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(54) **An ultrasound probe, particularly for diagnostic imaging**

Ultraschallsonde, insbesondere zur diagnostischen Bilderzeugung

Sonde ultrasonore, en particulier pour l'imagerie diagnostique

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(56) References cited:
WO-A-94/13411 **US-A- 3 952 216**
US-A- 5 115 809 **US-A- 5 724 976**
US-A- 5 974 884 **US-B1- 6 645 145**

- **PATENT ABSTRACTS OF JAPAN vol. 1999, no. 11, 30 September 1999 (1999-09-30) -& JP 11 155863 A (TOIN GAKUEN), 15 June 1999 (1999-06-15)**
- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 08, 6 October 2000 (2000-10-06) -& JP 2000 139907 A (TOSHIBA CORP), 23 May 2000 (2000-05-23)**

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Description

[0001] The invention relates to an ultrasound probe for diagnostic purposes, the ultrasound probe comprising the combination of features of the preamble of claim 1.

[0002] Such a construction is disclosed in document US 5,974,884. In this document an ultrasonic probe is disclosed comprising an acoustic matching layer which is fixed on the front side of a transducer for transmitting an ultrasonic wave and receiving a reflected wave thereof. The said acoustic matching layer matches in acoustic impedance the transducer to a living tissue in an object to be examined and is formed with such a structure that the acoustic impedance thereof is varied continuously in the thickness direction from the transducer to the object to be examined. The acoustic matching layer is formed by two layers. Document US5,974,884 also refers to the publication TRANSACTION ON SONICS AND ULTRASONICS VOL.SU-13 NO.1 (MARCH 1996), pages 20 to 30 in which a two layer acoustic matching layer is disclosed for witch the following matching conditions are presented: When the central frequency of the transducer is 2,5MHz and the acoustic impedance thereof is 28Mrayl, the first acoustic matching layer is formed with the acoustic impedance of about 8MRayl and the film thickness which is one-quarter wavelength thick to the above mentioned central frequency. The second acoustic matching layer is formed with the acoustic impedance of about 2Mrayl and the film thickness which is equally one quarter wavelength thick thereto.

[0003] The above described structure is a typical structure of a so called ultrasound probe, particularly for the ultrasound probes used for ultrasound diagnostic imaging. Ultrasound transducers are piezoelectric elements, typically ceramic elements, which upon excitation with an electric potential are driven to oscillations of the crystal lattice which generate mechanical waves in the frequency range of the ultrasound acoustic waves. The frequency of the waves and the shape and spectral composition of the ultrasound waves generated depends on the frequency, shape and spectral composition of the electric excitation pulse.

[0004] On the other hand ultrasound transducers are capable of generating electric signals upon mechanical excitation of their crystal lattice by impinging mechanical waves. Frequency range, shape and spectral composition of the generated electric signal depends on frequency range, shape and spectral composition of the impinging acoustic waves.

[0005] The same transducer array may be used alternatively as a receiving and as an emitting device for ultrasound waves converting electric excitation pulses into acoustic pulses and acoustic excitation pulses in electric pulses.

[0006] In a typical ultrasound probe a so called transmission and receipt switch is provided which after each excitation by electric signals determining the emission of acoustic waves turns the conductors of the electric signals associated to the transducers to a receipt section of an ultrasound system by which the electric signals generated by the impinging reflected acoustic waves are elaborated in order to extract information such as for example image data. Due to the fact that the probe is connected to the said section by means of a cable having a certain length having a high capacity with respect to the power of the electric signals generated by the transducers upon acoustic excitation it would be desirable to have each transducer further connected to a preamplifier, or just a signal follower, which enhances the signal power in order to allow its conduction through the cable thus improving the sensitivity and/or the bandwidth.

[0007] The problem of the power of the electric signal does not arise for the excitation signals sent to the transducers, since a dedicated section generates these signals and the power of the signals can be adjusted easily at a level ensuring the correct transmission to the transducers.

[0008] Nevertheless in using the same transducers for emission of ultrasound waves and for receipt of ultrasound waves causes some problems for the preamplifiers that have to be rather complex, since, due to the fact that the same conductor line is used for transmitting the excitation signal to the transducers and for collecting the receipt signal generated by impinging reflected ultrasound waves from the transducers, the preamplifiers need a decoupling section for avoiding shortcuts during transmission of the excitation signals to the transducers.

[0009] These decoupling circuits need several components which increase the physical dimensions of the preamplifier in a dramatic way. The dimensional part of the preamplifier due to the decoupling circuits can be even grater that the one needed for the preamplifier itself. Furthermore the decoupling circuits give rise to major costs due to a more complicated structure of the preamplifier and to higher costs for miniaturization by means of the actual techniques of integration.

[0010] On the other hand the use of the same array of transducer for generating and emitting the ultrasound transmission waves and for receiving the reflected ultrasound waves allows to reduce the dimensions and the weight of the probe itself which, particularly for diagnostic applications, is very important due to the fact that the probe is manipulated mostly by hand.

[0011] Providing two different array of transducers one of which is only dedicated to generating the ultrasound transmission waves and the second of which is only dedicated to receiving the reflected or impinging ultrasound waves would overcome the above mentioned problems. On the other hand considering matching of the acoustic impedance, acoustic separation and electric separation of the two transducer arrays this solution would lead to a considerable increase of the dimensions and of the weight of the probe.

[0012] Another possible way of solving the above problem would consist in using only part of the transducer of the array for generating and transmitting the ultrasound

waves and part of the transducers of the array only for receiving the impinging or reflected ultrasound waves. Also this solution solves the above mentioned problems. No increase in the overall dimensions of the probe would be caused by this solution but on the other hand using only part of the transducers for transmitting and for receiving the ultrasound waves would cause a reduction of the quality of the data extracted from the reflected ultrasound beams such as power of the reflected ultrasound waves and image definition.

[0013] A third aspect has further to be considered which has a particular relevance in ultrasound diagnostic imaging and which is related to the matching layers. These layers must match the acoustic impedance of the transducers with the one of the body under examination but the matching must be achieved without reducing the bandwidth of the probe either for the case of the transmission of the ultrasound waves and in the case of the receipt of the reflected ultrasound waves. This aspect is relevant in the case two different arrays of transducers would be used independently for transmission and for receipt of the ultrasound waves. Thus using two separate arrays of transducers laid one over the other would cause problems for matching the acoustic impedance and furthermore for ensuring at the same time the expected or needed pass bandwidth.

[0014] The object of the present invention is to provide for an improved ultrasound waves transmitting and receiving probe of the type described at the beginning which allows to overcome the above mentioned problems of the known probes by providing separate ultrasound waves transmission and receipt array of transducers without taking into account an excessive dimensional increase of the probe and ensuring an optimum matching of the acoustic impedance with a sufficient bandwidth.

[0015] At the same time the invention has the aim to provide an ultrasound waves transmitting and receiving probe having a simplified and dimensionally limited array of preamplifiers for the electric receipt signals generated by the transducer of the array dedicated to the receipt of the reflected or impinging ultrasound waves.

[0016] The invention achieves the above mentioned aims by means of an ultrasound probe comprising in combination the features of the preamble and of the characterising part of claim 1.

[0017] The second array of transducers may comprise transducers made of Polivinilchloride PVC or polivinilidilenefluoride PVDF.

[0018] Each transducer coupled to two electrodes one for collecting the electric signal generated due to acoustic excitation of the transducer by means of the reflected beams and the other connected to ground potential.

[0019] Typically, transducers of an array are mechanically integrated in a layered pack which is formed by the transducers themselves which are spaced one from the other, the spaces between the transducers being filled with a filling and bonding material.

[0020] The transducer array in the form of a pack can comprise also the electrodes which are formed by an array of electrodes, each electrode of the array coinciding with a surface of one transducer and the array of electrodes being in the form of a layer.

[0021] Also typically the pack is formed by a first electric contact layer consisting in a first array of contact electrodes on which a layer of coinciding transducers is provided, and e second layer of contact electrodes comprising an array of second electrodes which second contact electrodes are coincident with the transducers and which second layer is laid on the transducer array, the filling material being provided for bonding the said array layers of transducers and contact electrodes in a pack.

[0022] Each contact electrode of each array of contact electrode is separately connected to a wire for connecting the electrode to the ground potential or to an electric excitation signal generating unit or to an electric signal receiving unit.

[0023] This construction is a typical construction of an array of ultrasound transducers and is identical for the first and for the second array of transducers respectively dedicated to emitting the ultrasound waves and to receiving the reflected or impinging ultrasound waves.

[0024] Different ways of producing the pack of transducers with the contact electrodes are used and any of this ways can be used in combination with the present invention.

[0025] Typically the contact electrodes associated to the transducers are layered on two opposite sides of the said transducers for example by vapour deposition or by plasma deposition. The conductors connecting the signal transmitting or receiving lines can be formed by conducing tracks provided on a substrate in the form of a printed circuit or the like.

[0026] The conductor for connecting to ground potential the ground electrodes of the transducers can consist simply by a continuous layer or thin plate of conductive material.

[0027] The electrodes can be applied to the transducers in several ways as for example bonding to two opposed surfaces of a transducer having the form of a small block a conducting sheet, or deposing a conducting layer on the said surfaces of the transducers by means of vaporization or by means of plasma deposition or by means of other known techniques.

[0028] In an ultrasound probe according to the actual technique as illustrated in figures 1 to 3, where the array of transducers typically of ceramic and having the form of a layer is provided with a front surface and a rear surface, the front surface being the one from which the ultrasound waves are emitted or the one oriented forward according to the ultrasound emission end of a probe, the said array of transducer is placed between a first layer formed by the array of contact electrodes for transmitting the electric excitation signals to the transducers and for receiving the electric signals generated by the transducers due to acoustic excitation of them and a layer of conducting material forming the ground electrodes of the

transducers, two further layers being provided placed on the said conducting layer forming the ground electrodes which layers are a first and a second matching layer having a different acoustic impedance relatively to the transducers and to the body under examination and relatively one to the other in order to progressively vary the acoustic impedance along the path of the emitted waves from the acoustic impedance of the transducers to the acoustic impedance of the body under examination. An acoustic lens may be laid on the second matching layer.

[0029] In this case the present invention provides for an improved probe wherein the second matching layer is made by a piezoelectric material and is formed by an array of elements having the function of ultrasound transducers, a layer made by an array of contact electrodes each one coinciding and in electric contact with one of the piezoelectric elements being provided between the said second matching layer and the first matching layer and a layer of conducting material forming the ground electrode being laid between the said second matching layer and the acoustic lens and being in electric contact with the piezoelectric elements forming the second matching layer.

[0030] In this configuration, the first array of transducers of ceramic material are dedicated to emit the ultrasound which passes the first and second matching layer as in the conventional probes, while the second matching layer formed by an array of piezoelectric elements is dedicated to generate the electric signals corresponding to the acoustic excitation of the said piezoelectric elements of the second layer by the reflected or the impinging ultrasound waves.

[0031] Because of the fact that the function of the matching layers is important only relatively to the ultrasound waves emitted by the probe and not for the reflected ultrasound waves impinging on the probe, the fact that the transducers for sensing the reflected beams are formed by the second matching layer and thus these ultrasound waves reached the said transducers without having to pass the matching layers as in the conventional probe does have no negative effects. On the contrary this condition is a positive one since the ultrasound waves impinging on the transducers are not attenuated by the matching layers.

[0032] A preferred but not limiting embodiment of the probe according to the present invention is defined in claim 9.

[0033] Thus the first layer of transducers is only dedicated to the emission of ultrasound waves and the electrodes for carrying the electric excitation signals to the emission transducers are connected directly to a unit for generating such electric excitation signals.

[0034] The reflected ultrasound waves are sensed or received by the second array of receiving transducers and the electric receipt signals generated by the said transducers upon acoustic excitation thereof are carried to a signal evaluation unit by means of the electric receipt signals electrodes of the said second array of receiving transducers. At the same time the second array of transducers or in combination the second array of transducers and the receipt contact electrodes for carrying the electric receipt signals and or the ground electrodes have the function of a second matching layer for the ultrasound waves emitted by the first array of emission electrodes.

[0035] According to a further feature of the present invention, the probe further comprises an array of preamplifiers to each one of which the receipt signal of a selected one of the transducers of the transducer array is fed by means of a signal feeding channel connecting the contact electrode of the said selected transducer element with one of the preamplifiers of the array of preamplifiers.

[0036] Advantageously the preamplifiers may be in the form of integrated circuits mounted in an array disposition on a printed circuit board comprising conductive tracks each one of which is a signal feeding channel connecting one of the integrated preamplifiers with the contact electrode of one selected transducer of the array of transducers.

[0037] In combination with a probe configuration according to the present invention and comprising an array of ultrasound wave emission transducers and a second array of ultrasound wave receiving transducers, the present invention suggests a receipt signal preamplifier having a very simple, cheap and small construction.

[0038] The preamplifier comprising only a tension follower together with the typical resistors for correctly driving the tension follower and a decoupling circuit comprising two antiparallel diodes.

[0039] In a preferred embodiment, the tension follower consist in only a Fet component.

[0040] The tension follower in the form of the Fet and the typical resistors for correctly driving it and the decoupling circuit formed by the two anti-parallel diodes is realized preferably as an integrated circuit.

[0041] Due to the fact that the preamplifier and the associated decoupling circuit consist in very few electronic basic components, producing an integrated circuit comprising all these components is very cheap and the resulting integrated circuit has very small dimensions. This allows to generate very large arrays of preamplifiers which can be housed within the probe casing without requesting huge dimensions of the probe casing and thus maintaining the probe casing within dimensional limits which allows a comfortable handling.

[0042] Also from the point of view of the weight, the probe according to the present invention can be easily maintained within acceptable weight limits concerning the comfort of handling the probe.

[0043] A probe according to the present invention can be so easily provided with arrays of transducers having a larger amount of transducers without having to take into account bigger dimensions and or an increased weight of the probe casing and thus incurring in uncomfortable handling of the probe.

[0044] According to a further feature of the present invention, the probe comprises at least an array of receipt

signal preamplifiers which are mounted on a printed circuit board, the printed circuit board being housed in the probe casing in a position which is transversal or substantially perpendicular to the surface of the array of transducers.

[0045] The preamplifiers of the receipt signals can be also distributed on two arrays which are mounted each one on a side of the printed circuit board.

[0046] Furthermore the preamplifiers can be distributed on two or more arrays each mounted on one circuit board.

[0047] More than two arrays of preamplifiers can be mounted on both sides of two or more printed circuit boards, depending on the total number of the arrays.

[0048] So for example if the preamplifiers are distributed on four arrays, two circuit boards can be provided each one carrying two arrays, each one of which two arrays is mounted on a side of the printed circuit board.

[0049] In a probe of essentially conventional shape with a casing having an elongated form in a direction parallel to the direction of propagation of the emitted ultrasound waves and which casing forms a handle for holding the probe having two opposite ends one of which carries the arrays of transducers and from the other of which ends a multi-channel cable departs for connecting the probe to an ultrasound system, the one or more printed circuit boards carrying the array or the arrays of preamplifiers are positioned in the axial direction of the probe casing.

[0050] The printed circuit board or boards are preferably provided parallel to the sides of the probe casing which are parallel to the longer sides of the arrays of transducers and at the end facing the arrays of transducers the printed circuit board or boards can be provided with contact termination pins of the conductive tracks provided on them or with a connector.

[0051] The array or the arrays of contact electrodes of the array or of the arrays of transducers are provided with a connector or with a contact termination pins with the said printed circuit board along one or both of the said longer sides which contact termination pins or which connector is complementary to the one provided on the printed circuit board in order to generate at least an electric connection by soldering together coinciding contact pins or to generate a disengageable electric and mechanical connection by means of the connectors.

[0052] It is also possible to provide a printed circuit board also along each side of the probe casing parallel, or tangential to three or to four or to more of the sides of the array of transducers, the arrays of contact electrodes being provided with a connector or with a contact termination pins on each of the said sides.

[0053] As to the way of realizing the connectors or the contact termination pins of the array of electrodes several alternatives are known to skilled person from the state of the art and forms part of the ordinary knowledge or skill of the skilled person.

[0054] Relating to the construction of a conventional probe more details are disclosed in the documents US 6,049,159 and US 4,686,409.

[0055] Further improvements of the present ultrasound probe according to the invention are subject matter of the depending claims.

[0056] The features of the present invention and the advantages deriving therefrom will appear more clearly from the following description of a preferred embodiment and which is illustrated in the annexed drawings, in which:

Figure 1 illustrates a perspective view of the construction of the ultrasound emitting and transmitting head of a conventional probe according to the state of the art.

Figure 2 illustrates an enlarged view of the probe head according to figure 1.

Figure 3 illustrates a schematic view of the principle according to which the said probe head of figures 1 and 2 is constructed.

Figure 4 illustrates a perspective view of the construction of the ultrasound emitting and receiving head of an ultrasound probe according to the present invention.

Fig. 5 is an enlarged view of a particular of the probe head according to figure 4.

Fig. 6 is a schematic view of the principle of the construction of the probe head according to the present invention and to figures 4 and 5.

Fig. 7 is a simplified block diagram of a particular preamplifier which can be applied in combination with the probe according to the present invention.

[0057] Referring to figures 1 to 3, a conventional probe is illustrated therein.

[0058] The conventional probe comprises an ultrasound waves emitting and receiving head 1 which has a front side from which the ultrasound waves are emitted in the direction against a body under examination or against another kind of target and on which the reflected ultrasound waves or incoming ultrasound waves falls and are sensed. The ultrasound head has a back side which is opposite to the said front side and which is oriented towards the inside of a probe casing (not illustrated) and towards means for supporting the said probe head provided inside the said probe casing.

[0059] The said probe head comprises, in an order starting from the back side of the said head towards the front side of the said head, which order corresponds also to the direction of propagation of the emitted ultrasound waves, a first layer 101 formed by an array of contact electrodes. Each contact electrode of this layer 101 of contact electrodes has a separate electric connection line to a corresponding contact pin on a contact termination provided along at least one edge of the layer of contact electrodes and indicated with 201.

[0060] On the layer formed by the array of contact electrodes, a layer 301 formed by an array of piezoelectric elements such as ceramic elements is laid. Each one of

the piezoelectric elements forms an emitting and receiving transducer. The single transducers are each one coincident and in electric contact with one of contact electrodes of the layer 101. A further layer of conductive material 401 is laid on the layer 301 formed by the array of transducers, i.e. of piezoelectric elements the said conductive material of the layer 401 being in electric contact with each one of the said piezoelectric elements and is connected to ground potential by means of a contact termination 501. Since the said layer 401 of conductive material forms the ground electrode of the transducers of the layer 301. The said layer 401 may be in the form of an array of ground electrodes, but since the ground potential is common to every of the transducers of the layer 301 there is no need to provide separate ground electrodes for each transducer, so that the said layer 401 can be easily formed by a continuous layer of conductive material. On the contrary the layer 101 of contact electrodes must be in the form of an array of at least electrically separated contact electrodes since each one of the said contact electrodes has the function of feeding the electric excitation signal to the associated transducer and of collecting the electric receipt signal from the associated transducer when the said transducer is mechanically excited by an impinging ultrasound wave.

[0061] On the grounded conductive layer 501 two further matching layers are provided which are indicated with numerals 601 and 701. These two layers has the function of adapting the acoustic impedance of the transducers to the acoustic impedance of the body under examination or of the target. Normally two layers are used in order to provide to a progressive stepwise adaptation which also allows to maintain a sufficiently large bandwidth for the passing ultrasound waves.

[0062] Typically the first matching layer 601 is made of a material having an acoustic impedance of about 3 to 3.6 MRayl and the second matching layer 701 has an acoustic impedance of about 2 MRayl.

[0063] As a last element on the second matching layer 701 an acoustic lens 801 is placed which forms the interface between the said head of the probe and the surface of a body under examination or a target body.

[0064] The contact terminations 201 and 501 of the layer 101 formed by the array of contact electrodes and of the layer 501 formed by the grounded conductive material are electrically and mechanically connected to a printed circuit board 2 which is provide with the necessary conductive tracks which are connected to a probe connection cable (non illustrated) and which cable connects the probe with an ultrasound apparatus as for example an ultrasound imaging apparatus.

[0065] Typically as indicated in figure 3, the single piezoelectric elements indicated by 30 which forms the single transducers of the array of transducers of the layer 301 are connected by means of the contact electrodes 10 associated to the said piezoelectric elements 30 by means of a common signal feeding line 31 for the electric exciting signal STX of the piezoelectric element and for the electric receipt signal SRX generated by the piezoelectric elements to the corresponding units of the ultrasound apparatus, namely respectively an excitation signals generating unit and a receipt signals evaluating unit non illustrated in detail.

[0066] Since the probe connection cable, which is typically a multi-channel cable, has a certain capacitance and the receipt signals generated by the transducers have not sufficient power to overcome the capacitance of the said probe connecting cable, in order to increase the sensitivity and/or the bandwidth it would be desirable to connect each sRx line to a corresponding preamplifier. The preamplifiers should be provided in the path of the receipt signals before reaching the probe connection cable and thus inside the probe casing.

[0067] However, due to the fact that a unique and common signal feeding line is provided for the excitation signals sTx and for the receipt signals sRx, the preamplifiers should be provided with complex decoupling circuits which avoid shortcuts during feeding of the electric excitation signals to the transducers. In fact, without such complex decoupling circuits, the output of any preamplifier would be short-cut with its input as the sRx and sTx share the common signal feeding line 31 as shown in figure 3. In order to reduce the dimensions of the single preamplifiers and of the associated decoupling circuits a high integration has to be carried out for these devices in order to reach a sufficiently small dimension that allows to fit the said devices all inside the probe casing. Thus costs of the preamplifiers are relatively high also considering the large number of these preamplifiers.

[0068] Regarding to figure 3, there has to be noted that the single piezoelectric elements 30 of the array of transducers of layer 301 are normally bond together at a distance by means of bonding material indicated with 32 and which bonding material is normally an acoustic wave absorber so to suppress the laterally emitted waves by the transducers. These technique is well known and common to all the arrays of transducers of ultrasound probes.

[0069] In the conventional probe according to figures 1 to 3, the array of transducers forming layer 301 has at the same time the function of emitting and of receiving the ultrasound waves so that the signal feeding lines for the excitations signals and for the receipt signals are forcedly the same one since they are short circuited at least at the level of the contact electrodes.

[0070] Figures 4, 5 and 6 illustrate a probe according to the present invention in which two separated array of transducers are provided. One solely for emitting the ultrasound waves and the other only for receiving ultrasound waves.

[0071] In the figures 4 to 6 the same numerals are used for indicating similar parts or parts having the same function as in the figures 1 to 3.

[0072] As it can be appreciated by simply comparing the structure of the probe head according to figure 4 to 6 with the one according to figure 1 to 3, in the probe head according to figure 4 to 6, the second matching

layer 701 has been substituted by a layer 70 formed by an array of piezoelectric elements i.e. of transducers. To this layer there are associated a dedicated further layer formed by an array of contact electrodes 101' and a dedicated further layer 401' formed by electric conductive material and forming the second electrode connected to ground potential of the second array of transducers of layer 70. Obviously once the layer 70 formed by the array of piezoelectric elements is provided the two other layers formed by the array of contact elements and by the conductive material connected to ground potential become forcedly necessary if the said array of transducers has to be used in order to be excited or to generate electric receipt signals.

[0073] According to the invention the array of transducers of the first layer 301 are only used for emitting ultrasound waves, while the said second array of transducers of layer 70 which are closer to the object under examination in the order of the layers are only used for generating the receipt signals due to the mechanical excitation of the transducers by means of the impinging reflected ultrasound waves.

[0074] In order not to create a prejudice to the matching of the acoustic impedance needed for the emitted ultrasound waves, this second array of transducers of the layer 70 are made by a piezoelectric material having an acoustic impedance which is comparable to the one of usual second matching layers as disclosed above in relation to the known probes.

[0075] A material showing the said values of acoustic resonance and a suitable piezoelectric behaviour is polyvinylchloride PVC or Polyvinyldilene fluoride PVDF.

[0076] Thus the probe according to the present invention provides a second layer 70 formed by an array of piezoelectric elements, i.e. transducers which are made of one of the said materials thus ensuring both the necessary matching for the ultrasound waves emitted by the first array of emitting transducers which is provided backwards of the said layer 70 formed by the second array of receiving transducers and the necessary piezoelectric behaviour for ensuring that the mechanical excitation exercised by the impinging ultrasound waves is transformed in a corresponding electric signal.

[0077] For the array of receipt transducers no matching layer is necessary so that no further matching layer is needed between the said array of transducers and the body under examination. Furthermore, due to the fact that the said second array of receiving transducers is not covered by the matching layers as in the conventional probe heads and that it is closer to the body under examination from which the impinging or reflected ultrasound waves arrives provides for higher intensity of the impinging waves.

[0078] By separating the transducers for emitting the ultrasound waves and for receiving the said ultrasound waves has the advantage that separated feeding lines respectively for the excitation signals sTx and for the receipt signals sRx are possible. This is highlighted schematically in figure 6 where the feeding lines for the excitation signals sTx are indicated with numeral 31 and the feeding lines for the receipt signals sRx are indicated with 31'.

[0079] Normally however for avoiding an increase of the separate conductors in the probe connection cable the said separated signal feeding lines 31, 31' relative to the same or to corresponding transducers of the two arrays of transducers are connected together to a common conductor of the multi-channel cable for connecting the probe to the ultrasound apparatus and respectively to the unit generating the electric excitation signals and to the unit evaluating the electric receipt signals. This connection takes place however at the level of the output line 31" of the preamplifier 3 of the same or corresponding transducer of the second array of transducers so that if at all decoupling is necessary this can be carried out with a very simple decoupling unit which does not lead to a considerable increase in circuital complexity.

[0080] Thus in order to reduce the dimensions of the single preamplifiers and eventually of the simple decoupling unit there is no need to carry out an extreme integration and miniaturization process reducing the costs of each preamplifier.

[0081] An example of a simple preamplifier and of the simple decoupling circuit associate to it is illustrated in figure 7. The preamplifier is formed by a Fet 40 which is associated to typical elements for correctly driving such a component as an inductance I and resistance R1, resistance R2 and resistance R3. The receipt signal sRx generated by a transducer and collected by its electrode 10 is fed to the Fet 40 by means of the signal feeding line 31. The Fet 40 output is connected by means of an output line 31" to a conductor of a multi-channel probe connection cable. The same conductor is used for transmitting the excitation signal sTx to the transducer 30 of the first array of emitting transducers which by means of the separated feeding line 31 which connects the said conductor to the contact electrode 10 of the said emitting transducer 30. A decoupling circuit basically formed by two diodes D1, D2 connected in an antiparallel way is provided for avoiding that the excitation signal sTx is fed also to the Fet via its output line 31".

[0082] As it appears clearly from the above either the preamplifier and the decoupling circuit are very simple and the number of components is very low so that no high integration has to be carried out in order to reduce the said circuits to dimensions allowing the said preamplifiers to be housed within the probe casing.

[0083] As it appears clearly from figure 4 the preamplifiers 3 can be mounted in form of an array of preamplifiers on a printed circuit board 4.

[0084] The printed circuit board 4 is provided with conductive tracks forming each one a separate input channel to a preamplifier 3 which input channel is connectable or connected to the signal feeding line of a contact electrode of one selected transducer of the second array of receiving transducers which forms the layer 70 of the probe

head. A separate output line departs from each preamplifier 3 which ends at a corresponding pin of a connector 5. The connector 5 is made of two parts one stably connected to the said output lines and the other complementary part stably connected to the a multi-channel cable for connecting the probe to a ultrasound system.

[0085] The printed circuit board 4 is provided also with conductive tracks forming the channels for the excitation signals which conductive tracks are connected on one side to the feeding lines of the said excitation signals leading each one to a contact electrode 10 of the array of contact electrodes associated to the first array of emitting transducers forming the layer 301 of the probe. The said conductive tracks are connected at the opposite ends to the connector pins to which the output lines of the preamplifiers 3 are connected which preamplifiers 3 are associated to the same or corresponding transducer of the second array of receiving transducers forming the layer 70 of the probe head.

[0086] Thus the multi-channel cable for connecting the probe to the apparatus has a common channel in form of a common conductor for each couple of corresponding transducers of the first and of the second array of transducers provided in the probe head.

[0087] As it appears from figure 4, the probe may be provided with two printed circuit boards each one carrying a partial array of preamplifiers 4. Furthermore the printed circuit boards may be of the kind having conductive tracks on both sides (double sided printed boards) so that a part of the total number of preamplifiers is arranged on each side of each of the printed circuit boards.

[0088] As it appears also from figure 4, the printed circuit boards 4 carrying the preamplifiers 3 are positioned in the probe casing along the longitudinal sides of the probe casing having the major width, since normally the probe head as a essentially rectangular symmetry. According to a variant, the printed circuit boards could be positioned along three or four sides of the probe casing and extend in the direction of the longitudinal axis of the probe which normally is essentially perpendicular to the probe head. Normally the probe casing has an elongated shape in a direction perpendicular to the probe head and the part extending backwards away from the probe head forms the probe handle. The part of the casing forming the handle has normally a rounded cross section so that the printed circuit board are placed along the sides of a parallelepipedon having a polygonal cross section which is inscribed in the rounded cross section of the part of the casing forming the handle.

[0089] Many variants of the disposition of the printed circuit boards can be chosen depending on the final shape of the probe casing and the above cited are only non limiting examples of preferred embodiments of arranging the printed circuit boards carrying the arrays of preamplifiers 3.

Claims

1. An ultrasound probe for diagnostic purposes, the ultrasound probe comprising:

   at least a first array (301) of ultrasound transducers (30) capable of generating ultrasound waves by electric excitation and of transforming ultrasound waves impinging on them in electric signals;
   each transducer of the first array being provided with a couple of contact electrodes (10, 401) which are connected respectively to a ground potential and to conductors for transmitting or receiving an electric signal;
   each transducer (30) being at least electrically isolated form the adjacent surrounding transducers of the first array;
   the first array of transducers being covered on its side, which is formed by the ultrasound emitting surfaces of the transducers (30) by means of at least one matching layer (601, 701) for adapting the acoustical impedance of the transducer array to the one of the body to be examined in order to avoid abrupt changes in the acoustic impedance which would generate reflection surfaces preventing the ultrasound beam to penetrate within the body to be examined
   characterised in that
   the first array of transducers comprises only emitting transducers (30) and is intended only for generating and transmitting the ultrasound waves;
   a second array (70) of transducers is provided and laid over the first array (301) of emitting transducer, which second array of transducers comprises receiving transducers and is intended only for generating electric signals due to acoustic excitation of the receiving transducers by means of impinging or reflected ultrasound waves;
   said second array of transducers being formed by a material having piezoelectric behaviour and an acoustic impedance intermediate to the one of the first array of transducers and of the bod under examination, thereby forming at the same time the matching layer covering the first array of transducer on the side thereof oriented in the direction of propagation of the ultrasound waves emitted by said first array of transducers.

2. An ultrasound probe according to claim 1, in which the receiving transducers are made of Polivinilchloride PVC or polivinilidilenefluoride PVDF.

3. An ultrasound probe according to claim 1 or 2, **characterised in that** each receiving transducer of the

second array of transducers is provided with two electrodes, one for collecting the generated electric signal generated and the other being connected to ground potential.

4. An ultrasound probe according to one or more of the preceding claims, **characterised in that** the emitting and the receiving transducers of the first and second arrays, respectively, are mechanically integrated in a layer-shaped pack which is formed by the transducers themselves which are spaced one from the other, the spaces between the transducers being filled with a filling and bonding material.

5. An ultrasound probe according to claim 1 or 4, **characterised in that** the contact electrodes form an array of electrodes, each electrode of the array coinciding with a surface of each transducer of the first array (301) and the array of electrodes being in the form of a layer.

6. An ultrasound probe according to claim 4, **characterised in that** the contact electrodes connected to the ground potential are formed by a continuous layer or thin plate of conductive material connected to ground potential.

7. An ultrasound probe according to claim 1, **characterised in that** between the first and the second array a first matching layer (601) is provided, while the matching layer formed by the second array of receiving transducers is a second matching layer for the ultrasound waves emitted by the first array of emitting transducers (301).

8. An ultrasound probe according to claim 7, **characterised in that** the second array of receiving transducers is made by a piezoelectric material and is formed by an array of elements having the function of ultrasound transducers, wherein a further layer made by an array of contact electrodes each one coinciding and in electric contact with one of the piezoelectric elements is provided between said second array of piezoelectric elements and the first matching layer and a layer of conducting material forming a ground electrode is laid between said second array of transducers and an acoustic lens and is in electric contact with the piezoelectric elements forming the second array of receiving transducers.

9. An ultrasound probe according to claim 1, **characterised in that** the probe comprises a probe head for emitting and receiving ultrasound waves which head comprises in an order from the back side of the probe to the probe head from which the waves are emitted and at which the waves are received:

a first layer (101) made by an array of said contact electrodes, which are connected to the conductors for carrying excitation signals separately to each one of the transducers (30) of the first array (301) of ultrasound waves emission transducers, said transducer of the first array being laid on said first layer (101);

a first layer (401) of electric conductive material laid on the first array (301) of emitting transducers and in electric contact with said emitting transducers (30), which first layer (401) of electric conductive material is connected to ground potential and forms the contact electrodes connected to the ground potential;

a first matching layer (601) made of a material having a first value of acoustic impedance between the one of the first array (401) of emitting transducers and the one of the body under examination and which first matching layer (601) is laid on said grounded first layer (401) of conductive material;

a layer (101') made by an array of receipt contact electrodes for carrying the receiving electric signals generated by the second array (70) of receiving transducers due to the acoustic excitation of the receiving transducers of said second array (70) and which layer (101') of receipt contact electrodes is laid on the first matching layer (601);

the second array (70) of receiving transducers being laid on the layer (101') formed by the array of receipt contact electrodes, each one of the receiving transducers of said second array (70) being in electric contact with one of the receipt contact electrodes;

wherein the material forming the second array (70) of receiving transducers has a value of acoustic impedance between the value of the acoustic impedance of the first matching layer (601) and the value of the acoustic impedance of the body under examination;

a second layer (401') of electric conductive material laid on the second array (70) of receiving transducers and being in electric contact with said receiving transducers, which second layer (401') of electric conductive material is connected to ground potential and forms ground electrodes of said second array (70) of receiving transducers; and

an acoustic lens (801) being laid over said grounded second layer of electric conductive material.

10. An ultrasound probe according to claim 9, **characterised in that** the contact electrodes (10) of the array of contact electrodes associated to the first array (301) of emitting transducers (30) are connected each one to a separated feeding channel or line for the electric excitation signal and that the receipt con-

tact electrodes of the array of contact electrodes associated to the second array (70) of receiving transducers are connected each one to a separate feeding line or channel (31', 31") for an electric receipt signal, wherein said feeding lines (31, 31', 31") for the electric excitation signals and for the electric receipt signals are separated lines or channels.

11. An ultrasound probe according to claim 1 or 10, **characterised in that** the probe further comprises an array of preamplifiers (3) each one of which is connected with a separated input channel (31') for the receipt signal to the receipt contact electrode of one of the receiving transducers of the second array (70) of receiving transducers.

12. An ultrasound probe according to claim 11, **characterised in that** the preamplifiers (3) are in the form of integrated circuits mounted in an array disposition on a printed circuit board (4) comprising conductive tracks, wherein at least part of each one of said conductive tracks is a separated receipt signal feeding channel or line (31') connecting one of the integrated preamplifiers (3) with the receipt contact electrode of one of the receiving transducers of the second array (70) of receiving transducers.

13. An ultrasound probe according to claim 11 or 12, **characterised in that** the preamplifiers (3) comprise only a tension follower together with the typical passive components for correctly driving the tension follower.

14. An ultrasound probe according to claim 13, **characterised in that** a decoupling circuit comprising two antiparallel diodes is associated to each tension follower.

15. An ultrasound probe according to claim 13, **characterised in that** the tension follower consists in only a Fet component.

16. An ultrasound probe according to claim 11 or 12, **characterised in that** the probe comprises at least an array of receipt signal preamplifiers (3) which are mounted on a printed circuit board (4), the printed circuit board being housed in the probe casing in a position which is transversal or substantially perpendicular to the surface of the array of transducers (301, 70).

17. An ultrasound probe according to claim 16, **characterised in that** the preamplifiers (3) of the receipt signals are distributed on two arrays which are mounted each one on a side of the printed circuit board which is double sided.

18. An ultrasound probe according to claim 16, **characterised in that** the preamplifiers (3) are distributed on two or more arrays each mounted on one circuit board (4).

19. An ultrasound probe according to claim 16, **characterised in that** more than two arrays of preamplifiers (3) are mounted on both sides of two or more double sided printed circuit boards (4), depending on the total number of the arrays of preamplifiers.

20. An ultrasound probe according to one or more of the preceding claims 16 to 19, **characterised in that** the probe has a shape with a casing having an elongated form in a direction parallel to the direction of propagation of the emitted ultrasound waves and which casing forms a handle for holding the probe having two opposite ends, one of which carries the first and second arrays (301, 70) of transducers, wherein from the other one of said ends a multi-channel cable departs for connecting the probe to an ultrasound system, while the one or more printed circuit boards (4) carrying the array or the arrays of preamplifiers (3) are positioned in the axial direction of the probe casing.

21. An ultrasound probe according to claim 20, **characterised in that** the printed circuit board or boards (4) are provided parallel to the sides of the prof casing which are parallel to the longer sides of the first and second arrays of transducers and at the end facing the arrays of transducers the printed circuit board or boards (4) are provided with contact termination pins of the conductive tracks provided on them or with a connector engageable and disengageable, while the array or the arrays (101, 101') of contact electrodes of the array or of the arrays (301, 70) of transducers are provided with a connector or with a contact termination pins along one or both of the said longer sides, which contact termination pins or which connector is complementary to the one provided on the printed circuit board or boards (4) in order to generate at least an electric connection by soldering together coinciding contact pins or to generate a disengageable electric and mechanical connection by means of the connectors.

22. An ultrasound probe according to claim 20 or 21, **characterised in that** a printed circuit board is provided along each side of the probe casing parallel, or tangential to three or to four or to more of the sides of the array of transducers, the arrays of contact electrodes being provided with a connector or with a contact termination pins on each of the said sides.

Patentansprüche

1. Ultraschallsonde für diagnostische Zwecke, mit:

mindestens einem ersten Array (301) von Ultraschallwandlern (30), die in der Lage sind, Ultraschallwellen durch elektrische Erregung zu erzeugen und auf sie auftreffende Ultraschallwellen in elektrische Signale zu transformieren;
wobei jeder Wandler des ersten Arrays mit mehreren Kontaktelektroden (10,401) versehen ist, die jeweils mit einem Massepotenzial und mit Leitern verbunden sind, um ein elektrisches Signal zu senden oder zu empfangen;
wobei jeder Wandler (30) mindestens elektrisch von den angrenzenden umliegenden Wandlern des ersten Arrays isoliert ist;
wobei das erste Array von Wandlern an seiner durch die ultraschallemittierenden Flächen der Wandler (30) gebildeten Seite von mindestens einer Anpassungsschicht (601,701) bedeckt ist, um die akustische Impedanz des Wandler-Arrays an diejenige des zu untersuchenden Körpers anzupassen, damit abrupte Veränderungen der akustischen Impedanz vermieden werden, die Reflexionsflächen erzeugen würden, welche die Penetration des Ultraschallstrahls in dem zu untersuchenden Körper verhindern würden;
dadurch gekennzeichnet, dass
das erste Array von Wandlern nur emittierende Wandler (30) aufweist und nur zum Generieren und Ausgeben der Ultraschallwellen vorgesehen ist;
ein zweites Array (70) von Wandlern vorgesehen und auf das erste Array (301) emittierender Wandler gelegt ist, wobei das zweite Array von Wandlern empfangende Wandler aufweist und nur zum Generieren elektrischer Signale aufgrund akustischer Erregung der empfangenden Wandler mittels auftreffender oder reflektierter Ultraschallwellen vorgesehen ist,

wobei das zweite Array von Wandlern aus einem Material ausgebildet ist, dessen piezoelektrisches Verhalten und dessen akustische Impedanz zwischen denjenigen des ersten Arrays von Wandlern und denjenigen des zu untersuchenden Körpers liegt, wodurch gleichzeitig die Anpassungsschicht gebildet wird, die das erste Array von Wandlern an derjenigen Seite des Arrays bedeckt, welche in die Ausbreitungsrichtung der von dem ersten Array von Wandlern emittierten Ultraschallwellen gerichtet ist.

2. Ultraschallsonde nach Anspruch 1, bei der die empfangenden Wandler aus Polyvinylchlorid PVC oder Polyvinylidenfluorid PVDF gebildet sind.

3. Ultraschallsonde nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** jeder empfangende Wandler des zweiten Arrays von Wandlern mit zwei Elektroden versehen ist, von denen eine zur Aufnahme des generierten elektrischen Signals vorgesehen und die andere mit Massepotenzial verbunden ist.

4. Ultraschallsonde nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die emittierenden und empfangenden Wandler des ersten bzw. zweiten Arrays mechanisch in einen schichtförmigen Packen integriert sind, der von den Wandlern selbst gebildet ist, die voneinander beabstandet sind, wobei die Zwischenräume zwischen den Wandlern mit einem Füll- und Bondungsmaterial gefüllt sind.

5. Ultraschallsonde nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Kontaktelektroden ein Array von Elektroden bilden, wobei jede Elektrode des Arrays mit einer Fläche jedes Wandlers des ersten Arrays (301) koinzidiert und das Array von Elektroden in Form einer Schicht ausgebildet ist.

6. Ultraschallsonde nach Anspruch 4, **dadurch gekennzeichnet, dass** die mit dem Massepotenzial verbundenen Kontaktelektroden aus einer mit Massepotenzial verbundenen durchgehenden Schicht oder dünnen Platte leitenden Materials gebildet sind.

7. Ultraschallsonde nach Anspruch 1, **dadurch gekennzeichnet, dass** zwischen dem ersten und dem zweiten Array eine erste Anpassungsschicht (601) vorgesehen ist, wobei die von dem zweiten Array empfangender Wandler gebildete Anpassungsschicht eine zweite Anpassungsschicht für die von dem ersten Array emittierender Wandler (301) emittierten Ultraschallwellen ist.

8. Ultraschallsonde nach Anspruch 7, **dadurch gekennzeichnet, dass** das zweite Array empfangender Wandler aus einem piezoelektrischen Material besteht und aus einem Array von Elementen gebildet ist, welche die Funktion von Ultraschallwandlern haben, wobei eine weitere Schicht, die aus einem Array von Kontaktelektroden gebildet ist, von denen jede mit einem der piezoelektrischen Elemente koinzidiert und sich in elektrischem Kontakt mit diesem befindet, zwischen dem zweiten Array piezoelektrischer Elemente und der ersten Anpassungsschicht vorgesehen ist, und eine Schicht aus leitendem Material, die eine Masseelektrode bildet, zwischen das zweite Array von Wandlern und eine akustische Linse gelegt ist und sich in elektrischem Kontakt mit den das zweite Array empfangender Wandler bildenden piezoelektrischen Elementen befindet.

9. Ultraschallsonde nach Anspruch 1, **dadurch gekennzeichnet, dass** die Sonde einen Sondenkopf zum Emittieren und Empfangen von Ultraschallwel-

len aufweist, wobei dieser Kopf in der folgenden Abfolge von dem hinteren Ende der Sonde zu dem Sondenkopf, aus dem die Wellen emittiert werden und an dem die Wellen empfangen werden, aufweist:

eine erste Schicht (101) aus einem Array der Kontaktelektroden, die mit den Leitern verbunden sind, um die Erregungssignale separat zu jedem der Wandler (30) des ersten Arrays (301) von Ultraschallwellenemissions-Wandlern zu übermitteln, wobei die Wandler des ersten Arrays auf die erste Schicht (101) gelegt sind;
eine erste Schicht (401) elektrisch leitenden Materials, die auf das erste Array (301) emittierender Wandler gelegt ist und sich in elektrischem Kontakt mit den emittierenden Wandlern (30) befindet, wobei die erste Schicht (401) elektrisch leitenden Materials mit Massepotenzial verbunden ist und die mit dem Massepotenzial verbundenen Kontaktelektroden bildet;
eine erste Anpassungsschicht (601), die aus einem Material gebildet ist, das einen ersten akustischen Impedanzwert hat, der zwischen demjenigen des ersten Arrays (401) emittierender Wandler und demjenigen des zu untersuchenden Körpers liegt, und wobei die erste Anpassungsschicht (601) auf die geerdete erste Schicht (401) leitenden Materials gelegt ist;
eine aus einem Array von Empfangs-Kontaktelektroden gebildete Schicht (101') zum Übermitteln der empfangenen elektrischen Signale, die von dem zweiten Array (70) empfangender Wandler aufgrund der akustischen Erregung der empfangenden Wandler des zweiten Arrays (70) generiert werden, und wobei diese Schicht (101') von Empfangs-Kontaktelektroden auf die erste Anpassungsschicht (601) gelegt ist;
ein zweites Array (70) empfangender Wandler, das auf die von dem Array von Empfangs-Kontaktelektroden gebildete Schicht (101') gelegt ist, wobei sich jeder der empfangenden Wandler des zweiten Arrays (70) in elektrischem Kontakt mit einer der Empfangs-Kontaktelektroden befindet;
wobei das das zweite Array (70) empfangender Wandler bildende Material einen akustischen Impedanzwert hat, der zwischen dem akustischen Impedanzwert der erste Anpassungsschicht (601) und dem akustischen Impedanzwert des zu untersuchenden Körpers liegt;
eine zweite Schicht (401') elektrisch leitenden Materials, die auf das zweite Array (70) empfangender Wandler gelegt ist und sich in elektrischem Kontakt mit den empfangenden Wandlern befindet, wobei die zweite Schicht (401') elektrisch leitenden Materials mit Massepotenzial verbunden ist und Masseelektroden des zweiten Arrays (70) empfangender Wandler bildet; und
eine akustische Linse (801), die auf die geerdete zweite Schicht elektrisch leitenden Materials gelegt ist.

10. Ultraschallsonde nach Anspruch 9, **dadurch gekennzeichnet, dass** die Kontaktelektroden (10) des dem ersten Array (301) emittierender Wandler (30) zugeordneten Arrays von Kontaktelektroden jeweils mit einem separaten Zuführkanal oder einer separaten Zuführleitung für das elektrische Erregungssignal verbunden sind und dass die Empfangs-Kontaktelektroden des mit dem zweiten Array (70) empfangender Wandler verbundenen Arrays von Kontaktelektroden jeweils mit einer separaten Zuführleitung oder einem separaten Zuführkanal (31',31") für ein elektrisches Empfangssignal verbunden sind, wobei die Zuführleitungen (31,31',31") für die elektrischen Erregungssignale und für die elektrischen Empfangssignale separate Leitungen oder Kanäle sind.

11. Ultraschallsonde nach Anspruch 1 oder 10, **dadurch gekennzeichnet, dass** die Sonde ferner ein Array von Vorverstärkern (3) aufweist, von denen jeder mit einem separaten Eingangskanal (31') für das Empfangssignal der Empfangs-Kontaktelektrode eines der Empfangs-Wandler des zweiten Arrays (70) empfangender Wandler verbunden ist.

12. Ultraschallsonde nach Anspruch 11, **dadurch gekennzeichnet, dass** die Vorverstärker (3) in Form integrierter Schaltungen ausgebildet sind, die in Array-Form auf einer Leiterbahnen aufweisenden Schaltungsplatine (4) angeordnet sind, wobei mindestens ein Teil jeder der Leiterbahnen ein separater Empfangssignal-Zuführkanal oder eine separate Empfangssignal-Zuführleitung (31') ist, der bzw. die einen der integrierten Vorverstärker (3) mit der Empfangs-Kontaktelektrode eines der Empfangs-Wandler des zweiten Arrays (70) empfangender Wandler verbindet.

13. Ultraschallsonde nach Anspruch 11 oder 12, **dadurch gekennzeichnet, dass** die Vorverstärker (3) nur einen Spannungsverfolger zusammen mit den typischen passiven Komponenten zum korrekten Treiben des Spannungsverfolgers aufweist.

14. Ultraschallsonde nach Anspruch 13, **dadurch gekennzeichnet, dass** jedem Spannungsverfolger eine Entkopplungsschaltung zugeordnet ist, die zwei antiparallele Dioden aufweist.

15. Ultraschallsonde nach Anspruch 13, **dadurch gekennzeichnet, dass** der Spannungsverfolger nur aus einer FET-Komponente besteht.

16. Ultraschallsonde nach Anspruch 11 oder 12, **dadurch gekennzeichnet, dass** die Sonde mindestens ein Array von Empfangssignal-Vorverstärkern (3) aufweist, die auf einer gedruckten Schaltungsplatine (4) angeordnet sind, wobei die gedruckte Schaltungsplatine in dem Sondengehäuse in einer Position untergebracht ist, die transversal oder im Wesentlichen senkrecht zu der Oberfläche des Arrays von Wandlern (301,70) verläuft.

17. Ultraschallsonde nach Anspruch 16, **dadurch gekennzeichnet, dass** die Vorverstärker (3) für die Empfangssignale auf zwei Arrays verteilt sind, die jeweils an einer Seite der doppelseitig ausgebildeten gedruckten Schaltungsplatine angeordnet sind.

18. Ultraschallsonde nach Anspruch 16, **dadurch gekennzeichnet, dass** die Vorverstärker (3) auf zwei oder mehr Arrays verteilt sind, die jeweils an einer Schaltungsplatine (4) angeordnet sind.

19. Ultraschallsonde nach Anspruch 16, **dadurch gekennzeichnet, dass** in Abhängigkeit von der Gesamtanzahl der Arrays von Vorverstärkern mehr als zwei Arrays von Vorverstärkern (3) an beiden Seiten der zwei oder mehr doppelseitigen gedruckten Schaltungsplatinen (4) angeordnet sind.

20. Ultraschallsonde nach einem oder mehreren der vorhergehenden Ansprüche 16 bis 19, **dadurch gekennzeichnet, dass** die Sonde eine Ausgestaltung mit einem Gehäuse hat, das eine in einer parallel zur Ausbreitungsrichtung der emittierten Ultraschallwellen verlaufenden Richtung langgestreckte Form hat und das einen Griff zum Halten der Sonde bildet, der zwei gegenüberliegende Enden aufweist, von denen eines die ersten und zweiten Arrays (301,70) von Wandlern trägt, wobei von dem anderen der Enden ein Mehrkanalkabel zum Verbinden der Sonde mit einem Ultraschallsystem abgeht, wobei eine oder mehrere gedruckte Schaltungsplatinen (4), die das Array oder die Arrays von Vorverstärkern (3) tragen, in der Axialrichtung des Sondengehäuses positioniert sind.

21. Ultraschallsonde nach Anspruch 20, **dadurch gekennzeichnet, dass** die gedruckte Schaltungsplatine oder die gedruckten Schaltungsplatinen (4) parallel zu denjenigen Seiten des Sondengehäuses vorgesehen sind, die parallel zu den längeren Seiten der ersten und zweiten Arrays von Wandlern verlaufen, und an dem zu den Arrays von Wandlern weisenden Ende die gedruckte Schaltungsplatine oder die gedruckten Schaltungsplatinen (4) mit Kontaktanschluss-Stiften für die auf ihr bzw. ihnen vorgesehenen Leiterbahnen oder mit einem in und außer Eingriff bringbaren Konnektor versehen ist bzw. sind, wobei das Array oder die Arrays (101,101') von Kontaktelektroden des Arrays oder der Arrays (301,70) von Wandlern entlang einer oder beider der längeren Seiten mit einem Konnektor oder mit Kontaktanschluss-Stiften versehen ist bzw. sind, wobei die Kontaktanschluss-Stifte oder der Konnektor zu denjenigen bzw. demjenigen, die bzw. der an der gedruckten Schaltungsplatine oder den gedruckten Schaltungsplatinen (4) vorgesehen sind bzw. ist, komplementär sind bzw. ist, um durch Zusammenlöten koinzidierender Kontaktstifte mindestens eine elektrische Verbindung zu erzeugen oder mittels der Konnektoren ein lösbare elektrische oder mechanische Verbindung zu erzeugen.

22. Ultraschallsonde nach Anspruch 20 oder 21, **dadurch gekennzeichnet, dass** an jeder Seite des Sondengehäuses parallel oder tangential zu drei oder zu vier oder zu mehr der Seiten des Arrays von Wandlern eine gedruckte Schaltungsplatine vorgesehen ist, wobei die Arrays von Kontaktelektroden an jeder der besagten Seiten mit einem Konnektor oder mit Kontaktterminations-Stiften versehen sind.

Revendications

1. Sonde ultrasonore à des fins diagnostiques, la sonde ultrasonore comprenant:

   au moins un premier groupement (301) de transducteurs ultrasonores (30) apte à générer des ondes ultrasonores par excitation électrique et à transformer les ondes ultrasonores incidentes sur ceux-ci en signaux électriques;
   chaque transducteur du premier groupement étant muni d'un couple d'électrodes de contact (10, 401) qui sont connectées respectivement à un potentiel de masse et à des conducteurs pour transmettre ou recevoir un signal électrique;
   chaque transducteur (30) étant au moins électriquement isolé des transducteurs environnants adjacents du premier groupement;
   le premier groupement de transducteurs étant couvert sur son côté, qui est formé par les surfaces émettrices d'ultrasons des transducteurs (30), au moyen d'au moins une couche correspondante (601, 701) pour adapter l'impédance acoustique du groupement de transducteurs à un du corps à examiner pour éviter des changements abrupts dans l'impédance acoustique qui produiraient des surfaces de réflexion empêchant la pénétration du faisceau ultrasonore dans le corps à examiner,
   caractérisée en ce que
   le premier groupement de transducteurs comprend seulement des transducteurs émetteurs (30) et est destiné seulement à générer et à transmettre les ondes ultrasonores;

un deuxième groupement (70) de transducteurs est réalisé et posé sur le premier groupement (301) de transducteurs émetteurs, ledit deuxième groupement de transducteurs comprend des transducteurs récepteurs et est destiné seulement à générer des signaux électriques dûs à l'excitation acoustique des transducteurs récepteurs au moyen d'ondes ultrasonores incidentes ou réfléchies;

ledit deuxième groupement de transducteurs étant formé par un matériau ayant un comportement piézoélectrique et une impédance acoustique entre l'un du premier groupement de transducteurs et le corps à examiner, en formant ainsi en même temps la couche correspondante couvrant le premier groupement de transducteurs sur son côté orienté dans la direction de propagation des ondes ultrasonores émises par ledit premier groupement de transducteurs.

2. Sonde ultrasonore selon la revendication 1, dans laquelle les transducteurs récepteurs sont réalisés en polychlorure de vinyle (PVC) ou polyfluorure de vinylidène (PVDF).

3. Sonde ultrasonore selon la revendication 1 ou 2, **caractérisée en ce que** chaque transducteur récepteur du deuxième groupement de transducteurs est muni de deux électrodes, une pour recueillir le signal électrique produit, et l'autre étant connectée au potentiel de masse.

4. Sonde ultrasonore selon l'une ou plusieurs des revendications précédentes, **caractérisée en ce que** les transducteurs d'émission et de réception des premier et deuxième groupements, respectivement, sont intégrés mécaniquement dans un paquet en forme de couche qui est formé par les transducteurs eux-mêmes qui sont espacés les uns des autres, les espaces entre les transducteurs étant remplis d'un matériau de remplissage et de liaison.

5. Sonde ultrasonore selon la revendication 1 ou 4, **caractérisée en ce que** les électrodes de contact forment un groupement d'électrodes, chaque électrode du groupement coïncidant avec une surface de chaque transducteur du premier groupement (301) et le groupement d'électrodes se présentant sous la forme d'une couche.

6. Sonde ultrasonore selon la revendication 4, **caractérisée en ce que** les électrodes de contact connectées au potentiel de masse sont formées par une couche continue ou plaque mince de matériau conducteur connectée au potentiel de masse.

7. Sonde ultrasonore selon la revendication 1, **caractérisée en ce qu'**entre les premier et deuxième groupements, une première couche de correspondance (601) est réalisée, tandis que la couche de correspondance formée par le deuxième groupement de transducteurs de réception est une deuxième couche de correspondance pour les ondes ultrasonores émises par le premier groupement de transducteurs émetteurs (301).

8. Sonde ultrasonore selon la revendication 7, **caractérisée en ce que** le deuxième groupement de transducteurs de réception est réalisé en un matériau piézoélectrique et est formé par un groupement d'éléments ayant la fonction de transducteurs ultrasonores, où une autre couche formée par un groupement d'électrodes de contact, chacune coïncidant et en contact électrique avec un des éléments piézoélectriques est réalisée entre ledit deuxième groupement d'éléments piézoélectriques et la première couche de correspondance et une couche de matériau conducteur formant une électrode de masse est posée entre ledit deuxième groupement de transducteurs et une lentille acoustique et est en contact électrique avec les éléments piézoélectriques formant le deuxième groupement de transducteurs de réception.

9. Sonde ultrasonore selon la revendication 1, **caractérisée en ce que** la sonde comprend une tête de sonde pour l'émission et la réception d'ondes ultrasonores, ladite tête comprend selon un ordre du côté arrière de la sonde à la tête de sonde à partir de laquelle les ondes sont émises et à laquelle les ondes sont reçues:

une première couche (101) formée par un groupement desdites électrodes de contact, qui sont connectées à des conducteurs pour porter des signaux d'excitation séparément à chacun des transducteurs (30) du premier groupement (301) de transducteurs d'émission d'ondes ultrasonores, ledit transducteur du premier groupement étant posé sur ladite première couche (101);
une première couche (401) en matériau conducteur électrique posée sur le premier groupement (301) de transducteurs d'émission et en contact électrique avec lesdits transducteurs d'émission (30), ladite première couche (401) en matériau conducteur électrique est connectée au potentiel de masse et forme les électrodes de contact connectées au potentiel de masse;
une première couche de correspondance (601) réalisée en un matériau ayant une première valeur d'impédance acoustique entre un du premier groupement (401) de transducteurs d'émission et un du corps sous examen, et ladite première couche de correspondance (601) est

posée sur ladite première couche mise à la masse (401) en matériau conducteur;
une couche (101') réalisée par un groupement d'électrodes de contact de réception pour porter les signaux électriques reçus produits par le deuxième groupement (70) de transducteurs de réception en raison de l'excitation acoustique des transducteurs de réception dudit deuxième groupement (70), et ladite couche (101') d'électrodes de contact de réception est posée sur la première couche de correspondance (601);
le deuxième groupement (70) de transducteurs de réception étant posé sur la couche (101') formée par le groupement d'électrodes de contact de réception, chacun des transducteurs de réception dudit deuxième groupement (70) étant en contact électrique avec une des électrodes de contact de réception;
où le matériau formant le deuxième groupement (70) de transducteurs de réception a une valeur d'impédance acoustique entre la valeur de l'impédance acoustique de la première couche de correspondance (601) et la valeur de l'impédance acoustique du corps sous examen;
une deuxième couche (401') en matériau électriquement conducteur posée sur le deuxième groupement (70) de transducteurs de réception et étant en contact électrique avec lesdits transducteurs de réception, ladite deuxième couche (401') en matériau électriquement conducteur est connectée au potentiel de masse et forme des électrodes de masse dudit deuxième groupement (70) de transducteurs de réception; et
une lentille acoustique (801) étant posée sur ladite deuxième couche mise à la masse en matériau électriquement conducteur.

10. Sonde ultrasonore selon la revendication 9, **caractérisée en ce que** les électrodes de contact (10) du groupement d'électrodes de contact associé au premier groupement (301) de transducteurs d'émission (30) sont connectées chacune à un canal ou ligne d'amenée séparée pour le signal d'excitation électrique, et **en ce que** les électrodes de contact de réception du groupement d'électrodes de contact associé au deuxième groupement (70) de transducteurs de réception sont connectés chacune à une ligne ou canal d'amenée séparée (31', 31") pour un signal de réception électrique, où lesdites lignes d'amenée (31, 31', 31") pour les signaux d'excitation électriques et pour les signaux de réception électriques sont des lignes ou canaux séparés.

11. Sonde ultrasonore selon la revendication 1 ou 10, **caractérisée en ce que** la sonde comprend en outre un groupement de préamplificateurs (3) dont chacun est connecté à un canal d'entrée séparé (31') pour le signal de réception à l'électrode de contact de réception d'un des transducteurs de réception du deuxième groupement (70) de transducteurs de réception.

12. Sonde ultrasonore selon la revendication 11, **caractérisé en ce que** les préamplificateurs (3) se présentent sous la forme de circuits intégrés installés selon une position de groupement sur une carte de circuit imprimé (4) comprenant des chemins conducteurs, où au moins une partie de chacun desdits chemins conducteurs est un canal ou ligne d'amenée de signaux de réception séparé (31') connectant un des préamplificateurs intégrés (3) à l'électrode de contact de réception d'un des transducteurs de réception du deuxième groupement (70) de transducteurs de réception.

13. Sonde ultrasonore selon la revendication 11 ou 12, **caractérisée en ce que** les préamplificateurs (3) comprennent seulement un suiveur de tension conjointement avec les composants passifs typiques pour entraîner correctement le suiveur de tension.

14. Sonde ultrasonore selon la revendication 13, **caractérisée en ce qu'**un circuit de découplage comprenant deux diodes anti-parallèles est associé à chaque suiveur de tension.

15. Sonde ultrasonore selon la revendication 13, **caractérisée en ce que** le suiveur de tension est constitué d'un seul composant Fet.

16. Sonde ultrasonore selon la revendication 11 ou 12, **caractérisée en ce que** la sonde comprend au moins un groupement de préamplificateurs de signaux de réception (3) qui sont montés sur une carte de circuit imprimé (4), la carte de circuit imprimé étant logée dans le boîtier de sonde dans une position qui est transversale ou sensiblement perpendiculaire à la surface du groupement de transducteurs (301, 70).

17. Sonde ultrasonore selon la revendication 16, **caractérisée en ce que** les préamplificateurs (3) des signaux de réception sont distribués sur deux groupements qui sont montés chacun sur un côté de la carte de circuit imprimé qui est à double face.

18. Sonde ultrasonore selon la revendication 16, **caractérisée en ce que** les préamplificateurs (3) sont distribués sur deux ou plusieurs groupements, chacun monté sur une carte de circuit (4).

19. Sonde ultrasonore selon la revendication 16, **caractérisée en ce que** plus que deux groupements de préamplificateurs (3) sont montés sur les deux côtés de deux ou plusieurs cartes de circuit imprimé double face (4), en fonction du nombre total des groupe-

ments de préamplificateurs.

20. Sonde ultrasonore selon l'une ou plusieurs des revendications précédentes 16 à 19, **caractérisée en ce que** la sonde a une forme avec un boîtier ayant une forme oblongue dans une direction parallèle à la direction de propagation des ondes ultrasonores émises et ledit boîtier forme une poignée pour tenir la sonde ayant deux extrémités opposées, dont une porte les premier et deuxième groupements (301, 70) de transducteurs, où part de l'autre desdites extrémités un câble multi-canaux pour connecter la sonde à un système ultrasonore, pendant qu'un ou plusieurs cartes de circuit imprimé (4) portant le ou les groupements de préamplificateurs (3) sont positionnées dans la direction axiale du boîtier de sonde.

21. Sonde ultrasonore selon la revendication 20, **caractérisée en ce que** la ou les cartes de circuit imprimé (4) sont réalisées parallèlement aux côtés du boîtier de sonde qui sont parallèles au côté plus long des premier et deuxième groupements de transducteurs et à l'extrémité orientée vers les groupements de transducteurs, la ou les cartes de circuit imprimé (4) sont réalisées avec des axes de terminaison de contact des chemins conducteurs réalisés sur elles ou avec un connecteur pouvant être mis en et hors prise, pendant que le ou les groupements (101, 101') d'électrodes de contact du ou des groupements (301, 70) de transducteurs sont munis d'un connecteur ou d'axes de terminaison de contact le long d'un ou des deux desdits côtés plus longs, lesdits axes de terminaison de contact ou ledit connecteur est complémentaire à celui réalisé sur la ou les cartes de circuit imprimé (4) pour produire au moins une connection électrique en brasant ensemble des axes de contact coïncidants ou pour produire une connexion électrique ou mécanique pouvant être mise hors prise au moyen des connecteurs.

22. Sonde ultrasonore selon la revendication 20 ou 21, **caractérisée en ce qu'**une carte de circuit imprimé est réalisée le long de chaque côté du boîtier de sonde parallèlement ou tangentiellement à trois ou à quatre ou à plus des côtés du groupement de transducteurs, les groupements d'électrodes de contact étant munis d'un connecteur ou d'axes de terminaison de contact sur chacun desdits côtés.

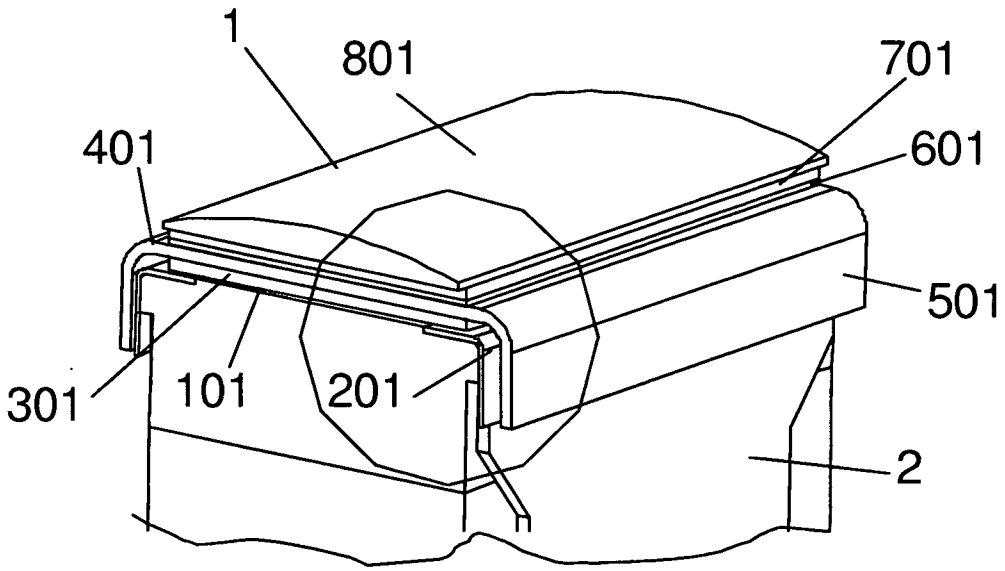

Fig. 1

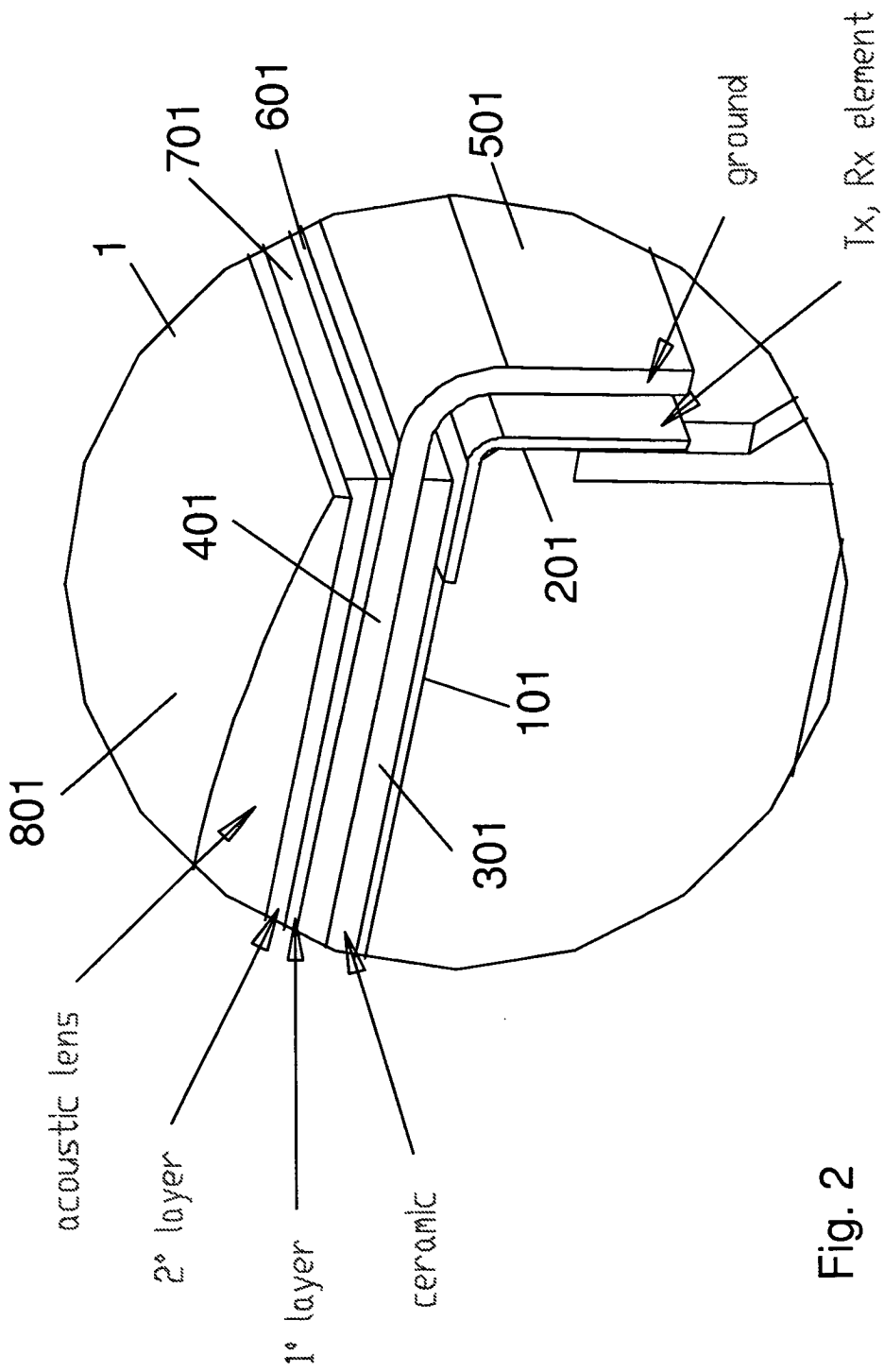
1
701
601
501
ground
Tx, Rx element
401
201
101
801
301
acoustic lens
2° layer
1° layer
ceramic

Fig. 2

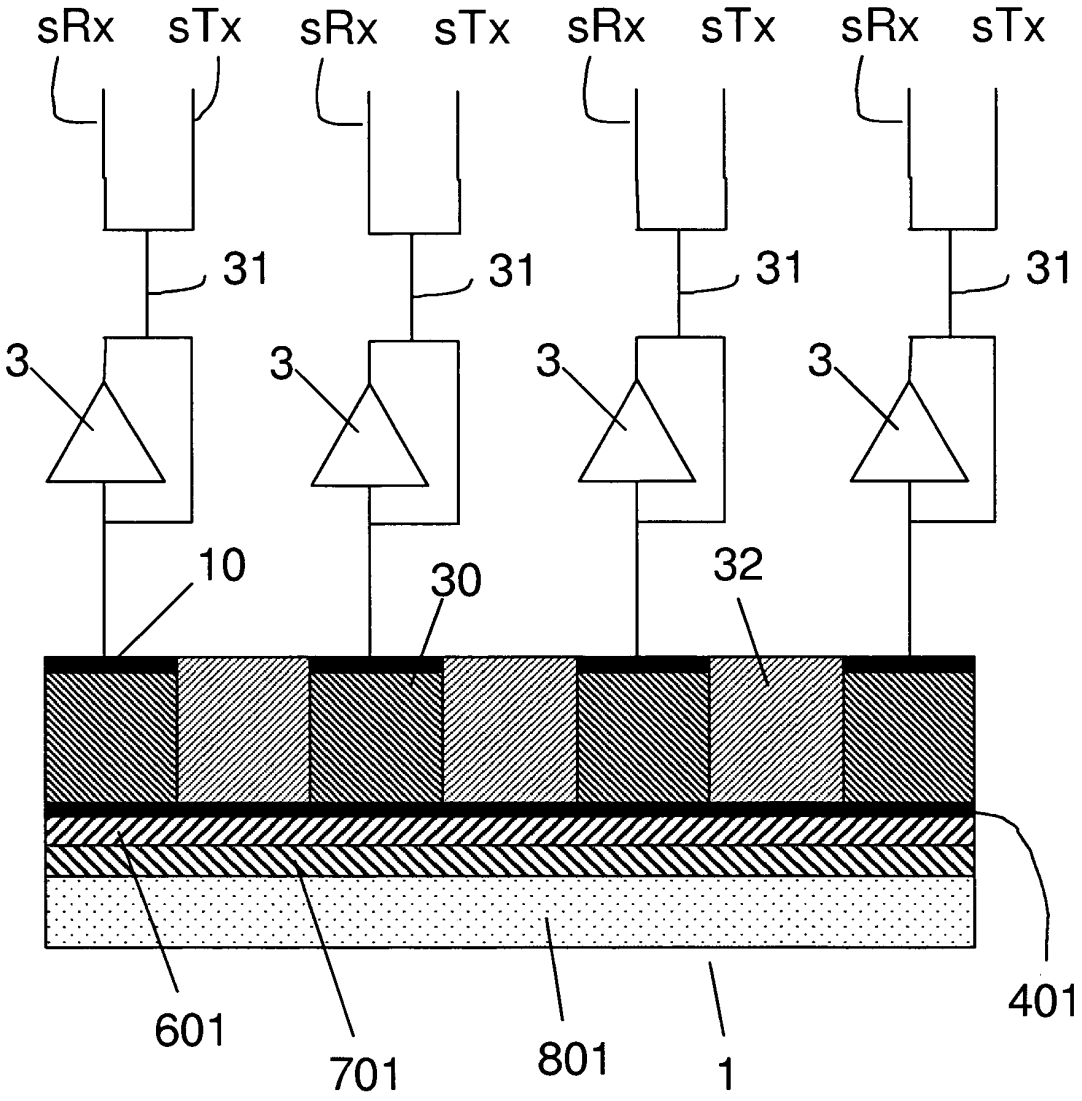
sRx
sTx
sRx
sTx
sRx
sTx
sRx
sTx
31
31
31
31
3
3
3
3
10
30
32
601
701
801
1
401

Fig. 3

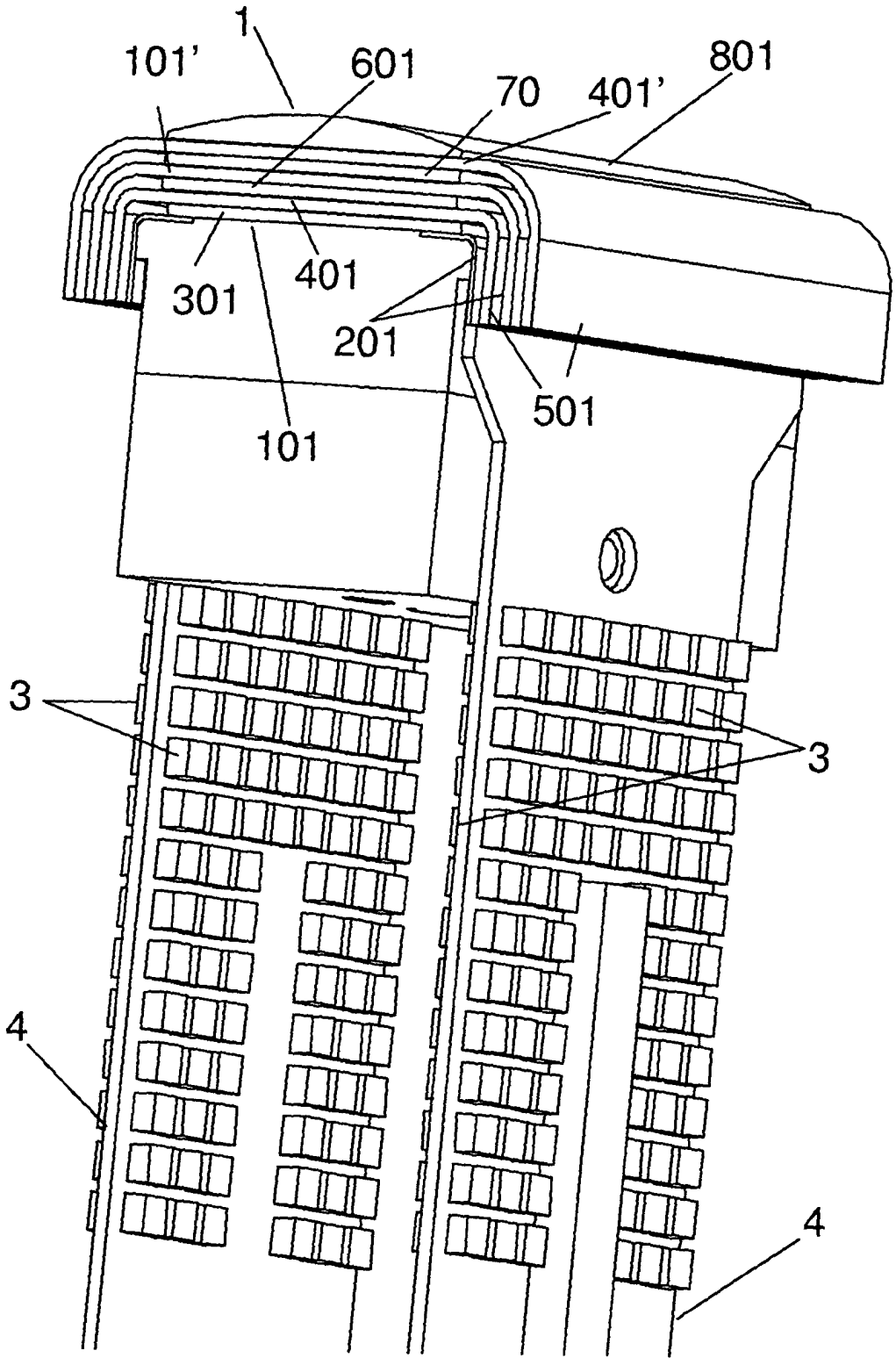

Fig. 4

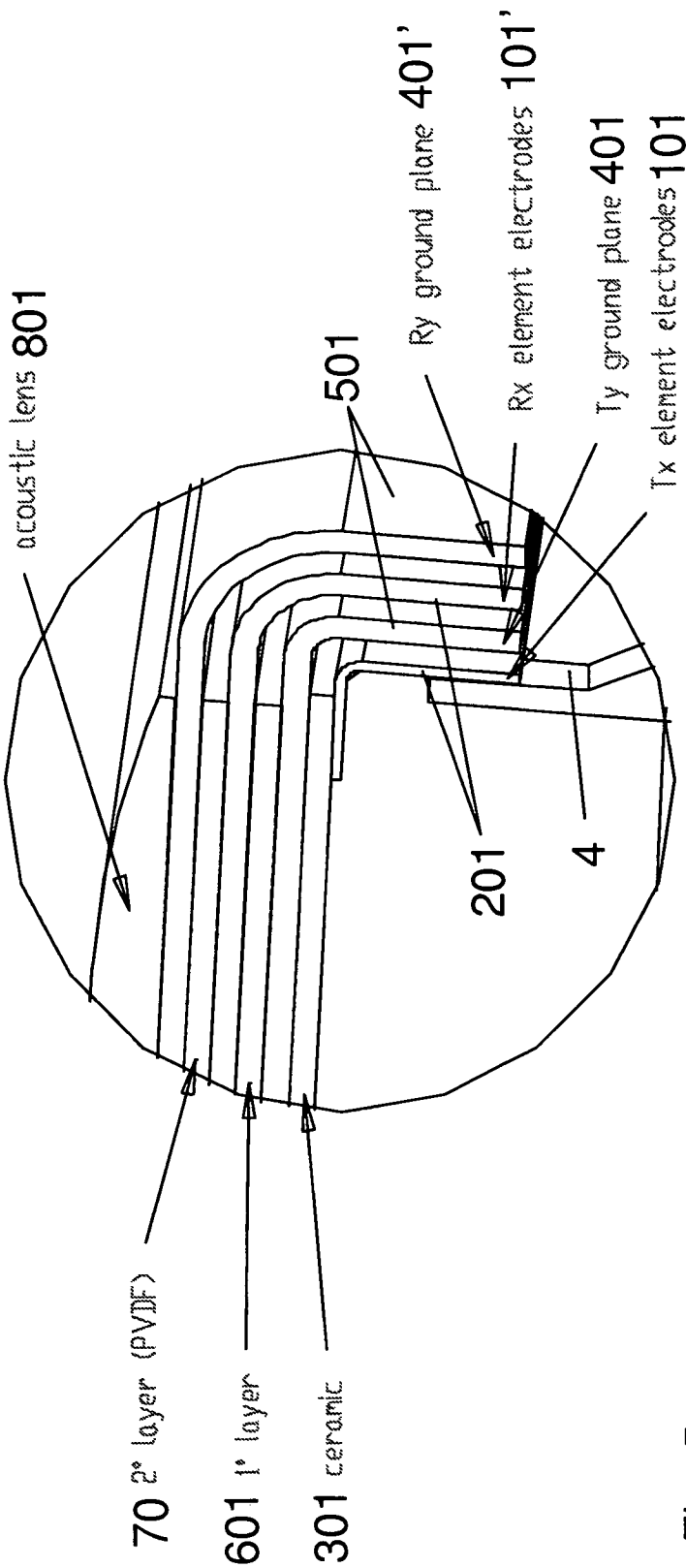
acoustic lens 801
501
Ry ground plane 401'
Rx element electrodes 101'
Ty ground plane 401
Tx element electrodes 101
201
4
70 2° layer (PVDF)
601 1° layer
301 ceramic

Fig. 5

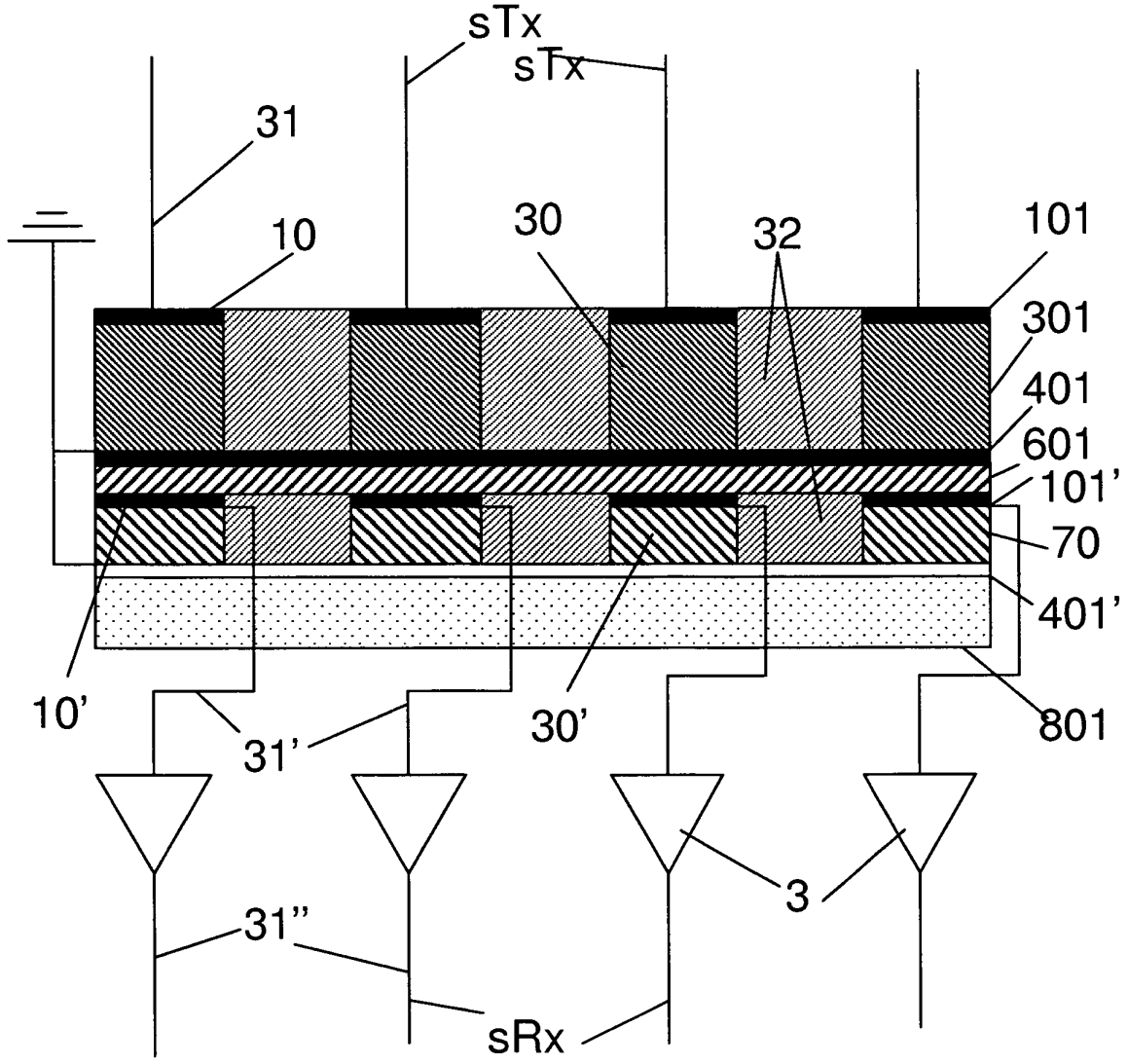

Fig. 6

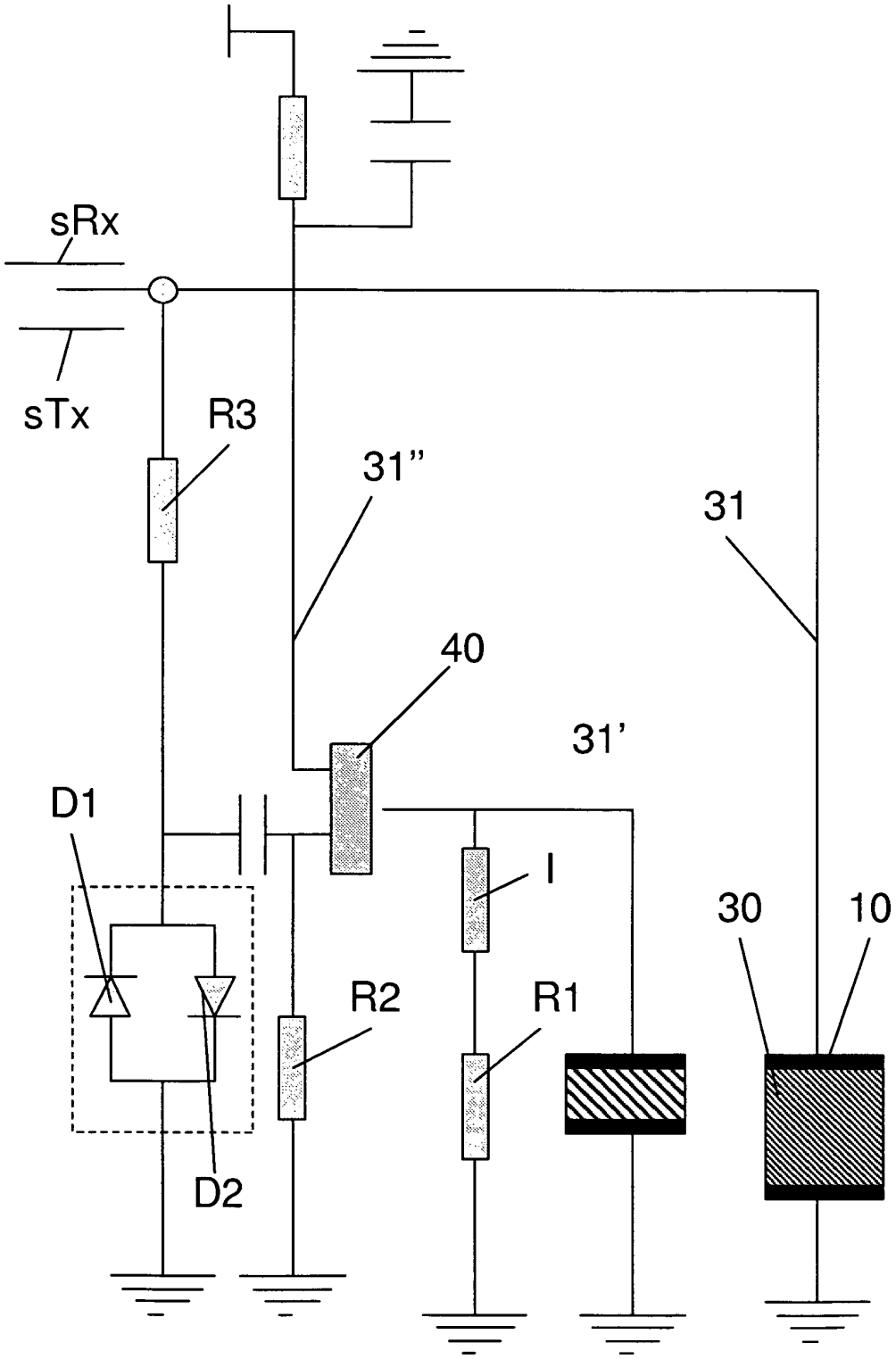

Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5974884 A **[0002]**
- US 6049159 A **[0054]**
- US 4686409 A **[0054]**

Non-patent literature cited in the description

- *TRANSACTION ON SONICS AND ULTRASONICS VOL.SU-13 NO.1,* March 1996, 20-30 **[0002]**

专利名称(译)	超声探头，特别是用于诊断成像		
公开(公告)号	EP1681019B1	公开(公告)日	2010-06-02
申请号	EP2005100284	申请日	2005-01-18
[标]申请(专利权)人(译)	百胜集团		
申请(专利权)人(译)	ESAOTE S.P.A.		
当前申请(专利权)人(译)	ESAOTE S.P.A.		
[标]发明人	CEROFOLINI MARINO		
发明人	CEROFOLINI, MARINO		
IPC分类号	A61B8/00 B06B1/06 G10K11/02		
CPC分类号	A61B8/00 A61B8/4483 B06B1/0622		
其他公开文献	EP1681019A1		
外部链接	Espacenet		

摘要(译)

特别用于诊断目的的超声探头包括第一超声换能器阵列（30），其通过电激励产生超声波并且在电信号中转换冲击它们的超声波，每个换能器设置有一对接触电极（10,401）。分别连接到地电位和电信号馈电线。根据本发明，第一换能器阵列仅包括发射换能器（30）并且仅用于产生和发射超声波，而第二阵列换能器被提供在第一发射换能器阵列上并且包括用于接收换能器。仅由于接收换能器的声激励而产生电接收信号。所述第二换能器阵列由具有压电行为和声阻抗的材料形成，所述声阻抗位于第一换能器阵列和被检查身体之一的中间，因此同时具有匹配层和超声波的功能。接收器。

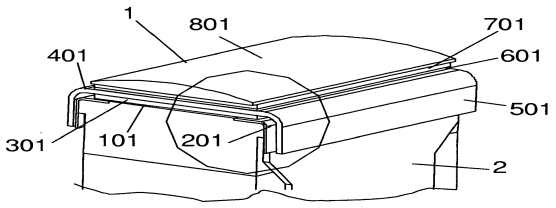

Fig. 1