In a sonar system an apparatus is utilized to transmit and receive signals. This apparatus is located within a housing and the signals must pass through a portion of the housing called an acoustical window. The acoustical window is a reinforced composite structure comprising an epoxy containing resin and either an elastomeric polymer or microspheres of glass or both reinforced with either Type E fiberglass, carbon (at least 80% carbon assay) or graphite fibrous material.

21 Claims, 2 Drawing Figures
ACOUSTICAL WINDOW FOR SONAR SYSTEMS

Sonar systems have been widely used for various underwater purposes, such as defining distances between objects, ocean floor mapping, etc. A signal is usually sent from a transmitter to an object and reflected back to a receiver. Obviously, the signal must pass through a structural member hereinafter called an acoustical window or dome, in which the transmitter and receiver are housed and protected from the surrounding water. Up until now, the acoustical window has been usually constructed of very thin metallic sheet material, basically steel. This has been quite satisfactory when low or medium frequency signals are being utilized since the distortion caused by the thin window is not a problem. However, sophisticated instruments have been developed for utilizing very high frequency signals to increase definition or accuracy. When high frequency signals are utilized, any distortion caused by the thin window is magnified thus becoming a great problem. Attempts have been made to utilize a reinforced laminate which comprises layers of fiberglass cloth impregnated with an epoxy resin which is pressure molded and heat cured. This laminate has not been found totally satisfactory for this purpose and therefore there is still a need for an acoustical window which will allow a range of very low to very high frequency signals to pass therethrough substantially free of distortion and yet possess adequate structural characteristics.

In view of the foregoing, it is an object of this invention to provide an acoustical window which will allow a range of very low to very high frequency signals to pass therethrough substantially free of distortion.

In accordance with this invention, it has been found that by using an acoustical window which comprises a composite laminate of layers of fiberglass or carbonaceous material impregnated with an epoxy resin mixed with either an elastomer polymer or microspheres of glass or both, which is heat cured under pressure, very low to very high frequency signals pass therethrough substantially free of distortion when compared to materials used previously. Also, these composites exhibit the necessary structural characteristics.

In accordance with this invention, it has been found that the signal distortion problem is substantially improved by using as an acoustical window any of the following reinforced composite structures made from:

A. A woven fabric impregnated with a mixture of an epoxy containing resin and high strength glass microspheres;

B. A woven fabric impregnated with a mixture of an epoxy containing resin and an elastomeric polymer;

C. A woven fabric impregnated with a mixture of an epoxy containing resin, an elastomeric polymer, and high strength glass microspheres.

The woven fabric may be made from Type E glass fibers or may be carbon cloth of at least 80% carbon assay or graphite cloth. The preferred epoxy resin may be diglycidyl ether of bisphenol-A or a novolac modified therewith or similar resins. The preferred elastomeric polymer may be an acrylonitrile-butadiene co-polymer or poly(chloroprene) or a similar type material. The elastomeric polymer may be present in an amount between 2% and 50% by weight of the mixture, preferably in the range from 2% to 15% by weight of the mixture. The glass microspheres may be present in an amount between 2% and 30% by weight of the mixture, preferably in the range from 15% to 20% by weight of the mixture. The specific gravity of the composite structures range between 0.6 and 2.

The reinforced structure is made by taking plies of preimpregnated fabric and stacking one on top of another and then heat curing in an autoclave. Another method is to stack plies of cloth on top of one another and impregnate the whole stack and then heat cure in an autoclave. Rather than utilizing a fabric for reinforcement, the structure may be filament wound with the same materials as stated above that comprises the fabric.

The method for making the composite structures and the composite structure themselves are not new and do not form an invention per se. These composite structures have been well known for aerospace applications, such as internal and external rocket parts, where it is required to have high resistance to disintegration as a result of the part being subjected to excessive temperatures. U.S. Pat. No. 3,402,085 describes such an application. It was surprising to find that the utilization of the above described composites in sonar systems substantially eliminated signal or wave distortion.

The acoustical window of this invention is illustrated in the drawings.

FIG. 1 illustrates the acoustical window in a typical sonar housing.

FIG. 2 is a partial cross-sectional view of the acoustical window illustrating the reinforced composite structure of the window.

Referring to the drawings, a housing 10 in the shape of a sonar dome is illustrated containing an acoustical window 12. The window can be prepared in various shapes and curvatures to correspond the housing in which the acoustic window is housed. The shape of the window does not form a part of this invention.

Referring to FIG. 2, a cross-section of the acoustic window of FIG. 1 is illustrated. The acoustic window 12 is a cured composite laminate of layers of fiber 14 in an epoxy resin binder 16 which extends through the layers of fiber 14. The epoxy resin binder 16 contains high strength glass microspheres 18 dispersed throughout the resin binder 16.

The following examples exemplify the invention.

Example I

A composite structure was made by stacking plies of Type E woven fiberglass cloth (THALCO STYLE 1500) preimpregnated with a mixture of:

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (lbw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diglycidyl ether of Bisphenol-A resin</td>
<td>100 parts</td>
</tr>
<tr>
<td>(Shell Chemicals Epon 828)</td>
<td></td>
</tr>
<tr>
<td>Nadic methyl anhydride (NMA)</td>
<td>90 lbw</td>
</tr>
<tr>
<td>Benzylidimethylamine (BDMA)</td>
<td>1/4 lbw</td>
</tr>
</tbody>
</table>

The stack of plies was then placed in an autoclave and cured by raising the temperature slowly to about 320°F, and holding this temperature under a vacuum of 50 psi for about 2½ to 3 hours. The composite was then tested for its acoustic performance.

Example II

A composite structure was made by stacking plies of Type E woven fiberglass cloth preimpregnated with a mixture of:
The stack of plies were then cured in the same manner as in Example I. The resulting composite was then tested for its acoustic performance and it was found that there was less signal distortion than with the composite of Example I and other known acoustical windows.

Example III

A composite structure was made by stacking plies of Type E woven fiberglass cloth preimpregnated with a mixture of:

- Epon 828 resin
- BDMA
- NMA
- Acrylonitrile-butadiene copolymer
- High strength Volan treated glass microspheres, particle density 0.37 g/cc, particle size, 20-80 microns
- Glass Microspheres B-40-A

The stack of plies were then cured in the same manner as in Example I. The resulting composite was then tested for its acoustic performance and it was found that there was substantially less signal distortion than with the composite of Example II.

Example IV

A composite structure was made by stacking plies of Type E woven fiberglass cloth preimpregnated with a mixture of:

- Epon 828 resin
- BDMA
- NMA
- Acrylonitrile-butadiene copolymer
- High strength Volan treated glass microspheres, particle density 0.37 g/cc, particle size, 20-80 microns
- Glass Microspheres B-40-A

The stack of plies were then cured in the same manner as in Example I. The resulting composite was then tested for its acoustic performance and it was found that the signal distortion was substantially less than the composites of Examples I, II, and III.

Examples V through VIII

Composite structures were made by utilizing carbon cloth (at least 80% assay) as the reinforcing medium impregnated with the mixtures of Examples I through IV, respectively. Each composite had better signal distortion characteristics than the composite with the corresponding resin mixture in Examples I through IV, respectively.

Examples IX through XII

Composite structures were made by utilizing graphite cloth as the reinforcing medium impregnated with the mixture of Examples I through IV, respectively. Each composite had substantially the same signal distortion characteristics as the composite with the corresponding resin mixture in Examples V through VIII, respectively.

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

1. In a sonar system comprising apparatus for transmitting and receiving signals and a housing in which said apparatus is enclosed, said housing including an acoustical window through which signals pass, the improvement comprising: said acoustical window being a composite structure comprising a cured composite laminate of layers of fiber said fiber being selected from the group consisting of Type E glass, carbon and graphite, said fibers being impregnated with epoxy resin, and said epoxy resin containing high strength glass microspheres or elastomeric polymer.

2. In a sonar system as recited in claim 1, said epoxy resin containing elastomeric polymers and glass microspheres.

3. In a sonar system comprising apparatus for transmitting and receiving signals and a housing in which said apparatus is enclosed, said housing including an acoustical window through which signals pass, the improvement comprising: said acoustical window being a composite structure comprising a cured composite laminate of layers of fiber, said fiber being selected from the group consisting of Type E glass, carbon, and graphite said fibers being impregnated with epoxy resin and an elastomeric polymer.

4. A system as recited in claim 1, wherein said fiber is Type E glass.

5. A system as recited in claim 2, wherein said fiber is Type E glass.

6. A system as recited in claim 1, wherein said elastomeric polymer is acrylonitrile-butadiene copolymer.

7. A system as recited in claim 2, wherein said elastomeric polymer is acrylonitrile-butadiene copolymer.

8. A system as recited in claim 6, wherein said epoxy containing resin is selected from the group consisting of diglycidyl ether of bisphenol-A or a novolac modified therewith.

9. A system as recited in claim 7, wherein said epoxy containing resin is selected from the group consisting of diglycidyl ether of bisphenol-A or a novolac modified therewith.

10. A system as recited in claim 1, wherein said fiber is carbon.

11. A system as recited in claim 1, wherein said fiber is graphite.

12. A system as recited in claim 2, wherein said fiber is carbon.

13. A system as recited in claim 2, wherein said fiber is graphite.

14. A system as recited in claim 10, wherein said elastomeric polymer is acrylonitrile-butadiene copolymer.

15. A system as recited in claim 11, wherein said elastomeric polymer is acrylonitrile-butadiene copolymer.

16. A system as recited in claim 12, wherein said elastomeric polymer is acrylonitrile-butadiene copolymer.

17. A system as recited in claim 13, wherein said elastomeric polymer is acrylonitrile-butadiene copolymer.

18. A system as recited in claim 14, wherein said epoxy containing resin is selected from the group consisting of diglycidyl ether of bisphenol-A or a novolac modified therewith.

19. A system as recited in claim 15, wherein said epoxy containing resin is selected from the group consisting of diglycidyl ether of bisphenol-A or a novolac modified therewith.

20. A system as recited in claim 16, wherein said epoxy containing resin is selected from the group consisting of diglycidyl ether of bisphenol-A or a novolac modified therewith.

21. A system as recited in claim 17, wherein said epoxy containing resin is selected from the group consisting of diglycidyl ether of bisphenol-A or a novolac modified therewith.