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ADJUSTABLE DELAY LINE

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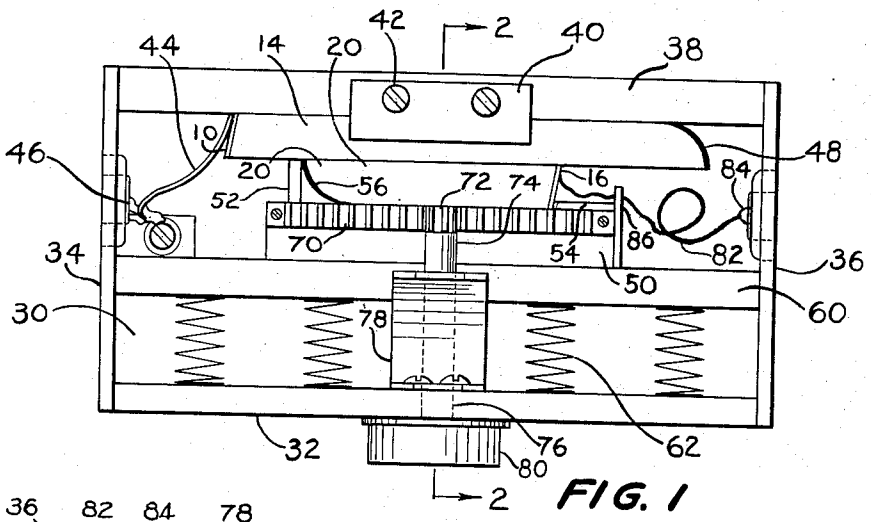


FIG. 1

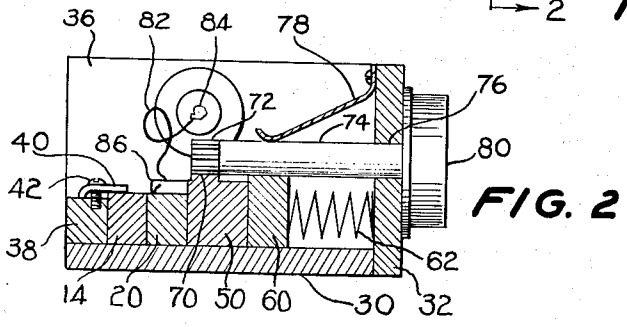


FIG. 2

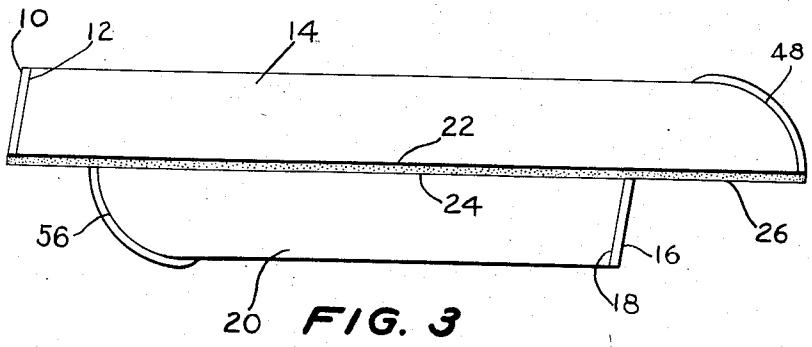


FIG. 3

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ADJUSTABLE DELAY LINE

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The present invention relates to delay lines of the type comprising a transmitting and a receiving crystal for connection in an electrical circuit and having disposed therebetween an acoustically suitable material conductive of ultrasonics. The invention is particularly concerned with a construction and arrangement of the elements of a delay line of the character referred to which permits variation and adjustment of the length of the time delay or transmission time between the transmitting and the receiving crystal.

As is well known to those skilled in the art of manufacturing and utilizing time delays of the type referred to here, such time delays are of critical and sensitive construction and the utmost care must be taken to avoid non-uniformity, reflections and attenuation not only in the various elements themselves but particularly at the interfaces therebetween. Furthermore, the precise dimensions of the various elements are extremely critical and uniformity of characteristics is extremely difficult to attain.

The principal object of the present invention is to devise a construction for time delays which will permit adjustment thereof after assembly and which despite its unique adjustment feature will not be adversely affected from the standpoint of uniformity and attenuation.

A further object of the invention is to provide an adjustable time delay having desirable performance characteristics without using complicated and expensive mechanisms and designs.

Another object is to provide an adjustable time delay in which the adjustment operation is simple and easy to perform with a minimum of instruction and experience.

Another object of the invention is to provide an adjustable time delay which will operate satisfactorily over long periods of time without malfunctioning and which will be comparatively rugged in construction and foolproof in operation.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawing:

Fig. 1 is a plan view of a mechanism including the adjustable delay line of the present invention;

Fig. 2 is a cross-sectional view taken along the line 2—2 of Fig. 1; and

Fig. 3 is an enlarged diagrammatic view of the operating elements of the adjustable delay line per se.

Referring to the drawing, the basic invention of

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the present application is best illustrated in Fig. 3. As viewed in this figure, a quartz crystal 10 which may be either the transmitting or receiving crystal is disposed at one end of an angularly related face 12 of a bar 14 composed of acoustically suitable material for conducting ultrasonic sound such as quartz, alloys such as Invar, magnesium, certain glasses, etc. A second crystal 16 is applied to the diametrically opposite angularly related face 18 of a bar 20 formed of the same type of material as the bar 14 and disposed in close parallel relationship therewith. The bar 14 has a flat surface or face 22 adjoining the flat surface or face 24 of the bar 20. Disposed between the faces or surfaces 22 and 24 is a thin layer or film 26 of an unctuous material, such as petrolatum or similar material which is viscous and flowable.

In accordance with the invention, I have discovered that if the crystals 10 and 16 are disposed substantially parallel to each other and are inclined inwardly at a small angle vertical to the faces 22 and 24, and the bars 14 and 20 are pressed together with a film of unctuous material therebetween, the ultrasonic waves produced by one of these crystals and transmitted into its associated bar of acoustic material will successfully pass through the adjoining faces of the bars 14 and 20 and will continue on through the other bar to the other crystal without undesirable distortion, reflection and attenuation. I have also found that this condition will exist even though one bar is moved longitudinally with respect to the other within reasonable limits.

As a result of the ability of the device to transmit ultrasonic waves in an angular direction between separate side by side bars of acoustic material without undesirable attenuation and distortion, it is possible to vary the effective distance between the crystals 10 and 16 and thus to vary or adjust the time period for transmission of the ultrasonics from one crystal to the other.

Referring to Figs. 1 and 2, there is shown one embodiment of a mechanism for adjustably mounting the arrangement shown in Fig. 3 of the drawing. The embodiment shown in Figs. 1 and 2 is illustrative only and merely shows one way to carry out the invention in a practical manner. However, it will be readily apparent to one skilled in the art that the mechanical arrangement for mounting and adjusting the parts of the delay line may be subject to a wide variety of modifications within the skill of one versed in the art and all such arrangements are intended to be within the scope of the invention.

Referring to Figs. 1 and 2, the device is housed for convenience in a rectangular casing consisting of a bottom plate 30, front plate 32, and side plates 34 and 36. Fixed to the base plate 30 at the rear thereof is a support 38 in the form of a metal

bar of rectangular cross section. The bar 14 of acoustic material, such as quartz, Invar, magnesium or the like, as previously mentioned, is clamped to the supporting bar 38 by means of a clamp 40 fixed to the bar by screws 42. The crystal 10 secured to the inclined end face 12 of bar 14 is connected by means of lead line 44 to the terminal 46 by means of which the same may be connected to an electrical circuit (not shown). The opposite end of the acoustic bar 14 is preferably curved as shown at 48 and this curved end 48 is preferably coated with sound absorbing material, such as collodion, etc., all of which aid in minimizing reflections.

The acoustic bar 20 and crystal 16 secured thereto are mounted on a movable supporting bar 50 and for convenience may be attached thereto by disposing the same between a pin 52 and a plate insulator 54. The bar 20 is similarly arcuate at the end 56 opposite from the crystal 16 and this curved end also is coated with sound absorbing material. The movable support bar 50 rests on the base plate 30 and is slidable along a guide rod 60. The guide rod 60 is urged rearwardly by a plurality of springs 62 whereby it in turn urges the adjustable bar 50 and hence the acoustic bar 20 toward the acoustic bar 14 with substantial force.

In order to adjust the longitudinal position of the movable bar 50 the same is provided on its upper face with a rack 70 which meshes with a pinion 72 on the end of a shaft 74 which is journaled in the opening 76 in the front plate 32. The pinion 72 is urged into engagement with the rack 70 by means of a leaf spring 78 bearing upon the upper surface of the shaft 74. This spring 78 also tends to prevent inadvertent movement of the shaft 74. The outer end of the shaft 74 is provided with a knob 80 by means of which the shaft 74 may be manually rotated to adjust the position of the acoustic bar 20.

The crystal 16 is connected by lead line 82 to a terminal 84. In order to avoid any strain on the connection with the crystal 16, the lead line 82 may be supported in an insulator 86 supported on the end of the movable support bar 50.

As previously mentioned the crystals 10 and 16 are mounted substantially parallel to each other and at an angle vertical to the faces 22 and 24. The particular angle is not critical and will, of course, depend upon the dimensions of the acoustic bars 14 and 20 and also on the amount of variation of adjustment required. For practical purposes, I have found that the disposing of the crystals at an angle of from 2 to 15 degrees, for example, will usually provide all of the adjustment required or desired in most cases and will function satisfactorily.

While the acoustic bars 14 and 20 are illustrated as being square in cross section, this has been done merely as a matter of convenience. The cross section of bars 14 and 20 is not critical, it being necessary only that they be provided with preferably flat complementary parallel mating surfaces 22 and 24.

The means by which the mating surfaces 22 and 24 are made to cooperate with each other is believed to be a critical feature of the invention. It is possible to provide mating surfaces 22 and 24 such as by lapping techniques which will conduct ultrasonic vibrations through the separation, but this is not practical from the standpoint of producing uniform delay lines in large quantities at reasonable cost and, in any event, the transmission is not at an optimum. However, by applying a viscous and flowable unctuous material to the mating surfaces 22 and 24, a marked improvement is noted in the manner in which the vibrations will be sustained and the bars 14 and 20 may be longitudinally adjusted relative to each other without difficulty. It is not desired to limit the invention to the selection of any particular unctuous material since a wide variety of such materials have been tested successfully. In general, preferred results are obtained when the unctuous material is somewhat sticky so that it will adhere to the faces 22 and 24 and it is preferred to use a material which is stable and which will not evaporate or otherwise deteriorate or change over long periods of use. As mentioned, the material must be viscous since in general liquids do not have sufficient body to sustain shear ultrasonic vibrations. Similarly, the material must be flowable so as to permit sliding of the faces 22 and 24 relative to each other and also, it is believed, so that it will tend to fill any irregularities between the surfaces. In general, any of the unctuous materials available commercially, such as mineral oil derivatives and synthetic resins, will sustain wave sound and the chemical composition does not appear to be critical. I have successfully employed such material as petrolatum, resins, and particularly the unctuous material sold under the trade name Vistac No. 1.

While the present invention is not necessarily limited to any particular type of receiving and transmitting crystals, nonetheless, it is principally directed as a practical matter to delay lines employing crystals of the shear type commonly referred to as Y-, AT-, or AC-cut crystals. When shear type crystals are employed, the crystals are arranged so that the particle motion of the ultrasonic waves generated is parallel to the faces 22 and 24.

With the arrangement as shown in the drawing, the distance between the crystals 10 and 16 may be varied over wide limits without adversely affecting the acoustical and electrical characteristics of the device and there is thus provided an adjustable time delay suitable for practical use in the art.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above descriptive or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim as my invention:

1. An adjustable ultrasonic delay line comprising a pair of side by side bars formed of material acoustically suitable for conducting sound in the ultrasonic range, said bars being formed with complementary parallel mating surfaces, an unctuous material between the mating surfaces, a transmitting crystal affixed to one end of one bar, and a receiving crystal affixed to the opposite end of the other bar, said crystals being substantially parallel and inclined at a

small angle toward the mating surfaces of the bars.

2. An adjustable ultrasonic delay line comprising a pair of bars formed of material acoustically suitable for conducting sound in the ultrasonic range, said bars being mounted for relative longitudinal movement and having flat adjoining surfaces, a film of unctuous material between the adjoining surfaces, means for pressing the bars together, a transmitting crystal affixed to one end of one bar, and a receiving crystal affixed to the opposite end of the other bar, crystals being substantially parallel and tilted inwardly at a small angle toward the said adjoining surfaces of the bars.

3. An adjustable ultrasonic delay line comprising a pair of bars formed of material acoustically suitable for conducting sound in the ultrasonic range, means mounting the bars in parallel side by side relationship and permitting relative longitudinal movement of the bars, the bars being formed with flat longitudinally extending adjoining surfaces, means biasing said surfaces together, an unctuous material on said surfaces, a first crystal affixed to one end of one bar, and a second crystal affixed to the diametrically opposite end of the other bar, said diametrically opposite ends having substantially flat parallel surfaces inclined inwardly toward the said adjoining surfaces at an angle of from 2° to 15°.

4. An adjustable ultrasonic delay line comprising a pair of bars of uniform rectangular cross-section throughout, means for mounting the bars in side by side relationship and movable longitudinally relative to each other, means for pressing the bars laterally together, an unctuous material between adjacent surfaces of the bars, a first transducer crystal affixed to one end of one bar, and a second transducer crystal affixed to the diametrically opposite end of the other bar, said diametrically opposite end surfaces being substantially flat parallel surfaces inclined inwardly at a small angle toward the other bar.

5. An adjustable ultrasonic delay line comprising a pair of generally rectangularly shaped bars formed of material acoustically suitable for conducting sound in the ultrasonic range, means for mounting said bars for relative longitudinal movement in parallel side by side relationship with adjacent surfaces engaging, a viscous flowable material between said adjacent surfaces, each of said bars being formed with an angularly related end surface at one end, said bars being mounted with said angularly related end surfaces diametrically opposite from each other and inclined toward said adjacent surfaces of the bars, and a pair of crystals on said angularly related end surfaces.

6. An adjustable ultrasonic delay line as claimed in claim 5 in which the crystals are of the shear type and are arranged so that the particle motion of the ultrasonic waves generated are parallel to said adjacent surfaces of the bars.

7. An adjustable ultrasonic delay line comprising a pair of generally rectangularly shaped bars formed of material acoustically suitable for conducting sound in the ultrasonic range, means for mounting said bars for relative longitudinal sliding movement in parallel side by side relationship with adjacent surfaces engaging, a viscous flowable material between said adjacent surfaces, each of said bars having a rounded external corner at one end and an angularly related end surface at the other end, said bars being arranged with the ends of one bar diametrically opposite from the similar ends of the other, and a transmitting and receiving crystal secured on the diametrically opposite angularly related end surfaces of the bars.

8. An adjustable ultrasonic delay line as claimed in claim 7 wherein the rounded external corners of the bars are coated with sound absorbing material.

9. An adjustable ultrasonic delay line comprising a pair of generally rectangularly shaped bars formed of material acoustically suitable for conducting sound in the ultrasonic range, said bars being arranged in parallel side by side relationship with adjacent surfaces engaging, means for pressing said bars together and for adjusting the bars longitudinally of each other, a viscous flowable material between said adjacent surfaces, said bars being formed at diametrically opposite ends with parallel flat end surfaces inclined at a small angle toward said adjacent surfaces, and a transducer crystal secured to each of said end surfaces.

10. An adjustable ultrasonic delay line comprising a pair of supporting members mounted for movement in a parallel direction relative to each other, a pair of bars supported on said members in side by side relationship, said bars having flat parallel engaging surfaces and being formed of material acoustically suitable for conducting sound in the ultrasonic range, a viscous flowable material between said engaging surfaces of the bars, means biasing the supporting members together in a lateral direction whereby said engaging surfaces of the bars are put under pressure, said bars being formed with diametrically opposite flat parallel end surfaces inclined at a small angle toward said engaging surfaces, a crystal on each of said end surfaces, and means for adjusting said supporting members longitudinally of each other.

11. An adjustable ultrasonic delay line as claimed in claim 10 in which the means for adjusting said supporting members longitudinally of each other comprises a control knob and gear means interconnecting the knob and one supporting member including a rack fixed to said one supporting member.

12. An adjustable ultrasonic delay line comprising a casing, a pair of supporting members mounted in the casing for longitudinal sliding movement in a parallel direction relative to each other, spring means biasing the supporting members laterally toward each other, a pair of generally rectangular bars of material acoustically suitable for conducting sound in the ultrasonic range disposed between the supporting members in side by side relationship with their adjacent surfaces engaging, each bar being fixed to the adjacent supporting member, an unctuous material between said adjacent surfaces of the bars, means for moving one of said supporting members longitudinally of the other, a first quartz crystal affixed to one end surface of one of said bars, and a second quartz crystal affixed to the diametrically opposite end surface of the other of said bars, said end surfaces being substantially flat and parallel and inclined at an angle of from 2° to 15° toward the engaging surfaces of the bars.

SVEN J. JOHNSON.

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