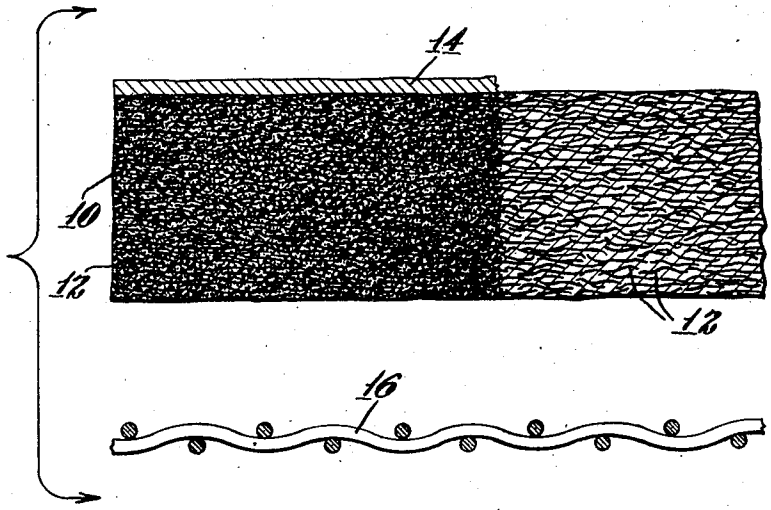
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ART OF STIFFENING

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ART OF STIFFENING

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This invention relates to improvements in the art of stiffening. More particularly it relates to sheets and articles made from sheets, especially such as require to be convertible between a flexible condition in which the article can be deformed to some desired shape, and a stiff condition in which the article performs its function by resisting deformation. Examples are, toe boxes for shoes; linings for suit cases and trunks; packing cases; body part of sheets of "leather substitutes"; water proof conduits to carry electric or gas mains. Many substances are known, among which choice may be made, whose stiffness undergoes change upon suitable treatment, the ordinarily stiff substance becoming more or less liquid upon application of heat or of a solvent; but in most cases the utility of the substance in its stiff state depends upon the presence of a fibrous strengthening element.

It is to this strengthening that the present invention relates, in that it provides a new material, with which the convertible stiff sheet ultimately desired can be made with new and advantageous results. The new material is an aggregate of fibres derived from ligneous wood sources, individually short and stiff, as from the long leaf pine, preferably undercooked and thus retaining the whole of their natural length and strength, but separated individually and arranged in layers deposited gently from water so that they are only loosely matted together and are uncompressed. When dried in this form, the order of magnitude of their interfibrous spaces is such that the sheet will absorb, by capillary attraction alone, and will adequately strengthen, a viscous liquid which is the convertible stiffener.

In this specification the term "short and stiff fibres" are used to indicate fibres whose lengths are of the order of those derived from ligneous wood, of which the long leaf pine is an example, and are used to distinguish such from bast or leaf fibres of plants such as flax, jute, sisal, manila and from seed hairs, as cotton, and from animal fibres as wool and cattle hair, which relatively are much longer, and from mineral fibres. They also indicate whole fibres, of the sort stated, and distinguish them from ground wood, wool flocks and other finely cut, pulverized, or similarly shortened fibres.

Thus a liquid such as high ratio sodium silicate, having such viscosity that it may be quickly and cheaply converted into solid form, can be commercially combined with the fibres by mere absorption, making a union which is adequately complete; and the stiff or hardened liquid is so improved over its natural state, for strength, for resilience and for durability, that it does not require the support of a foundation or carrier sheet. And this is done at a cost for materials and for manufacture far below anything previously known so far as I am aware. Heretofore wool or cotton felt or fabric have been used; and the spreading of disintegrated fibre of wool, cotton or cellulose (as ground wood, sulfite or sulfate pulp) over a burlap sheet, duly compressed, has been proposed. But I am not aware that the use of pulp alone has been found commercially possible. Neither ordinary dried pulp, nor even blotting paper, will absorb a viscous liquid within a range of viscosity desired to be used in a commercially sufficient way. But the high bulk pulp sheet of the invention does this.

The broad distinction that exists, on the basis of bulk, between the material of the invention and the closest approach by pulp or fibres heretofore available, is indicated by measurements made by me which showed Swedish kraft pulp to have a "bulk density" or "apparent specific gravity" of 0.75; white bleached pulp 0.53; ground wood pulp 0.49; and blotting paper 0.45; while the loosely matted uncompacted pulp of the invention, in its preferred form, measured only 0.13. The blotting paper examined, having the apparent specific gravity of 0.45 could be used only with a relatively thin condition of stiffening liquid, that is, liquid of low viscosity, and was far more compact than is desirable. A sample of pulp, which has been especially prepared for me to have greater bulk than any previously known, was found to have an apparent specific gravity of 0.28 and was found barely porous enough for use according to the invention far more compact than was desirable.

Thus it appears that the blotting paper and the bleached pulp which were the closest approach to the material of the invention found in the commercial world, were three or four times too dense to embody the invention, the material of which may be defined as loosely matted pulp having "apparent specific gravity" or "bulk density" of the order of 0.15 to 0.25. By contrast it was observed that the true specific gravity of the kraft pulp above mentioned, determined in the usual way in a specific gravity bottle, was 1.43, which would also be an approximate figure for each of the samples mentioned. This indicates that the bulk density of the material of the invention is six to ten times that of the fibres of which it is composed.

When the selected viscous liquid has been absorbed into such a material, each fibre is very com-

pletely surrounded (and perhaps to an extent penetrated) by the liquid, and thus each fibre exerts its whole strength as a minute strut or beam within the stiffened liquid. Because of this high bulk of the sheet relative to the bulk of the fibres composing it, a wetting of the product does not markedly increase the size of the sheet, which is contrary to experience when ordinary paper is employed, the wetting of which usually results in considerable increase in size so that, when applied to toe boxes, the lasting operation causes wrinkles in the toe.

Other qualities found in the finished product are that the liquid can be applied and retained as a single layer of greater thickness than with fibrous materials employed heretofore. This is because of the high viscosity at which the liquid can be combined with the fibres. As each interlaced fibre is more perfectly embedded and is not so much held in constraint by proximity of neighboring fibres, as in paper or in a denser pulp, the native resilience of the hardened liquid has greater opportunity for expression, and is reinforced by that of the wood fibres, when bent, without cracks or crackling, and without cleavages along a line of imperfect penetration of a compressed sheet of fibres. Experience shows that there is a marked increase of strength as compared with the cheaper felts. This is probably because the superior strength and stiffness of the woody fibres make independent contribution of these qualities to the composite whole. These advantages permit the requirements of any given situation to be satisfied by a stiffening sheet which is thinner than heretofore, thus consuming less of the stiffening liquid. And thus in the case of toe boxes a thinner and more elegant toe becomes adequate.

The convertibility of the finished product and the characteristics of the stiffened sheet, depend in part on the nature of the liquid employed; but in the manner above indicated the use of the high bulk fibrous arrangement favors the stiffened sheet having the property of resilient yielding, and having a certain toughness which prevents both cracking and crackling when the yielding occurs. The finished sheet may also embody the qualities of waterproofness; of quasi-fluidity, which results in self-healing ability in case it becomes cracked; and of cleanliness for handling, and safety from risk of fire.

When account is taken of the extremely low cost of the material which is made commercially available by the invention, the inexhaustible abundance with which that material is available, and the superior results as to strength, flexibility and resilience which are attained in the completed product at this lower cost, the novelty and marked utility of the stiffening sheets produced by the invention can be recognized.

By this successful utilization of the short and stiff fibres which compose the pulp, the woven sheet of burlap or other material on which it has been hitherto proposed to carry the fibre can be dispensed with. This material and the long-fibred cotton or the wool flock, heretofore proposed to be matted together under pressure in order to cover the interstices in the burlap and to form a smooth face, all are replaced by the stout short vegetable fibres of the wood. The two cents per square yard which the high bulk fibre of the invention may cost is from one-fifth to one-fiftieth of the cost of material which it supplants while producing qualities in the finished article which are superior.

The invention may be embodied in various forms.

The accompanying drawing represents a transverse section, greatly enlarged and somewhat diagrammatical, through one sort of a composite sheet embodying the invention, indicating also stages of its manufacture, and showing a temporary support 16 used in its manufacture.

In the drawing, the stippling 10 indicates a body of stiffener, being a hardening liquid appearing as a solid body in the midst of which are lines 12 indicating embedded fibres, which may be understood to be fibres of kraft pulp. These fibres are layered horizontally i. e. they lie more or less in parallelism with the faces of the sheet. They are entangled together and extend in all directions in said parallelism, but they are not compacted together to any substantial degree. The hardened liquid 10 may be assumed to be any one of those herein indicated, with or without modifying ingredients. At its upper surface is a surface coating 14, for waterproofing or other purposes, to afford a desired finish or to serve a desired function. The actual thickness of the body or fibres may vary according to desire, and the fibres may be in one or more layers according to convenience in manufacture.

The fibres are conveniently obtained by purchase of chemical wood pulp, prepared as is customary in making kraft paper by the sulfate process from stock such as the long leaf pine. But in every case known to me, the commercial pulp thus obtainable has been found to have too great a density, too little bulk, to be suitable for the purposes of the invention, so that a first step consists in beating the commercial pulp in water, until the fibres are uniformly distributed through the water, after which they are arranged in a loosely formed deposit in sheet form and thus dried. This deposit is preferably accomplished by dipping with a screen of metal or of cloth, taking care to avoid compressing the fibres upon each other. The product is then in the form herein referred to as being "loosely matted", wherein the fibres by reason of being deposited or gathered from a floating position in water individually tend to lie approximately flattened against or somewhat parallel to the screen, as distinguished from lying in all directions of space which might be termed a flocculent arrangement because of being produced when shredded material falls through air like flakes.

The setting of the pulp on the screen may be by a continuous process in which the screen is moved through the fluid mixture of water and fibres. A cylinder screen machine may be used, accumulating successive increments in a single layer. But in any case, upon removal of the pulp from water the pulp is not to be squeezed or otherwise compressed for drying it, but is to be left to dry by drainage and evaporation. This is contrary to the practice in pulp mills which always squeeze the pulp in order to remove a large part of its contained water for drying it. But if the layer thus produced has greater bulk density than is desired the bulk may be reduced by a gentle compacting which does not amount to what would generally be understood by the word "compression". Having been dried, on its screen or apart from it, the layer of fibres ordinarily has sufficient strength to be handled and it may be rolled or folded for storage or for transportation; or it may be treated immediately with the hardening liquid.

Such a high bulk arrangement of fibres is strong

enough to be handled as a sheet, but with certain stiffeners it requires a temporary support during its application to the stiffening liquid. In such a case it is carried on a metal or textile screen 16; if textile, the screen may be very thin and coarse, as cheese cloth. The cloth may be removed before the hardening of the stiffener has reached its final state.

One stiffener which may be used includes latex. Commercial latex contains ammonium hydroxide as a preservative. The presence of this produces so marked an increase in the hydrolysis of the pulp fibres that when the pulp is treated with latex a pasty mass is quickly produced, which mass is practically entirely lacking in strength. Therefore when combining the pulp sheet with latex it is sometimes necessary to support the sheet by a screen of metal or cloth as above indicated. This may be removed when the stiffener is partly dry, if the sheet of strengthened and hardened liquid is desired to be without external support; or it may be allowed to remain adhering to the hardened liquid, if there is any reason for desiring that. A similar situation prevails if any aqueous liquid is used as a binder, and contains free alkali, although the hydrolysis and need of a support may not be so marked as with latex. When the binder is resinous, and is softened by heat to fluidity, the strength of the pulp sheet is not appreciably diminished from what it had in dry form, but the binder itself adds nothing to the strength, so that a temporary support may often be used here also with advantage.

For an illustrative example, one may consider the use of an aqueous liquid in a case where a screen support is desirable, choosing for this example, preferably sodium silicate, in which the ratio of silica radicals to alkali oxide radicals is of the higher orders, say 3 or 4 silica radicals to 1 of the sodium oxide. With this liquid there may preferably be mixed a small proportion of a liquid which will introduce toughness into the dried composition, such that the dried stiffener does not crackle or break upon being bent, when a superior force is applied sufficient to overcome its stiffness. For this purpose 5 or 10 per cent glycerine, soft soap or linseed oil may be used. In such an alkali silicate, solidification of the liquid is accomplished very quickly, because only a small percentage of moisture has to be removed in order for the liquid to become solid, as I have disclosed in my Patent No. 1,799,949 of April 7, 1931, for Art of stiffening, where the stiffener and toughener are more fully described and are claimed. Such a liquid, for example, may become dry and hard, while it is still half water.

In place of the silicate, other stiffening substances may be used. Among such are melted natural or synthetic organic materials such as waxes, rosins, asphalts and glues, all of which are known as having more or less utility.

If it is desired to use the sodium silicate or other liquid in viscous form, which ordinarily is advantageous, because of the quicker solidification, I have found that penetration by the viscous liquid can be effected with greater rapidity and thoroughness by first saturating the dried pulp sheet with solvent vapor or moistening it with the solvent which is used in the stiffening liquid; or with an organic mobile liquid such as benzol if the stiffener is an organic waxy, resinous or asphaltic material.

The sheet of pulp, penetrated entirely or partly by its layer of stiffening material, may then be used according to the methods already known in the manufacture of the thing whose stiffening is required. Thus, for making box toes, it may be associated with the prepared vamp, usually consisting of the leather or cloth outside of the shoe and one or more lining layers of cloth, by inserting the prepared sheet, softening it before or after insertion, lasting the toe, and afterward letting its stiffening material harden in the lasted shape.

Resilience, as herein used, means the property of returning elastically to a certain normal shape. This is obtainable in a notable degree by use of the said alkali silicate for the primary stiffener; and further resilience is contributed by the woody fibres; while if the stiffener employed be one of these previously known, such as a waxy material, the woody fibres introduce resilience to a composite sheet which would otherwise have none.

Additions and variations may be made. For example it has been discovered that solutions of high ratio soluble silicates form emulsions with latex. Such a mixture, made in the proportions of about three to one by volume, produces a stiffening material which has an enhanced degree of elastic flexibility, when dry. In such case the softening glycerine, etc. may be omitted.

However, I have discovered that latex itself can be absorbed freely by the above described kraft pulp sheets so that when dry, or if the gum be precipitated from the latex chemically, a very marked increase in strength is imparted to the kraft sheets while they at the same time become almost entirely waterproof. Yet such a treated pulp sheet will still take up the silicate stiffener, with sufficient freedom so as to hold the sodium silicate when solidified.

Waterproofing may be applied by brushing or otherwise spreading any suitable material, melted into a sufficiently liquid state, on the soft sheet, if the toe support is to be applied in sheet form or by brushing or spraying it on the leather or adjacent fabric. Or a solution of a cellulose ester, or any commonly used waterproofing material, may be applied by painting or spraying on either or both sides. In any case it is desirable that the film so produced be uniform and as free from holes as possible.

The kraft pulp referred to is that which is produced by the sulphate process, the sodium sulphate thereof being more or less reduced to sulphide before action on the pulp and the pulp being undercooked. In the pulp product the fibres remain untorn and unbroken, as seen under the microscope, indicating that they have the whole of their natural length. It will be observed that as contrasted with felt and cloth, which have previously been used as carriers for stiffened material, the described pulp affords a material composed of relatively short and stout vegetable fibres whereas the cotton is a long fibre, the wool is animal, and neither of them is stiff. Moreover the wood is relatively stout and elastic. Undercooking preserves those qualities in the fibres while separating the fibres so that they can become loosely interlaced and conveniently mobile with respect to each other.

And it will be observed that as contrasted with burlap, which also has been proposed as a foundation or carrier for a stiffener, the thread crossings of the burlap produce an irregular surface with interstices which require to be covered with some compacted substances in order to obtain the smooth surface which is requisite. Such a product is essentially an impregnated and thus stiffened fabric and must always be relatively

thick; while the product of the invention is essentially the introduction of strong resilient fibres into a hardened liquid, and can therefore be extremely thin and yet be smooth.

This application is in part a continuation of my earlier application Serial No. 641,767, filed May 26, 1923, under the title "Art of stiffening." It is intended that the patent based hereon shall cover by suitable expression in the appended claims whatever features of patentable novelty exist in the invention disclosed.

In the claims, the term "stiffener" or "stiffening material" is used for convenience to indicate by brief phraseology any material having the properties with respect to which this term is commonly applied in the trade, meaning those which have the property of changing between hard and soft conditions rather quickly, with moderate change of temperature or of content of heat or water or other liquid, many examples of which are known and several of which are hereinbefore mentioned. Likewise the term "toughener" is used as a generic term for an ingredient such as glycerine, soft soap, linseed oil, deliquescent salt or other devices which prevent the stiffener from being too brittle when in its hard condition.

I claim as my invention:

1. A composite sheet comprising a viscous-hardenable liquid and, homogeneously combined therewith, a co-extensive water-laid sheet of wood fibres, without admixture of longer fibres, the fibres distributed through said sheet lying matted together loosely with the viscous liquid between them, and said fibres having individual directions which in general are mutually diverse, but which are all in approximate parallelism with the surface of the sheet; and being neither substantially compacted nor loosened from their water-laid positions, relative to each other.

2. An intermediate impregnatable product for the fabrication of a composite sheet of fibres and viscous-hardenable liquid, comprising a body of undercooked wood fibres, free from admixture of longer fibres, arranged in a water-laid manner in a sheet formation, the said fibres being scattered and matted in such slight mutual contact as gives to the sheet an apparent specific gravity substantially of the range of one-eighth to one-quarter of that of water; said fibres being not substantially upset or loosened from their water-laid positions of parallelism with the faces of the sheet; and having such large interfibrous interstices that mutually adjacent fibres scattered and matted as aforesaid cooperate to admit the flow of a viscous liquid to the interstices between them and so to pass the viscous liquid through the thickness of their sheet.

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