310-334 SR CROSS REFERENCE SEARCH ROOM
XR 3,350,665 P9112
X89213

Oct. 31

3,350,665

VARIABLE ELASTIC WAVE DELAY LINE USING TWO STRIPS PRESSED TOGETHER

Filed Nov. 19, 1965

FIG. 1

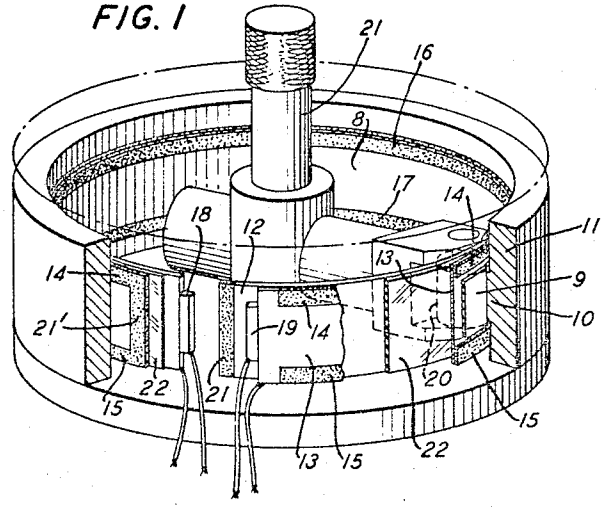


FIG. 1A

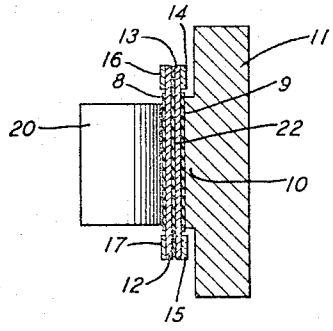


FIG. 2

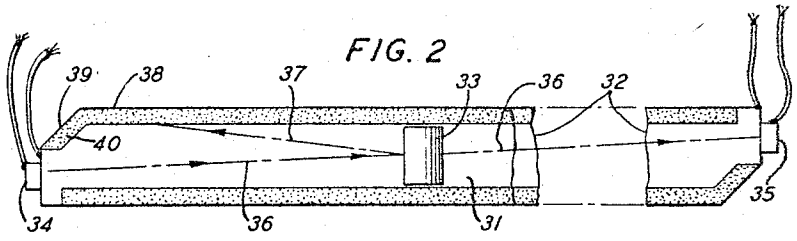
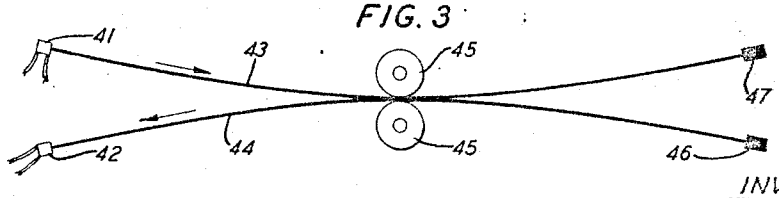


FIG. 3



INVENTOR
I.E.FAIR
BY
Roy M. Porter Jr.
ATTORNEY

3350665
OR IN 333/30R

United States Patent Office

3,350,665

Patented Oct. 31, 1967

3,350,665

VARIABLE ELASTIC WAVE DELAY LINE USING TWO STRIPS PRESSED TOGETHER

Irvin E. Fair, Center Valley, Pa., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Nov. 19, 1965. Ser. No. 508,674

7 Claims. (Cl. 333—30)

This invention relates to delay devices and more particularly to elastic wave strip delay lines of the type in which the delay time may be varied.

The art is familiar with a class of devices in which blocks of elastic wave transmission material are held in slidable contact with each other such that relative movement between the blocks varies the path length of elastic wave vibrations launched in one and received from another. While a variable delay is thus obtained, the sliding contacts between the blocks' are unavoidable sources of undesirable noise and the wave motion possible in the blocks does not have the desirable transmission properties which are characteristic of particular guided elastic wave modes in thin strips of elastic wave transmission material as described in Patent 3,041,556, granted June 26, 1962, to A. H. Meitzler.

It is, therefore, an object of the present invention to smoothly and noiselessly vary an elastic wave delay.

It is a further object to vary the delay of elastic wave strip delay lines.

In accordance with the present invention it has been discovered that an elastic wave can be transferred between two contiguous strip delay lines at a given area along their length simply by pressing the two strips together in this area and that a minimum of energy is transferred between them in the absence of pressure.

In accordance with a first embodiment of the invention this principle is utilized by employing two nearly contiguous strip delay lines that are formed respectively from materials that have substantially different first and second elastic wave velocities. An elastic wave is initially launched by a first transducer upon the line having the first velocity, is transferred by pressure to the other line having the second velocity, and is received by a second transducer at the end of the other line. By varying the location of the area of pressure along the length of the lines, the relative proportion of the total path travelled at the different velocities is varied, thus varying the total delay.

These and other objects and features, the nature of the present invention and its various advantages, will appear more fully upon consideration of the specific illustrative embodiments shown in the accompanying drawings and described in detail in the following explanation of these drawings, in which:

FIG. 1 is a cutaway perspective view of a preferred embodiment of the invention;

FIG. 1A is an enlarged cross-sectional view taken through a portion of FIG. 1 as indicated;

FIG. 2 is a developed view of an alternative transducer arrangement for FIG. 1; and

FIG. 3 is a schematic diagram illustrating an alternative mode of operation of the embodiment of FIG. 1.

Referring more particularly to FIG. 1, an illustrative embodiment of the invention is shown comprising a cylindrical housing **11** within which two concentric sections **12** and **13** of strip delay line are located adjacent to the inside cylindrical surface of the housing. Lines **12** and **13** are formed as strips having widths that are substantially greater than their thickness from materials which are isotropic and have grain sizes that are small compared to the wavelength of the elastic wave motion

to be carried but which have respectively different velocities of propagation for elastic wave energy.

For example, one strip can be formed from aluminum which has a relatively fast velocity and the other from a nickel iron alloy which has a relatively slow velocity. Other examples of fast velocity materials are beryillium and quartz. Examples of slow velocity materials are tungsten, titanium and brass. Located upon the two outer edges of the convex wide face of outer strip **13**, between it and surface **11**, are elongated regions of acoustical absorbing material in the form of strips **14** and **15** of cloth or plastic-backed adhesive tape. Similar tapes **16** and **17** are disposed upon the edges of the concave face of inner strip **12**.

A pair of transducers **18** and **19**, each of conventional design, are bonded respectively to one end of each of the strip lines **12** and **13**. According to a preferred embodiment the transducers are of one of the several designs known to couple an electrical signal to and from a thickness shear mode of elastic vibration on strips **12** and **13**. For example, the transducers may comprise piezoelectric crystals or piezoelectric ceramic members, together with appropriate electrodes, bonded to the end faces of the strips. The piezoelectric material is poled in a direction perpendicular to the length axis of the strip and parallel to the major surfaces thereof so as to produce a thickness shear mode having a vibration parallel to the direction of poling of the transducer. Further details concerning the thickness shear mode and the effect of the dimensions of the strip lines upon the mode character may be found in the above-mentioned patent of A. H. Meitzler. Alternatively, the transducers may be of the type which respond to vibrations parallel to the axis of the strip, known as the thickness longitudinal mode. In either case transducers **18** and **19** are located on respectively remote ends of the lines while the end of the other line adjacent to each transducer is treated to absorb wave motion either in absorbing tapes **21** and **21'** as illustrated, or by cutting these ends in a diagonal taper or by employing both absorbing tape and tapers.

Means are provided for pressing lines **12** and **13** together in a restricted area that can be moved along the length of the lines. In the specific embodiment illustrated this means comprises a spring loaded roller **20** extending from a centrally mounted spindle **21** such that rotation of spindle **21** causes roller **20** to move along the circumferential length of the strips. Preferably the outer strip **13** is left in a springy state so that it expands firmly against raised boss **10** extending around the center of cylindrical wall **11** and the inner strip **12** is pre-formed so that its fits loosely along the majority of its length within strip **13**. Thus when the ends of both strips are suitably anchored, contact sufficient to transfer vibrations is maintained only at the position of roller **20**. Alternatively or additionally, a thin strip **22** of plastic material such as polyethylene teraphthalate film, known by the trade name Mylar, may be located between strips **12** and **13** to separate the strips in the absence of pressure and to serve as an acoustical impedance matching transformer between the strips under pressure. The dimensions of both roller **20** and boss **10** are such as to contact strips **12** and **13** in the region between the absorbing tapes **20** and **21** as may be seen in the cross-sectional view of FIG. 1A. In addition, it has been found that further thin strips of plastic material **8** and **9** located respectively between roller **20** and strip lines **12** and **13** and between the strip lines and boss **10** smooth out the transmission band and reduce noise. It is believed that this is due to reduction of reflections back into the strip lines from the roller and the housing.

Elastic wave energy launched, for example, by trans-

ducer 18 serving as the input, travels down strip 12 to roller 20 where it divides into four principle components which travel toward each of the four ends of strips 12 and 13. The energy traveling in strip 13 toward transducer 19 constitutes the useful signal. The energy reaching the remaining ends is dissipated in terminations 20 and 21. The delay introduced to the useful signal is the sum of the time travelled in the strip of slower velocity and the time travelled in the strip of faster velocity. Adjustment of the position of roller 20 to increase the path length in the slow strip and simultaneously decrease the length in the fast strip, decreases the total delay.

In FIG. 2 a developed view of strip lines 31 and 32 illustrates a way in which reflections from a roller 33 may be minimized. Thus, the path 36 between input transducer 34 and output transducer 35 is directed at an angle to the axis of roller 33, as for example, by having the transducers located near the top and bottom edges respectively of the strips. Thus, the wave reflected from roller 33 returns along the path 37 and is dissipated by absorbing material 38 or 40 along the edges of the strip. FIG. 2 illustrates the combined use of tapers 39 and dissipative member 40 at one end of each strip.

In FIG. 3 the driving and receiving transducers 41 and 42 are located upon adjacent ends of strips 43 and 44. Thus, the signal reflected from a pair of rollers 45 into the undriven strip 43 constitutes the useful signal. The total time delay is the sum of travel times to and from the position of roller 45. For operation in accordance with this mode, it is unnecessary that the respective strips be of different composition. Terminals 46 and 47 on adjacent ends remote from the transducers absorb energy components in both strips which pass the roller.

It should be understood that the cylindrical housing-roller arrangement of FIG. 1 represents only one particularly useful form of the invention and that the principles thereof may be applied to a pair of strips supported along their lengths and arranged for the application of a movable pressure in numerous other ways which will readily occur to those skilled in the art.

In all cases it is to be understood that the above-described arrangements are merely illustrative of a small number of the many possible applications of the principles of the invention. Numerous and varied other arrangements in accordance with these principles may readily be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A variable delay line comprising a pair of elongated thin strips of elastic wave transmission material having respective elastic wave velocities that are substantially different from each other, transducer means mounted on an end of each of said strips for generating and responding to elastic wave motion in said strips, and means for pressing said strips together in a restricted region that can be moved along the length of said strips.

2. A variable delay line comprising a pair of elongated thin strips of elastic wave transmission material each having rectangular cross sections with width dimensions many times that of the thickness dimensions thereof, a transducer mounted on one end of each of said strips for generating and responding to elastic wave motion in that strip, and means for pressing said strips together in a restricted region that can be moved along the length of said strips to transfer wave motion from one strip to the other to define a transmission path between said transducers which has a propagation time along said path that depends upon the position of said region along said strips.

3. The delay line of claim 2 wherein said strips are formed of material having substantially different elastic wave transmission velocities.

4. The delay line of claim 2 wherein said strips are arranged concentrically with respect to each other in substantially circular form and wherein said means for pressing includes a roller adapted to travel the path of said circular form and to bear against said strips.

5. The delay line of claim 2 wherein said transducers are mounted respectively on contiguous ends of said strips.

6. The delay line of claim 3 wherein said transducers are mounted respectively on remote ends of said strips.

7. The delay line of claim 2 including elastic wave absorbing material located near the edges on the face of each of said strips.

No references cited.

ROY LAKE, *Primary Examiner.*

D. R. HOSTETTER, *Examiner.*