# United States Patent [19]

**Lewiner et al.**

[11] **3,742,152**

[45] **June 26, 1973**


[54] **ULTRASONIC TRANSDUCERS**


[75] Inventors: **Jacques Lewiner**, Saint Cloud; **Pierre Biquard**, Paris, both of France

[73] Assignee: **Agence Nationale De Valorisation De La Recherche (Anvar)**, Courbevoie, France



[22] Filed: **Nov. 22, 1971**

[21] Appl. No.: **200,795**

[52] **U.S. Cl.** ..... **179/111 E**, 179/111 R

[51] **Int. Cl.** ..... **H04r 19/00**

[58] **Field of Search** ..... 179/111 R, 111 E



[56] **References Cited**

UNITED STATES PATENTS

3,544,733 6/1967 Reylek ..... 179/111 R

FOREIGN PATENTS OR APPLICATIONS

1,147,423 5/1966 Great Britain ..... 179/111 E



*Primary Examiner*—Ralph D. Blakeslee

*Attorney*—Roberts B. Larson, Ross F. Hunt, Jr. et al.



[57] **ABSTRACT**

A condenser has two plates capable of vibrating, separated from one another by a thin electrostatically charged dielectric. One of the plates is in contact with the propagation medium of the ultrasonic waves. The two plates are connected to an electrical emitter and/or receiver. The dielectric is permanently charged by prior treatment and an external DC voltage is applied between the plates in reverse sense to that used for charging the dielectric. The two electrostatic fields so created are added in effect.


**2 Claims, 2 Drawing Figures**

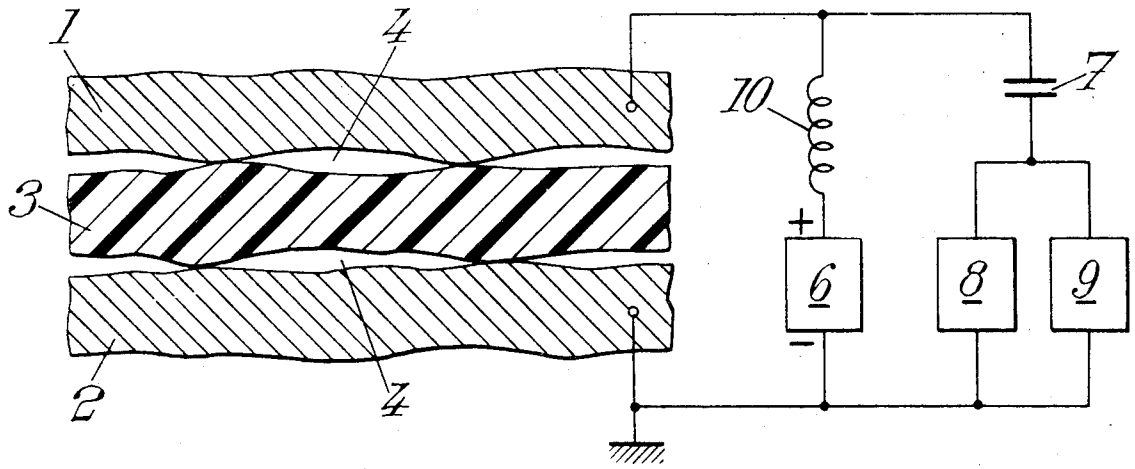


Fig. 1.

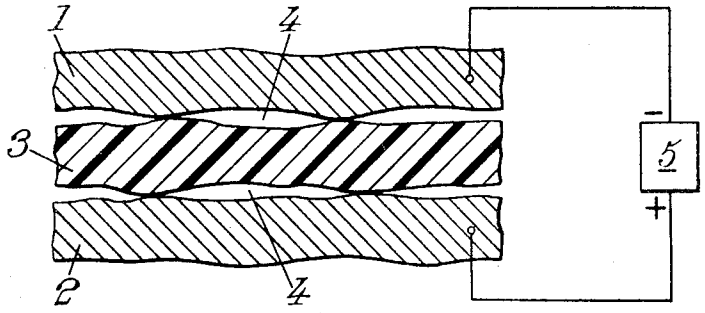
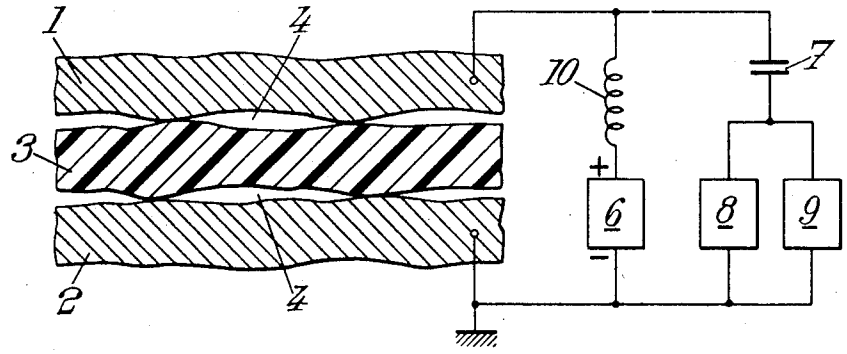



Fig. 2.



# ULTRASONIC TRANSDUCERS

The invention relates to ultrasonic transducers intended for transforming into mechanical vibrations electrical voltages whose frequencies are comprised preferably between 200 kHz and 20 MHz or conversely.

It relates more particularly, among these devices, to those of the electrostatic type, that is to say comprising a condenser with two plates capable of vibrating separated from one another by a dielectric of small thickness electrostatically charged, one of these two plates being placed in contact with the medium in which are propagated the ultrasonic waves to be emitted and/or received and the two plates being connected to an electrical emitting and/or receiving circuit.

It is a particular object of the invention to render these devices such that they respond to the various exigencies of practice better than hitherto, especially as regards the bandwidth of the frequencies used.

The devices of the type concerned according to the invention are characterized in that on the one hand the dielectric placed between the plates of the condenser is, in a manner known in itself in the field of acoustic frequencies, permanently charged electrostatically by preliminary treatment and in that on the other hand, an external DC voltage is applied between these plates in the reverse sense to that which has served for charging the dielectric so that the two electrostatic fields created respectively by the permanent charge of the dielectric and by this external polarization are added.

In preferred embodiments, the dielectric is constituted by a solid thin sheet of which the thickness is comprised between 3 and 70 microns, which sheet is separated from the two plates which clamp it by two very thin layers of air due to the presence of irregularities on the facing surfaces of this sheet and of these plates.

The invention comprises, apart from these main features, certain other features which are preferably used at the same time and which will be more explicitly considered below.

In the following, a preferred embodiment of the invention will be described with reference to the accompanying drawing, purely by way of illustrative and non-limiting example.

In the drawing:

FIG. 1 shows diagrammatically in the course of its charging, an electrical condenser adapted to equip an ultrasonic transducer device according to the invention; and,

FIG. 2 shows diagrammatically the ultrasonic transducer device concerned, equipped with the said condenser.

In manner known in itself, the transducer comprises a condenser composed of two plates or conductive sheets 1 and 2 (which can if necessary be constituted by conductive coatings of non-conducting plates or sheets) held separated from one another by the interposition of a thin dielectric sheet 3, a very thin layer of air 4 being reserved automatically between each surface of the sheet 3 and the facing conductor surface due to the fact of the inevitable irregularities of these surfaces.

This transducer comprises in addition, in a manner also known in itself, means for creating in the dielectric sheet a continuous electrostatic field.



Generally these means are constituted by an external source of DC voltage.

In certain other transducers of the type concerned, operating in the range of audible frequencies, that is to say below 20 kHz, it is known to use dielectric sheets 3 permanently charged previously by the application of a DC electrical voltage $V_1$ of relatively high value to the terminals of two plates 1 and 2 clamping these sheets : the use of such sheets with electrostatic charges, called "electrets," then replaces external polarization, which can be advantageous for certain applications such as the auditive prosthesis.

These two methods of energization of the dielectric sheet, respectively by external polarization and by the use of electrets, are apparently mutually exclusive.

According to the invention there are combined in, a transducer intended to operate at ultrasonic frequencies these two methods of energization :

by using an electret as the dielectric, that is to say using a sheet previously charged in permanent manner,

and by applying from the outside on the plates of the condenser having this electret as dielectric, a DC voltage of which the polarity is the inverse of the voltage which has served to polarize the electret : so the electrostatic fields created in the layers of air 4 which separate the sheet 3 from the facing plates 1 and 2, which fields are due respectively to the permanent charge of the electret and to the external polarization, are added.

The value of this external DC voltage is selected to be as high as possible with the reservation :

that on one hand, the electrostatic field inside the dielectric sheet 3 is less than the breakdown field of this dielectric,

and that on the other hand, the electrostatic field in the layers of air 4 interposed between the sheet 3 and the plates 1 and 2 is less than the ionization potential of these layers of air.

It is observed that which such a combined energization, not only is no "depolarization" of the electret found as could be feared, but also the transducer obtained operates with an extremely wide bandwidth, which has considerable advantages for a certain number of applications, such as :

distant ultrasonic transmissions of electrical signals without distortion, which enables particularly the preservation with distinctness of the forward wave front of sonar pulses by improving thus the accuracy of the corresponding measurements,

frequency modulated ultrasonic communications, which enable especially the realization or submarine telephones.

In FIG. 1, there is seen the condenser in the course of the preliminary charging phase of its dielectric sheet 3 : the source of external continuous voltage $V_1$ is represented at 5.

In FIG. 2, the transducer equipped with this previously charged condenser is in operational condition.

The source 5 is replaced here by a source 6 of DC voltage $V_2$ of which the connection to the plates 1 and 2 is effected in reverse sense to that of the preceding source 5.

The value of this voltage $V_2$ must respect the conditions indicated above.

The plates 1 and 2 are also connected, through a bypass condenser 7, to emitting 8 and receiving 9 assemblies.

The emitting assembly **8** is adapted to apply to the plates **1** and **2**, the high frequency voltage which it is desired to transform into ultrasonic waves.

A choke **10** protects the source **6** from this high frequency.

The sheet **3** may be constituted of any desirable dielectric material, particularly such as a polypropylene, a polystyrene, a polycarbonate, mica or one of the plastics materials known under the commercial designations Mylar, Teflon, Kapton or Bakelite.

Purely by way of illustration and of course intended to be in no way limiting, there are indicated below several specifications regarding an embodiment of the latter which has given satisfaction in a range of frequencies comprised between 100 kHz and 200 MHz :

the dielectric **3** is constituted by a sheet of polypropylene of 10 microns thickness,

the preliminary polarization of this sheet was obtained by applying between its two surfaces a voltage $V_1$ of 1200 V for 5 minutes,

the external polarization voltage $V_2$ then applied in the course of operation, in reverse sense to the voltage $V_1$, had a value slightly below 400 V,

the transducer obtained had, for a working frequency of 20 MHz, a bandwidth of $\pm$ 10 MHz.

As is self-evident, and as emerges already from the foregoing, the invention is in no way limited to those of its methods of application or production, which have been more especially envisaged; it encompasses, on the contrary, all variations.

We claim :

**1.** Ultrasonic transducer of the electrostatic type comprising a condenser with two plates capable of vibrating, a thin electrostatically charged dielectric separating said plates, one of said two plates being placed in contact with the medium in which the ultrasonic waves to be emitted and/or received are propagated and the two plates being connected to an electrical emitter and/or receiver circuit, said dielectric being permanently electrostatically charged by prior treatment and an external DC voltage being applied between said plates in the reverse sense to that which has served for charging the dielectric so that the two electrostatic fields created respectively by the permanent charge of the dielectric and by this external polarization are added.

**2.** Ultrasonic transducer according to claim **1**, wherein the dielectric is constituted by a solid thin sheet whose thickness is comprised between 3 and 70 microns, which sheet is separated from the facing plates by very thin layers of air.

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# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,742,152 Dated June 26, 1973

Inventor(s) Jacques Lewiner, Pierre Biquard, Mrs. Danielle Legros

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover page, correct the listing of inventors to read:

--[75] Inventors: Jacques Lewiner, Saint Cloud;
Pierre Biquard, Paris; and
Mrs. Danielle Legros, Paris, all of France--.

On the cover page, add the following reference to priority information:

--Priority claimed application in France, No. 70/41766 filed November 20, 1970--.

Signed and sealed this 11th day of February 1975.

(SEAL)
Attest:

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Attesting Officer

C. MARSHALL DANN
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FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
U.S. GOVERNMENT PRINTING OFFICE : 869-930

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