

[54] **TERMINATED ACOUSTIC WAVE DEVICE**

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[58] Field of Search ..... **181/5 R; 333/30 R; 310/8.9, 9.1, 9.2; 332/4; 340/8 MM**

[56] **References Cited**

**UNITED STATES PATENTS**

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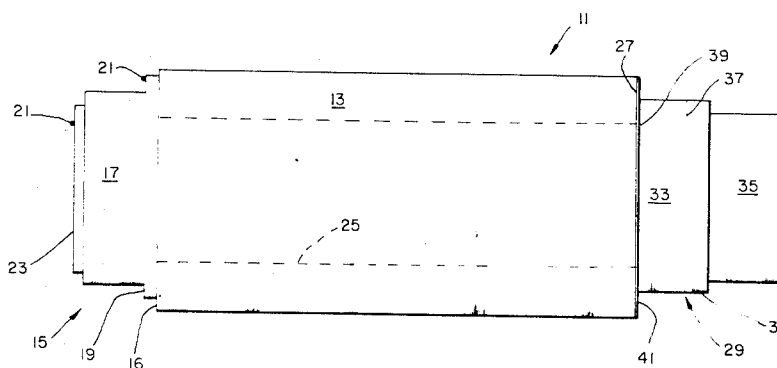
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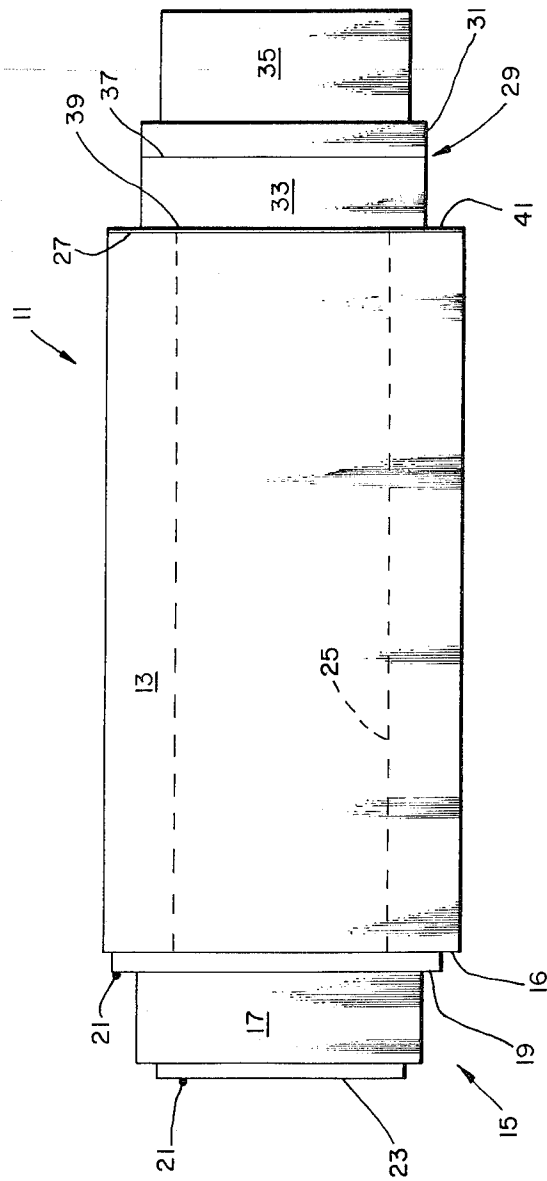
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[57] **ABSTRACT**

An acoustic wave device wherein a termination is mounted on an acoustic wave medium in order to attenuate reflected acoustic wave energy. The device incorporates a thermal isolation layer between the medium and the termination to prevent heat generated in the termination from reaching the medium and causing undesirable consequences.

**18 Claims, 1 Drawing Figure**





**TERMINATED ACOUSTIC WAVE DEVICE**

The invention herein described was made in the course of or under a contract with the United States Air Force.

**BACKGROUND OF THE INVENTION****1. Field of the Invention**

This invention relates to the field of acoustic wave devices and more particularly to such devices incorporating an acoustic termination.

**2. Description of the Prior Art**

High intensity acoustic waves are required in many acoustic wave devices such as, for example, acousto-optic modulators, deflectors, filters, and the like. In the case of acousto-optic devices the scattered optical efficiency is related to the acoustic power; however, the acoustic wave is not depleted in the interaction.

An acoustic termination is generally required at the end of the acoustic medium, especially in acousto-optic deflectors, to prevent the buildup of acoustic resonances, to prevent spurious optical scattering, and to avoid unnecessary heating of the acousto-optic material through the ultrasonic attenuation of the reflected acoustic wave. Thermal considerations are especially important in germanium acoustic devices because of the thermal runaway tendency of this material.

Typically, the acoustic termination must absorb more power than is dissipated in the acoustic medium due to acoustic and possibly optical attenuation. In the prior art, such acoustic terminations have consisted of high attenuation materials such as mercury, lead, or Kovarcopper. The heat generated in these terminations can re-enter the acoustic medium to heat it, especially in materials of high thermal conductivity such as germanium.

In order to alleviate this problem to some extent, it has been the practice to couple the termination to a very good heat sink such as a fluid heat extractor arrangement, for example. Even with this technique, a very highly thermal conductive material must be used for the termination. Materials such as mercury are detrimental here because of its relatively low conductivity. The mercury becomes so warm that the heat may be conducted back into the acoustic medium more easily than it is conducted to the heat sink.

This problem has been found to exist even if one of the best conductors, copper, is used as a termination by bonding directly to an acoustic medium having a relatively low thermal resistance, such as germanium for example. In this prior art configuration, the thermal resistance when water cooled has been calculated to be about 0.45° C/Watt. The germanium thermal resistance has been estimated to be approximately 0.8° C/Watt, or about twice that of the copper-water path. This means that about 2/3 of the thermal power would re-enter the germanium. This is an unacceptable level of heating from the termination that is expected to absorb most of the power.

Contrary to the prior art schemes, an acoustic device has been constructed wherein a thermal isolation layer separates the acoustic medium from the termination. This isolation layer material is chosen to have a relatively low acoustic loss and an acoustic impedance relatively near that of the acoustic medium so that acoustic wave energy will pass through to the termination. The layer material is also chosen to have a relatively low

thermal conductivity so that once converted to heat, the energy will not be conducted into the medium.

**SUMMARY OF THE INVENTION**

In view of the foregoing factors and conditions characteristic of the prior art, it is a primary object of the present invention to provide an improved terminated acoustic wave device whereby heat generated in the termination is inhibited from reaching the acoustic medium.

It is another object of the present invention to provide a terminated acoustic wave device incorporating a thermal isolation layer between the acoustic medium and the termination.

Thus, in accordance with an embodiment of the present invention, an acoustic wave device is provided that includes transducer means mounted on a medium capable of supporting acoustic waves, for propagating acoustic wave energy in the medium. The invention also includes terminating means mounted on the medium in the path of the acoustic energy for absorbing this energy. There is further included thermal isolation means disposed intermediate the medium and the terminating means for limiting the amount of thermal energy reaching the medium from the terminating means.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by making reference to the following description taken in conjunction with the accompanying drawing in which like reference characters refer to like elements in the several views.

**BRIEF DESCRIPTION OF THE DRAWING**

The FIGURE is a schematic representation of a terminated acoustic wave device constructed in accordance with the present invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

Referring now to the drawing there is shown an acoustic wave device 11 having a main body portion 13 of a material capable of supporting acoustic wave energy. A material often used in many applications such as an acousto-optic deflector, for example, is germanium.

Acoustic wave energy is coupled to the body portion 13 by means of a transducer arrangement 15 attached to an end 16 of the body portion. The transducer 15 may be of any known type and any of many well-known techniques may be utilized to efficiently attach the transducer to the acoustic wave supporting body portion. In this embodiment of the invention, the transducer 15 includes a block 17 of piezoelectric material, such as barium sodium niobate ( $Ba_2NaNb_3O_{15}$ ), bonded to the portion 13 by means of a bonding layer 19 of, for example, gold, silver, indium or epoxy. Of course where the transducer material is not too thick, it may be vacuum deposited and no bonding layer will be required. An input signal (from a source not shown) is coupled to the transducer 15 via leads 21, one being attached to the "ground" layer 19 and the other to a top conductive electrode 23 mounted by conventional means to the top of the piezoelectric block 17. A more

complete treatment of the area of acoustic wave energy transducers may be found in many available references, one such reference being "Characteristics of Microwave Acoustic Transducers for Volume Wave Excitation" in IEEE Transactions, Microwave Theory and Technique, MTT-17, 729, November, 1969, by T. M. Reeder and D. K. Winslow.

Once launched by the transducer 15, the acoustic wave energy propagates generally along a path roughly defined by dashed lines 25 in the main body 13 until it reaches the body's opposite end 27 where it encounters an acoustic energy termination 29. The termination, in accordance with this invention, includes a termination element 31 and a thermal isolation element 33 disposed intermediate the element 31 and the main body end 27. The termination element is in the path of acoustic wave energy propagating along the body 13 for absorbing the energy incident thereon and converting it into heat, through attenuation. Materials generally used in this application have a relatively high acoustic attenuation characteristic and may be mercury, silver, lead, or preferably copper which also has a relatively high thermal conductivity.

As to the thermal isolation element 33, it must exhibit a relatively low thermal conductivity in order to limit the amount of thermal energy generated in the termination element 31 from reaching the main body portion 13. The isolation element 33 should also have a relatively low acoustic loss characteristic and should represent a relatively good acoustic impedance match to the material comprising the main body portion 13. This is so the ultrasonic wave will readily pass through the isolation element into the termination element while representing a very poor heat conducting path for heat generated in the element 31. Such materials as fused quartz, crystalline quartz, cadmium telluride (CdTe), sapphire, YIG, YAG, or rutile (TiO<sub>2</sub>) may be used for this isolation application. However, where germanium is used as the main body portion 13, spinel (MgAl<sub>2</sub>O<sub>4</sub>) has been found to be the preferred material to be used in this application.

In order to effectively limit the heating of the device's main body material, a very highly conductive heat sink arrangement 35 is attached to the termination element 31. In the drawing, the arrangement 35 preferably represents a conventional fluid heat extractor, but other forms of heat sinks 39, such as finned copper structures and the like, may be utilized.

In a particular construction of the invention, the isolation element 33 was fabricated from a single crystal of rutile, 2 mm thick, which was electroplated with copper to a thickness of about 0.300 in. on one side 37 to form the termination element 31. The other side 39 of the rutile crystal was polished flat and indium bonded (very thin indium layer 41) to the end 27 of the germanium main body portion 13 at about 80° C. With this thickness of rutile, the thermal resistance of the element 33 is about 11.9° C/W. Comparing this with the 0.45° C/W resistance for the copper-water path termination-heat sink configuration, roughly less than 5 percent of the thermal power is conducted to the germanium body portion 13 through the thermal isolation element 33. Of course epoxy or fluid coupling techniques may be substituted for this indium bonding procedure.

Another long-standing problem encountered in the art in the field of terminated acoustic wave devices is

that there often exists a generally large thermal coefficient mismatch between the termination element and the acoustic wave supporting body to which it is directly attached. An additional advantage in using the intermediately disposed thermal isolation element 33 of the present invention is that the large thermal expansion coefficient mismatch is now at the isolation-termination (rutile-copper) interface 37. This is more favorable since, in the preferred embodiment of the invention, the rutile is far stronger than the germanium.

What is claimed is:

1. An acoustic wave device, comprising: a medium capable of supporting acoustic waves; transducer means mounted on said medium for propagating acoustic wave energy in said medium; terminating means mounted on said medium in the path of said energy for absorbing said energy; heat sink means mounted on said terminating means for extracting heat therefrom; and thermal isolation means disposed intermediate said medium and said terminating means for limiting the amount of thermal energy reaching said medium from said terminating means.
2. The device according to claim 1, wherein said thermal isolation means has a relatively high acoustic energy conducting characteristic and a relatively low thermal energy conducting characteristic.
3. The device according to claim 2, wherein said thermal isolation means has an acoustic impedance relatively close to that of said medium.
4. The device according to claim 1, wherein said thermal isolation means is bonded to said medium.
5. The device according to claim 4, wherein said isolation means is bonded to said medium by a low temperature indium compression bond.
6. The device according to claim 1, wherein said medium is germanium.
7. The device according to claim 4, wherein said isolation means is attached to said medium by a thin epoxy bond.
8. The device according to claim 4, wherein said isolation means is attached to said medium by a compressive bond between two optically flat surfaces.
9. The device according to claim 4, wherein said isolation means is brought into acoustic contact by a fluid coupling arrangement disposed between said isolation means and said medium.
10. The device according to claim 1 wherein said thermal isolation means is a single rutile crystal, and wherein said terminating means is copper layer electroplated on said rutile crystal.
11. The device according to claim 6, wherein said thermal isolation means is rutile.
12. The device according to claim 1, wherein said heat sink means is a fluid heat extractor.
13. The device according to claim 1, wherein said heat sink means is a finned copper structure.
14. The device according to claim 1, wherein said transducer means includes a block of piezoelectric material bonded to the medium.
15. The device according to claim 1, wherein said transducer means includes piezoelectric material vacuum deposited on said medium.
16. The device according to claim 1, wherein said device is an acousto-optic modulator.
17. The device according to claim 1, wherein said device is an acousto-optic deflector.
18. The device according to claim 1, wherein said device is a filter.

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