United States Patent [19]

Higgs

[11] **3,737,004**

[45] **June 5, 1973**

[54] **COMPOSITE ACOUSTIC DECOUPLER**

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[73] Assignee: **Honeywell Inc.,** Minneapolis, Minn.

[22] Filed: **Feb. 10, 1972**

[21] Appl. No.: **225,054**

[52] **U.S. Cl.** .....**181/0.5 A,** 181/33 A, 340/5 A, 340/8 S

[51] **Int. Cl.** **G10k 11/00,** H04b 11/00, E04b 1/99

[58] **Field of Search** .....181/33 A, 33 G, .5 A; 340/5 A, 8 S, 10, 16

[56] **References Cited**

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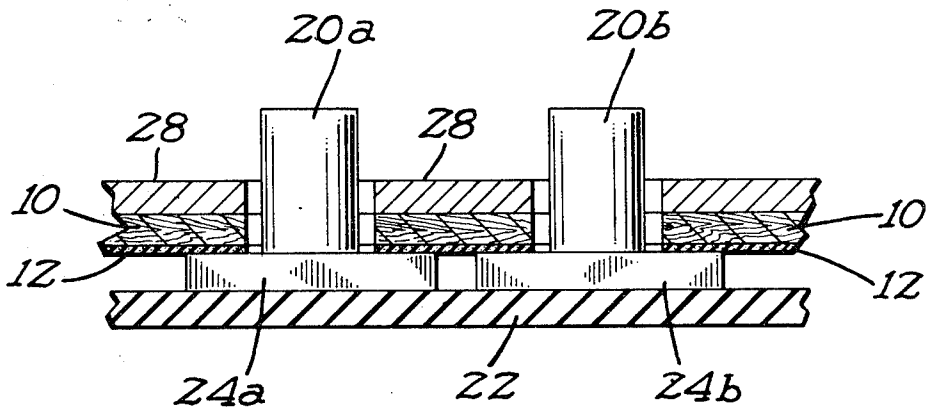
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[57] **ABSTRACT**

An acoustic decoupler which isolates both shear and longitudinal acoustic waves comprises a body of transversely isotropic low acoustic impedance material with a thin layer of elastomer material attached to one surface of the body of low acoustic impedance material.

7 Claims, 4 Drawing Figures



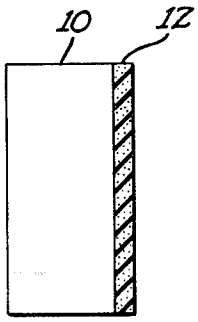


Fig 1

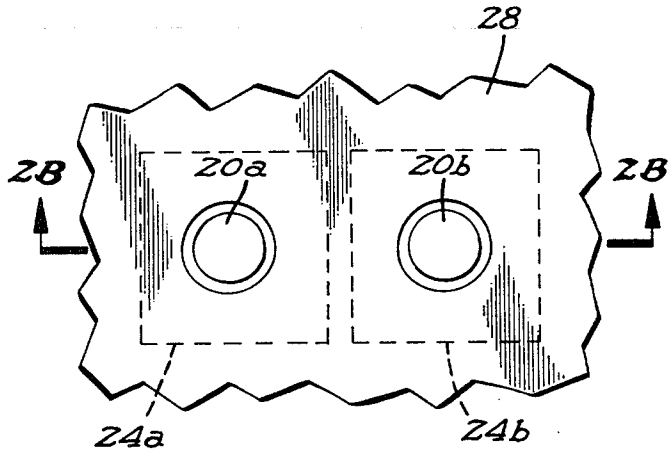


Fig 2A

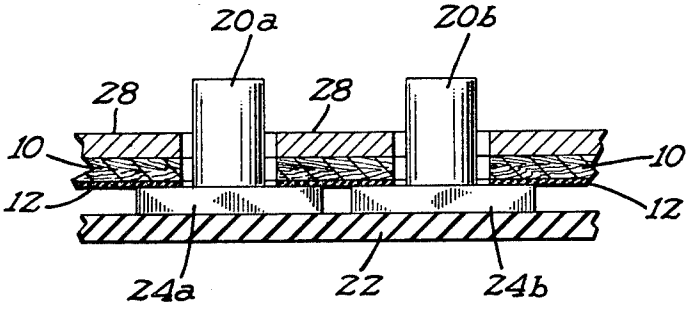


Fig 2B

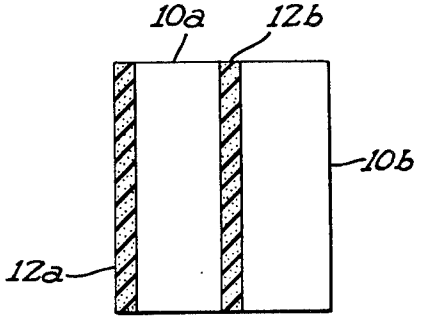


Fig 3

COMPOSITE ACOUSTIC DECOUPLER

REFERENCE TO RELATED PATENT APPLICATIONS

Reference should be made to an abandoned patent application Serial Number **225,053** by P. M. D'Amico, entitled "Acoustic Decoupler," which was filed on an even date herewith and which is assigned to the same assignee as this application.

BACKGROUND OF THE INVENTION

This invention relates to an acoustic decoupler useful in sonar systems. In particular, it relates to a composite acoustic decoupler capable of decoupling both shear and longitudinal acoustic waves.

In the design of sonar devices, it is often desirable to isolate the transducer elements acoustically from each other and from the structure of the device. This isolation is normally accomplished by acoustic decoupling materials, which provide acoustic isolation through impedance mismatch and internal attenuation.

The characteristic impedance, ρc, of any material may be represented as the product of the material's density ρ and sound velocity c. For a free plane wave, this is also equal to the specific acoustic impedance. When the acoustic impedance of one material is the same as that of an adjacent material, the materials are said to be "matched;" when the acoustic impedances of the two materials are different, the materials are "mismatched."

Two of the desired properties of an acoustic decoupler are first, an insertion loss of at least 30 db per centimeter through a combination of reflection and absorption; and second, stable acoustical and mechanical properties with temperatures from 0°C to 30°C and with pressures or uniaxial stresses, or both, up to 10,000 psi.

In a copending patent application Ser. No. 225,149 by P. M. D'Amico and R. W. Higgs, which was filed on an even date herewith, an acoustic decoupler material satisfying these requirements is described. This material is balsa wood which has been precompressed to a precompression pressure of between about 2,500 psi and about 20,000 psi. As described in the copending patent application, precompressed balsa wood is the only known acoustic decoupler material which has been able to satisfy the above-mentioned requirements, although a large variety of materials have been used as acoustic decoupler materials.

Despite the many advantages of precompressed balsa wood, it does have one disadvantage as an acoustic decoupler. Balsa wood has been found to have transverse isotropy; the sound velocity along balsa wood's fiber structure (or "grain") being greater than 10 times the sound velocity in directions normal to the grain. It is believed that this transverse isotropy is the result of the unidirectional grain or fiber structure of balsa wood. Experimental results indicate that the sound velocity of acoustic waves having particle motion normal to the grain structure is much less than those acoustic waves having particle motion parallel to the grain structure. Therefore, sound propagation in the direction of the fiber structure must be avoided in decoupling applications. This is achieved by orienting the precompressed balsa wood body such that the longitudinal acoustic waves impinging on the decoupler are essentially normal to the fiber structure of balsa wood. While this effectively decouples longitudinal acoustic waves, shear waves can pass through the decoupler with very little absorption.

SUMMARY OF THE INVENTION

The acoustic decoupler of the present invention decouples both shear and longitudinal acoustic waves. A transversely isotropic low acoustic impedance material is oriented such that the direction of minimum acoustic propagation is normal to the surfaces of the body and the direction of maximum acoustic propagation is parallel to the surfaces of the body. A thin layer of elastomeric material is attached to one surface of the low acoustic impedance material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows one embodiment of the composite acoustic decoupler of the present invention.

FIGS. **2***a* and **2***b* show top and cross sectional views of a sonar system including the composite acoustic decoupler of the present invention.

FIG. **3** shows a multiple section composite decoupler.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** is shown one embodiment of the acoustic decoupler of the present invention. The body of transversely isotropic low acoustic impedance material **10** has a thin layer of elastomeric material **12** attached to one surface. In the preferred embodiment of the present invention, the transversely isotropic low acoustic impedance material is precompressed balsa wood which has been precompressed to between about 2,500 psi and about 20,000 psi. While precompressed balsa wood is the preferred material due to its low acoustic impedance and pressure insensitivity, other transversely isotropic materials such as Sonite, manufactured by Johns Manville Company, can also be used. "Sonite" is the registered trademark of the Johns Manville Company material designed for underwater sound applications.

When precompressed balsa wood is used, the fiber structure is oriented essentially parallel to the surfaces of the acoustic decoupler. In this manner, the direction of minimum acoustic propagation is essentially normal to the surfaces of the body, and the direction of maximum propagation is essentially parallel to the surfaces. To achieve maximum decoupling of longitudinal waves, the thickness of the precompressed balsa wood is $n\lambda/4$, where n is an odd integer and λ is the wavelength calculated from the velocity of acoustic waves in the balsa wood at the midband frequency of the sonar system.

As described previously, although precompressed balsa wood effectively decouples longitudinal acoustic waves, shear waves propagate through the body with little attenuation. Therefore, the thin elastomeric layer **12** is attached to one surface of the balsa wood body. In one preferred embodiment of the present invention, elastomeric layer **12** is a thin coating of silicone rubber such as RTV-112 silicone rubber. However, other elastomeric materials such as neoprene rubber, polyurethane rubber, and black gum rubber may also be used. The transmission coefficient for shear waves propagating between rigid materials (high shear wave velocity) and elastomeric materials (very low shear wave velocity) is very low; therefore shear waves, as well as longi-

tudinal waves, are decoupled by the composite decoupler of the present invention.

As described previously, precompressed balsa wood is highly advantageous acoustic decoupler material due to its pressure insensitivity. The addition of a thin layer of elastomeric material to form a composite acoustic decoupler does not adversely affect the pressure insensitivity of the acoustic decoupler, although the elastomeric layer does exhibit some pressure sensitivity. In particular, the longitudinal sound velocity-pressure coefficient for elastomers is approximately 0.05 m/sec-psi for longitudinal waves. Therefore, a pressure change of 1,000 psi increases the sound velocity in the elastomeric material by only 50 m/sec. Since the elastomeric layer is quite thin, the effect of the pressure sensitivity is very slight.

FIGS. 2*a* and 2*b* show top and cross sectional views of a sonar assembly in which the composite acoustic decoupler of the present invention is used. Transducers **20***a* and **20***b* are typically made from piezoelectric or piezomagnetic materials. Rubber window **22** protects the transducer assembly and improves coupling and directivity of the sound waves. The matching elements **24***a* and **24***b* are typically a quarter wavelength section of aluminum. Since aluminum has a characteristic impedance which is almost the geometric mean of the impedances of a typical piezoelectric crystal and a rubber window, and since the thickness of each aluminum matching element is one quarter wavelength, aluminum matching elements **24***a* and **24***b* greatly improve the coupling between crystals **20***a* and **20***b* and the water.

The composite decoupler is positioned between aluminum matching elements **24***a* and **24***b* and steel support **28**. Although elastomer layer **12** is shown adjacent aluminum matching elements **24***a* and **24***b* it is to be understood that the composite decoupler is equally effective when elastomeric layer **12** is adjacent steel support **28**. A large acoustic impedance mismatch occurs between acoustic matching elements **24***a* and **24***b* and the composite decoupler. Therefore, very little of the longitudinal acoustic waves produced by the transducers propagate into steel support **28**. As described previously, elastomeric layer **12** attenuates shear waves such that both longitudinal and shear waves are decoupled by the composite decoupler.

If it is desired to increase the insertion loss of the composite decoupler at low frequencies, multiple sections of the basic composite decoupler shown in FIG. **1** can be used. FIG. **3** shows a multiple section of composite decoupler having alternating layers of precompressed balsa wood **10***a* and **10***b* and elastomer material **12***a* and **12***b*.

It is readily apparent to those skilled in the art that many modifications to the present invention are possible. It should therefore be understood that the invention is not to be limited by the embodiments shown, but only by the scope of the attached claims.

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows:

1. In an acoustic system having an acoustic transducer for producing acoustic waves, and having support means for supporting the acoustic transducer, an acoustic decoupler for acoustically isolating the acoustic transducer by decoupling both longitudinal and shear acoustic waves, the acoustic decoupler comprising:

a body of transversely isotropic low acoustic impedance material having first and second surfaces, the direction of minimum acoustic transmission being essentially normal to the first and second surfaces, and the direction of maximum acoustic transmission being essentially parallel to the first and second surfaces, and

a thin layer of elastomeric material attached to one of the first and second surfaces.

2. The acoustic decoupler of claim **1** wherein the body has a thickness essentially equal to $n\lambda/4$, where n is an odd integer and λ is the acoustic wavelength in the low acoustic impedance material calculated at the midband frequency of the longitudinal acoustic waves.

3. The acoustic decoupler of claim **1** wherein the transversely isotropic low acoustic impedance material is Sonite.

4. The acoustic decoupler of claim **3** wherein the the body has a thickness essentially equal to $n\lambda/4$, where n is an odd integer and λ is the acoustic wavelength in the Sonite claculated at the midband frequency of the longitudinal acoustic waves.

5. The acoustic decoupler of claim **1** wherein the transversely isotropic low acoustic impedance material is balsa wood isostatically precompressed to between about 2,500 pounds per square inch and about 20,000 pounds per square inch.

6. The acoustic decoupler of claim **5** wherein the body has a thickness essentially equal to $n\lambda/4$, where n is an odd integer and λ is the acoustic wavelength in the balsa wood calculated at the midband frequency of the longitudinal acoustic waves.

7. The acoustic decoupler of claim **1** wherein the thin layer of elastomer material is silicone rubber.

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