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BROADBAND EXCITER FOR ELECTROACOUSTIC AND MAGNETOACOUSTIC TRANSDUCERS

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Fig. 1.

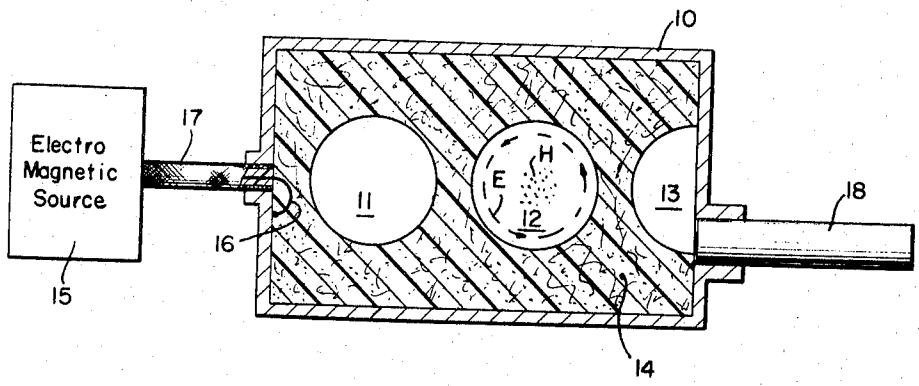
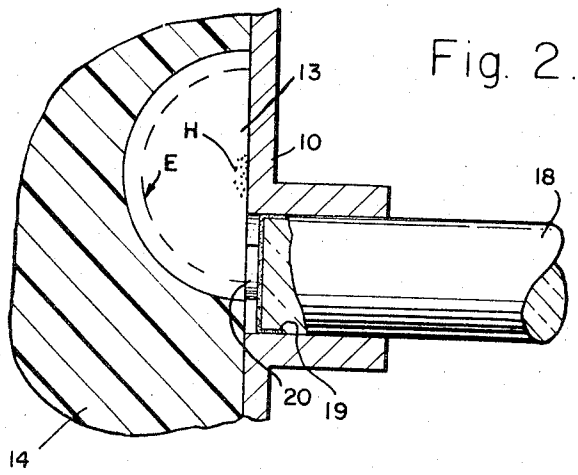


Fig. 2.



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BROADBAND EXCITER FOR ELECTROACOUSTIC AND MAGNETOACOUSTIC TRANSDUCERS

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7 Claims

ABSTRACT OF THE DISCLOSURE

A broad band exciter, having a plurality of electromagnetically coupled dielectric resonators, is excited into resonance by a source of electromagnetic energy. An acoustic transducer is positioned adjacent one of the dielectric resonators for converting the coupled electromagnetic energy into acoustic energy.

Background of the invention

This invention relates to dielectric resonators and more particularly to a broadband exciter which utilizes dielectric resonators for coupling broadband electromagnetic energy to an acoustic transducer.

The use of very high permativity material to form resonators suitable for creating high field strengths for exciting electro- and magnetoacoustic transducers has been discussed in the literature (H. J. Shaw et al., "Attenuation of Hypersonic Waves in Sapphire and Rutile at 2.8 gc. and Room Temperature," Appl. Phys. Letters, vol. 4, No. 2, p. 28, Jan. 15, 1964). These resonators have loaded Q's ranging up to about 10,000 and hence, in normal use, would be a quite narrow band. It is therefore highly desirable to create acoustic exciters having relatively large band widths.

Because the exciters are resonators, they can be used in multiples, with proper coupling between them, to form broadband pass networks. That is, a broadband filter can be produced using these dielectric resonators.

Summary of the invention

In a preferred embodiment of the invention, the problem of providing a broadband exciter for microwave acoustic transducers is efficiently solved by positioning a plurality of dielectric microwave resonators so as to provide electromagnetic coupling between successive resonators, thereby forming a broadband pass network. A source of electromagnetic energy is used to excite the resonators and a band of electromagnetic energy is coupled to the last resonator. The last resonator is coupled by a coupling means, which may be an acoustic transducer, to an acoustic medium.

Brief description of the drawings

FIGURE 1 illustrates in a partially sectioned view the preferred embodiment of the present invention; and

FIGURE 2 is an enlarged view of a portion of the embodiment illustrated in FIGURE 1.

Description of the preferred embodiments

Referring now to FIGURE 1, wherein is shown a housing **10** in which there is positioned three dielectric disc-shaped resonators **11**, **12** and **13**, which may be made from various crystal type materials such as rutile, calcium titanate or lead titanate. The housing itself may be partially conductive or fully conductive; it is only necessary to have the wall which completes the electric field of the last resonator conductive. The coupling of the last resonator through the conductive wall will be explained in detail in the following discussion. The resonant frequency of these resonators depends not only

upon the material of which they are constructed but also upon their shape, size and the ambient temperature and pressure. The housing **10** should be small enough so that its resonant frequency is substantially higher than the resonant frequency of the dielectric resonators. The resonators may be supported within the metal housing **10** by sandwiching them in a solid foam insulating material **14**, such as "Polyfoam." Resonator **11** is coupled to a source of electromagnetic radiation **15** by means of a co-axial cable **17** and a coupling loop **16** passing through a wall of the housing **10**. An acoustic line **18**, which may be a cylindrical quartz rod, is inserted into the metal housing opposite the coupling loop **16**. The end of the acoustic rod which is inserted into the metal housing, is coated with a conductive metal film **19** onto which is deposited a thin film or disc of piezoelectric acoustic transducer material **20**, such as cadmium sulfide or zinc oxide.

The resonator **13** is split along its diameter and positioned with the split surface in contact with the metal housing **10** such that the transducer **20** lies parallel to but not in contact with a part of the surface such that the electric fields E which are generated in the plane of the resonator pass through the transducer material **20**, exciting it into acoustic motion which in turn excites the acoustic line transmitting an acoustic wave through the line to a utilization device (not shown) positioned at the end of the acoustic line. Positioning the split surface against the wall of the housing effectively terminates the electric fields. A magnetoacoustic transducer, which may be made from nickel, can be used in place of the electroacoustic transducer **20**. It should be placed substantially parallel to the magnetic field, H, at the center of the resonator **13**.

The requisite band-pass characteristic may be obtained by inserting the desired number of resonators into the housing and spacing the resonators to achieve the desired coupling.

Dielectric resonators have magnetic fields which decay exponentially outside of the resonator; therefore, effective coupling is achieved between adjacent resonators only. In the embodiment of FIGURE 1, the disc-type resonators **11**, **12** and **13** are positioned adjacent each other with their centers in line. With this configuration, coupling from the loop **16** to the transducer **20** is by way of sequential coupling through the resonators **11**, **12**, and **13** respectively. Sequential coupling may also be achieved with the centers staggered and/or the resonators rotated about their diameters. Each of the resonators in the embodiment of FIGURE 1 are turned to substantially the same resonant frequency. Various combinations of resonant frequencies and spacing of resonators may be used to achieve a desired frequency response.

As shown in FIGURE 2, the E field is a dense field which is stored inside the resonator and which rotates about the center of the discs in a plane defined by the circumference of the discs. Because of the high microwave reflection at the walls of the resonators, only a very small exponentially decaying small E field extends outside the walls of the resonator discs. The resonators are substantially transparent to the magnetic field and coupling between resonators is accomplished by the magnetic H field.

The H field is perpendicular to the E field through the circumference plane of the resonators. Each resonator has at least a partial toriodal, external magnetic field and absorbs that electromagnetic energy which corresponds to its resonant frequency. By overlapping the magnetic fields between resonators, a band of electromagnetic energy can be coupled to the last resonator **13**. This band of coupled energy is then applied to the acoustic transducer to be transformed into acoustic energy.

While there has been shown what is considered to be

the preferred embodiment of the invention, it will be manifest that many changes and modifications may be made therein without departing from the essential spirit of the invention. It is intended, therefore, in the annexed claim, to cover all such changes and modifications as fall within the true scope of the invention.

What is claimed is:

1. In combination:

a partially conductive housing;

a plurality of dielectric resonator discs including a first disc and a last disc supported within said conductive housing;

a source of electromagnetic energy;

means coupling said source to said first disc;

an acoustic line; and

means coupling said last disc to said acoustic line.

2. The invention, according to claim 1, wherein said plurality of discs are positioned with the centers of said discs substantially all in the same plane.

3. The invention, according to claim 1, wherein said plurality of discs are rutile crystals.

4. The invention, according to claim 1, wherein said acoustic line is a magnetoacoustic line.

5. The invention, according to claim 1, wherein said acoustic line is a quartz rod and said coupling means is a piezoelectric material in contact with said quartz rod.

6. The invention, according to claim 1, wherein the resonant frequencies of said plurality of dielectric resonators is substantially equal.

7. The invention, according to claim 1, wherein said plurality of dielectric resonator discs are spaced apart so as to provide a desired sequential coupling of electromagnetic energy from said first to said last disc.

References Cited

UNITED STATES PATENTS

3,371,264	2/1968	Carr	310—8.2 X
3,260,969	7/1966	Jacobsen	333—30
2,927,285	3/1960	Curran et al.	333—72

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