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G. BRADFIELD

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APPARATUS FOR LAUNCHING ULTRASONIC WAVES

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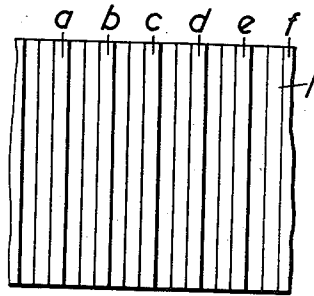


Fig. 1

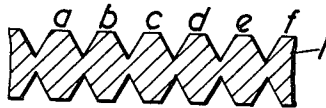


Fig. 2

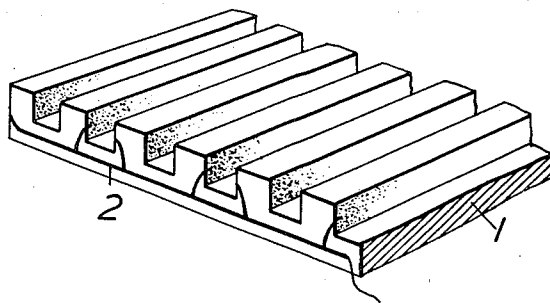


Fig. 3

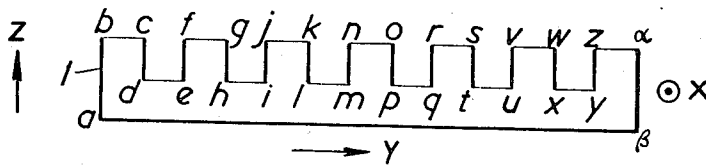


Fig. 4

Inventor
Geoffrey Bradfield
Stevens David Miller & Moore
his Attorneys

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APPARATUS FOR LAUNCHING ULTRASONIC WAVES

Geoffrey Bradfield, Surbiton, England, assignor to National Research Development Corporation, London, England, a British corporation

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12 Claims. (Cl. 310—9.6)

The present invention relates to methods of and apparatus for examining the properties of materials by propagating ultrasonic waves in such materials. These methods are useful for discovering and locating discontinuities in the structure of a mass of material. For example, this method of examination may be used for discovering internal flaws in metallic forgings and castings.

It is known that ultrasonic vibrations can be launched in a medium by coupling an electro-mechanical transducer element, such as a magnetostrictive or piezoelectric device, to the surface of the medium. It has moreover been proposed to provide an array of electromechanical transducers energised in appropriate phases to launch in the medium a beam of ultrasonic radiation having a maximum intensity of propagation in a given direction.

The arrays used hitherto have been made up of separate piezoelectric crystals but according to the present invention there is provided apparatus for launching ultrasonic waves in a medium and comprising a slab of piezoelectric material effectively divided by grooves into discrete piezoelectric elements with means for applying electrical potentials to the discrete elements to excite them into vibration. The material of the slab may be quartz but according to a feature of the invention the material may be one that can be rendered piezoelectric by the application of a polarising potential, for example barium titanate.

The invention will be described, by way of example, with reference to the accompanying drawings in which: Figures 1 and 2 illustrate one embodiment of the invention, and

Figures 3 and 4 illustrate another embodiment of the invention.

In Figures 1 and 2 there is shown in plan and elevation a slab 1 of piezoelectric material which is grooved, as shown, so as to be effectively divided into a series of parallel piezoelectric elements. These elements have opposite faces silvered and may be excited to oscillate as required. The material of which slab 1 is made may be quartz suitably cut but alternatively it may be material of the barium titanate type. This material in polycrystalline form has the property that it can be rendered anisotropic and piezoelectric by a direct current polarising potential applied to it, the piezoelectric polarity being dependent on the polarity of the applied potential.

The polarising potential may be applied continuously while the array is in use but preferably the array retains its anisotropic properties induced by an applied potential. It has been found that an admixture of about from 3% to 5% lead titanate with barium titanate gives good retentivity of polarisation. For example, if in the specimen shown in the drawing the plates *a*, *c*, *e*, etc. have been polarised at about plus 1,000 volts and the plates *b*, *d*, *f*, etc. at about minus 1,000 volts than *a*, *c*, *e*, etc. will have their electric axis in one direction and *b*, *d*, *f*, etc. will have them in the opposite direction. Hence

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when a common high frequency exciting potential is applied to the array of plates the mechanical displacements of adjacent plates will be in anti-phase. Alternatively, of course, the elements may all be polarised in the same direction and adjacent elements excited in anti-phase.

This array will generate compressional waves in a medium to which it is applied and the depth of the V-shaped grooves should be such that shear strains, set up by the out-of-phase compressional strains in adjacent elements, are negligible.

The invention may also be applied to an array for launching shear waves and such an array is illustrated in Figures 3 and 4. Figure 3 shows a perspective view of the array and Figure 4 shows an end view.

In this case the slab 1 is cut from a quartz crystal with the Y and Z axes running in the directions shown in Figure 4 and the X axis running normal to the drawing as indicated. The slab 1 is channelled on one side only, as shown, and the faces *ab*, *cd*, *ef* . . . *wx*, *yz* and *αβ* are metallised, for example by silvering. Faces *ab*, *gh*, *ij*, *op*, *qr* and so on are all connected to a metallised bus bar 2 on the slab 1 as shown in Figure 3 and the other faces *cd*, *ef*, *kl*, *mn* and so on, are connected to another bus bar (not shown) at the other end of the slab 1. The application of a suitable alternating voltage to these bus bars will then cause the slab 1 to shear in the XY plane with adjacent elements of opposite curl so that the desired pair of waves can be launched from the un-channelled lower surface of the slab 1.

The form of the invention shown in Figures 1 and 2 may also be modified by channelling one side of the slab 1 and in this case the metalizing can completely cover the unchannelled side and, of course, the upper surfaces of the ridges left between the channels. The polarising of the discrete piezoelectric element should be carried out separately by connecting the polarising voltage to the elements one at a time.

The slab 1 has been shown plane but it may if required be curved in one direction to fit a given surface.

What I claim is:

1. Apparatus for launching ultrasonic waves in a medium comprising a slab of piezoelectric material divided by a plurality of grooves into an array of discrete piezoelectric elements and means for applying electrical potentials separately to these discrete elements to excite them into vibration, the said potentials being applied in such phases that adjacent discrete elements of the array oscillate in anti-phase.

2. Apparatus as claimed in claim 1, in which the potentials are arranged to be applied to set up electric fields in directions perpendicular to the slab.

3. Apparatus as claimed in claim 2, in which the material of the slab is of the kind which becomes effectively piezoelectric when a polarizing potential is applied to it.

4. Apparatus as claimed in claim 2, in which the material of the slab comprises barium titanate.

5. Apparatus as claimed in claim 2, in which the material of the slab comprises barium titanate with a small quantity of lead titanate added to enhance the piezoelectric retentivity of the slab.

6. Apparatus as claimed in claim 1, in which the potentials are arranged to be applied to set up electric fields in directions parallel to tangents to the slab.

7. Apparatus as claimed in claim 1, in which the material of the slab is of the kind which becomes effectively piezoelectric when a polarizing potential is applied to it.

8. Apparatus as claimed in claim 7, in which the material of the slab comprises barium titanate.

9. Apparatus as claimed in claim 7, in which the material of the slab comprises barium titanate with a small

quantity of lead titanate added to enhance the piezoelectric retentivity of the slab.

10. Apparatus for launching ultrasonic waves in a medium comprising a slab of piezoelectric material divided by a plurality of grooves into an array of discrete piezoelectric elements and electrode means for applying electrical potentials separately to opposite parallel faces of said discrete elements to excite them into vibration, the said potentials being applied in such phases that adjacent discrete elements of the array oscillate in anti-phase.

11. Apparatus for launching ultrasonic waves in a medium comprising a slab of piezoelectric material divided by grooves into an array of discrete piezoelectric elements, and electrode means for applying predetermined phases of electrical potentials separately to combinations of pairs of faces of said discrete elements to excite portions of said slab into vibration, the said potentials being applied in such phases that adjacent discrete elements of the array oscillate in anti-phase such as to propagate waves at a predetermined angle to the composite surface of said slab.

12. Apparatus for launching ultrasonic waves in a me-

dium comprising a slab-crystal of piezoelectric material divided by a plurality of grooves into an array of discrete piezoelectric elements, and electrode means for applying a plurality of selectively phased electrical potentials to said discrete elements to excite portions of said crystal into vibration, the said potentials being applied in such phases that adjacent discrete elements of the array oscillate to propagate waves at a predetermined angle to the composite crystal surface.

References Cited in the file of this patent

UNITED STATES PATENTS

1,746,788	Morrison	Feb. 11, 1930
2,018,246	Beard	Oct. 22, 1935
2,497,108	Williams	Feb. 14, 1950
2,540,194	Ellett	Feb. 6, 1951
2,543,500	Kettering	Feb. 27, 1951
2,607,216	Mason	Aug. 19, 1952

FOREIGN PATENTS

847,744	France	Oct. 16, 1939
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