

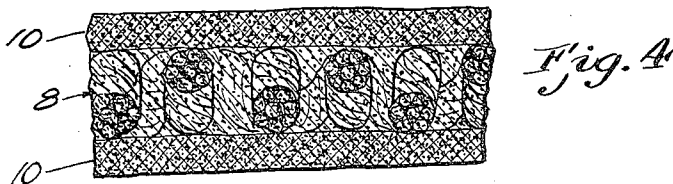
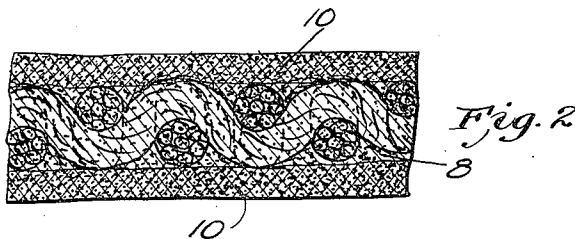
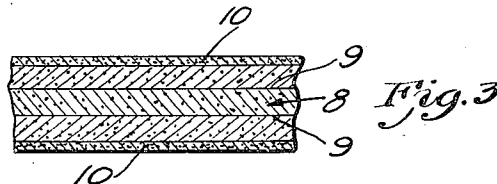
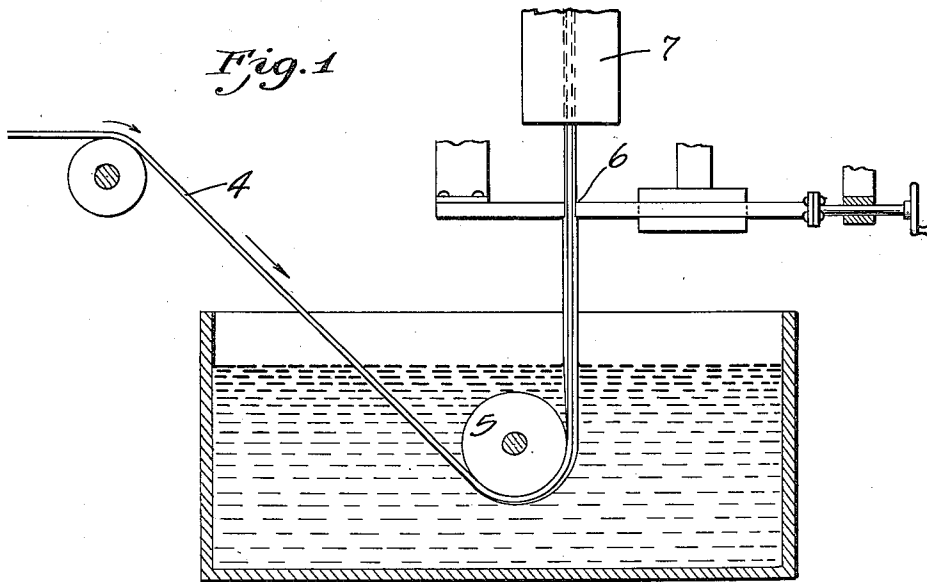
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H. Y. JENNINGS ET AL

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DIAPHRAGM AND METHOD OF FORMING SAME

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INVENTORS
HARLEY Y. JENNINGS
JOSEPH A. GILLEN
BY
Barrows, Kinsell, Laughlin & Rausch
ATTORNEYS

UNITED STATES PATENT OFFICE

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DIAPHRAGM AND METHOD OF FORMING SAME

Harley Y. Jennings, Clio, and Joseph A. Gillen, Flint, Mich., assignors to Copeman Laboratories Company, Flint, Mich., a corporation of Michigan

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This invention relates to a diaphragm and method of forming same, and has to do more particularly with a method of treating fabrics to make the same impervious, flexible and durable. This application is a continuation in part of our prior application Serial No. 127,801, filed February 25, 1937.

Heretofore in the fabrication of diaphragms such as fuel pump diaphragms, in accordance with patented and commercial methods, it has been the general practice to apply a light coat of treating material to the fabric, then curing this material at a low temperature for a relatively long period; following this, it has been customary to apply and then cure additional coats until the coating is built up to the desired thickness; the result being that the finally cured coating is of the same consistency throughout the membrane, and having a tendency to hold the threads firmly in position. In the use of such diaphragms in fuel pumps and similar devices, it is customary to have a plurality of diaphragms, up to five in number, and a multiple diaphragm such as used in a fuel pump, that will flex continuously for a period of seventy to eighty hours before it breaks down or ruptures has heretofore been considered to be a commercially practical diaphragm.

It is an object of the present invention to so treat diaphragm fabrics and the like as to form a tougher protective surface coating or layer adapted to contact the fuel to be pumped, this coating being of such a nature as to be substantially unaffected by the selected fuel, and another coating or layer surrounding the fibers of the diaphragm material, which layer remains relatively soft and pliable, and is protected from contact with the fuel by the first-named tough surface coating. The result is that this relatively soft pliable portion or layer acts as a lubricant between the fibers or cloth laminations of the diaphragm when it is flexed, thereby reducing the tendency for wearing friction between the fibers or between the laminations, such as is produced in the prior art diaphragms where the treating substance used thereon has the same general consistency throughout its cross-section.

More specifically, the present invention contemplates the partial curing of the treating material to a predetermined degree before it is applied to the fabric, this degree of curing being preferably such that the material becomes so viscous that it will penetrate the fabric only when it is heated. In this heated state the material is applied in a thick layer to the fabric and the

treated fabric is then subjected to a predetermined relatively high temperature for a predetermined time, until a relatively tough, hard and impervious outer surface is rapidly formed, while the rest of the material around the fabric remains relatively soft.

A further feature of the invention is that the method of treating may be applied to either a laminated diaphragm or a single layer diaphragm, the characteristics of the resulting product being substantially the same. Other features of the invention including detail methods of application, temperature limits, and characteristics of the resulting product will be more clearly set forth in the specification and claims.

In the drawing:

Fig. 1 is a diagrammatic view illustrating one method of impregnating the fabric with the treating solution, controlling the depth of the coating and final curing.

Fig. 2 is an enlarged cross sectional view taken from a micro-photograph of a single layer diaphragm treated in accordance with the present invention.

Fig. 3 is a view similar to Fig. 2 but illustrating a laminated diaphragm with a relatively tough, impervious outer layer and a relatively soft central portion.

Fig. 4 is a view similar to Fig. 2 but showing one of the cross yarns removed to leave the tough surface coatings intact.

It will be understood that while the present invention relates particularly to diaphragms of the type suitable for fuel pumps, gas meters, etc., the treated fabrics may be used for various other commercial purposes where flexibility and impermeability are important factors. It will be appreciated that the type and general properties of the treating materials used will depend largely upon the purpose for which the fabric is to be utilized. For example, it will be understood that the type of fabric or textile used for impregnation should have a fairly high tensile strength in order to stand the repeated flexing and the pressures applied against its surface or surfaces. The fabric should have a relatively high thread count, at least sixty threads per inch in both warp and fill, to make the interstices between the threads small. Furthermore, the fabric should be practically free from starch, waxes, and other foreign material, so that the treating material will adhere readily to the surface of the fibers. Any projecting fibers may be removed by a singeing operation; fabrics known to the textile trade as balloon cloth, airplane fabric and

sail duck are suitable for carrying out the present invention.

The types of treating materials suitable for use with the present invention are those which in their untreated condition are free flowing liquids at ordinary temperatures, but become viscous when heated, and finally if heated long enough become sufficiently cured to reach the solid state. For the purposes of this specification, the materials which may be used for treating the fabrics will be hereinafter referred to as "resinous substances" and include materials falling under the general classification of (a) natural resins, (b) synthetic resins, such as phenol-formaldehyde and glyptal resins, and (c) substances such as tung oil and linseed oil, or mixtures thereof, which while not in themselves true resins, do, when at least partially polymerized and oxidized, physically resemble true resins.

The change of physical condition of these resinous substances from the liquid state through the viscous stage and to the solid state is a complicated chemical one, due primarily to polymerization and oxidation although other chemical reactions may be involved. The change of physical condition takes place most rapidly on the surface of the mass when heat is applied, and on the surfaces exposed to air where oxidation takes place. A tough impervious film forms on these exposed surfaces first, and this film retards the reaction of the remaining material, because oxidation of the remaining material is practically prevented and heat transfer is substantially decreased by the formation of the aforesaid tough impervious film on the exposed surface or surfaces. When this curing is carried on under properly controlled conditions the protected portions of the material are retained in a relatively soft plastic state after the exposed surface has become relatively tough and impervious.

It is this condition, produced by practising the present invention, which produces the unexpected flexibility of the fabric, and at the same time provides a relatively tough, impervious protective outer coating.

In carrying out the preferred method, a selected resinous substance is first partially cured before it is applied to the cloth; this partial curing is usually effected by heating the resinous substance under controlled conditions until it becomes so viscous that it will penetrate the fabric only when it is heated between predetermined limits. The hot viscous material is applied to the cloth in a thick layer and as rapidly as possible, after which the coated cloth is heated rapidly at a predetermined higher temperature for a predetermined time so that a relatively tough, hard and impermeable outer surface of cured resinous substance is formed on the exposed surface or surfaces of the cloth while the unexposed mass of the resinous substance surrounding the fibers of the cloth remains in its partially cured condition, or, in other words, relatively soft and viscous.

The faster this outer film or layer is formed, the more plastic the remaining material will remain, and it is this plasticity which contributes so much to the success of the present invention, as the resultant diaphragm is very flexible and the soft inner layer or mass of material serves as a natural lubricant for the fibers composing the fabric and thereby adds materially to the life of the article. It is desirable that the curing of the outer layer be done as quickly as possible and accordingly the curing temperature should

be as high as the nature of the resinous substance will permit without decomposition thereof.

In present commercial methods, as generally practiced in the treating of diaphragms, the procedure is substantially the opposite, in that it is customary to apply a light coat of treating material and then cure the same at a low temperature for a long period, after which additional coatings are applied and cured until the final coating is built up to the desired thickness with the result that the coating is of substantially the same consistency throughout and has a tendency to hold the threads firmly in position.

Application of our method is illustrated by the following examples:

Example I.—A mixture of drying oils, say, equal volumes of tung and linseed oils, are used; this mixture is heated to around 400° F. and maintained at this temperature while air is continually drawn through the mass. The length of time the oils are heated depends upon their condition prior to treatment. Samples are withdrawn from the bath at frequent intervals and when the cured samples reach the desired viscosity, the heating of the mass is stopped and the mixture cooled. In treating the fabric, the mixture is again heated to around 200° F. in a suitable tank, such as shown at 2 in Fig. 1, the heated material being indicated as at 3. In treating the fabric 4, whether in one or a plurality of layers, it is pulled down through the liquid 3 and around a roll 5 and then up through an adjustable slot 6. The opening in the slot 6 is so regulated that the layers are just pressed together (if a laminated product is desired) and at the same time the excess of hot liquid is scraped off, but leaving a relatively heavy coating on the outer surface of the fabric. We prefer to apply approximately seven ounces of the treating material per square yard of cloth. The coated cloth is moved through the adjustable slot 6 rather slowly, giving plenty of time for penetration of liquid into the fabric and also allow the thick outer layer sufficient time to cool and thicken so that it remains on the cloth.

The next step is to subject the coated cloth to a predetermined temperature for a predetermined time. For example, the cloth treated with this mixture of oils may be subjected to a temperature of between 225° F. and 325° F. for a period of time ranging from ten hours to one hour; that is, the lower the temperature of this heat treatment the longer the curing time required. We have found that a cloth coated as described above and treated at a temperature of 300° F. for four hours produces a very satisfactory diaphragm.

When first subjected to the heat in the chamber 7, there is a tendency for the treating material to drip from the strips of treated fabric, but this tendency exists only for a few minutes due to the rapid formation of a surface film at this relatively high temperature. At the end of this treatment a relatively tough film of resinous substance has formed on the exposed surface or surfaces of the cloth while the unexposed portions have remained comparatively soft.

The same method of procedure with slight variations and changes of time and temperature conditions may be applied to other combinations of drying and semi-drying oils, such as soy bean oil, rubber seed oil, oiticica oil, etc.

Example II.—This method of application also gives satisfactory results with resins of the modified phenol-formaldehyde type. For example, if

a commercial phenol-formaldehyde resin, such as liquid Durez flexible resin is applied to the fabric at temperature of 200° F. in the manner described in Example I, and then cured at a selected temperature between 225° F. and 325° F. for a selected time between ten hours and one hour, the inner layer, if three layers of fabric are treated, will be soft and pliable compared with the outer surface coating. Specifically, we have found that curing at 300° F. for one hour produces an excellent diaphragm fabric. This material also makes a suitable flexible fabric, although it stiffens somewhat at low temperatures.

Example III.—Resin materials included under the generic term, alkyd, which covers in a broad way the resins made from polybasic acids or anhydrides (such as phthalic, maleic, or succinic) and polyhydric alcohols (such as glycerine or glycol), with various modified forms may be applied to fabrics by this method. If commercial alkyd resins, such as modified Rezyl resins, are heated to 200° F. and applied to the fabric as described in detail in Example I, and are then cured at predetermined temperatures between 225° and 325° F. for a predetermined time between ten hours and one hour, a very flexible fabric is produced. For example, I have found that a fabric treated with this substance and cured at a temperature of 300° F. for three hours is exceptionally flexible over a wide range of temperatures and is very long-lived and durable.

As mentioned before, the unexposed portion of a laminated coated fabric will be softer and more pliable than the exposed surfaces of the fabric. The resultant product is a fabric very flexible at all temperatures and having durable impermeable exposed surfaces particularly resistant to the solvent action of gasoline and chemically related solvents.

When a laminated fabric of three layers is pulled apart after this type of treatment, the central layer, see the portion 8 in Fig. 3 as well as the inner surfaces 9 of the outer layers, are relatively soft and plastic while the outer exposed surfaces 10 are tough and relatively hard. Normally in a three layer diaphragm such as shown in Fig. 3, when used in a fuel pump, the laminations remain stuck together, so that the diaphragm acts as a unit, the inner portion or layer of soft material acts as a lubricant between the cloth and the laminations and between the discrete fibers of the cloth when flexed, thus materially reducing the tendency and wearing friction between the layers and fibers, as is the case if a laminated structure is made up of separately cured sections.

Even more striking and unexpected are the results produced by treating a single layer of fabric in this manner. This is well illustrated in Figs. 2 and 4, which are sketches made from photo-micrographs of a cross section of a single section of fabric treated in accordance with the present invention. After the final curing step, when the outer tough and relatively hard layers 10 are formed, the fact that the central portion 8 is still relatively soft and tacky is proved by the fact that the yarns in the central portion 8 may be readily pulled out or unraveled leaving the tough outer coatings or surfaces 10 intact. This is clearly shown by comparing Figs. 2 and 4 which indicate very definitely that within the tough outer coatings 10 the junction of the warp and fill yarns are surrounded by a relatively soft pliable form of material which permits free movement during flexing operations. The relatively

soft tacky material surrounding the yarns serves as a lubricant, permitting this relative movement and thus greatly increasing the life of the diaphragm. Actual tests of both single diaphragms and multiple layer diaphragms used in standard type fuel pumps, show that diaphragms treated in accordance with the present invention stand up for many hundreds of hours, when operated under the standard conditions, without rupturing or breaking in any way.

It has also been found that by applying a sheet of oiled or waxed paper to one side of a treated fabric after the fabric has passed through the hot treating bath, and then by curing the fabric with the aforesaid paper applied, that only the exposed or uncovered surface of the fabric polymerizes and oxidizes rapidly. The resultant product, therefore, is a fabric having a single hard durable impervious surface, which may be placed in a fuel pump to contact the gasoline or other similar product, while all of the remaining resinous substance surrounding the fibers of the fabric remains relatively soft and substantially unoxidized. It is understood, of course, that the paper is removed from the diaphragm before the diaphragm is placed in the pump. Then, too, two pieces of fabric thus treated may be placed with their soft sides together, and then pressed or rolled, with the result that a two layer laminated diaphragm is produced having hard impermeable outer surfaces and a relatively soft interior portion.

It is understood that the types of resinous substances mentioned in the above examples may be blended with each other in varying amounts to produce flexible fabrics for specific purposes and the same method of application used. The blending of these materials may in some cases be accompanied by a chemical reaction but in every case the physical properties will be modified.

As stated above, this method of application applies to those materials which are free flowing before heat treatment and gradually change upon heating to viscous liquids and then solids. It might be more specifically stated that this method of application and the resulting product are especially adapted for materials which form thermo-setting resinous substances. Thermo-setting resinous substances being the term describing those substances which upon further heating or curing become tougher and harder and finally decompose if too much heat is applied. These are distinguished from the thermoplastic type of resinous substance which soften and become plastic upon heating and when cooled return to the original condition.

In carrying out the present invention, with all the types of materials mentioned, certain optimum conditions may be defined which will give good penetration of the fabric and at the same time apply a heavy coating. The materials used must be heated or pre-cured until they have a relatively high viscosity; in fact, a viscosity such that it is necessary to heat the viscous materials to about 200° F. before they will thoroughly penetrate the capillary spaces of the fabric. In general practice, the viscosity of the material used in carrying out the process should be such that it should be heated some place between 150° F. and 250° F. in order to obtain penetration and proper coating of the fabric; the preferred temperature is approximately 200° F. It will be understood that materials that are of low viscosity at temperatures below 125° are too thin for they will flow

from the fabric without leaving sufficient material for the proper coating and other materials that are viscous above 300° F. are too thick to handle properly and will not give proper impregnation of the fabric. It also will be understood that the question of time in coating the fabric is important and that the bath of treating material, after being brought to the required temperature, should be thereafter used in coating and penetrating the cloth, for only a relatively short period of time, as otherwise the treating material will cure in the bath to the point where it becomes too viscous to properly penetrate the fabric. The conditions of temperature and time of treatment may vary considerably with each group of materials used, but the procedure and technique of application will generally be the same.

What we claim is:

1. As a new article of manufacture, a diaphragm comprising a fabric having an exposed surface coated with a relatively tough and hard layer of a cured thermo-setting resinous substance rendering the fabric substantially impermeable, and a relatively soft uncured mass of plastic material of the same composition as the hard layer surrounding the fibers of the fabric whereby to render the diaphragm relatively soft and flexible.

2. As a new article of manufacture, a diaphragm comprising a fabric the exposed surfaces of which are coated with a relatively tough and hard layer of a cured thermo-setting resinous substance rendering the fabric substantially impermeable, the fibers of the fabric in between said relatively tough and hard outer layers being surrounded with a relatively soft uncured plastic material of the same composition as the hard layer.

3. As a new article of manufacture, a diaphragm comprising a fabric the exposed surfaces of which are coated with a relatively tough and hard layer formed from cured thermo-setting, viscous, resinous substances rendering the fabric substantially impermeable, the fibers of the fabric in between said relatively tough and hard outer layers being surrounded with a relatively soft plastic material of the same composition as the hard layer but in a less cured state.

4. As a new article of manufacture, a diaphragm, comprising a fabric the exposed surfaces of which are coated with a relatively tough and hard layer of a thermo-setting resinous substance the viscosity of which is increased by precuring, thereby rendering the fabric substantially impermeable, the fibers of the fabric in between said relatively tough and hard outer layers being surrounded with the same kind of resinous substance in a relatively soft plastic condition whereby to permit relative movement of the fibers of the inner portion of the fabric when the diaphragm is flexed.

5. As a new article of manufacture, a laminated diaphragm, comprising a fabric, the exposed surfaces of which are coated with a relatively tough and hard layer of a thermo-setting resinous substance, the viscosity of which is increased by precuring, thereby rendering the fabric substantially impermeable, the fibers of the fabric in between said relatively tough and hard outer layers being surrounded with the same kind of a resinous substance in a relatively soft plastic condition whereby to permit relative movement of the fibers of the inner portion of the fabric

when the diaphragm is flexed, said soft material serving to hold the laminations together.

6. As a new article of manufacture, a diaphragm, comprising a fabric, the exposed surfaces of which are coated with a relatively tough and hard layer formed from cured resinous substance rendering the fabric substantially impermeable, the fibers of the fabric in between said relatively tough and hard outer layers being surrounded with the same kind of material forming the outer relatively tough and hard surfaces but being retained in a relatively soft plastic form.

7. As a new article of manufacture, a flexible fabric for fuel pumps and the like, impregnated with a relatively tough impervious exposed outer coating of a substance of the class consisting of rosin, phenol-formaldehyde and glyptal resins, tung oil, and linseed oil, and an inner concealed portion of the same substance as that forming the outer coating, but maintained in a relatively soft plastic state, whereby to increase the flexibility and life of the fabric.

8. The method of treating fabrics whereby to render the same impermeable and highly flexible, for use as fuel pump diaphragms and the like, which comprises utilizing a thermo-setting resinous substance composed of alkyl resins the viscosity of which is increased by precuring, precuring the substance by application of heat and air to such an extent that it becomes so viscous that it will penetrate fabrics of the closely woven type only when in heated condition, heating the viscous substance and applying the same in a relatively thick layer to the fabric in a quantity of approximately seven ounces per square yard of cloth, and then subjecting the coated fabric to a relatively high temperature of around 300° F. for about 3 hours to form a tough relatively hard outer layer on the exposed surfaces of the fabric and retain the substance between the outer layers in a relatively soft plastic condition.

9. The method of treating fabrics whereby to render the same impermeable and highly flexible, for use as a fuel pump diaphragm and the like, which comprises utilizing a thermo-setting resinous substance the viscosity of which is increased by precuring, precuring the substance to such an extent that it becomes so viscous that it will penetrate fabrics of the closely woven type only when in heated condition, heating the viscous substance to a temperature between 150° F. and 250° F. and applying the same in a relatively thick layer to the fabric, and then subjecting the coated fabric to a relatively high temperature between 225° and 325° for a period of one to ten hours to form a tough relatively hard outer layer on the exposed surfaces of the fabric and retain the substance between the outer layers in a relatively soft plastic condition.

10. The method of treating fabrics whereby to render the same impermeable and highly flexible, for use as a fuel pump diaphragm and the like, which comprises utilizing a resinous substance the viscosity of which is increased by precuring, precuring the substance to such an extent that it becomes so viscous that it will penetrate fabrics of the closely woven type only when in heated condition, heating the viscous substance and applying the same in a relatively thick layer to the fabric, a part of the substance penetrating into the interstices of the fabric, and then subjecting the coated fabric to a temperature above 225° to form a tough relatively hard outer layer on the exposed surfaces of the fabric and retain the

substance between the outer layers in a relatively soft viscous condition.

11. The method of treating fabrics to make them impermeable, durable and highly flexible which comprises using a partially polymerized alkyd resin having a viscosity such that it will penetrate the fabric only when heated between 150° F. and 250° F., applying a relatively thick coating of the heated resin to the fabric, and then subjecting the coated fabric to a temperature between 225° F. and 325° F. for a period of from one to ten hours so that the exposed surface of the coating becomes substantially completely polymerized and relatively hard, while the inner layer around the fibers remains in a relatively soft and partially polymerized condition.

12. The method of treating fabrics to make them impermeable, durable and highly flexible which comprises using a partially polymerized phenol-formaldehyde resin having a viscosity such that it will penetrate the fabric only when heated between 150° F. and 250° F., applying a relatively thick coating of the heated resin to the fabric, and then subjecting the coated fabric to a temperature between 225° F. and 325° F. for a period of from one to ten hours so that the exposed surface of the coating becomes substantially completely polymerized and relatively hard, while the inner layer around the fibers remains in a relatively soft and partially polymerized condition.

13. The method of treating fabrics to make them impermeable, durable and highly flexible which comprises using a partially polymerized mixture of tung and linseed oils having a viscosity such that it will penetrate the fabric only when heated between 150° F. and 250° F., applying a relatively thick coating of the heated mixture to the fabric, and then subjecting the coated fabric to a temperature between 225° F. and 325° F. for a period of from one to ten hours so that the exposed surface of the coating becomes substantially completely polymerized and relatively hard, while the inner layer around the fibers remains in a relatively soft and partially polymerized condition.

14. The method of treating fabrics whereby to render the same impermeable and highly flexible, for use as fuel pump diaphragms and the like,

which comprises using a thermo-setting resinous substance the viscosity of which is increased by precuring, precuring the substance to such an extent that it becomes so viscous that it will penetrate fabrics of the closely woven type only when it is heated, heating the viscous substance and applying the same in a relatively thick layer to the fabric, covering one side of the coated fabric with a sheet of material which adheres closely enough to prevent subsequent oxidation and hardening of said covered side, then subjecting the coated fabric to a relatively high temperature to form a tough, relatively hard impermeable surface on the uncovered exposed surface of the fabric and retain the remaining resinous substance adhering to the diaphragm in a relatively soft plastic condition, removing the sheet of covering material and thereafter pressing two pieces of the fabric thus treated together with their hardened surfaces outermost to form a laminated diaphragm having relatively hard outer surfaces and a soft center layer.

15. The step in preparing a laminated diaphragm for use in fuel pumps and the like, which comprises pressing together two pieces of fabric, each bearing a thick layer of resinous substance and each having a hard impervious surface and a soft plastic surface, with the soft plastic surface pressed together and the hard outer surfaces exposed.

16. The method of treating fabrics to make them impermeable, durable and highly flexible which comprises using a partially polymerized thermo-setting alkyd resin having a viscosity such that it will penetrate the fabric only when heated between 150° F. and 250° F., applying a relatively thick coating of the heated resin to the fabric, and then subjecting the coated fabric to a temperature of approximately 300° F. for a period of approximately three hours so that the exposed surface of the coating becomes substantially completely polymerized and relatively hard, while the inner layer around the fibers remains in a relatively soft and partially polymerized condition.

HARLEY Y. JENNINGS.
JOSEPH A. GILLEN.