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CEMENT INTEGRATED FIBROUS SHEET AND METHOD OF MAKING IT

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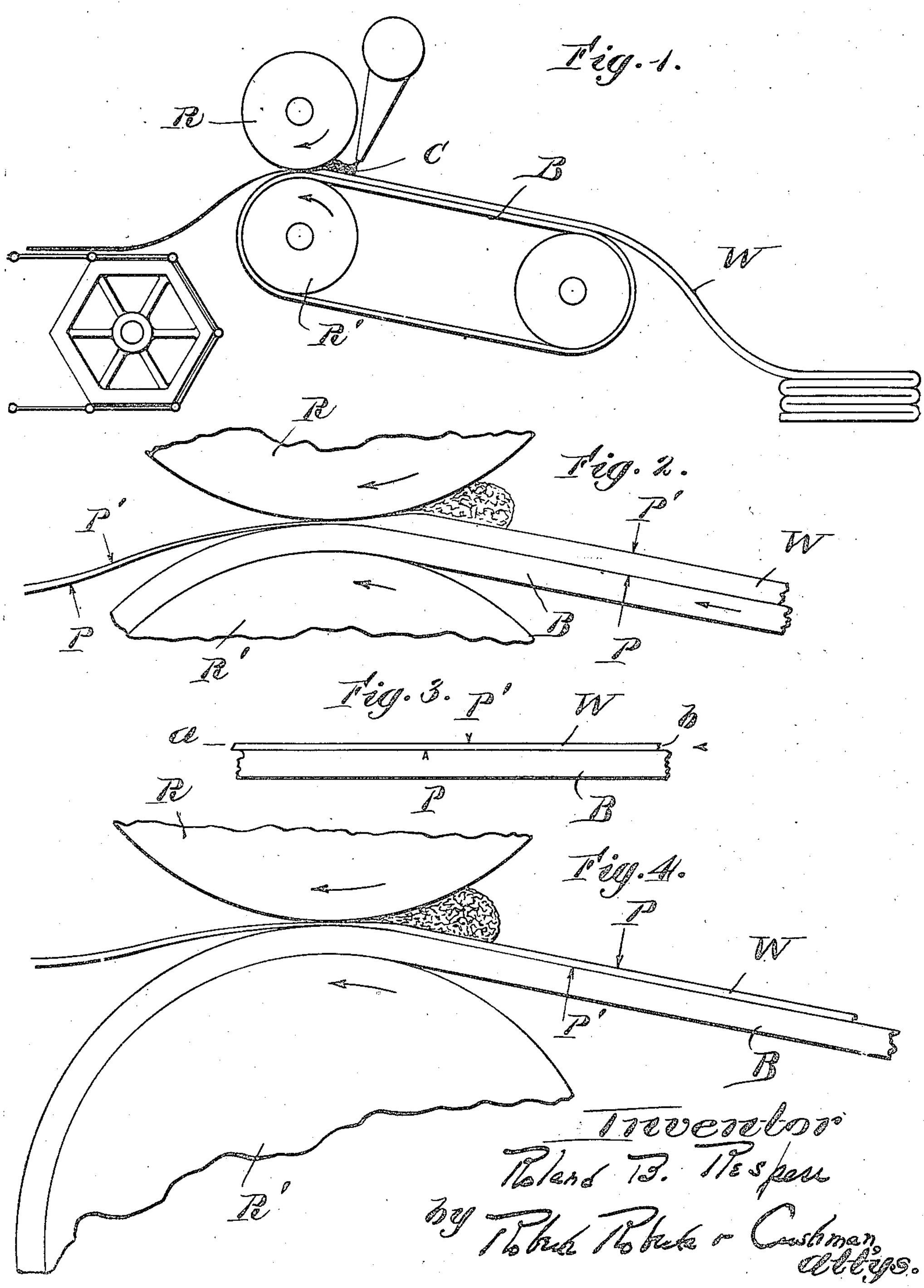

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UNITED STATES PATENT OFFICE.

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CEMENT-INTEGRATED FIBROUS SHEET AND METHOD OF MAKING IT.

Application filed May 17, 1921. Serial No. 470,269.

To all whom it may concern:

Be it known that I, Roland B. Respess, a citizen of the United States of America, and resident of New York, in the county of New York and State of New York, have invented new and useful Improvements in Cement-Integrated Fibrous Sheets and Methods of Making Them, of which the following is a specification.

This invention relates to the manufacture of impregnated, compressed, sheets of fibrous material, and comprises a method by which such sheets, in their final condition compact, tough, flexible, and impervious, may be expeditiously made from very loose, flimsy, and therefore mechanically weak, webs of fibrous material; and the product which results from the practice of the method.

Very many methods, and their products, involving saturation or impregnation of bodies, sheets, webs, felts, etc., composed of fibres (either woven or unwoven, twisted, felted, carded, etc.) with cementitious, glutinous, or adhesive binding materials, have been proposed and described, and not a few of such methods have been practised. A usual object of such methods has been to produce a substitute for leather, and the composite bodies made by these methods have been, either actually or in prospect, treated with the same kind of miscellaneous dressings and finishes as have been from time almost immemorial, applied to leather; these differing according to the specific use to which leather, or its artificial substitutes, have been intended.

Leather itself is, as is well known, composed of fibres which are bound together by natural adhesive material; and many leather substitutes have, as I am aware, exemplified attempts to produce artificially a similar constitution; the endeavor, in the manufacture of such substitutes, has been to approximate as closely as possible, to the strength of leather fibre and natural adhesive, respectively, and at the same time to produce a material which shall also approach leather in the qualities of toughness and flexibility which leather possesses to so eminent a degree.

Fibres which are individually as strong as those of leather are easily obtainable; cotton, flax, ramie, kapok, and many other seed-hair and cortex cells of fibre plants, for instance, possess tensile strength in high degree, and are, moreover, when cleansed, absorbent or capable of being individually wetted by liquid or semi-liquid materials, so that a sheet or web of such fibres furnishes one of the factors necessary to the production of a material resembling leather; and cotton sheets, woven and unwoven, have been employed for the purpose in many instances. The association of an efficient binding material, or agglutinant, with such fibres in such manner that the composite product shall in degree as well as in kind resemble natural leather, has been the chief and most difficult problem; and it is the object of the invention herein described, to solve that problem, and to produce an agglutinant and fibrous aggregate structure which shall possess strength, flexibility, and elasticity in such degree as to enable the product to serve uses, both those of leather, and also others, for which a sheet having the stated physical characteristics is adapted.

If it were possible to isolate each fibre, and coat it with the maximum quantity of a dense, strong, semifluid adhesive (as for instance a strong, heavy, viscous rubber cement composition) and then lay a number of such cemented fibres in close juxtaposition, and finally subject the structure thus formed to heavy pressure, so that the adhesive material should fill all the interspaces or voids between the fibres, the resulting sheet, when the cementitious material had set to final condition, would possess a tensile strength nearly equivalent to or greater than the aggregate tensile strengths of all the cotton fibres in a given cross section and a flexibility nearly if not quite equal to that of the cementitious material. The method herein described nearly approaches, in its various stages, and in its result, to the ideal—and I believe unattainable—method above suggested.

In the first place, in order to present fibres to the coating action of an adhesive cement substantially as if each fibre were an isolated individual, I employ for the fibrous body which is to be treated, a loose, flimsy web of fibre—preferably cotton—such as ordinary carded cotton batting. This material is usually about one quarter of an inch thick, but the fibres of which it is composed actually occupy only a minor part of the cubical content between the outer surfaces of the fibre layer; the air spaces around the fibres are of far greater volume than the fibres themselves. Thus the individual fibres are as nearly separate and free, as individuals, as is consistent with the very feeble integrity of the sheet, as a sheet, and are therefore ready for individual absorption of cementitious material. Moreover, the net quantity of fibrous material in such a flimsly web is relatively so small, that the fibres, if compacted together in a sheet having the same superficial area as the original web, will constitute a very thin sheet, and therefore one possessing flexibility in high degree.

If the product is to possess strength approximating to or exceeding the aggregate strength of its constituent fibres, the cementitious material must be incorporated with the fibres in such quantity as to cover each fibre completely and thus afford a maximum anchorage for each fibre, and must also be substantially continuous in the spaces between fibres, so that any strain in one fibre will be communicated to and shared by its neighbors. The maximum anchorage referred to is a hold upon a fibre from which it cannot be pulled without exceeding the ultimate tensile strength of the fibre. If, therefore, it be attempted to coat the individual fibres of a loose and flimsy web by immersion of the web in a solution of cementitious material, the solution, if thin enough to permit uniform and thorough fibre coating by immersion, will deposit on each fibre too little of the dissolved cementitious material to accomplish the purpose. If the solution be very thick, and laid on the loose web, introduction will proceed slowly, and will be accompanied by filtration of the solute from the solvent, which in real measure defeats the object, producing unequal coating of the fibres which compose the web.

By my method now to be described, a heavy, viscous cementitious substance, typically a solution extended by solvents to a minimum degree consonant with plasticity, so that loss of volume upon hardening may be relatively slight, is forced into a loose, fluffy web, as of cotton batting, and squeezed lengthwise of the web, while the fibres themselves are shifted, also lengthwise of the web, and in relation to each other, so that one side of the web, after impregnation, is offset from its original position by a distance about equal to the original thickness of the web or batting. This localized drawing action, coupled with the instrusion of a heavy cement lengthwise of the web and the fibres (which are laid by carding predominantly in one direction, in an approximation to parallelism) coats each fibre with a concentrated adhesive. The web may thus be made to contain a weight of adhesive greater than the weight of the fibres. The preferred adhesive is adapted to harden or set by evaporation of its solvents with an increase of viscosity and adhesiveness disproportionate to the slight loss of volume by evaporation. The act of shifting one side of the batting lengthwise in the act of introducing cementitious material redistributes and interlocks the fibres so that they are laid like a thatch in the impregnated web.

The action of redistributing the fibres is caused chiefly by the fact that one side of the sheet lies upon and adheres (at the time the liquid cement is introduced and the sheet subjected to pressure) to a moving surface while the other side of the sheet which receives the liquid adhesive upon its surface is subjected to a gradually increasing downward pressure, which action forces the upper layers of the fibres, which compose the sheet, in a backward direction. In this action the fibres are pressed out of their original position in the sheet and the ends of many individual fibres tend to follow the liquid, as it flows into the sheet, under pressure, so that the ends of many of the fibres penetrate the adjacent layers of fibres, so that when the adhesive coating sets the different layers of fibres are thereby interlocked by the penetrating fibres from adjacent layers and held in their new place by the adhesive. The web is heavily compressed in the act of impregnation, but the cementitious material still contains enough solvent to permit the natural elasticity of the fibres to assert itself and restore the web as a whole to a thickness about one quarter that of the thickness of the original batting. This opening of the fibrous structure facilitates evaporation of the cement solvent; when the greater part of the solvent has evaporated, the cementitious material remaining lodged upon the fibres is highly adhesive, exceeding the power of the fibres to separate by natural resilience, and the sheet is then ready to have its final consolidation effected.

For most purposes a single pass of the fibrous material through the impregnating operation will suffice to incorporate with the fibres enough cementitious material. If more be desired, the sheet may be passed again, and again rid of volatile solvent by evaporation.

In order to lay the fibres during impregnation, as well as to lend support to the mechanically weak batting, the fibre sheet should be carried to the impregnating mechanism upon a moving supporting surface, as a belt, and the viscous impregnating material should be applied to the other surface of the web, in such manner as to be pressed not only against the web, but against the direction of movement of the web. A mechanism adapted to the characteristic performance here described, is diagrammatically illustrated in the drawings hereto annexed, in which,—

Figure 1 represents one form of the impregnating apparatus;

Fig. 2 represents the operation of the apparatus and impregnating material, and

Figs. 3 and 4 illustrate the fabric after a first pass of the impregnating rolls and during a second pass, respectively.

The web of cotton batting, W, is taken by the belt B, which travels on rolls, of which R′ is the lower of two pressure rolls, R being the upper. The surface of the belt B becomes slightly tacky by reception of a little cementitous material, so that the web W clings to it, and is given a broad support and sure traction to the point where the heavy pressure is applied. A heavy, viscous cement, which in the preferred case is a rubber cement solution, but for other purposes may be an appropriate cementitious solution of amorphous substances such as other gums, gutta-percha, glue or bichromated glue, or compounds of or substitutes for such substances, and so viscous that any attempt to draw such a web as cotton batting through it would probably result in destruction of the web, is deposited on the batting just in front of the roll R. The supply of cement is kept up so that the mass in front of the nip of the roll R is usually an inch to an inch and one-half thick.

As the traction of the belt B on the web W draws the web into the nip of the rolls for a primary compression, the cement is pressed against the web and pushes the upper layers of fibre backward and then downward. The leading ends of the fibres become engaged with each other and with the impressed cement, so that the change of location and distribution of the fibres is much the same as would be the case if the upper layers of fibres were moved toward the lower layer in circular paths of which the maximum radius is the length of a fibre between the surfaces. The progressively increasing condensation of the fibres, coupled with the local drawing movement of the fibres in relation to each other and the squeezing action of the curved surfaces of roll R and the opposed surface of the belt B carries the viscous cement lengthwise into and upon the fibres as the web passes under the cement mass and between the rolls.

The displacement of fibres is indicated in Fig. 2, when, if P, P′, be points directly opposite each other on the original batting, as seen at the right of this roll R, these points P, P′ will be found displaced as seen at the left of this roll. As the web emerges from the rolls, the elasticity of the fibres causes the web to swell or open up; it acquires a thickness about one-fourth that of the original thickness of the cotton batting, and presents everywhere interstices between the coated fibres. Thus the evaporation of the cement solvent, or other stiffening reaction, is facilitated; the impregnated web is carried through a drying chamber D and on emergence therefrom is ready for a further, and secondary, compression. If it be desired to impregnate the web with still more cementitious material, it can be passed again, preferably before drying, through impregnating rolls, and again treated to compressive impregnation with cementitious material. The same, or a similar, apparatus, as that above described, may be employed for a second pass of the web (see Fig. 4); but the web impregnated by one pass such as described possesses such integrity and strength that the precautions observed at the first pass, against injury or disintegration, will not be necessary in making a second pass. Preferably the length *a*, *b*, of the web, if given a second pass, will have the cementitious material applied to that side which lay on the carrying belt during the first pass, and will be reversed end for end, as shown in Fig. 4, so that any further offset of one side of the web in relation to the other will be added to, and not subtracted from, the offset produced by the first pass.

Comparative microscopic examinations of the cotton-batting web before and after impregnation by the above described method shows clearly that each fibre has acquired a substantial cementitious coating which when a heavy cement is used, may quite equal the coated fibre in thickness; the coated fibres present a much coarser appearance than the uncoated; and the expansion subsequent to the release from the primary compression has everywhere opened up interstices between the coated fibres, which are nevertheless held together by partial cemented contacts. The web, impregnated as described, is wrinkled, and in subjecting the web to final consolidation, it should be subjected to sufficient tension to smooth out these wrinkles before the final compacting pressure is applied.

The secondary compacting pressure is preferably applied between the rolls of a calendering machine, to which the web is fed under tension which takes out the wrinkles and thus guards against the formation of creases in the calendered product. As the drying operation eliminates nearly all of the cement solvent, the cement remaining on and between the fibres is highly adhesive, and, under the compressive action of the calender-rolls, binds the fibres together in an impervious thin sheet, in which each fibre is embedded in an adhesive, cementitious anchorage, which is substantially continuous between fibres. The fabric is smooth-faced, of uniform thickness, and the fibres in it are predominatly longitudinal, sloping from face to face in the same direction, but in interlacement, every fibre typically having parts lying otherwise than in the predominant direction, and many of the fibres lying wholly otherwise. The product, as completed by the final compression of the dried impregnated fibrous web, possesses tensile strength in high degree, being stronger than leather, split to the same thickness. It is also extensible, and will stretch considerably under tension in the general direction of the fibres before fracture. In a direction transverse to the general lay of the fibres it is extensible also; its maximum tensile strength is, of course, in the direction parallel with the general lay of the fibres.

The cement which I have employed, and which produces the best product for most purposes, is essentially a rubber cement containing about 20% rubber gum or compound and 80% volatile solvent, such as naphtha or gasolene. Other gummy materials, similarly soluble, may be added.

The product, manufactured by the above described method and with the aforesaid specific cement, contains as much cementitious material as fibre, by weight, and may be made to contain more, as by passing the sheet more than once through the impregnating rolls.

The physical characteristics of the above described product are perhaps best exemplified by its behavior when subjected to molding manipulations, which demonstrate its plasticity. For instance, a strip or tape of this material, by reason of its high dielectric strength, constitutes an effective insulating material, and, when wound tightly around a cable or coil of wire can be locally stretched, and molded when overlaid in several thicknesses, to accommodate the insulation thus produced, to conformity with objects such as slotted metal cores or winding formers. Or, when several plies of this material are doubled to form a laminated structure, with cementitious material compressed between and into the several layers or plies, the thicker sheet thus formed can be molded into such shapes as shoe tips or counters, without developing wrinkles or creases.

This physical characteristic is due to the residual viscidity of the binding material, which, while adhering tenaciously to the fibres nevertheless permits the composite sheet to stretch either in the general direction of the lay of the fibres, or across the lay; this extensibility of the sheet is demonstrable by manipulation of a sheet of the material, such as a ribbon or tape. The fibres slip, straighten and move in the viscous binder, the binder itself elongates in the direction of tension. The behavior of the sheet is comparable to that of extensible leather in a stretching machine, and substantiates the structural similarity of the composite sheet to a piece of leather. Both are essentially composed of fibres matted together in and by a viscous cementitious matrix, and both will sustain a measurable degree of extension before rupture.

While loose and open unwoven fibrous webs, thicker than the ordinary cotton batting, may be treated in the manner above described, the thicker the original web, the less adequate will be the coating of individual fibres by the cementitious material. My object is served by the production of a thin impregnated and compacted sheet of fibres individually and uniformly coated with cementitious material, specifically and preferably rubber, in quantity not less—substantially—than the fibre itself, by weight. Having such material for a basis, I am enabled to produce therewith, as by doubling and cementing together several such sheets, or by treating them either with solutions or emulsions of which the solvents, being solvent or rubber, will carry the dissolved or suspended materials into admixture with the rubber binder—as for instance, sundry gum varnishes, or by surface dressing them with any of the materials used heretofore for dressing and finishing leather, an indefinitely large variety of useful products. Where rubber cement is the material employed, the product may be vulcanized if desired.

While I have described, for example, a preferred cementitious substance capable of hardening to a sticky plastic mass by air evaporation of a solvent, the impregnation step of my invention is concerned in its broader aspects with applying and thereafter reaching a state of increased hardness and viscosity with increased adhesiveness of the agglutinant substance throughout the fabric prior to its secondary compression, rather than with the precise character of the substance or of the reaction by which hardening, increased viscosity and increased adhesiveness is obtained.

For instance, having forcibly coated the fibres by primary compression and allowed the texture of the mass to open by their inherent resilience and recovery of original shape, as described, the cement coated fibres are then interstitially open to fluid reactions, and it is not essential that the reaction should be an evaporative reaction. The cementitious substance might be an oxidizable oleaginous compound, or any solidifiable substance capable of being rendered more viscid and more adhesive by treatment; and the hardening step migh be, for example, one of oxygenization by an air or gas bath, or of induration by a reagent chemical or heat, or completion to the desired state of plastic adhesiveness by any other reaction-treatment by a penetrating fluid reagent appropriate to cause the particular cementitious substance used to become stiffer or more viscid and to remain adhesive and plastic.

I attribute, for instance, the successful attainment of homogeneous solidity and impenetrability of the fabric resulting from the preferred treatment with a rubber or equivalent cement (which is impervious to gases and dielectrically continuous, notably high in tensile strength per unit cross-sectional area, highly plastic, and slightly adhesive) to the individual capacity of every fibre, attained between the primary and secondary compressions, to carry into the mass resulting from the secondary compression a sufficient charge of a properly stiffened cement in a quantity and a state adapting it to homogeneous adherence together and filling of all voids in the final fabric. These qualities, attained by the way of making, are independent of the particular viscous binding substance which may be chosen for particular qualities of the finished fabric.

I claim:

1. The art of making cement-integrated fibrous sheets comprising as a step compressing an unwoven sheet of the fibre in the presence of an excess of viscid cement, and advancing one face of the sheet in respect to the other face during such compression.

2. The art of making cement-integrated fibrous sheets comprising as a step supporting an unwoven sheet of the fibre at one face, compressing the sheet of fibre in respect to its support in the presence of an excess of viscid cement applied to its other face, and displacing said other face of the sheet in respect to the supported face during such compression.

3. The art of making cement-integrated, unwoven fibrous sheets, which comprises temporarily reinforcing a loose open textured web of fibres by adhesion to a moving support, conveying said sheet on said support to a viscous cement-solution, pressing said solution into the web while on and adhering to said support, causing the solution to intrude into the web in a direction opposite to the movement of the web, and displacing the unsupported fibres in the same direction, compressing the cement-impregnated web; allowing the said web to expand after compression, evaporating the cement solvent from the web, and compacting the dried web by pressure.

4. The art of making cement-integrated, unwoven fibrous sheets, which comprises temporarily reinforcing a loose open textured web of fibres by adhesion to a moving support, conveying said sheet on said support to a viscous cement-solution, pressing said solution into the web while on and adhering to said support, causing the solution to intrude into the web in a direction opposite to the movement of the web, and displacing the unsupported fibres in the same direction, compressing the cement-impregnated web; allowing the said web to expand after compression, evaporating the cement solvent from the web, and compacting the dried web by pressure under tension.

5. The art of making cement-integrated unwoven fibrous sheets, which comprises compressively intruding a viscous cement-solution into a loose open textured fibrous web longitudinally of the same, and at the same time displacing the fibres at one surface of the web longitudinally in relation to fibres at the other surface and thereafter compressively setting the fibres in their new positional relation.

6. The art of making cement-integrated fibrous sheets comprising as steps, causing interpenetration of a flocculent sheet of fibres by a solidifiable viscid cementitious substance by a primary compression of the sheet and a mass of said substance, releasing pressure on the treated sheet to permit resilient recovery of coated fibres to a reticular, relatively open state; exposing the expanded sheet and the substance carried thereby to the reaction of a penetrating fluid increasing the viscosity and adhesiveness of said substance, and subjecting the sheet to a secondary compression sufficient to solidify the fabric.

7. The art of making cement-integrated fabrics comprising a primary simultaneous compression of a sheet of resilient fibres and a viscid mass of cementitious substance, permitting the treated sheet to expand by the inherent resilience of its fibre component, subjecting the expanded sheet to treatment adapted to increase the viscosity of the coating throughout the fabric by interpenetration of the interstices of the expanded fabric by a reagent fluid, and thereafter subjecting the material to a secondary compression in the direction of its thickness in sufficient degree to compact and solidify the fibres and their coating into an impervious solid.

8. The art of making cement-integrated fibrous sheets comprising as steps; compressing together a mass of viscid cement and a sheet or bat of fibres, the operation including drawing the fibres longitudinally in respect to the anchorage of fibres at the faces of the bat, releasing pressure and permitting access to the interstitial spaces of the bat of a cement-hardening fluid reagent, and finally compressing the material.

9. The art of making cement-integrated fibrous sheets comprising as steps, compressing together a mass of viscid cement and a sheet or bat of fibres, the operation including drawing the fibres longitudinally in respect to the anchorage of fibres at the faces of the bat, releasing pressure and permitting

access to the interstitial spaces of the bat of a cement-hardening fluid reagent, during a sufficient time to increase the adhesiveness of the cement to a point preventing resilient separation of the fibres, and finally compressing the material to cause mutual adherence of the fibres in an impervious sheet.

10. The art of making cement-integrated unwoven fibrous sheets which comprises compressively forcing a viscous rubber cement both transversely and longitudinally into a loose open textured web of fibres from one side of said web, while displacing fibres in the web in the same longitudinal direction and compressing the web as a whole, the maximum longitudinal fibre-displacement being of fibres on that side of the web into which the cement is intruded, the longitudinal displacement of fibres within the web diminishing in extent proportionate to their original distance from the surface.

11. The method of making cement-integrated unwoven fibrous sheets, which comprises subjecting a loose open textured web of fibres to progressive rolling pressure, intruding a viscous rubber cement both transversely and longitudinally into the web, from one side thereof engaging the leading ends of the fibres with intruded cement with progressively increasing intimacy while progressively displacing fibres longitudinally of the web, to distances decreasing as the distance of fibres from the cement-applying surface increases.

12. An impervious cement-integrated fibre sheet fabric comprising individually cement-coated fibres predominantly arranged in one dimension of the fabric and predominantly sloping from one face to another in the same direction of slope and bound together by a plastic and adhesive binder.

13. An impervious cement-integrated thin sheet fabric having therein inherently resilient interlaced vegetable fibres predominantly sloping from one face to another in the same direction of slope anchored in an adhesive cement interpenetrating the fabric, the fabric having smooth, parallel and equidistant faces resulting from heavy aggregating compression in the direction of its thickness.

14. Cement-integrated fibrous sheet, comprising unwoven fibres predominantly sloping from one face to another in the same direction of slope matted with adhesive cement, the weight of the cement being not substantially less than the weight of the fibre.

15. Cement-integrated fibrous sheet, comprising unwoven cotton fibres predominantly sloping from one face to another in the same direction of slope matted with adhesive rubber cement, the weight of the cement being not substantially less than the weight of the fibre.

16. A stage-product of the hereinabove described process comprising a sheet of inherently resilient vegetable fibres predominantly sloping from one face to another in the same direction of slope individually coated with a heavy coating of a plastic adhesive cement, the fabric having interstices between the coated fibres everywhere in its substance and the weight of the cement being not substantially less than the weight of the fibre.

17. Cement-integrated fibrous sheet, comprising unwoven fibres predominantly sloping from one face to another in the same direction of slope matted with adhesive cement, the latter possessing sufficient permanent viscidity to permit extension of the sheet and being substantially not less in weight than the weigth of the fibre.

18. Cement-integrated fibrous sheet, comprising unwoven fibres extending predominantly in one direction and predominantly sloping from one face to another in the same direction of slope, matted together with a relatively large proportion of adhesive cement, said cement being flexible and adherent in the completed structure, the fabric as a whole being plastic and having its maximum tensile strength in the predominant direction of the fibres.

19. Cement-integrated fibrous sheet, comprising unwoven cotton fibres extending predominantly in one direction and predominantly sloping from one face to another in the same direction of slope, matted together with a relatively large proportion of rubber cement, said cement being flexible and adherent in the completed structure, the fabric as a whole being plastic and having its maximum tensile strength in the predominant direction of the fibres.

20. As a new article of manufacture, a flexible fabric, comprising unspun, unwoven fibres coated substantially throughout the thickness of the fabric with a binding material, without completely filling the interfibre spaces, said fibres being united at their intersections and points of contact by the cohesion of their coatings, said coated fibres being maintained in the fabric in slightly separated relation and forming minute interstices between their coatings throughout the fabric.

21. As a new article of manufacture, a flexible elastic fabric, comprising a base fabric of unspun, unwoven fibres, the fibres being coated substantially uniformly throughout the thickness of the fabric with elastic binding material, without completely filling the interfibre spaces, said fibres being united at their intersections and points of contact by the cohesion of their coatings and held yieldingly in slightly separated relation.

22. As a new article of manufacture, a waterproof fabric consisting of an unwoven fabric, the fibres of which are coated and united throughout the fabric by and main-

tained in slightly separated relation by colloidal binding material, without completely filling the interfibre spaces, said fabric being pervious to air and dry gases, and substantially impervious to water.

23. The herein described process which consists in applying to a roller of a calender an adhesive coating of binding material plastic at the time of application and passing between said coated roller and another opposed roller of the calender a non-woven fabric composed of unwoven, unspun fibres, to force the said binding material into the fabric and around and upon the individual fibres to unite the fibres in said fabric.

Signed by me at Boston, Massachusetts, this sixteenth day of May, 1921.

ROLAND B. RESPESS.