VARIABLE ULTRASONIC DELAY LINE
Filed Dec. 20, 1961

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This invention pertains generally to solid ultrasonic delay lines and particularly to improved lines of such type in which the delay time may be varied.

In known variable delay lines, except the type described in my co-pending application Serial No. 139,454, filed September 20, 1961, and assigned to the same assignee as the present invention, delay time is varied by varying the length of the path of acoustic energy in an homogeneous acoustic transmitting medium. In my cited co-pending application, on the other hand, the length of the path of acoustic energy is substantially constant, variations in delay time being accomplished by directing an acoustic beam through a non-homogeneous acoustic transmitting medium so that the time taken for such a beam to travel from a transmitting transducer to a receiving transducer may be varied.

While the structure shown in my cited co-pending application has proven to be useful, the fact that both the transmitting acoustic transducer and the receiving acoustic transducer must be moved simultaneously has given rise to some difficulty. It is evident that mechanical tolerances must be reduced to the lowest practicable value if the full advantages of the cited invention are to be attained. It is also evident that, even if mechanical tolerances are kept within close limits, it may be necessary to move the two transducers relative to each other to attain best results.

Therefore, it is an object of this invention to provide a variable solid delay line requiring only one movable acoustic transducer to cover a range of delay times.

Another object is to provide an improved variable solid delay line in which the path of acoustic energy is kept substantially constant throughout a range of delay times.

Still another object of the invention is to provide a solid acoustic delay line in which the foregoing objects are attained in a mechanically simple and rugged device.

These and other objects of the invention are attained generally by providing an acoustic transmitting medium consisting of two wedges of different kinds of acoustic transmitting material joined together to form a unitary block, a transmitting transducer affixed to one of the wedges to flood the interface between the two wedges with acoustic energy so that such energy is reflected to a movable receiving transducer. For a more complete understanding of the invention reference is now made to the drawings in which:

The single figure is a perspective view, partially cut-away and greatly simplified, of a preferred embodiment of the invention.

Referring now to the figure, it may be seen that a delay line according to the invention comprises an acoustic transmitting assembly 10 mounted within a case 11. The acoustic transmitting assembly 10 consists of a first wedge 13 of material, as fused quartz, bonded to a second wedge 15 of a different material, as glass, at an interface 17. Preferably the interface 17 is formed by grinding the opposing surfaces of the wedges 13, 15 and cementing the two surfaces together with a bonding material, as phenyl benzoate. A mounting bracket 19 screwed to an end wall of the case 11 serves to clamp the acoustic transmitting assembly in place, as illustrated. A relatively long acoustic transmitting transducer 21, as a piezo-electric crystal, is cemented, again as by a film of phenyl benzoate to a surface of the first wedge 13. The transducer 21 is energized from any convenient known source (not shown) through lead wires 23. An acoustic receiving transducer 25, as a piezo-electric crystal, is cemented, again as by a film of phenyl benzoate, to an acoustic coupler 27, as glass, which is pressed against the second wedge 15 by the action of a spring 29 as shown. A lead screw 31 is connected on one end to the acoustic coupler 27 and led through a threaded bushing 33 in an end wall of the case 11. A hand wheel 35 affixed to the outer end of the lead screw 31 completes the assembly.

In operation, the acoustic transmitting transducer 21 is energized with the signal to be delayed. Acoustic energy is then projected through the first wedge 13 to impinge all along the interface 17. The energy is there refracted and directed through the second wedge 15. A portion of the refracted energy is intercepted by the acoustic coupler 27 and directed to the receiving acoustic transducer 25, there being converted into an electric signal and led to any appropriate utilization circuit (not shown) through the unnumbered leads projecting from the receiving acoustic transducer 25.

Variations in delay time are obtained by rotating the hand wheel 35 to turn the lead screw 31 in the threaded bushing 33, thereby causing the acoustic coupler 27 to move along the surface of the second wedge 15. As a result of such movement of the acoustic coupler 27, different portions of the energy propagated by the acoustic transmitting transducer 21 are intercepted by the acoustic coupler 27. Consequently, the receiving acoustic transducer 25 is energized by energy which has been delayed for varying times.

It will be apparent that the shape and material of the various elements making up the acoustic path may be varied within wide limits, depending on the characteristics of the chosen material and the desired range of delay times. It is essential only that the velocity with which acoustic energy is passed through the first and second wedges 13, 15 differs and that the wedges be so shaped that some of the acoustic energy is refracted rather than reflected at the interface 17. In a practical case, for example a range of delay between 120 and 150 microseconds may be attained in a device in which the first wedge 13 is fused quartz and the second wedge 15 and the acoustic coupler 27 are glass and the wedges are cut approximately as shown in the drawing. To be specific (referring to the figure) to attain such a range of delays: (the velocity ratio between the two materials being approximately 3:2)
What is claimed is:

A variable solid ultrasonic delay line comprising:
(a) a wedge of fused quartz having a first and a second surface intersecting each other at an acute angle greater than 45°;
(b) a transmitting acoustic transducer in intimate contact with and substantially covering the first surface;
(c) a wedge of glass;
(d) means bonding the second surface of the wedge of fused quartz to a first surface of the wedge of glass to form a refracting interface between the wedge of fused quartz and the wedge of glass;
(e) an acoustic coupler of glass slidably mounted on a second surface of the wedge of glass, the surface of the acoustic coupler removed from the wedge of glass being normal to the path of acoustic energy in the wedge of glass;

(f) a receiving acoustic transducer affixed to the surface of the acoustic coupler removed from the wedge of glass to receive acoustic energy intercepted by the acoustic coupler; and,

(g) means for moving the acoustic coupler and the receiving acoustic transducer along the second surface of the wedge of glass.

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