UNITED STATES PATENT OFFICE.

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METHOD OF WATERPROOFING FABRICS.

994,931. Specification of Letters Patent. **Patented June 13, 1911.**

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To all whom it may concern:

Be it known that I, PIERRE O. KEILHOLTZ, citizen of the United States of America, residing at the city of Baltimore, State of Maryland, have invented certain new and useful Improvements in Methods of Waterproofing Fabrics, of which the following is a specification.

My invention consists of a method for the elimination of the bound and free moisture and contained air present in fabrics composed of cotton, paper and other materials, and the substitution for the moisture and free air of a liquid which will cause the fabric to be waterproof; that is to say, which will so fill the voids, interstices and capillaries of the fabric as to prevent the reabsorption of moisture or air, thus rendering the fabric non-hygroscopic and insulating it if it be used for electrical purposes.

In order that the method may be fully understood, the following explanation is made, reference being had to a cotton textile fabric as an example, but by the word "fabric" I desire to be understood any fabricated structure: a thread, a yarn, a textile, a combination of textiles, a structure made of metal or metal and textile; in fact, everything from which it is desired to extract air and moisture and to fill the voids formerly occupied by the air and moisture with a liquid which will serve for waterproofing and insulating purposes.

As is well known, a cotton textile fabric is composed of strands of cotton, the structure consisting of longitudinal strands interlacing with lateral strands. The strands cannot be woven so tightly that the fabric will have no voids or interstices and the coarser the fabric—that is, the larger the strands—the greater will be the interstices. The interstices formed by the intersection of the strands may be considered as voids of the first order of magnitude. The strands consist of a bundle of fibers twisted together. Several strands may be combined to form a larger strand. The spaces between the adjacent fibers composing the strands and the spaces between the strands of a single yarn may be considered as voids of a second order of magnitude. The fibers themselves consist of flattened tube-like structures and the spaces within the fibers, the interior of the tubes, may be considered as voids of a third order of magnitude. It will be readily perceived that the surface of a cotton fabric is of enormous extent when the internal and external spaces of the fibers composing the fabric are considered.

The superficial energy of a solid and liquid in contact in cases where the liquid does not dissolve the solid depends upon the nature and extent of the surface. When the liquid dissolves the solid, the surface disappears and there is no superficial energy. It is known that the molecular activity or energy of a liquid is greatest very close to its surface. It is probable that this increase of energy is sensible within a distance of one-thousandth of a millimeter or less from the surface. It is also known that the superficial tension or energy decreases with an increase of temperature and in the case of water becomes *nil* at the temperature of boiling water. At this temperature the moisture in the fabric is no longer bound, but is freed. It is also known that the viscosity of liquids descreases with an increase of temperature and the heavy oils and liquefiable solids have a viscosity many times greater than water at a temperature which is destructive of the structure composing the fibers of the fabric it is desired to impregnate. Cotton and paper begin to lose their strength when heated to 100° centigrade. It is unnecessary to heat cotton, paper, etc., to 100° C. to eliminate the moisture, as a reduction of pressure will cause vaporization at a lower temperature. The vacuum process is efficient in the elimination of moisture, but it has been difficult to apply the proper degree of heat to fabrics in a vacuum. Particularly is this true of electrical structures which consist of insulated wire, the layers of which are further insulated from each other by layers of insulation. This insulation also insulates thermally. In my process I distribute the heat throughout the mass of an electrical structure or fabric by heating the wires of such structure electrically, and thus avoid unequal and excessive local heating. The structures may be heated otherwise, but it is apparent that the process will take longer and not be so effective. The fabric or structure is then placed in a vacuum chamber which is exhausted. Vaporization will take place at a temperature corresponding to the pressure.

As above stated, the superficial tension decreases with an increase of temperature. The viscosity decreases with an increase of temperature and the strength of the fabric decreases with an increase of temperature above the boiling point of water; therefore it is essential, in order that the voids of the second and third magnitude heretofore described shall be completely filled, that the filling material shall be liquid and its fluidity such that it can penetrate these minute spaces at a temperature which will not deteriorate the strengh of the fiber and will be drawn into capillary spaces by the surface tension existing between the solid and the liquid.

In some of the arts it is important that structures composed in whole or in part of fibrous material shall not respond to changes of humidity or absorb moisture in cooling or liberate it in heating. Textile fabrics, paper, cardboard, rope, cord, clothing, insulated wire, electric structures, cotton belting, etc., are a few examples of such structures, which are responsive to the hygrometric quality of the atmosphere. Substances which are fluid, insoluble in water and possess a superficial tension for the solid with which they are in contact, are suitable weather-proofing or water-proofing agents. In some cases, oxidizable oils are employed. Varnishes, boiled linseed oil, cottonseed oil, resin oil, are a few of the weather-proofing substances that have been successively employed. Some of these substances solidify at a temperature considerably above normal. With these substances the surface tension of the water-proofing or insulating liquid and the solid or fabric will be maximum at the temperature at which the liquid becomes so nearly solid as to cease to flow under the influence of surface tension.

In some cases it will be best to use a liquid filler which is fluid at ordinary temperatures, because with such a fluid the highest degree of surface tension will be utilized; but some of the substances which solidify at higher temperature possess qualities which are valuable and it may in some cases be desirable to use them.

The general mode of application of the process consists of heating the structure to expel moisture and contained air to a temperature which may be regulated by the pressure and which should not exceed 100° C., and after said elimination is complete, to submerge the fabric while hot into a bath of the filling compound, which may be heated to increase its limpidity, and then, the fabric being submerged, allow the structure and the bath to cool together until there has been a complete exchange of the moisture and contained air for the filling compound. The fabric is then removed from the bath and its exterior surface hardened, if desired, or coated with another compound which hardens quickly, for the purpose of retaining the liquid filler in the larger interstices.

The preferred method of impregnating electrical fabrics in which electric conductors are embedded is to heat them electrically in a vacuum chamber by passing a current through their conductors and thus eliminate the air and moisture. When the air and moisture have been completely eliminated, the impregnating insulating liquid is allowed to flow into the chamber and submerge the structure. Air pressure may be applied to assist the surface tension of the fabric and liquid and the whole allowed to cool together, the structure remaining submerged, with the result that the most minute voids, as well as the coarser ones of the fabric, will be completely filled with the insulating liquid and this liquid once in these minute capillary voids will remain there and prevent the re-absorption of moisture or air, unless it evaporates, which is prevented as above described.

I am aware that cables composed of conductors covered with hygroscopic materials, such as paper and jute, have been dried electrically in a vacuum chamber and then sealed in a lead sheath or envelop. Also that cables interred in conduits have been dried electrically, the lead sheath being used as a vacuum chamber and a vacuum pump connected to the lead sheath producing the necessary degree of exhaustion. Also that insulated conductors and electrical structures have been boiled at high temperatures in a liquid insulation to remove the moisture, but none of these methods employ my process. I believe I am the first who has attempted to impregnate a fabric or structure composed in whole or in part of fibrous materials at a temperature which will not impair the strength of the fibrous material with a substance that completely fills all the voids or spaces, capillary and intersticial, by using one of requisite fluidity at a temperature at which the surface tension of the structure and the fibrous material is maximum.

I do not intend to limit myself to an application of my process to the insulation of electric structures or electric insulating material of any sort, because my process is applicable to the impregnation of any fabric with any suitable waterproofing material or insulating liquid for the purpose of rendering the fabric non-hygroscopic.

What I claim and desire to secure by Letters Patent is:

1. The process of treating fabrics to render them moisture-proof, which consists of first heating the fabric to a temperature and at a pressure sufficient to expel the moisture and contained air, and then submerging the fabric in a suitable fluid, and then cooling

the fabric and the fluid, the fabric remaining submerged, to a temperature which is normal or below normal, and at which the surface tension of the fluid and fabric is substantially maximum and then removing the fabric from the fluid.

2. The process of treating fibrous fabrics to render them moisture-proof, which consists of first heating them to a temperature and at a pressure sufficient to expel the moisture and contained air without impairing the strength of the fabric, and then submerging the fabric in an insulating fluid, and then cooling the fabric and fluid to a temperature which is normal or below normal, and at which the surface tension of the fluid and fabric becomes substantially maximum, and then removing the fabric from the fluid.

3. The process of treating fabrics made from hygroscopic fibers to render them non-hygroscopic, which consists of first treating the fabric under conditions adapted to expel moisture and contained air without impairing the strength of the fabric, and then submerging the fabric while hot in a bath of suitable liquid, fluid at ordinary temperatures, and then cooling the structure while submerged and the liquid to a normal temperature or one lower than normal whereby the surface tension of the liquid and fabric becomes substantially maximum and then removing the fabric from the liquid.

4. The process of insulating an electric structure containing conductors and insulating fabric, which consists of first heating the structure to expel moisture and contained air, and then while hot submerging the structure in a bath of hot liquid insulating fluid which will remain fluid at ordinary temperatures, and then cooling the structure and fluid, the structure remaining submerged, until the associated substances reach normal temperatures, whereby the surface tension becomes maximum, and then removing the structure from the liquid.

5. The process of insulating an electric structure containing conductors and insulating fabric, which consists of first heating the structure to a temperature and at pressure necessary to expel moisture and air, and then while hot submerging the structure in a bath of liquid insulating fluid which will remain fluid at ordinary temperatures, and heating to increase the fluidity of the liquid, and then cooling the liquid and the fabric, the fabric remaining submerged, until a temperature which is normal or below normal is reached, whereby the surface tension between the liquid and the fabric becomes substantially maximum and then removing the fabric from the liquid.

6. The process of treating fibrous fabrics to render them non-hygroscopic, which consists of first heating the structure at a temperature and pressure to expel moisture and permit the withdrawal of contained air, and then submerging the fabric in a bath of liquid weatherproofing compound, heating to increase the fluidity of the liquid, and then cooling the fabric and liquid, the fabric remaining submerged, until a normal temperature or one below normal at which the surface tension between the liquid and the fabric becomes substantially maximum is reached and then removing the fabric from the liquid.

7. The method of insulating electric structures by substituting hygroscopic moisture held in capillaries and upon the surfaces of the fibrous materials composing in part such structure and air contained in the interstices, by an insulating liquid, which consists in assembling the structure with green insulating material, heating the structure and insulating material by passing a current of electricity through its conductors and thus driving out the hygroscopic moisture and air, and then while still electrically heated submerging the structure in a bath of insulating liquid, continuing the heating for a period and finally allowing the structure and insulating liquid to cool together, the structure remaining submerged, whereby the capillaries and interstices will be filled with the insulating liquid.

Signed by me at Baltimore, Maryland this 8th day of July 1909.

PIERRE O. KEILHOLTZ.

Witnesses:

EDWARD L. BASH,

S. RALPH WARNKEN.