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54 **Improvements in or relating to ultrasonic transducers.**

57 An ultrasonic transducer including a plate of piezoelectric material which can be excited to produce ultrasonic vibrations in a medium which is coupled acoustically to the transducer, and means for so exciting the plate of piezoelectric material, wherein the plate of piezoelectric material is divided into elements such that each element has at least one dimension which is considerably smaller than the thickness of the plate of piezoelectric material.

Improvement in or relating to ultrasonic transducers

The present invention relates to ultrasonic transducers.

One form of ultrasonic transducer has a transmitting element which consists of a plate of piezoelectric material which is excited so as to vibrate in the thickness, or piston mode, that is to say its outer face moves normal to itself. Unfortunately, in practice the surface of the plate of piezoelectric material does not move uniformly but divides up into regions which vibrate with differing phases relative to one another. This can have the effect of producing ultrasonic vibrations which, instead of being in the form of a single beam with a simple polar diagram, have a complicated polar diagram with a number of side lobes. This undesirable effect occurs when the linear dimensions of the surface of the plate are larger than its thickness.

According to the present invention there is provided an ultrasonic transducer including a plate of piezoelectric material which can be excited to produce ultrasonic vibrations in a medium which is coupled acoustically to the transducer, and means for so exciting the plate of piezoelectric material, wherein the plate of piezoelectric material is divided into elements such that each element has at least one surface dimension which is considerably smaller than the thickness of the plate of piezoelectric material, and each element is coupled to the exciting means so that the elements are excited simultaneously.

The divisions between the elements preferably pass right through the plate of piezoelectric material. However, providing the divisions are deep enough for the basic criterion to be satisfied, this is not essential. Furthermore, a continuous strip of piezoelectric material may be left around the edge of the plate so as to maintain the plate form of the transducer. The individual piezo-

electric elements so formed preferably are decoupled from one another completely, but again the decoupling need not be total. For example, if a transducer is to be used under water, the water can be allowed to penetrate  
5 into the gaps between the elements of the plate of piezoelectric material.

The invention will now be described by way of example, with reference to the accompanying drawing which shows three orthogonal sections of a transducer embodying  
10 the invention.

Referring to the drawing, an ultrasonic transducer consists of a plate 1 made of any suitable piezoelectric material, such as that known in the art as PZT, which has layers 2 of silver deposited on its major faces.  
15 Copper foils 3 are soldered to the layers 2 of silver to provide electrodes by means of which the plate 1 can be excited to emit ultrasound. The plate 1 is bonded to a sound absorbing backing member 4 which is made of tungsten dispersed in a resin material. The plate 1 is  
20 divided into a plurality of elements 5 by means of a series of slits 6 which penetrate right through the plate 1, the lower silver layer 2, and copper foil 3, and into the backing member 4. The top copper foil 3, however, is continuous having been placed in position after the  
25 division of the plate 1. Two strips 7 of insulating material are attached to opposite sides of the backing member 4 so as to close off the slits 6 in the plate 1. The top layer 3 of copper is brought down and it is bonded to the strips 7, so that the slits 6 in the plate 1 are  
30 totally enclosed. The strips 7 also serve to prevent electrical contact between the copper foils 3.

A suitable spacing between the slits 6 is between one half and one third of the thickness of the plate 1.

When air is used to decouple the elements 5 of the plate 1 from one another, the slits 6 can be made as thin as is convenient.

Claims

1. According to the present invention there is provided an ultrasonic transducer including a plate (1) of piezoelectric material which can be excited to produce ultrasonic vibrations in a medium which is coupled acoustically to the transducer, and means (3) for so exciting the plate of piezoelectric material, wherein the plate (1) of piezoelectric material is divided into elements (5) such that each element (5) has at least one surface dimension which is considerably smaller than the thickness of the plate (1) of piezoelectric material, and each element (5) is coupled to the exciting means (3) so that the elements (5) are excited simultaneously.

2. An ultrasonic transducer according to claim 1 wherein the plate (1) of piezoelectric material is attached to a backing member (4) and the divisions (6) pass right through the plate (1).

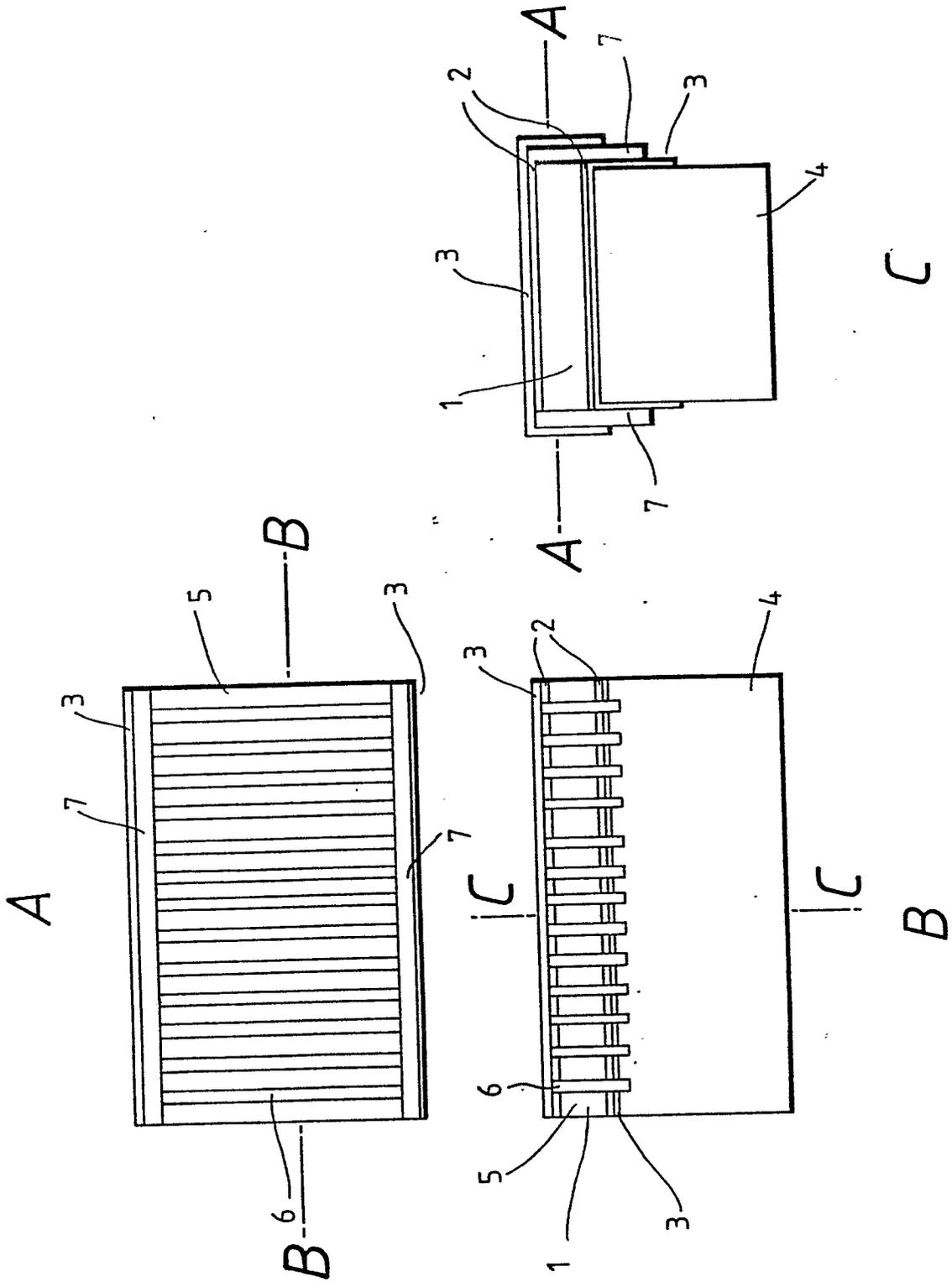
3. An ultrasonic transducer according to claim 1 or claim 2 wherein a continuous strip of piezoelectric material extends around the periphery of the plate (1) of piezoelectric material.

4. An ultrasonic transducer according to any of claims 1 to 3 wherein the individual piezoelectric elements (5) are arranged to be acoustically decoupled from one another.

5. An ultrasonic transducer according to any preceding claim wherein the individual elements (5) of piezoelectric material are separated by gaps (6) of between one third and one half of the width of the plate (1) of piezoelectric material.

6. An ultrasonic transducer substantially as hereinbefore described with reference to the accompanying drawing.

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<p><u>GB - A - 2 035 010</u> (GENERAL ELECTRIC COMPANY) * Page 1, line 111 to page 2, line 93; figure 2 *</p> <p>--</p> <p><u>EP - A - 0 006 623</u> (SIEMENS AG) * Page 4, line 11 to page 6, line 30; figures 1,2 *</p> <p>--</p> <p><u>US - A - 3 952 387</u> (JINUMA et al.) * Column 3, lines 24-64; figure 6 *</p> <p>--</p> <p><u>EP - A - 0 005 071</u> (TOKYO SHIBAURA DENKI KABUSHIKI) * Page 4, line 16 to page 7, line 13; figure 2 *</p> <p>--</p> <p><u>US - A - 4 122 725</u> (R.B. THOMPSON) * Column 3, line 44 to column 5, line 5; figures 1,2 *</p> <p>--</p> <p>EP <u>EP - A - 0 025 092</u> (SIEMENS AG) * Page 5, line 34 to page 6, line 31; figures 1-3 *</p> <p>----</p>	<p>1,2,4</p> <p>1,2</p> <p>1,2,4,5</p> <p>1-4</p> <p>1,2,4,5</p> <p>1,2,4</p>	<p>G 10 K 11/34</p> <p>TECHNICAL FIELDS SEARCHED (Int. Cl.)</p> <p>G 10 K 11/34</p> <p>CATEGORY OF CITED DOCUMENTS</p> <p>X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons</p> <p>&amp;: member of the same patent family, · corresponding document</p>
	<p>The present search report has been drawn up for all claims</p>		
Place of search	Date of completion of the search	Examiner	
The Hague	21-09-1981	STUBNER	