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DIAPHRAGM AND ITS PROCESS OF MANUFACTURE

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Fig. 1.

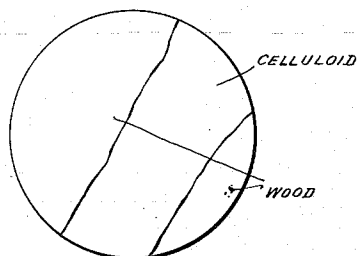


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.

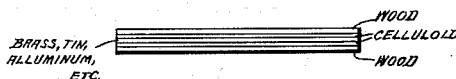


Fig. 6.



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DIAPHRAGM AND ITS PROCESS OF MANUFACTURE

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The present invention relates to diaphragms for sound reproducing and recording instruments such as phonographs, dictaphones, telephones and the like, and to processes for their manufacture; and its object, stated briefly, is to produce an improved diaphragm which can replace with great advantage the various types heretofore in use.

It is well known that laminated structures in general have a peculiar efficacy for acoustic purposes, whether the laminae be of natural formation, as in the case of mica, for example, or whether the structure be produced by building up a plurality of layers of various materials and securing them together by means of adhesives. A single layer of wood, however, may be utilized to produce a good tone of fair volume, provided that it is so prepared that, by virtue of its thickness, contour and after-treatment, it becomes an appropriate medium for unimpaired propagation and development of sound-waves; but experiments have conclusively shown that whereas single-layer wood diaphragms produce, on the average, finer tones than those of any other material, in single layer, yet even though the wood be filled, parchmented either before or after more or less complete carbonization, and strengthened in every possible way, it still remains too frail for successful commercial adaptation.

I have found, after an extended series of experiments, that this defect can be completely overcome and the natural fine acoustic properties of the wood utilized to the full by bonding the wood with one or more layers of other materials, such, for instance, as celluloid or other cellulose ester specially prepared, in flexible sheet form, bakelite, either translucent or laminated, mica, and even certain metals, all as subsequently explained.

The total quality of the wood is controlled more or less by the factors of thickness, character of cut and finishing. The element of thickness is of great importance. It has been found that different woods require different thicknesses to bring out their best acoustic properties; a section cut out thin enough to show plainly by transmitted light the cellular structure of the wood in question to the

naked eye, generally producing the best tone. When the sections are cut thicker than permissible for a given wood, wave action is impeded and the sound becomes hard and dull, whereas when cut thinner a tendency to "blasting" and echoing is developed, which perseveres even when the number of laminations is increased. When a large number of laminations are utilized with excessively thin materials, we arrive at the hard, brilliant tones and noises of natural mica.

The character of the wood section, whether cut tangentially, radially or transversely, that is to say to the axis of the original log, or to the longitudinal cellular structure of any piece of wood thereof has also been found to exert the most marked influence upon the sound, because of the effect of the cellular arrangement upon uniform propagation of sound-waves. From actual tests, it has been demonstrated that transverse cuts give by far the best results from every standpoint, viz: fullness, roundness and purity of tone, freedom from surface noises, and remarkable increase in volume. This is more true of certain woods than of others, but it always holds good when different cuts of the same wood are directly compared.

As will be understood from the foregoing, the number of wood laminae and their thickness, may vary. The laminae with which they are bonded may likewise vary, not only as to the materials of which they are constructed, but also as to their arrangement relative to the wood laminae; and different methods for effecting the bonding or welding may also be employed. I utilize a sheet of celluloid as an adhesive and laminating medium as that material has given most satisfactory results; and in constructing a laminated diaphragm I may adopt the following procedure:—

The wood sections, transversely cut, together with a sheet or sheets of celluloid cut to the proper size, are immersed in a liquid, such as fusel oil, which will exert a latent or retarded solvent action upon the surface of the celluloid. Depending upon how many laminae are desired, and whether celluloid or wood shall form the surface layers, the wood sections and celluloid are alternately super-

imposed upon each other beneath the solution, so that all air bubbles are eliminated. The composite is then lifted out of the solution, subjected to a light cold pressure to remove the excess liquid, and placed in a press capable of developing pressures up to 100 lbs. per sq. in. and provided with suitable arrangements for heating and cooling. The press is then closed, heat applied, and pressure gradually increased until the maximum suitable for the work in hand has been reached. When the proper degree of heat has been obtained (100° C. being found a very satisfactory limit), the temperature is lowered to about 80-85° C. At this temperature, the material is maintained under pressure until thoroughly dried out (generally one hour). The press is now cooled as rapidly as possible and the composite removed. If the operation has been properly conducted, the various layers will be permanently bonded, the sheet of celluloid will have retained its original shape and toughness, though fractionally reduced in thickness because of its partial dissolution by the solvent, and the cellular structure of the wood will not have been distorted or injured in any manner, nor will the cells have been filled with celluloid. The composite itself will be very tough and flexible, and may be utilized at this point to produce a diaphragm of very superior quality.

In order, however, to bring out added resonance and to increase the flexibility, the composite may be dipped into a hot wax mixture and left therein until all cellular structures are completely filled. After withdrawal, the excess wax is removed and the desired surface contour imparted by means of a lathe or by pressure, or in some other suitable way. I preferably use a hot mixture composed of 1 part of carnauba wax and 5 parts of bees wax for the purpose above stated, though mixtures of various other waxes and oils may be substituted therefor, as well as shellac and varnishes; and I may, if desired, also use in place of the wax mixture a mixture of gelatin and glycerine, with or without the addition of glucose, such mixture forming a rubber-like compound which promotes the utmost flexibility.

As previously stated, the number of laminae, the materials of which they are constructed, and their arrangement relative to one another may vary. The composites above described, consisting of a single sheet of celluloid welded between two surface layers of wood, have given the most satisfactory results, particularly when the celluloid does not fill the cellular structures of the wood. Remarkably fine tonal results have also been obtained with five-layer composites consisting of two outside or surface layers of wood, a central layer of wood and two intermediate layers of celluloid. Thin brass may be used for the central layer, in place of wood, or, if desired,

tin or aluminum, and even bakelite or mica or textile materials can be substituted therefor. Furthermore, the wood sections may be cut tangentially instead of transversely, though the latter cutting is preferred, as already explained.

The accompanying drawing illustrates, by way of examples, some of the forms which the invention may take:

Figure 1 thereof is a plan view of the preferred form of diaphragm, with some of the layers partly broken away;

Fig. 2 is an edge view of Fig. 1; and

Figs. 3 to 6 are similar views of various other forms.

Referring to Figs. 1 and 2, the diaphragm therein shown is of the three-layer type and consists of two outer or surface layers of wood and an inner layer of celluloid. In Fig. 3, the diaphragm consists of alternating layers of wood and celluloid, seven in all, with the wood forming the surface layers, as before. Figs. 4 and 5 show five-layer diaphragms, with the surface layers of wood and the two intermediate (second and fourth) layers of celluloid; but the central or third layer in Fig. 4 is of bakelite, whereas in Fig. 5 it may be brass, tin, aluminum or other suitable metal. Fig. 6 shows another five-layer diaphragm, the two surface layers of which are of metal, the two intermediate layers of celluloid, and the central layer of wood, bakelite or mica.

The thicknesses of the several layers may, of course, vary, but for present purposes the following approximate ranges may be given: celluloid and gelatin, .001" to .010"; wood, .002" to .020"; metals, .001" to .003"; bakelite, .005" to .020". It will be observed that these materials are all non-vitreous.

While the invention has been shown and described as embodied in an acoustic diaphragm, yet it will be apparent that analogous composites can be used for similar purposes as a constructing material for the sounding boards of musical instruments, such as violins, mandolins, guitars, etc., and that they can also be used in constructing amplifiers for talking machines. It is also possible to utilize composites of this character as substitutes for the heads of banjos and the like. And it will further be understood that my laminae, as when comprising wood, metal and sheet celluloid with the surface substantially dissolved to form an adhesive, and the remainder left intact to constitute a layer, may be used in various other products.

Having thus described my invention, I claim:

1. The herein described process of making laminated articles, consisting in assembling one or more sheets of non-vitreous material, in combining therewith celluloid in sheet form; in subjecting the celluloid, before assembling it with the other layers, to the ac-

tion of a solvent to partially dissolve its surface; and in subjecting the now composite structure to the application of pressure accompanied by heat to cause the final union of the parts.

5 2. The herein described process of making laminated articles, consisting in assembling one or more sheets of wood veneer, in combining therewith celluloid in sheet form, in
10 subjecting the celluloid, before assembling it with the other layers, to the action of a solvent to partially dissolve its surface, and in subjecting the now composite structure to the application of pressure accompanied by heat
15 to cause the final union of the parts.

3. The herein described process of making laminated articles, consisting in assembling a plurality of wood veneers, in placing between the wood veneers celluloid in sheet form; in
20 subjecting the celluloid, before assembling it with the wood veneers, to the action of a solvent to partially dissolve its surface; in immersing this composite structure in a liquid which will soften the surfaces of the celluloid;
25 in withdrawing the structure from such liquid and subjecting it to pressure; and in then heating it while maintaining the pressure.

4. The herein described process of making laminated articles, consisting of assembling
30 one or more sheets of non-vitreous material, in combining therewith celluloid in sheet form; in subjecting the celluloid, before assembling it with the other layers, to the action of a solvent to partially dissolve its
35 surface, and in subjecting the composite structure to the application of pressure to cause the final union of the parts.

5. The herein described process of making laminated articles, consisting in assembling
40 one or more sheets of non-vitreous material, in combining therewith celluloid in sheet form and in subjecting the composite structure to the application of pressure accompanied by heat to cause the surface of the
45 celluloid to partially dissolve to form a union of the parts.

6. A laminated article including a lamina of wood and a lamina of tough pliable sheet celluloid both laminae forming a portion of
50 the thickness of the articles the wood lamina being securely held to the surface of the celluloid by the celluloid on the surface of the sheet of celluloid.

In testimony whereof I affix my signature.
55 OTTO S. MARCKWORTH.