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(54) An ultrasound probe, particularly for diagnostic imaging

(57) An ultrasound probe particularly for diagnostic purposes, the ultrasound probe comprising:
At least an array of ultrasound transducers (30) capable of transforming ultrasound waves impinging on them in electric signals and/or generating ultrasound waves by electric excitation. The array of transducers is housed in a probe casing and each transducer of the array being provided with at least a signal transmission line. Each signal transmission line is connected or connectable with a conductor of a multi-channel cable. According to the invention, at least part of the transducers or all of the transducers are connected with a separated preamplifier to the corresponding conductor of the multi-channel cable and the said preamplifiers are housed inside the probe casing.

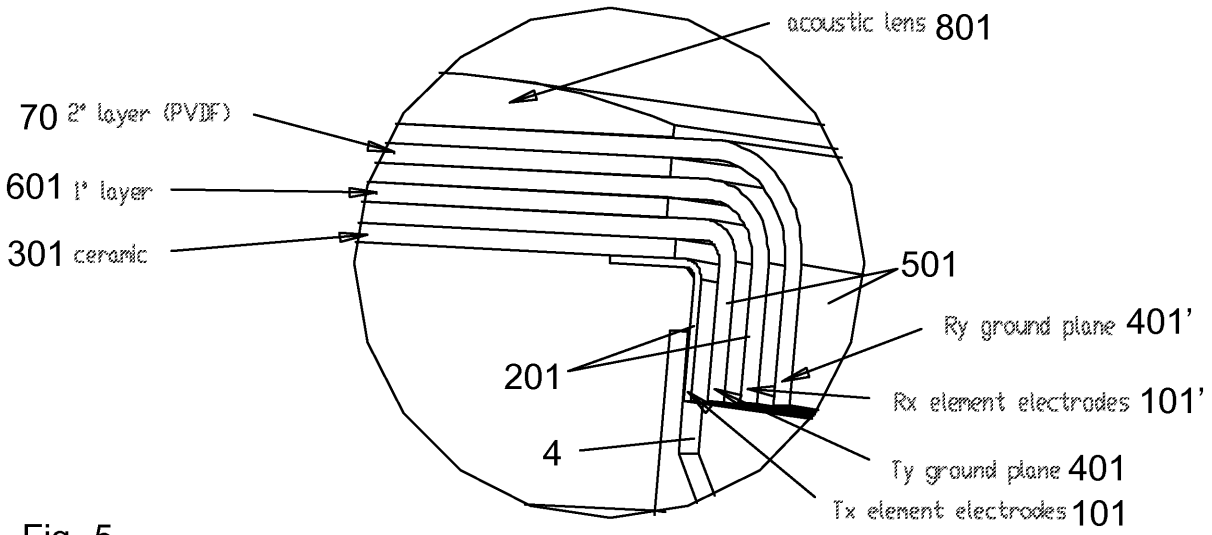

Fig. 5

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Description

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

[0002] 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.

[0003] 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.

[0004] 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.

[0005] 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.

[0006] 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.

[0007] 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.

[0008] 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.

[0009] 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.

[0010] 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.

[0011] 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.

[0012] 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 fur-

thermore for ensuring at the same time the expected or needed pass bandwidth.

[0013] The object of the present invention is 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.

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.

[0014] At the same time the invention has the aim to provide an improved ultrasound waves transmitting and receiving probe 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.The invention achieves the above mentioned aims by means of an ultrasound probe of the kind described at the beginning according to the preamble of claim 1 and further comprising the features of the characterising part of claim 1.

[0015] One advantageous embodiment provied for a probe having a first array of transducers is intended only for generating and transmitting the ultrasound waves;

[0016] And a second array of transducers being provided laid over the first transducer array which second array of transducers is intended only for generating the electric signals due to acoustic excitation of the transducers of the said second transducer array by means of the impinging or of the reflected ultrasound waves.;

[0017] The 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 body under examination, forming at the same time one of the matching layers covering the first array of transducer on the side thereof oriented in the direction of propagation of the ultrasound waves emitted by the said first array of transducers.

[0018] The second array of transducers comprises transducers made of Polivinilchloride PVC or polivinilidilenefluoride PVDF.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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 transduc-

ers.

[0031] 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.

[0032] 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.

[0033] In a preferred embodiment, the tension follower consist in only a Fet component.

[0034] 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.

[0035] 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.

[0036] Also form 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] Furthermore the preamplifiers can be distributed on two or more arrays each mounted on one circuit board.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] 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.

[0047] 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.

[0048] Relating to the construction of a conventional probe more details are disclosed in the documents US 6,049,159 and US 4,686,409.

[0049] Further improvements of the present ultrasound probe according to the invention are subject matter of the depending claims.

[0050] The features of the present invention and the advantages deriving therefrom will appear more clearly form 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.

[0051] Referring to figures 1 to 3, a conventional probe is illustrated therein.

[0052] 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.

[0053] The said probe head comprises, in an order starting form 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.

[0054] 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.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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.

[0061] 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.

[0062] 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.

[0063] 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] A material showing the said values of acoustic resonance and a suitable piezoelectric behaviour is polyvinylchloride PVC or Polyvinyldilene fluoride PVDF.

[0070] 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.

[0071] 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.

[0072] 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'.

[0073] 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.

[0074] 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.

[0075] 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 anti-parallel way is provided for avoiding that the excitation signal sTx is fed also to the Fet via its output line 31".

[0076] 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.

[0077] As it appears clearly form figure 4 the preamplifiers 3 can be mounted in form of an array of preamplifiers on a printed circuit board 4.

[0078] 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.

[0079] 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.

[0080] 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.

[0081] 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.

[0082] 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.

[0083] 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 particularly for diagnostic purposes, the ultrasound probe comprising:

   At least an array of ultrasound transducers (30) capable of transforming ultrasound waves impinging on them in electric signals and/or generating ultrasound waves by electric excitation; the array of transducers being housed in a probe casing;
   each transducer of the array being provided with at least a signal transmission line;
   each signal transmission line being connected or connectable with a conductor of a multi-channel cable; **characterised in that**
   at least part of the transducers or all of the transducers are connected with a separated preamplifier to the corresponding conductor of the multi-channel cable;

the said preamplifiers being housed inside the probe casing.

2. An ultrasound probe according to claim 1, **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 at least part of each one of which conductive tracks is a separated receipt signal feeding channel or line (31') connecting one of the integrated preamplifiers (3) with one of the transducers of the array (70.

3. An ultrasound probe according to claim 1 or 2, **characterised in that** the preamplifier (3) comprising only a tension follower together with the typical passive components for correctly driving the tension follower

4. An ultrasound probe according to claim 3, **characterised in that** a decoupling circuit comprising two antiparallel diodes is associated to each tension follower.

5. An ultrasound probe according to claim 3, **characterised in that** the tension follower consist in only a Fet component.

6. An ultrasound probe according to one or more of the preceding claims, **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).

7. An ultrasound probe according to one or more of the preceding claims, **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.

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

9. An ultrasound probe according to one or more of the preceding claims, **characterised in that** more than two arrays of preamplifiers (3) is mounted on both sides of two or more double sided printed circuit boards (4), depending on the total number of the arrays of preamplifiers.

10. An ultrasound probe according to one or more of the preceding claims, **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 arrays (301, 70) of transducers and from the other of which 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.

11. An ultrasound probe according to claim 10, **characterised in that** the printed circuit board or boards (4) are provided parallel to the sides of the probe casing which are parallel to the longer sides of the arrays of transducers (301, 70) and at the end facing the arrays of transducers the printed circuit board or boards (4) can be 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.

12. An ultrasound probe according to one or more of the preceding claims, **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.

13. An ultrasound probe according to one or more of the preceding claims, **characterised in that** the probe comprises

a first array of transducers comprising only emitting transducers (30) and being intended only for generating and transmitting the ultrasound waves;
a second array of transducers laid over the first array of emitting transducer which second array of transducers comprises receiving transducers and is intended only for generating the electric signals due to acoustic excitation of the receiving transducers of the said second array of transducers by means of the impinging or of the reflected ultrasound waves;
each array of transducers having an array of contact electrodes and

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 an electric excitation signal and that the contact 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 the electric receipt signal the said feeding lines (31, 31', 31'') for the electric excitation signals and for the electric receipt signals being separated lines or channels.

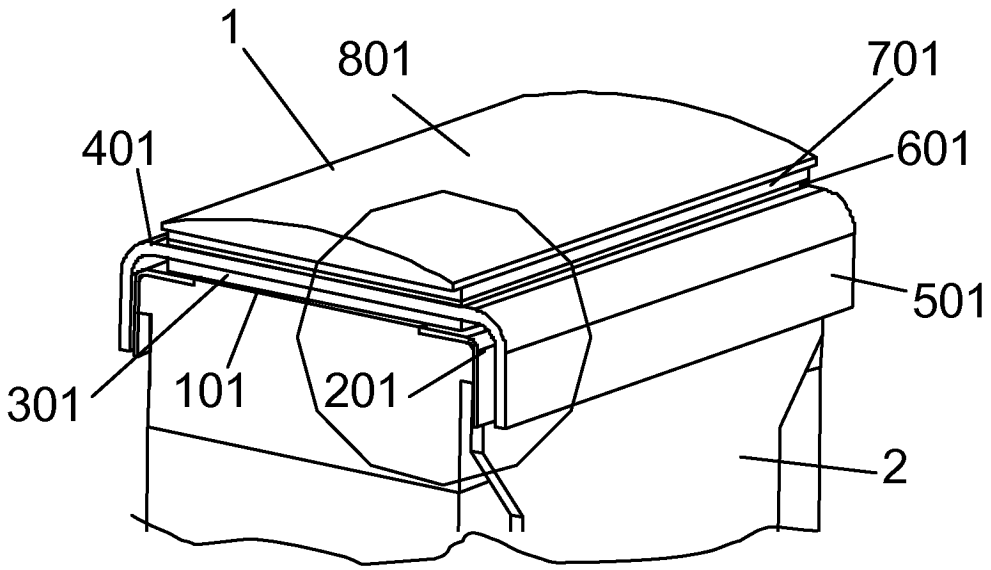

Fig. 1

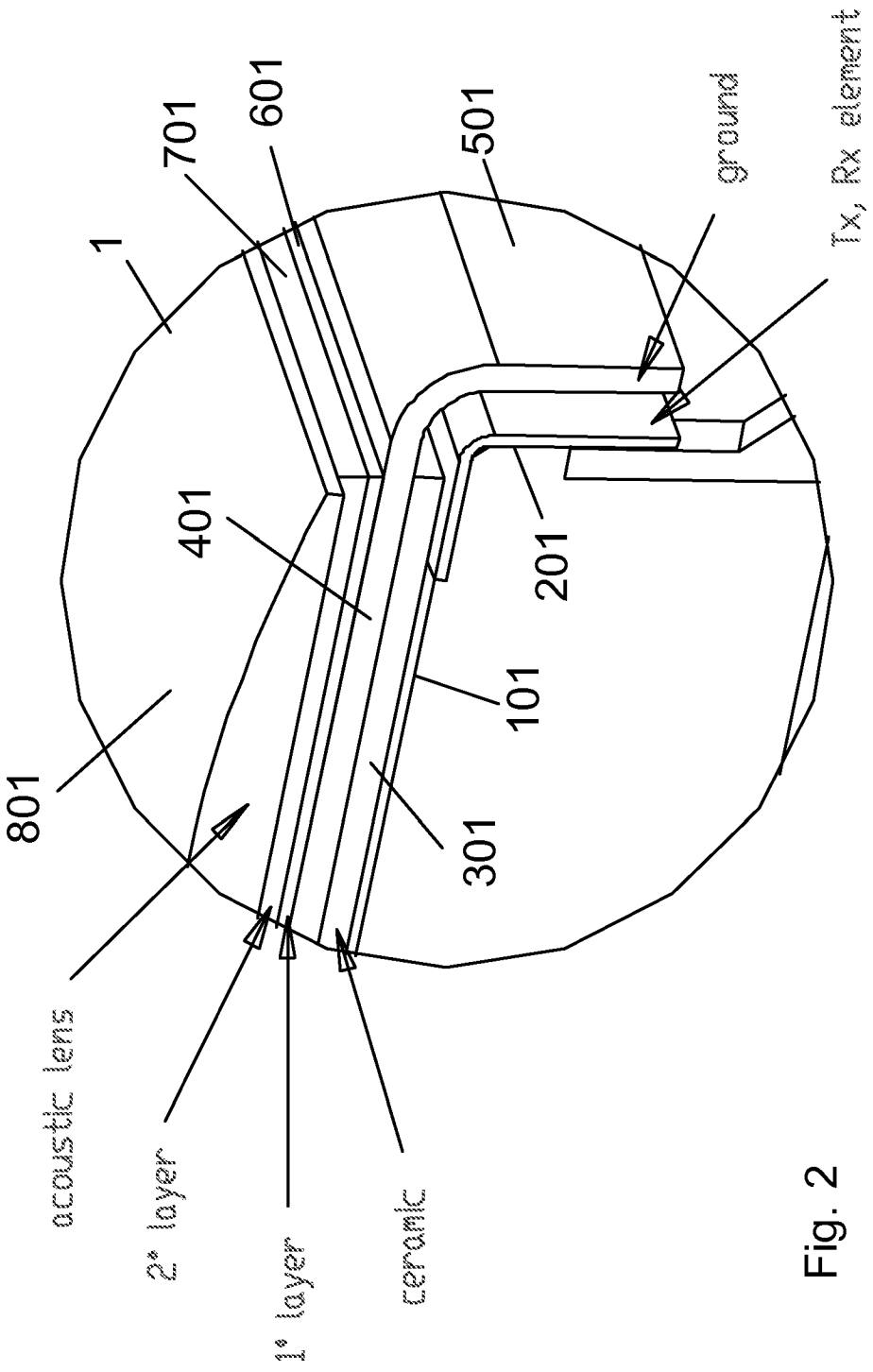
801
1
701
601
501
ground
Tx, Rx element
401
201
101
301
acoustic lens
2° layer
1° layer
ceramic

Fig. 2

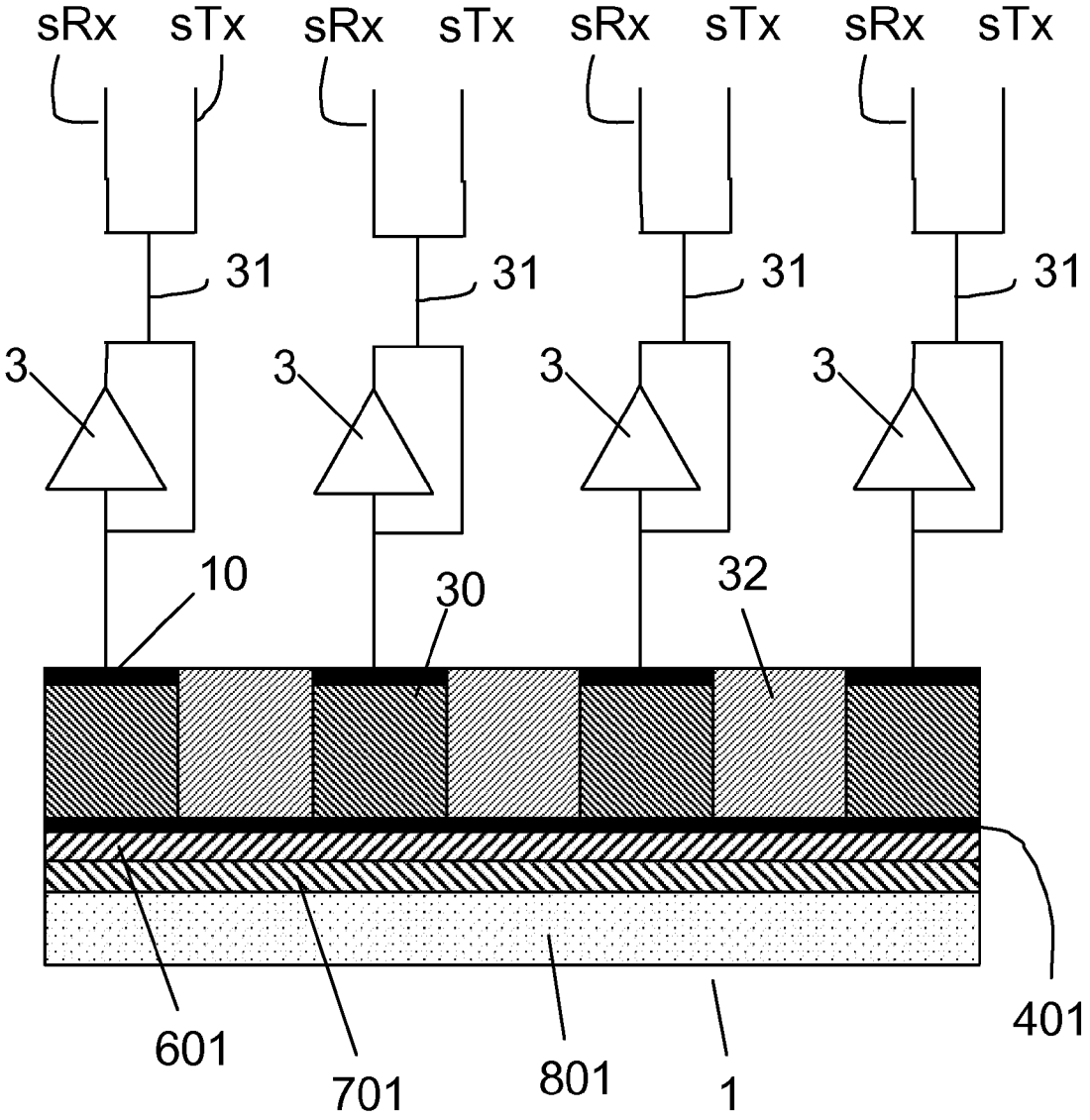
sRx
sTx
sRx
sTx
sRx
sTx
sRx
sTx
31
31
31
31
3
3
3
3
10
30
32
601
701
801
1
401

Fig. 3

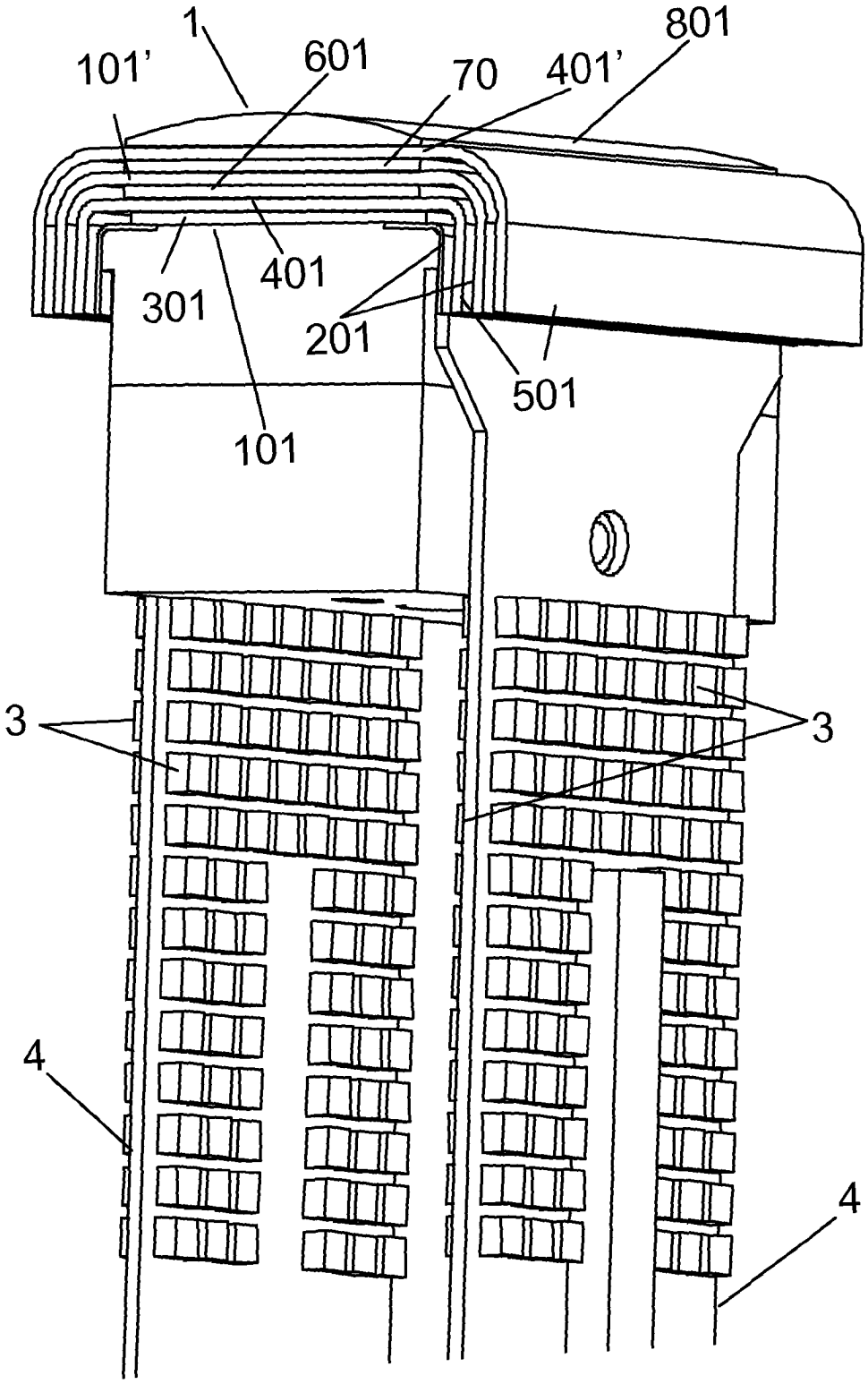

Fig. 4

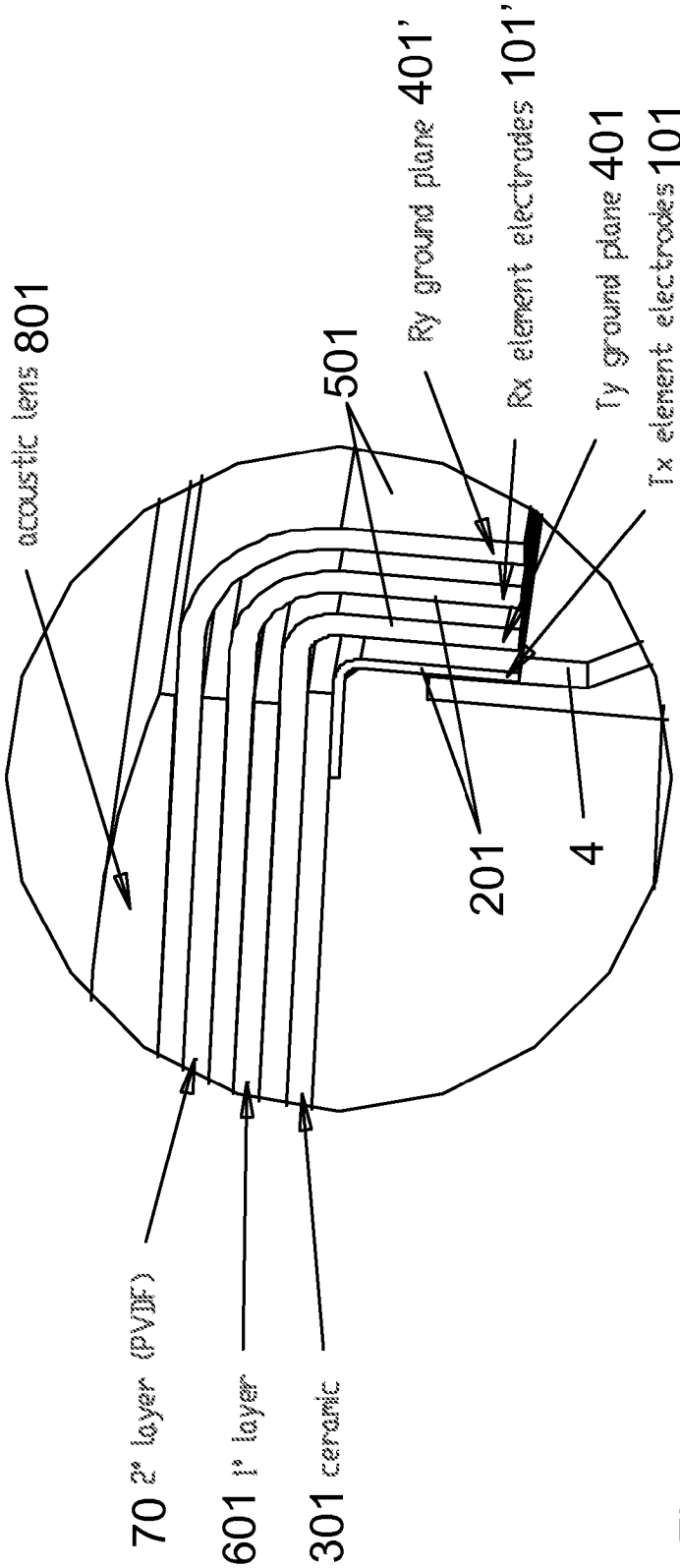
acoustic lens 801
501
Ry ground plane 401'
Rx element electrodes 101'
Ty ground plane 401
Tx element electrodes 101
201
4
70 2nd layer (PVDF)
601 1st layer
301 ceramic

Fig. 5

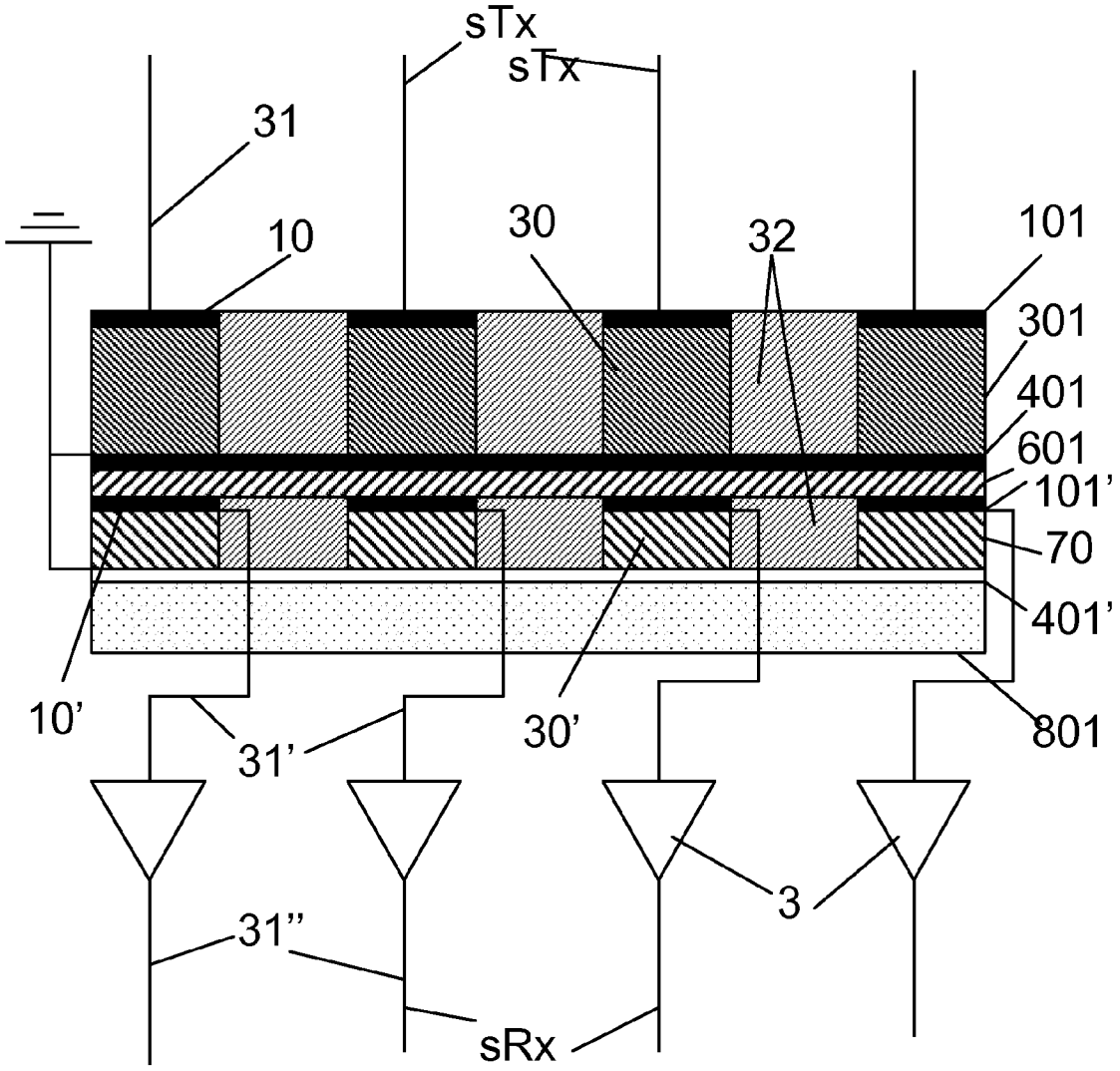

Fig. 6

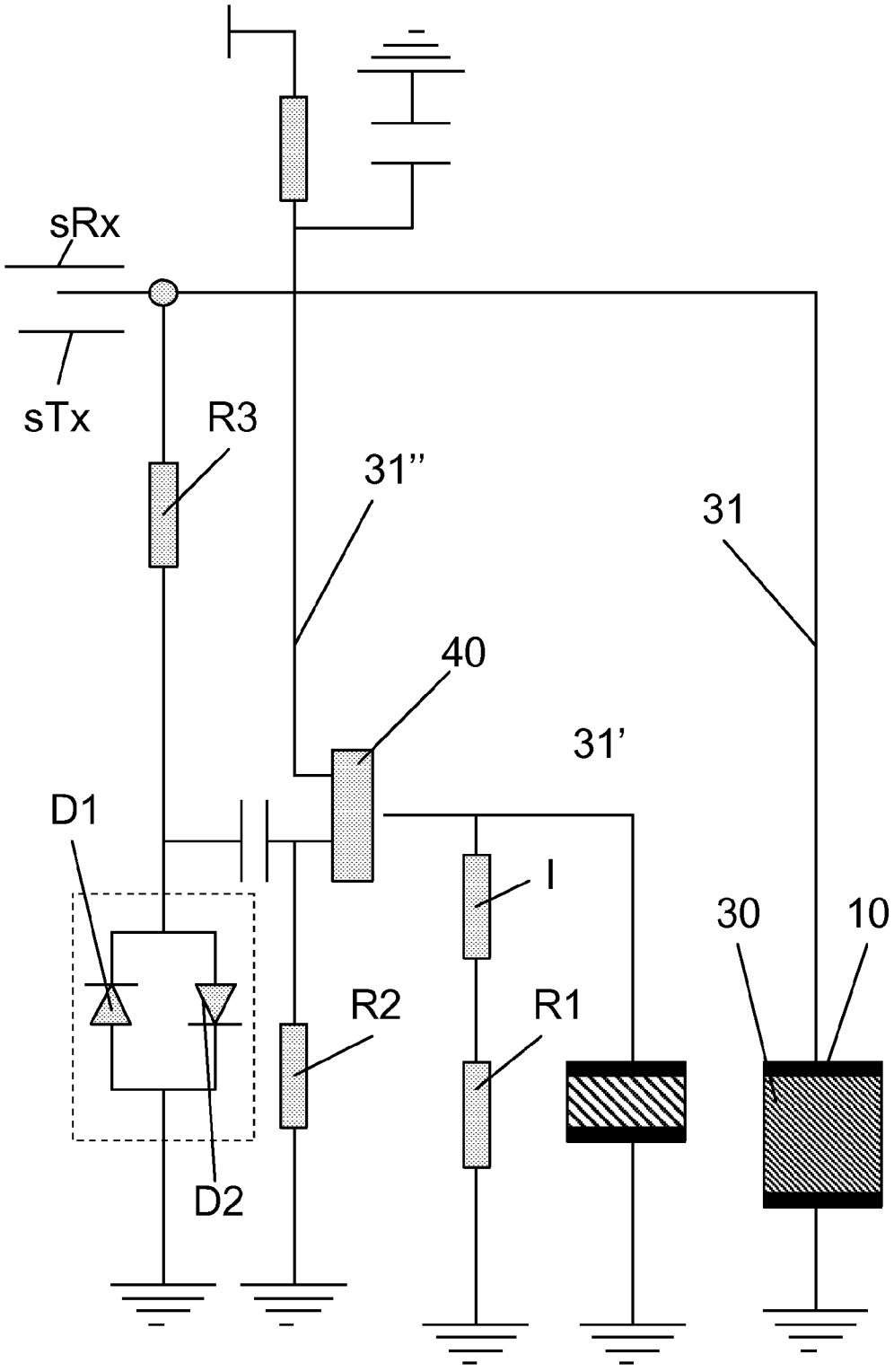

Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 11 2746

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 5 724 976 A (MINE ET AL) 10 March 1998 (1998-03-10) * column 6, line 35 - column 9, line 43; figures 1A-B * -----	1,3-5 2,7-9	INV. A61B8/00 B06B1/06 G10K11/02
Y A	US 6 645 145 B1 (DRESCHEL WILLIAM R ET AL) 11 November 2003 (2003-11-11) * column 7, line 6 - column 14, line 31; figures 2A-B,3 * -----	2,7-9 6	
A	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) * abstract * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

A61B
B06B
G10K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 September 2007	ARTIKIS, T

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
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EPO FORM 1503 03.82 (P04C01)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 11 2746

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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27-09-2007

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US 6645145 B1	11-11-2003	NONE	
JP 2000139907 A	23-05-2000	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	超声探头，特别是用于诊断成像		
公开(公告)号	EP1854413A1	公开(公告)日	2007-11-14
申请号	EP2007112746	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	EP1854413B1		
外部链接	Espacenet		

摘要(译)

特别是用于诊断目的的超声探头，超声探头包括：至少一个超声换能器阵列（30），其能够通过电激励转换在电信号上撞击它们的超声波和/或产生超声波。换能器阵列容纳在探针外壳中，并且阵列的每个换能器至少设置有信号传输线。每条信号传输线与多通道电缆的导体连接或可连接。根据本发明，至少部分换能器或所有换能器通过分离的前置放大器连接到多通道电缆的相应导体，并且所述前置放大器容纳在探头壳体内。

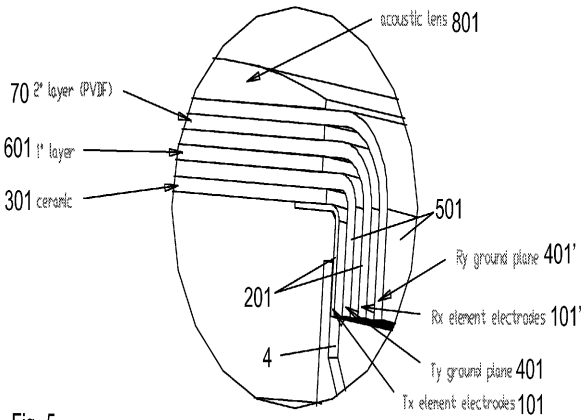

Fig. 5