Aug. 1, 1961 A. HELLER 2,994,400

ANECHOIC TANK LINING

Filed Dec. 29, 1955

FIG.1.

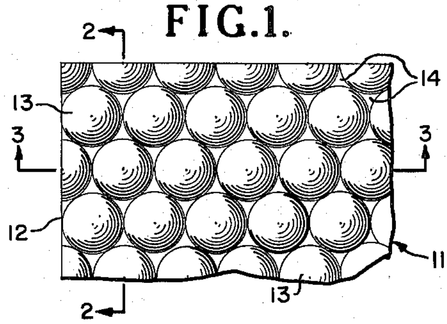


FIG.2.

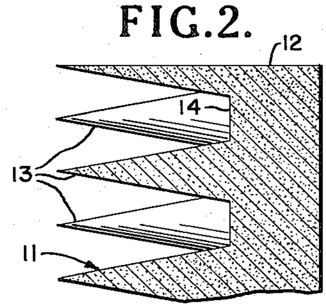


FIG.3.

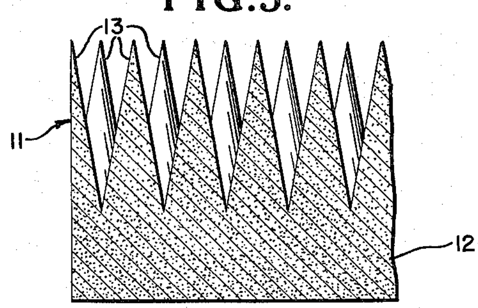


FIG.4.

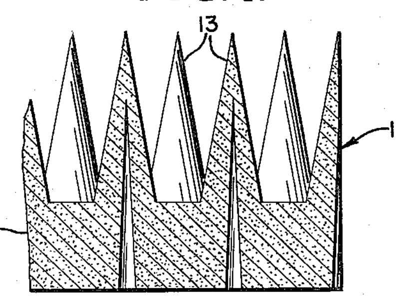


FIG.5.

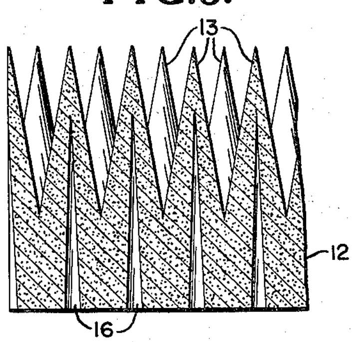


FIG.6.

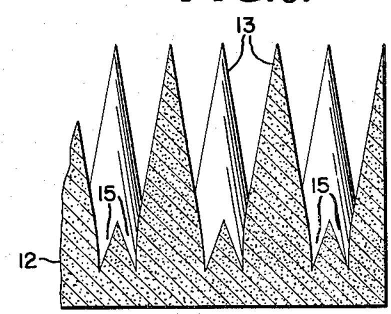
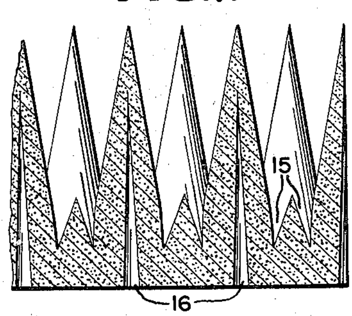


FIG.7.



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ANECHOIC TANK LINING

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a sound absorbing or anechoic material and more particularly to an underwater sound absorbing structured material usable as a covering for underwater ordnance items, linings for underwater acoustic tanks and sound baffles in underwater acoustic devices.

Acoustic devices intended for underwater functioning require testing and testing facilities must therefore be provided. As a general rule, it is not practicable to test such devices in a body of water at a location where there will be no reflection of sound and hence an acoustic tank must be provided for this purpose. The successful use of tanks for making underwater sound measurements is dependent on the elimination of the effect of tank boundaries on the desired measurements. That is, such tanks must be completely lined with a sound absorbing or anechoic material so that reflections of sound from the walls of the tank are eliminated or prevented. It has been proposed to line the inside surfaces of the walls of a steel tank with a layer of reflecting material, such as cork embodied in a binder of rubber or similar plastic material, the material being applied in a checkerboard pattern so that alternate surfaces are exposed surfaces of the bare steel walls. Another form of tank lining proposed consisted of rows of flat triangular rubber wedges mounted on a wood backing with water canals or ducts in the spaces between the rows. A material made from coarse sawdust and cement in the proportion of 4 to 1 has also been used to line acoustic tanks, the surface of the material being molded to provide elongated slim-tapered pyramids projecting into the tank. The checkerboard pattern lining and the lining consisting of flat triangular wedges are limited to a narrow band of frequencies, and the cement-sawdust material has a relatively low sound loss characteristic and the disadvantage that the cement dissolves and brings up the pH concentration of the water in the tank.

The requirements for an effective tank lining are first, a good impedance match to water to allow the sound to enter the material of the lining; and second, the material must have a high loss or sound-absorbent characteristic or property; i.e., be able to absorb all or substantially all the sound which enters with substantially no reflection thereof. A property which can further increase the effectiveness of a lining is scattering. If a transition medium is provided between the water and the lining and the impedance of the transition medium is a gradual continuous function of distance, it has been found there is practically no reflection caused by acoustic impedance mismatch. The use of a structured lining is an attempt to simulate such a transition medium. With such a medium, incident sound encounters a gradual change in acoustic properties in the transition region.

The sound absorbing structure of the present invention has been developed by employing the principle of a gradual impedance transition from water to sound absorbing material having a high loss sound-absorbent characteristic or property and comprises butyl rubber loaded with or containing metal particles, that is, having a metal in finely divided form dispersed therethrough, the material being molded into panels of closely packed right circular cones with a backing layer of the same material. This structure eliminates impedance discontinuity in the transition medium to a great extent and covers a frequency band from about 1 kilocycle to several megacycles and thus overcomes some of the limitations of the other forms of lining.

It is therefore an object of the present invention to improve the sound absorbing properties of a material used as a lining or as a covering in underwater items.

Another object is the provision of a sound absorbing material with greater sound absorbing properties and greater range than prior art materials.

A further object is to provide a sound absorbing structured material including a transition layer comprising a lattice work of cones between which the section of water gradually tapers, the material having a high loss sound-absorbent characteristic or property.

A final object to provide a new and improved anechoic lining which prevents or substantially eliminates reflections of sound in an acoustic tank.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a plan view of a portion of the sound absorbing structure or anechoic lining of this invention;

FIG. 2 is a sectional view of the structure taken on line **2—2** of FIG. 1;

FIG. 3 is a sectional view of the structure taken on line **3—3** of FIG. 1;

FIG. 4 is a sectional view similar to FIG. 2 of a modification of the structure;

FIG. 5 is a sectional view similar to FIG. 3 of the modification shown in FIG. 4;

FIG. 6 is a sectional view similar to FIG. 2 of still another modification; and

FIG. 7 is a sectional view similar to FIG. 4 but further modified like FIG. 6.

Referring now to the drawing wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIG. 1 a portion of the sound absorbing structured material or anechoic lining of this invention designated generally by reference character **11**. The sound absorbing structure **11** consists of a backing **12** and a plurality of right circular cones **13** formed integrally therewith of suitable acoustical material, the bases of the cones **13** being tangent to each other as shown in FIG. 1.

Butyl rubber loaded with or containing metal particles in different proportions, i.e., having a powdered metal or a metal in finely divided form dispersed therethrough, has been used as the acoustical material with varying degrees of success. For example, material comprising equal parts by weight of aluminum powder and butyl rubber has been used. Another composition employed consists of 95 parts of lead powder, 9.25 parts of cumar, and 1 part of blowing agent per 100 parts of butyl rubber. Still another form, heavily loaded with metal particles comprises 250 parts of lead powder per 100 parts of butyl rubber. Compositions containing aluminum powder gave best results over a wider band of frequencies than did other metals, and such compositions in which the aluminum content was varied from 50 parts to 200 parts of aluminum to 100 parts of butyl rubber by weight, are considered to make the best sound absorbing material for use in the lining of this invention. The proportions stated are cited as examples only and not as limitations, since it is obvious the proportions may vary somewhat without departing from the invention which resides in the combination of the material with the particular form of the structured transition medium.

In one embodiment which was found satisfactory for a band of frequencies from about 10 kilocycles to several megacycles, the backing included a thickness of material in the order of 1.25 centimeters. The right circular cones were made to have an apex angle of about 30 degrees, with the radius of the cone at its base being approximately one centimeter and the height of the cone being about 3.75 centimeters. Increasing the size of the structured material and at the same time retaining the relative scale thereof, would widen the band to include frequencies below 10 kilocycles down to about 1 kilocycle.

In FIG. 1 it will be observed that each cone is surrounded by 6 tangent cones and that there are plane or flat areas **14** of the backing between the central cone and the 6 tangent cones, which areas approximate small triangles. The sum of the flat substantially triangular areas is approximately 10 percent of the total plane area of the inner side of the backing.

The sound absorbing characteristics of the structure may be improved through elimination of the flat areas **14** by forming gradually tapering openings **15** therein, as shown in FIGS. 6 and 7, to avoid any discontinuity caused by areas **14**.

The acoustical properties of the structure may also be improved, especially at the lower frequencies, by forming a relatively small tapered opening in each cone centrally thereof, as shown in FIGS. 4, 5 and 7. Tapered opening **16** is of a relatively smaller diameter than the diameter of the cone and is air filled.

The structured material of this invention may be formed by mixing the various ingredients in the desired proportions and molding the same. Of course, it is obvious the structured material could be formed by other methods.

In operation, the lattice work of cones provides a transition medium which permits sound to enter the acoustical material or anechoic lining constructed in accordance with the present invention where it is absorbed and dissipated or lost and this occurs with very little or substantially no reflection.

It should be understood, of course, that the foregoing disclosure relates only to preferred embodiments of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention.

Applicant has achieved the objects of the invention by providing a sound absorbing material or anechoic lining for use underwater which combines the advantages of a structured medium and a metal loaded butyl rubber composition having a high loss to produce a lining possessing sound absorbing characteristics more effective and covering a wider band of frequencies than acoustical linings heretofore known.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A structured lining to be used in anechoic tanks for absorbing underwater sound, said lining comprising, in combination, a backing having a plane area, and a plurality of tapering elements projecting outwardly from said plane area, said backing and said elements being formed integrally of acoustical material having a high sound-absorbent characteristic and consisting essentially of butyl rubber containing metal particles dispersed therethrough.

2. A structured material as defined in claim 1, in which said metal is aluminum.

3. A structured material as defined in claim 2, in which the aluminum to rubber ratio is from 50 parts to 200 parts of aluminum to 100 parts of butyl rubber by weight.

4. A structured material as defined in claim 2, in which the weights of the aluminum and the butyl rubber are equal.

5. A structured material as defined in claim 1, in which said metal is lead.

6. A structured material as defined in claim 5, in which the lead to rubber ratio is from 95 parts to 320 parts of lead to 100 parts of butyl rubber by weight.

7. A structured lining to be used in anechoic tanks for absorbing underwater sound, said lining comprising a backing having a plane area, and a lattice work of right circular cones the bases of which are in tangency and disposed in the plane of said area, said backing and said cones being formed of an acoustical material having a high sound-absorbent characteristic and consisting essentially of butyl rubber with a powdered metal dispersed therethrough.

8. A structured material as defined in claim 7, in which the metal is aluminum.

9. A structure as defined in claim 8 in which the aluminum to rubber ratio is from 50 parts to 200 parts of aluminum to 100 parts of butyl rubber by weight.

10. A structured material as defined in claim 8, in which the weights of the aluminum and the butyl rubber are equal.

11. A structured material as claimed in claim 7 in which the metal is lead.

12. A structured material as claimed in claim 11, in which the lead to rubber ratio by weight is from 95 to 320 parts of lead to 100 parts of butyl rubber.

13. A structure for absorbing underwater sound comprising a backing having a plane area, and a plurality of right circular cones formed integrally with said backing and projecting from said plane area, said cones having an apex angle of approximately 30 degrees and being of equal height, and said backing having a thickness approximately one-third of the height of the cones, said cones and backing being formed of sound-absorbing material consisting essentially of butyl rubber containing metal particles.

14. A structure as defined in claim 13, wherein a tapered opening of smaller diameter than the diameter of the cone is formed in each cone at the center thereof.

15. A structure as claimed in claim 13, and further characterized in that the bases of the cones are in tangency; thereby bounding substantially triangular areas between said cones in the plane of said plane area, said backing having a plurality of tapered openings formed therein, the bases of said openings being disposed in the plane of said plane area and coincident with the aforesaid substantially triangular areas; thereby substantially eliminating any flat areas in the surface of said structure.

16. A structure as claimed in claim 15, and further characterized in that a tapered opening of relatively small diameter with respect to the diameter of the cones is formed at the center of each cone.

17. A structure as claimed in claim 13, in which the metal is aluminum.

18. A structure as claimed in claim 13, in which the metal is lead.

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