial leather compositions which include, establishing a sub-

stantially dry loosely piled fibrous mass of substantially uniform consistency, forcibly impregnating said loosely piled fibrous mass with a binder, subjecting the impregnated fibrous mass to a plurality of successively increasing compression steps, and removing the liquid fugitive components from the body under treatment.

3. The process of forming leather-like sheeting which includes, establishing a loosely piled layer of cellulose fibres of substantially uniform consistency, projecting a rubber-latex-containing liquid into said loosely piled layer, coagulating said latex in situ, and compressing said layer.

4. The process of making artificial leather compositions which includes, establishing a fluffed fibrous mass, forcibly impregnating said fluffed fibrous mass with a binder-liquid mixture, and injecting into said binder-liquid mixture a coagulating material for the solid constituents of said mixture in such a manner that the solid constituents of the mixture are deposited in and on the fibres before any substantial coalescing action of the solid residuum has an opportunity to take place.

5. The process of forming fibrous sheeting which includes, impregnating loosely piled cellulose fibres with a rubber-latex-containing material, compressing the fibres to form a web, withdrawing the liquid constituents contained in the web, and compressing said web at successive stages during withdrawal of the liquid constituents.

6. The process of forming leather-like sheeting which includes mixing rubber-latex and animal glue with stabilizing additions to provide a binder, spraying the binder into a loosely piled mass of cellulose fibres under conditions adapted to substantially uniformly impregnate the fibres, subjecting the impregnated fibrous mass to a series of successive compression steps whereby to establish a web of progressively decreasing thickness, withdrawing the non-coagulable liquid fugitive components of the binder from the web, and subjecting the so-formed product to finishing treatment.

7. The process of forming fibrous sheeting which includes, impregnating a loosely piled fibrous mass of cellulose fibres with a binder, and compressing the binder-impregnated mass between opposed and coacting traveling sheeting members.

8. Steps in the process of forming fibrous sheeting which include, impregnating a loosely piled fibrous mass of cellulose fibres with a binder, and initially felting and compressing the binder-impregnated fibres between opposed and coacting traveling foraminous members.

9. The process of forming artificial leather compositions, including, in combination, forcibly impregnating a continuous batting of loosely piled cellulose fibres with a binder, said binder comprising a mixture of solid and liquid components, initially compressing the binder impregnated fibres between foraminous members to establish a continuous web, applying finely divided surfacing material to said web, subjecting the web to a plurality of compression steps, treating said web to remove a substantial portion of the liquid components therein, and subjecting the web to a pressure finishing treatment.

10. The process of forming fibrous sheeting, including in combination, impregnating a layer of substantially dry loosely piled cellulose fibres with a binder, said binder comprising solid and liquid components, forming a continuous web from the impregnated fibrous mass, subjecting said web to a plurality of progressively-increasing compression steps whereby to prevent surface densification of the mass and ensure a substantially homogeneous structure thereto, and subjecting the web to treatments adapted to remove a substantial portion of the liquid during the movement of the web through said compression steps.

11. Apparatus for manufacturing a leather substitute which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a predetermined unitary layer of said substantially dry loosely piled unstratified fibres, pressure means for projecting a binder-liquid mixture into said loosely piled layer, and compression means for compacting said layer after impregnation into a self-sustaining web.

12. Apparatus for forming fibrous base sheeting which includes, means for establishing a predetermined layer of loosely piled unstratified cellulose fibres, means for projecting a binder-liquid mixture into said loosely piled layer, opposed conveyor means having a uniform direction of travel for compacting said impregnated layer into web form, and a series of compression rollers for progressively compacting and reducing the thickness of said impregnated web.

13. Apparatus for manufacturing artificial leather which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a predetermined layer of said loosely piled unstratified fluffed fibres, means for projecting a binder-liquid mixture under pressure into said layer of loosely piled fluffed fibres, said projecting means including a plurality of spray guns so constituted and arranged as to uniformly cover the surface of the fluffed fibre layer under treatment, and means for progressively compacting and reducing the thickness of said web.

14. Apparatus for forming fibrous base sheeting which includes, means for establishing a predetermined substantially dry layer of loosely piled unstratified celulose fibres, means for introducing a binder component substantially uniformly into and through said loosely piled fibre layer, means for compacting the binder-saturated fibrous layer, means for applying a surfacing material to said layer, and means for further compressing said layer to further reduce the thickness thereof and to cause said surfacing material to adhere to said web.

15. Apparatus for forming sheeting from fibres and a binder which includes, means for establishing a predetermined layer of loosely piled fibres, means for mixing and homogenizing the binder components, pressure storage means for receiving and retaining the homogenized binder, means for introducing setting and solidifying agents into the homogenized binder while under pressure, spraying means for introducing the binder into the fibrous layer, and means for compacting the binder-saturated fibrous layer.

16. Improved apparatus for impregnating a fibrous mass with a latex containing binder which includes, means for containing said latex binder under pressure, a pressure spray device adapted to force the latex containing binder into said fibrous mass, and means for introducing a latex coagulating agent into the latex stream flowing under pressure from said containing means through said pressure spraying device at such point and under such pressure

that said agent has no opportunity to substantially coagulate said latex prior to impregnation of said fibres.

17. Apparatus for manufacturing artificial leather which includes, a fibre fluffing device operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a unitary substantially dry unstratified layer of said fluffed fibres, means for introducing a binder component substantially uniformly into and through said fluffed layer, and means for initially compacting said fluffed saturated layer, said compacting means including a continuous conveyor belt upon which said web is supported and a continuous belt superimposed over said web and in contact therewith, and means for driving said belts uniformly in the same direction and at substantially the same rate of speed.

18. Apparatus for manufacturing leather substitutes which includes, a fiber fluffing device, operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry loosely piled layer of said fibres, and means for impregnating said loosely piled fibre layer with a liquid binder, said means including a plurality of spray devices operative to project said binder into and through said loosely piled layer, and means for advancing said impregnated layer continuously through said spray.

19. Apparatus for forming fibrous base sheeting which includes, means for establishing a substantially dry predetermined layer of loosely piled fibres, a continuous belt for supporting said layer and advancing the layer forwardly, means for impregnating said layer with a binder, a roller superimposed over said layer, and a continuous belt of paper-making wire extending around said roller and in pressure contact with said layer, and means for driving said supporting belt and said paper-making wire at substantially the same uniform speed.

20. Apparatus for forming fibrous base sheeting which includes, means for establishing a substantially dry predetermined layer of loosely piled fibres, means for impregnating said layer with a binder, and means for advancing said layer forwardly including a pair of continuous belts of paper-making wire in pressure contact with both sides of said layer, means for driving said belts in synchronism, and means for removing adhering particles of the binder from said belting as it moves out of contact with said layer.

21. Apparatus for manufacturing leather substitutes which includes, means for reducing wood pulp sheets into a substantially fluffed unstratified and loosely piled mass of individual fibres, means for spreading said fluffed fibres into a layer of substantially uniform thickness, means for adjusting said spreader means, and means for impregnating said fluffed fibrous layer with a binder.

22. Apparatus for forming a fibrous base sheeting which includes, means for establishing a substantially dry unstratified layer of loosely piled fibres, means for impregnating said layer with a binder, means for exerting an initial compacting action on said impregnated layer without disturbing the interlocked relationship of said fibres, means for further pressing and compacting said layer, means for drying said layer to remove the volatile components of said binder, and a series of paired compression rolls, each following pair of rolls exerting an increased pressure and compacting action on the fibrous layer moving therethrough.

23. Apparatus for making leather substitutes including, a shredder operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, a gate gauge for establishing an unstratified layer of said fluffed fibres of predetermined thickness, a continuous belt conveyor moving the fluffed fibrous layer forwardly, means for impregnating said fluffed fibrous layer with a binder, and a means operative to initially compress the impregnated layer supported upon said conveyor without disturbing the interlocked relationship of said fibres.

24. Apparatus for making leather substitutes which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry unstratified layer of said loosely piled fibres, means for impregnating said layer with a binder, a dusting mechanism for applying surfacing material to said layer, and means for compacting said layer into a firm self-sustaining web.

25. Apparatus for forming artificial leather sheeting which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry unstratified layer of said loosely piled fibres, means for impregnating said loosely piled fibre layer with a liquid binder, means for progressively compressing said layer into a compact self-sustaining web, and a festoon drier for removing the volatile components contained in said web.

26. Apparatus for forming fibrous sheeting which includes, means for establishing a substantially dry unstratified layer of loosely piled fibres, means for impregnating said loosely piled fibre layer with a liquid binder, means for applying a surfacing material to said layer, means for progressively compressing said layer into a self-sustaining web of the desired thickness, and a drier for removing the evaporable liquid constituents contained in said web.

27. Apparatus for making leather substitutes which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry unstratified layer of said loosely piled fibres, means for impregnating said loosely piled fibre layer with a liquid binder, means for progressively compressing said layer into a web of the desired thickness, a drier for removing the liquid volatile components contained in said web, and rolls for applying a surface finish to said web.

28. Apparatus for forming fibrous sheeting which includes, means for establishing an unstratified layer of loosely piled fibres, means for impregnating said layer with a binder, a continuous conveyor belt moving the fluffed fibres forwardly, means for removing adhering particles of the binder from said conveyor belt, and means for progressively compacting said layer into a continuous self-sustaining web.

29. Apparatus for making leather substitutes which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual interlaced fibres, means for producing a loosely piled layer of said interlaced fibres, a continuous conveyor belt moving the fluffed fibres away from said fluffing means, means for establishing a predetermined layer of said fluffed fibres on said conveyor, means for impregnating

said fluffed fibre layer with a binder, and means for progressively compacting said layer into a self-sustaining web.

30. Apparatus for forming artificial leather sheeting which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry unstratified layer of said loosely piled fibres, means for advancing said layer forwardly, spray devices for impregnating said moving layer of loosely piled fibres with a binder, and driving mechanism for reciprocating said spray devices transversely across said moving layer to uniformly saturate said layer with a liquid binder.

31. Apparatus for forming fibrous sheeting which includes, means for establishing a substantially dry unstratified layer of loosely piled fibres, a continuous belt adapted to support said layer of fibres, means for impregnating said layer with a binder, and a felter mechanism including a continuous Fourdrinier wire, means for supporting said wire, and a roller retaining said wire in pressing contact with said impregnated layer to initially compress and mat said layer.

32. Apparatus for forming fibrous sheeting which includes, a continuous belt adapted to support a layer of fibres, means for impregnating said layer with a binder, and a felter mechanism including a continuous Fourdrinier wire, means for supporting said wire, a roller retaining said wire in pressing contact with said impregnated layer to initially compress and mat said layer, and means for applying a binder solvent to said wire to remove particles of binder adhering thereto.

33. Apparatus for forming artificial leather sheeting which includes, mechanism operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry unstratified layer of said loosely piled fibres, means for advancing said layer forwardly, means for impregnating said loosely piled fibre layer with a binder, and mechanism for forming a self-sustaining web from said layer, said mechanism including a plurality of cooperating pressure rolls operative to press said layer by stages into a compact self-sustaining web.

34. Apparatus for forming artificial leather sheeting which includes, means for establishing an unstratified layer of loosely piled fibres, means for impregnating said layer with a binder, means for compressing said layer into a self-sustaining web, and a duster for applying surface material to said web, said duster including a housing having a discharge opening therein, a sieve extending over said discharge opening, and an agitator in said housing for ejecting the surface material through said opening.

35. Apparatus for forming artificial leather sheeting which includes, means for establishing an unstratified layer of loosely piled fibres, means for impregnating said layer with a binder, means for compressing said layer into a self-sustaining web, a drying tunnel, a conveyor in said tunnel for supporting and conveying a binder-saturated web of fibrous material, said conveyor having web supporting elements associated therewith, said elements being spaced apart and having a minimum surface contact with said web.

36. Apparatus for forming artificial leather sheeting which includes, means for establishing an unstratified layer of loosely piled fibres, means for impregnating said layer with a binder, means for progressively compressing said layer into a self-sustaining web, a drying tunnel, a conveyor in said tunnel for supporting and conveying a binder-saturated web of fibrous material therethrough, heating means in said tunnel for facilitating the escape of the volatile components of said binder-saturated web, and condensing apparatus associated with said drying tunnel for recovering the volatile material escaping from said web.

37. Apparatus for forming artificial leather sheeting which includes, a fibre fluffing device, operative to reduce wood pulp sheets to a loosely fluffed mass of individual fibres, means for establishing a substantially dry-unstratified loosely piled layer of said fibres, means for impregnating said layer with a liquid binder, means for compressing said layer into a self-sustaining web, and a festoon drier for drying said binder-saturated web, said drier including a housing, a series of web supporting rolls in said housing, and humidity and temperature controlling mechanism associated with said drier.

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