

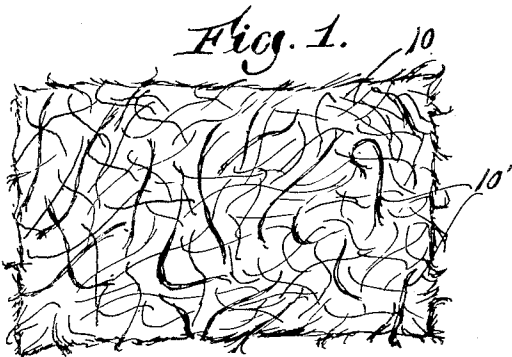
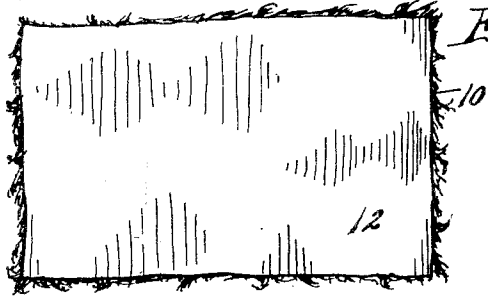
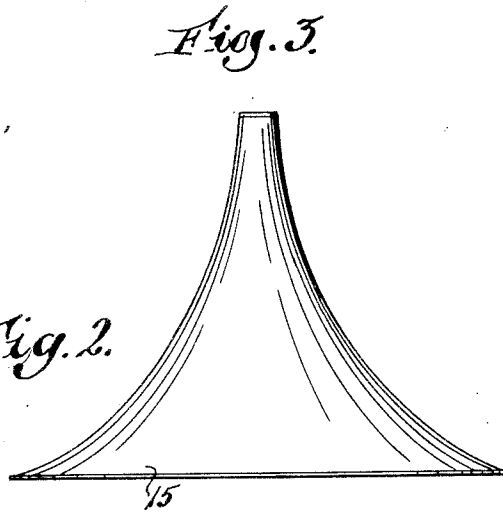
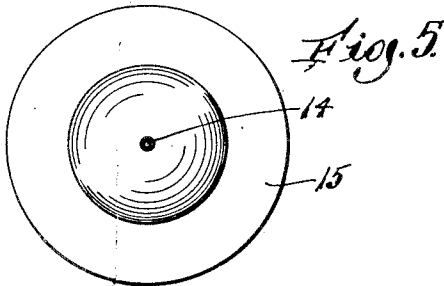
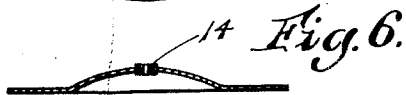
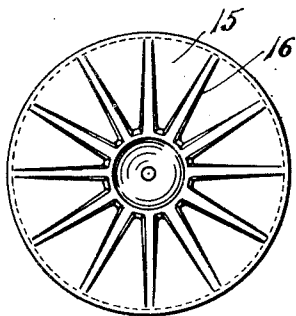
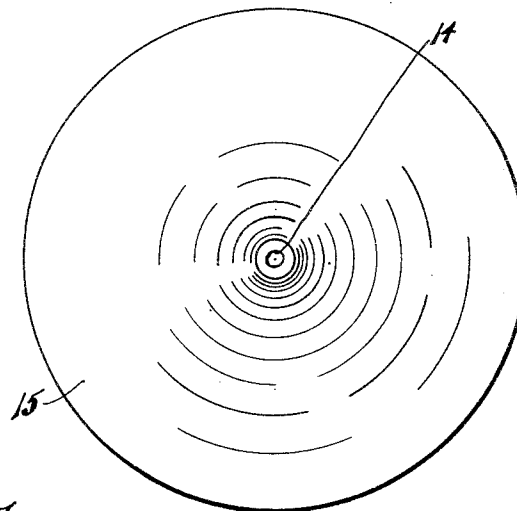
May 20, 1930.

C. BATEHOLTS

1,759,387

ACOUSTIC DIAPHRAGM AND PROCESS FOR ITS MANUFACTURE

Filed Oct. 16, 1928



Inventor
Clinton Batehols
by *Mitchell, Chapman & Kent*
Attorneys

UNITED STATES PATENT OFFICE

CLINTON EATEHOLTS, OF HOOSICK FALLS, NEW YORK, ASSIGNOR TO SPECIALTY INSULATION MANUFACTURING COMPANY, INC., OF HOOSICK FALLS, NEW YORK, A CORPORATION OF NEW YORK

ACOUSTIC DIAPHRAGM AND PROCESS FOR ITS MANUFACTURE

Application filed October 16, 1928. Serial No. 312,820.

This invention relates to improvements in acoustic diaphragms and processes for their manufacture. More particularly it relates to diaphragms for sending forth sound vibrations when the diaphragm is caused to vibrate by electrical or mechanical means, as in a loud speaker or telephone; or for converting sound vibrations received from the air in connection with transmitting or recording apparatus.

The especial nature of the invention is that, by heat and pressure applied to a liquid containing a promiscuous arrangement of suitable long and strong fibres in a very thin mold, a solidified reinforced rubber-like thin sheet is produced which has been found to embody desired qualities of an acoustic diaphragm in a superior manner. It has the combined peculiarities of great flexibility; adequate stiffness combined with resilience; strength; toughness; and extreme thinness, with resulting very low inertia. The thickness, for example, may be predetermined to be between .003 and .015 of an inch, according to the shape, use and results desired; and the thickness may be either uniform throughout or may be graduated to suit specific conditions. Metallic elements may be molded in the diaphragm so as to become an integral part of it, or may be attached to it. The invention is applicable to various shapes of diaphragms, such as disk or cone shapes, and shapes having curvature from centre outward, or with corrugations. For use in a loud speaker I have found the diaphragm to work well when made with its peripheral portion in a plane, and mounted with its periphery gripped tightly between shock absorbent rings or washers.

It is a particular feature that the combination of constituent elements starts with one of the elements in a liquid state, so that the chemical and mechanical processes of manufacture proceed with a perfect intimacy of mutual contact between this chemical material and the fibres, and with a uniformity of tension throughout the solidifying mass. Hence this uniformity of tension and perfect intimacy of mutual contact passes into the solid state and is preserved and perpetuated

in the final product. In the latter, the absence of irregular internal stresses when the diaphragm is in a state of rest, permits a more perfect vibratory response when sound waves are impressed upon it; with less distortion of the waves than if there were internal diversities of stress already existing in the material of the diaphragm. The said rubber-like portion of the diaphragm may be made by the methods set forth in Letters Patent 1,251,862 and 1,251,863, granted January 1, 1918 on application of William W. Carter, each entitled "Rubber substitute and process of making the same." This material does not combine in itself all of the properties needed for the object of the present invention, but a composite sheet is produced by introducing a promiscuous arrangement of long and strong small fibres. Cotton and other ordinary fibres are not satisfactory; but I have attained the desired results successfully by the use of rice paper, and particularly by the peculiar kind and arrangement of rice fibres which are found in a kind of paper that is made in Korea and is obtainable commercially under the name "Keijyo Kami". When this paper and the liquid residue, which settles from the emulsion described in said Patent 1,251,863, which is a composition resultant from the reaction of a sulfonate on an oil, as China-wood oil, which can be polymerized by sulfuric acid, are put together in a thin mould and are vulcanized under suitable heat and pressure, the product has been found to have the desired sound transmitting and sound converting qualities of a high order. If any other fibrous material be employed for the production of my improved diaphragms, it should be one which the liquid will equally thoroughly and intimately penetrate and whose fibres have a comparable measure of strength flexibility and durability in the thin resilient sheet after undergoing the vulcanizing process.

It is intended that the patent shall cover by suitable expression in the appended claims, whatever features of patentable novelty exist in the invention disclosed.

In the accompanying drawings:

Figure 1 is a face or flat side view of a

preliminary fixed arrangement of the fibres, being a fragment of a sheet of paper, called Keijyo Kami, for being assembled with the liquid material for the synthetic rubber in making my diaphragms;

5 Figure 2 is a similar view of the same after it has been treated with the liquid material which is to be vulcanized into synthetic rubber, the vertical lines being merely shade lines, and the said fibres concealed by the liquid coated over them;

10 Figure 3 is an edge view on a reduced scale of a horn-shaped diaphragm for a loud speaker, embodying features of the invention;

15 Figure 4 is a mouth view of the diaphragm of Figure 3;

Figures 5 and 7 are face views of modified disk diaphragms, with metallic elements embodied as integral parts; and

20 Figure 6 is an edge view in medial cross section of the diaphragm of Figure 5.

In the production of my diaphragms long and strong fibres of small size are first arranged in a thin sheet in interlaced net work formation. This is conveniently done by making them into a sort of paper. I have found that a suitable length and kind of fibre, with suitable openness of interlacing and thinness of layer can be obtained commercially as "Keijyo Kami." Although other fibres having suitable strength, resilience and other qualities may furnish the fibrous element of my composition, I have found that a perfection of tone of loud speaker, hitherto unattained within my experience, can be had by combining the described paper with the described materials for the synthetic rubber. In Figures 1, 2 of the drawings there are represented pieces of such paper, before and after being introduced into the combination. The paper illustrated is made in Korea, where the natives fashion it crudely by hand from the rice plant. Its fibres 10 are considerably longer than the fibres of any of the common commercial forms of hand or machine made paper. And it is particularly fit for the purposes of the present invention, even though irregular in thickness and in some places extremely thin. And it has the especial feature that while fibres 10 are arranged individually and promiscuously throughout the sheet, fibres are also to an extent arranged in groups 10', promiscuously throughout the sheet, each group being a bundle of parallel individual fibres and as a group constituting a very strong and long fibrous element. As a whole, it has the appearance of a thin, translucent paper, white in color, in which both the individual fibres and the bundles of fibres above mentioned are clearly visible. It has a characteristically high resistance to tearing and in general is light, tough and durable, with long, coarse fibres.

65 According to the invention, such a fibrous

sheet is impregnated by being dipped in liquid material 12, which constitutes the surface seen in Figure 2 and is to be solidified under heat and pressure. If the kind of synthetic rubber be that disclosed in said United States Letters Patent No. 1,251,863, resultant from the reaction of a sulfonate on an oil which can be polymerized by action of sulfuric acid, the said liquid may be some form of the washed residual composition there defined, which separates from the emulsion after conversion by the addition of formaldehyde. This residue, being a liquid which may have the consistency of molasses, or be thicker, may be used directly; but preferably it is used as in the varnish form there described, in which the washed and dried residue has been dissolved in a solvent. When the paper has been dipped in the liquid or the varnish sprayed over it, the varnish will be held in even distribution over its surface, indicated by shading lines on the surface 12, and so may be put into the mould for making the diaphragm. As a commercial method, the paper may be run from a roll into a bath of the varnish, then up over rollers for air drying, and be made into a roll again. As wanted it can then be cut by dies into shapes for diaphragms and these then be "vulcanized," as the process is here called, by analogy, which results in solidification to the hard material 15 when heat and pressure are applied. The perfect initial penetration of the liquid, and the further physico-chemical effect of the vulcanizing heat and pressure tend to make an extremely intimate solidified contact of liquid with all sides of each fibre. The amount of pressure for setting the materials may vary according to the nature of the liquid material and of the fibrous material and according to the thickness of the sheet being pressed; and also according to the final characteristics desired in the finished product. For the described liquid alone the pressure might range between 50 and 2000 pounds per square inch. For example, if great flexibility is desired the pressure will be less than if extreme hardness and stiffness or bone-toughness are wanted. But for best results the diaphragm is wanted to be both easily flexible and also to be stiff, rather than wobbly; that is, it must be able flexibly to respond to weak sound waves or impressed vibrations and to those coming in very rapid succession, and it must be stiff enough to have a definite form to which it seeks resiliently to return. The pressure should be applied slowly, with the vulcanizing proceeding as it is applied, thus letting the varnish be always strong enough to hold the fibres in place, and increasing the pressure as the gum becomes tougher. If pressure be applied too rapidly the fibres may split, and the mass pop out of the mold. The amount of heat necessary to effect the vulcanization will vary, under different condi-

tions, between 100° C. and 140° C., above which paper will char.

By the initial liquidity and the pressure in the mold the liquid is distributed into intimate contact with the fibres on every side of each fibre, and into position filling solidly all spaces between fibres however small. All this is accomplished with uniformity of tension, because the liquid nature of the mass makes the tension uniform through the mass. This intimacy and uniformity after solidification make for perfect transmission of vibrations in any direction through the mass, which is in fact a thin sheet of the synthetic rubber strengthened by the fibres.

Stiffness and flexibility may also be affected by the thickness.

A specific example of the process is the making of a diaphragm of bell shape as in Figures 3 and 4, five inches deep, eleven and one-half inches across and .005 inch thick. The total pressure in the mold in such case would be about 45000 pounds, or about 400 to 450 pounds per square inch, which can be attained in about fifteen minutes. The temperature used to effect vulcanization would be about 120°-130° C.

The diaphragm as a whole may have such various shapes as may be desired, with or without radial, circular or other corrugations 16; and it may be constructed to have its outer edge adapted to be either free or gripped between shock absorbent rings (not shown). If formed in concoidal shape it is capable of transmitting vibrations over the whole main vibratory parts of the diaphragm without buckling or side sway.

For use in loud speakers with magnetic or mechanical means of conversion of sound vibration, a small metal insert 14 may be either moulded in the composite at the proper place or may be clamped or otherwise mechanically fastened.

A diaphragm thus made is capable of receiving and transmitting vibrations over the entire audio frequency range. Unlike sheets made with phenolic condensation products, the diaphragms of the invention will not become brittle with use; also there is a superior continuity of the synthetic rubber constituent, in the ultimate composite, because of its superior penetration of the paper or fibrous mass, effected when this rubber constituent was in liquid form.

I claim as my invention:

1. As a new product, a composite material for diaphragms comprising a carrier-sheet of long, coarse vegetable fibres, and, combined therewith, a uniformly disseminated plastic composition, the long, coarse fibres of said carrier sheet being promiscuously distributed therethrough and constituting a thin, paper-like mass.

2. As a new product, a composite material for diaphragms comprising a carrier-sheet

of long, coarse fibres derived from a plant of the grass family, and, combined therewith, a uniformly disseminated plastic composition, the long, coarse fibres of said carrier sheet being promiscuously distributed therethrough and constituting a thin, paper-like mass.

3. As a new product, a composite material for diaphragms comprising a carrier-sheet of long, coarse fibres derived from the rice plant, and, combined therewith, a uniformly disseminated plastic composition, the long, coarse fibres of said carrier sheet being promiscuously distributed therethrough and constituting a thin, paper-like mass.

4. As a new product, a composite material for diaphragms comprising a carrier-sheet of Keijyo Kami, and, combined therewith, a uniformly disseminated plastic composition.

5. An acoustic diaphragm comprising a base of long, coarse fibres of vegetable origin, and, combined therewith, the reaction product of a sulphonate and an oil capable of polymerization by sulphuric acid.

6. An acoustic diaphragm comprising a base of long, coarse fibres derived from a plant of the grass family, and, combined therewith, the reaction product of a sulphonate and an oil capable of polymerization by sulphuric acid.

7. An acoustic diaphragm comprising a base of long, coarse fibres derived from the rice plant, and, combined therewith, the reaction product of a sulphonate and an oil capable of polymerization by sulphuric acid.

8. An acoustic diaphragm comprising a base of Keijyo Kami, and, combined therewith, the reaction product of a sulphonate and an oil capable of polymerization by sulphuric acid.

Signed at Hoosick Falls, New York, this 13th day of August, 1928.

CLINTON BATEHOLTS.