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(54) **Dual mode ultrasound system**

Doppelmodus-Ultraschallwandler

Transducteur ultrasonore bi-mode

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US-A- 5 798 461 **US-A- 6 104 673**
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EP 2 237 070 B1

Description

[0001] This invention relates to ultrasound systems, and, more particularly, to dual mode ultrasound systems.

[0002] In ultrasound diagnostic imaging, ultrasonic energy is emitted into a patient's body. The reflected energy is detected and processed to form images indicating the density and boundaries of tissue and the location and velocity of blood flow within the patient. Ultrasonic signals are typically emitted from a transducer including an array of individual piezoelectric transducer elements that also serve to detect the reflected signals.

[0003] Various transducers and scanning modes may be used to emit and receive the ultrasonic signals. In phased array imaging, multiple transducer elements emit signals having a phase and amplitude relationship such that they combine to form a single beam that can be steered to scan a pie-shaped sector viewing area. Sector mode imaging is particularly useful for imaging beneath a patient's ribs inasmuch as the beams can originate from a common vertex aimed between the patient's ribs, rather than a broader aperture emitting and receiving signals that can be blocked by the ribs.

[0004] In linear array scanning, a array of transducer elements sequentially emits signals from different groups of elements and receives signals from a viewing area within a patient. Linear arrays are typically used in applications requiring a wide view of a region close to the skin surface, and where acoustic access to the region of interest is not obstructed. Linear arrays are either flat or curved. A flat linear array provides a rectangular or trapezoidal field of view, while a curved linear provides a field of view that fans out due to the curvature of the array.

[0005] In practice, a technician will often need to have multiple transducers in order to adequately image different anatomies of a patient, which increases the cost of the ultrasound system. The technician will also need to switch the system operation from one transducer to another, which takes time. Inasmuch as transducers are used with a sound-conducting gel applied to the patient, each transducer therefore needs to be cleaned after use, requiring more time.

[0006] In view of the foregoing, it would be advantageous to provide an ultrasound transducer suitable for performing both sector and curved linear array scanning.

[0007] In accordance with the principles of the present invention, an ultrasound system includes a transducer having a face with a central portion and lateral portions on either side of the central portion. A first plurality of transducer elements are disposed on the central portion and a second plurality of transducer elements disposed on the lateral portions. The first plurality of transducer elements have a first, fine pitch for sector mode and the second plurality of transducer elements have a second, coarser pitch for linear mode. The array can be either curved or planar.

[0008] In sector mode, a beamformer is coupled to operate the transducer elements of the first plurality for phased array imaging. In linear mode, the beamformer is coupled to operate the transducer elements of both groups. In accordance with a further aspect of the present invention, pairs of adjacent transducers of the first plurality may be operated in tandem so that the transducer will exhibit a common element pitch over the full operable aperture.

[0009] Patent application US 6106472 discloses a portable ultrasound imaging system includes a scan head coupled by a cable to a portable battery-powered data processor and display unit. The scan head enclosure houses an array of ultrasonic transducers and the circuitry associated therewith, including pulse synchronizer circuitry used in the transmit mode for transmission of ultrasonic pulses and beam forming circuitry used in the receive mode to dynamically focus reflected ultrasonic signals returning from the region of interest being imaged.

[0010] Patent application US 6 104673 discloses a digital transmit beamformer system with multiple beam transmit capability has a plurality of multi-channel transmitters, each channel with a source of sampled, complex-valued initial waveform information representative of the ultimate desired waveform to be applied to one or more corresponding transducer elements for each beam. Each multi-channel transmitter applies beamformation delays and apodization to each channel's respective initial waveform information digitally, digitally modulates the information by a carrier frequency, and interpolates the information to the DAC sample rate for conversion to an analog signal and application to the associated transducer element(s). The beamformer transmitters can be programmed per channel and per beam with carrier frequency, delay, apodization and calibration values. For pulsed wave operation, pulse waveform parameters can be specified to the beamformer transmitters on a per firing basis, without degrading the scan frame rate to non-useful diagnostic levels. Waveform parameters can be specified to the transmitters by an external central control system which is responsible for higher level flexibility, such as scan formats, focusing depths and fields of view. The transmit pulse delay specified per-channel to each transmitter is applied in at least two components: a focusing time delay component and a focusing phase component. The carrier frequency can be specified for each transmit beam, to any desired frequency within a substantially continuous predefined range of frequencies, and a beam-interleaved signal processing path permits operation in any of several predefined processing modes, which define different parameter sets in a trade-off among (1) the number of beams produced; (2) per-beam initial waveform sample interval; and (3) transmit frequency.

[0011] Patent application US 2006/058672 discloses a single transducer, such as a phased array transducer, is provided for various imaging situations with limited loss of resolution and/or penetration. The transducer includes different groups of elements, such as a center group with a fine pitch and outer groups with a larger pitch. The difference in pitch allows for an increased lateral extent of the array, and the fine pitched grouping allows for higher resolution and higher frequency imaging. The same transducer can be used for different imaging situations, such as for neonate imaging as well as imaging 140 pound adults. The difference in pitch also allows for the use of ultrasound imaging systems or beamformers with a limited number of channels even with the total lateral extent provided by the transducer array.

[0012] In another aspect of the invention, the number of transducer elements of the first plurality that are activated in sector mode is varied according to the number of transducer elements in contact with the patient's skin.

[0013] In another aspect of the invention, a mode selection switch is provided enabling a user to switch between linear and sector modes.

Figure 1 is a block diagram of an ultrasound system in accordance with an embodiment of the present invention.

Figures 2A and 2B are schematic diagram of a transducer face in accordance with an embodiment of the present invention.

Figure 3 is a schematic block diagram of an alternative embodiment of an ultrasound system in accordance with an embodiment of the present invention.

Figures 4A and 4B are schematic diagrams of control lines coupled to transducer elements in accordance with an embodiment of the present invention.

Figure 5A and 5B are schematic diagrams of a switch matrix coupling control lines to transducer elements in accordance with an embodiment of the present invention.

Figure 6 is a process flow diagram of a method for using a dual mode transducer in accordance with an embodiment of the present invention.

Figure 7 is a schematic diagram of a curved transducer engaging a patient's skin in accordance with an embodiment of the present invention.

Figure 8 is a schematic diagram of a switch matrix enabling a variable transducer aperture in accordance with an embodiment of the present invention.

Figure 9 is a process flow diagram of a method for using a transducer having a variable aperture in accordance with an embodiment of the present invention.

[0014] Referring to Figure 1, an ultrasound system 10 includes a transducer 12 having a number of transducer elements suitable for transmitting ultrasonic signals into a patient and receiving echo signals. The transducer elements are preferably piezoelectric transducer elements. The transducer 12 is coupled to a beamformer 16 which is controlled by a beamformer controller 18. The beamformer 16 controls the phase and amplitude of excitation signals applied to the elements of the transducer 12 to create ultrasound beams scanning a viewing area within a patient. The beamformer 16 also relatively delays the phase of signals received by the transducer elements to bring the signals into phase coherence and then sums them. In the illustrated embodiment, a mode selector switch 20 is coupled to the beamformer controller 18 so that the user can set the beamformer operation for scanning with the transducer 12 in a sector mode, linear mode, and other operational modes. In other embodiments the mode selector switch 20' is located on the case of the transducer. In yet other embodiments, the mode selector switch is provided by a graphical user interface coupled to the beamformer controller 18.

[0015] The output of the beamformer 16 is filtered to extract information from the echo signal. In the illustrated embodiment, a quadrature bandpass filter 22 is used. The output of the filter 22 is provided to one or both of a B-mode processor 24 and a Doppler processor 26. The B-mode processor 24 processes the data to produce information regarding the structure of the tissue that reflected the excitation signal. The Doppler processor 26 processes the data to extract information regarding the velocity of blood flow within the viewing area. Data provided to the Doppler processor 26 may be stored in an ensemble store 28 before being processed by the Doppler processor 26 until sufficient samples of the viewing area have been acquired to form a Doppler image. The outputs of the B-mode processor 24 and Doppler processor 26 are provided to an image processor 30 that creates B-mode and Doppler images of the desired image format, which are then displayed on a display 32.

[0016] Referring to Figures 2A and 2B, the transducer 12 has a face 34 that is convex, having a center of curvature 36 located behind the face 34 and having a plurality of transducer elements 38 distributed along the face 34. The transducer elements 38 located on a central portion 40 of the face 34 have a first pitch 42 and the transducer elements 38 located on lateral portions 44 on either side of the central portion 40 have a second pitch 46 that is greater than the first pitch. In a preferred embodiment, the second pitch 46 is twice the first pitch 42. The combined number of transducer elements 38 on the lateral portions 44 may be equal to one half the number of transducer elements 38 on the central portion 40. The different pitches in the central portion 40 and the lateral portions 44 may be obtained by dicing a piezoelectric crystal at different lateral increments along the face 38.

[0017] The transducer elements emit an ultrasound wave with a wavelength λ. The first pitch 42 may be less than or about equal to V2 whereas the second pitch 46 is less than or about equal to λ. The different pitches 42, 46 facilitate use of the transducer 12 to perform different types of ultrasound scans.

[0018] Referring specifically to Figure 2A, in a linear scanning mode, the transducer elements 38 are activated sequentially to emit ultrasound beams 48 normal to the face 34. In the linear mode, the transducer elements 38 in the central portion 40 are preferably excited in pairs 50 such that the angular distribution of ultrasound beams 48 is constant.

[0019] Referring specifically to Figure 2B, in a phased array beam-steering mode, the excitation signals applied to the fmer pitched elements 38 have phases and amplitudes chosen such that the ultrasound signals emitted from the elements 38 combine to form a focused beam 52 during each transmission. The-phases and amplitudes are varied to change the angle of each beam 52 and perform a sector scan of the viewing area. In the illustrated embodiment, the beams 52 extent from an apex 54 located at the face 34 of the transducer. However, the apex 54 may be located at other positions by changing the steering angle, such as in front or behind the face 34. Only the transducer elements 38 of the central portion 40 are used to generate the beams 52 in the beam-steering mode. The finer pitch 42 in the central portion 40 advantageously allows for a greater range of steering angles as compared to a larger pitch without creating grating or significant side lobes or other artifacts that degrade image quality.

[0020] Referring to the embodiment of Figure 3, a switch matrix 56 is interposed between the beamformer 16 and the elements of transducer 12. The switch matrix 56 changes the coupling between signal lines of the beamformer 16 and the transducer elements 38 of the transducer 12 according to a mode selected by the operator. In an alternative embodiment, the signals applied to the transducer elements 38 are controlled programmatically to switch between modes, such as by the beamformer controller 18, without changing the coupling between the beamformer 16 and the transducer elements 38.

[0021] For example, referring to Figures 4A, the switch matrix 56 may couple control lines 58 from the beamformer 16 to individual transducer elements 38 of the central portion 40 in the sector mode. Referring to Figure 4B, in the linear mode, the switch matrix 56 couples the control lines 58 to the transducer elements 38 of the lateral portions 44 and to pairs 50 of transducer elements 38 in the central portion 40. In the embodiment of Figures 4A and 4B, the number of control lines 58 is less than the total number of transducer elements 38. In the illustrated embodiment, the number of control lines 58 is equal to the number of transducer elements 38 in the central portion, which is two thirds of the total number of transducer elements 38. In other embodiments, the number of control lines is equal to the total number of transducer elements 38. In some embodiments, 128 control lines 58 are used. Accordingly, the transducer 12 may include 128 transducer elements 38 in the central portion 40 and 32 transducer elements per lateral portion 44 for a total of 64 located in the lateral portions.

[0022] Referring to Figures 5A and 5B, in this embodiment the control lines 58 are coupled to the transducer elements 38 as illustrated. The illustrated coupling between the control lines 58 and the transducer elements 38 may be described mathematically by assigning each control line 58 a number (n) and assigning each transducer element 38 a number (i) corresponding to their position relative to the center 60 of the transducer 12. In sector mode, each control line n is coupled to transducer i=n of the central portion 40, as shown in Figure 5A. In linear mode, each control line n is coupled to two transducer elements i=2n-1 and i=2n in the central portion 40 and transducer element i=N/2+n in the lateral portions 44, where N is equal to one half of the number of transducer elements 38 in the central portion 40, as shown in Figure 5B.

[0023] Stated differently, each transducer element i in the central portion is coupled to control line n=i in sector mode and control line n=i - INT(i/2) in linear mode, where the INT( ) function returns the integer portion of its operand. Where i is equal to one, i - INT(i/2) is equal to one. Accordingly, transducer elements i=1 are coupled to control line n=1 in both sector and linear modes and no switching is needed. The remaining transducer elements i+1 to N of the central portion 40 are each coupled to the control lines 58 by two switches 62a, 62b, only one of which is closed at a time. Switch 62a is closed in the sector mode and couples transducer element i to control line n=i as shown in Figure 5A. Switch 62b is closed in linear mode and couples transducer element i to control line n=i-INT(i/2), as shown in Figure 5B. Switches 64 couple the transducer elements 38 of the lateral portions 44 to the control lines n=N+1 to n=N+M in linear mode, where M is the number of transducer elements 38 in an individual lateral portion 44. The switches 64 are closed in the linear mode and open in the sector mode.

[0024] Referring to Figure 6, a method 66 for performing ultrasound scans may include coupling control lines to the transducer elements 38 of a central portion 40 of a transducer 12 at step 68. At step 70, one or more sector scans of a viewing area within a patient 14 are performed using the ultrasound system 10. At step 72, a user mode selection input is received from the user by means of a mode selection switch 20, graphical user interface, or other input means.

[0025] Where the mode selection input indicates selection of a linear scanning mode, the method 66 includes coupling pairs of transducer elements 38 of the central portion 40 to a portion of the control lines at step 74. At step 76, another portion of the control lines are coupled to the transducer elements 38 of the lateral portions 44. At step 78, a linear scan is performed. The steps of the method 66 may be reordered such that a user mode selection input indicating a sector mode causes the ultrasound system 10 to execute steps 68 and 70.

[0026] In order to properly image a viewing area within a patient 14, it is typically necessary to reduce air gaps between the transducer 12 and the patient's skin. This is typically accomplished by placing a sound-conducting gel on the patient's skin in order to fill gaps and provide a good sound-conducting layer between the transducer 12 and the patient's skin. When the front face 34 is convex, not all of the transducer elements 38 may adequately contact the patient's skin or the sound-conducting gel in some uses. For example, when imaging through a patient's ribs, the ribs may not allow the transducer 12 to be pressed into the patient 14 sufficient to make good contact with all of the transducer elements of the central portion 40. Accordingly, in some embodiments, the number of transducer elements 38 within the central portion 40 that are activated in sector mode may be reduced according to the number of transducer elements 38 in contact with the patient's skin or the sound-conducting gel.

[0027] Thus, as shown in Figure 7, where a first area 80 of the central portion 40 makes adequate contact with the patient's skin 82 then the transducer elements 38 within the area 80 will be activated to produce the steered beam. Where a smaller area 84 contacts the patient's skin 82', only the transducer elements 38 of the smaller area 84 are activated.

[0028] Referring to Figure 8, reducing the number of transducer elements 38 used in sector mode may include opening some of the outermost switches 62a in sector mode, as illustrated, such that the outer transducers 38 of the central portion 40 are not coupled to the beamformer 16.

[0029] Referring to Figure 9, a method 86 for accommodating different patient skin compliance may include performing an initial scan at step 88. In some embodiments, the initial scan includes sequentially emitting from each transducer element 38 such that an echo signal can be readily associated with each transducer element. At step 90, the output of the transducer elements 38 are analyzed to determine which of the transducer elements are not adequately engaged with the patient 14 or sound-conducting gel. Determining which of the transducer elements is not adequately engaged may include analyzing the echo signal received for each transducer element 38 and comparing the intensity of the reflected signal to a threshold to determine if adequate sound reception is occurring. At step 92, transducer elements 38 for which no signal or a below-threshold echo signal are received are identified as not adequately engaging the patient 14 or the sound-conducting gel. The identifying step 92 may be performed automatically or by an operator presented with an ultrasound image representing the echo signals from the initial scan. At step 94, the transducer elements 38 identified as not adequately engaging the patient or the sound-conducting gel are decoupled from the beamformer 16, reducing the active aperture for this scan. The decoupling step of step 94 may be performed automatically or by an operator. For example, an operator may turn a dial or interact with a graphical user interface element to indicate to the beamformer controller 18 which transducer elements 38 are to be decoupled or used in the active aperture. As an alternative to step 94, the beamformer 16 may be programmed to refrain from using signals in beamforming from elements identified as being inadequately acoustically coupled to the patient, rather than decoupling them from control lines. At step 96, one or more beam steered scans of the patient 14 is performed using the transducer elements 38 that are adequately acoustically coupled to the patient 14.

Claims

1. An ultrasound system, comprising:

   - a mode selection switch (20) operable to select either a linear mode of scanning or a sector mode of scanning;
   - an ultrasound transducer (12) including a curved array of transducer elements having a front face having a central portion and lateral portions on either side of the central portion, the transducer elements of the central portion having a finer pitch than the transducer elements of the lateral portions, and
   - a beamformer (16), responsive to the mode selection switch and coupled to the elements of the curved array, and operable in the linear mode to cause the central and lateral portions of the curved array to transmit and receive beams normal to the face of the array, and operable in the sector mode to cause only the central portion of the curved array to transmit and receive phased array beams emanating from a common apex.

2. The ultrasound system of claim 1 wherein in the linear mode the curved array is operated as a linear array.

3. The ultrasound system of claim 2 wherein, in the linear mode, an active aperture for each beam is shifted along the face of the array from beam to beam, and in the sector mode, the same active aperture of transducer elements is used for phased array beam steering of each beam.

4. The ultrasound system of claim 1 wherein, in the sector mode, the signals from elements which are not acoustically coupled to a patient do not participate in beam formation.

5. The ultrasound system of claim 4, wherein elements which are not acoustically coupled to a patient are identified by comparing echo signals received by transducer elements to a threshold.

6. The ultrasound system of claim 4 further comprising an aperture control for adjusting the elements which contribute to the active aperture of the transducer.

7. The ultrasound system of claim 1 wherein, in the linear mode, the transducer elements of the central portion are operated in pairs.

Patentansprüche

1. Ultraschallsystem mit:

- einem Moduswahlschalter (20), der so funktioniert, dass er entweder einen Modus der linearen Abtastung oder einen Modus der Sektorabtastung auswählt,
- einen Ultraschallkopf (12), der ein konvexes Array mit Wandlerelementen umfasst, dessen Vorderseite aus einem mittleren Teilstück und seitlichen Teilstücken auf beiden Seiten des mittleren Teilstücks besteht, wobei die Wandlerelemente des mittleren Teilstücks einen geringeren Rasterabstand aufweisen als die Wandlerelemente der seitlichen Teilstükke, und
- einen Strahlformer (16), der auf den Moduswahlschalter reagiert und mit den Elementen des konvexen Arrays gekoppelt ist und der im linearen Modus derart funktioniert, dass er das mittlere und die seitlichen Teilstücke des konvexen Arrays veranlasst, Schallstrahlen senkrecht zur Vorderseite der Matrix zu senden und zu empfangen, und im Sektormodus derart funktioniert, dass er nur das mittlere Teilstück des konvexen Arrays veranlasst, Sektorstrahlen zu senden und zu empfangen, die von einem gemeinsamen Apex ausgehen.

2. Ultraschallsystem nach Anspruch 1, wobei das konvexe Array im linearen Modus als lineares Array betrieben wird.

3. Ultraschallsystem nach Anspruch 2, wobei im linearen Modus für jeden Schallstrahl eine aktive Apertur längs der Vorderseite des Arrays von Strahl zu Strahl verschoben wird und im Sektormodus die gleiche aktive Apertur mit Wandlerelementen für die Phasensteuerung jedes Strahls verwendet wird.

4. Ultraschallsystem nach Anspruch 1, wobei im Sektormodus die Signale von den Elementen, die nicht akustisch an einen Patienten gekoppelt sind, nicht an der Formung des Schallstrahls beteiligt sind.

5. Ultraschallsystem nach Anspruch 4, wobei die Elemente, die nicht akustisch an einen Patienten gekoppelt sind, durch Vergleichen der von den Wandlerelementen empfangenen Echosignale mit einem Schwellenwert identifiziert werden.

6. Ultraschallsystem nach Anspruch 4, das ferner eine Apertursteuerung zum Anpassen der Elemente, die zur aktiven Apertur des Wandlers beitragen, umfasst.

7. Ultraschallsystem nach Anspruch 1, wobei im linearen Modus die Wandlerelemente des mittleren Teilstücks paarweise betrieben werden.

Revendications

1. Système à ultrasons, comprenant :

- un interrupteur de sélection de mode (20) pouvant être actionné pour sélectionner soit un mode linéaire de balayage soit un mode sectoriel de balayage ;
- un transducteur à ultrasons (12) comprenant un réseau courbe d'éléments transducteurs ayant une face avant ayant une partie centrale et des parties latérales de chaque côté de la partie centrale, les éléments transducteurs de la partie centrale ayant un pas plus petit que les éléments transducteurs des parties latérales, et
- un formeur de faisceaux (16), réagissant à l'interrupteur de sélection de mode et couplé aux éléments du réseau courbe, et pouvant être actionné en mode linéaire pour provoquer la transmission et la réception de faisceaux perpendiculaires à la face du réseau par les parties centrale et latérales du réseau courbe et pouvant être actionné en mode sectoriel pour provoquer la transmission et la réception de faisceaux de réseau à commande de phase émanant d'un sommet commun par la seule partie centrale du réseau courbe.

2. Système à ultrasons selon la revendication 1, dans lequel en mode linéaire, le réseau courbe fonctionne comme un réseau linéaire.

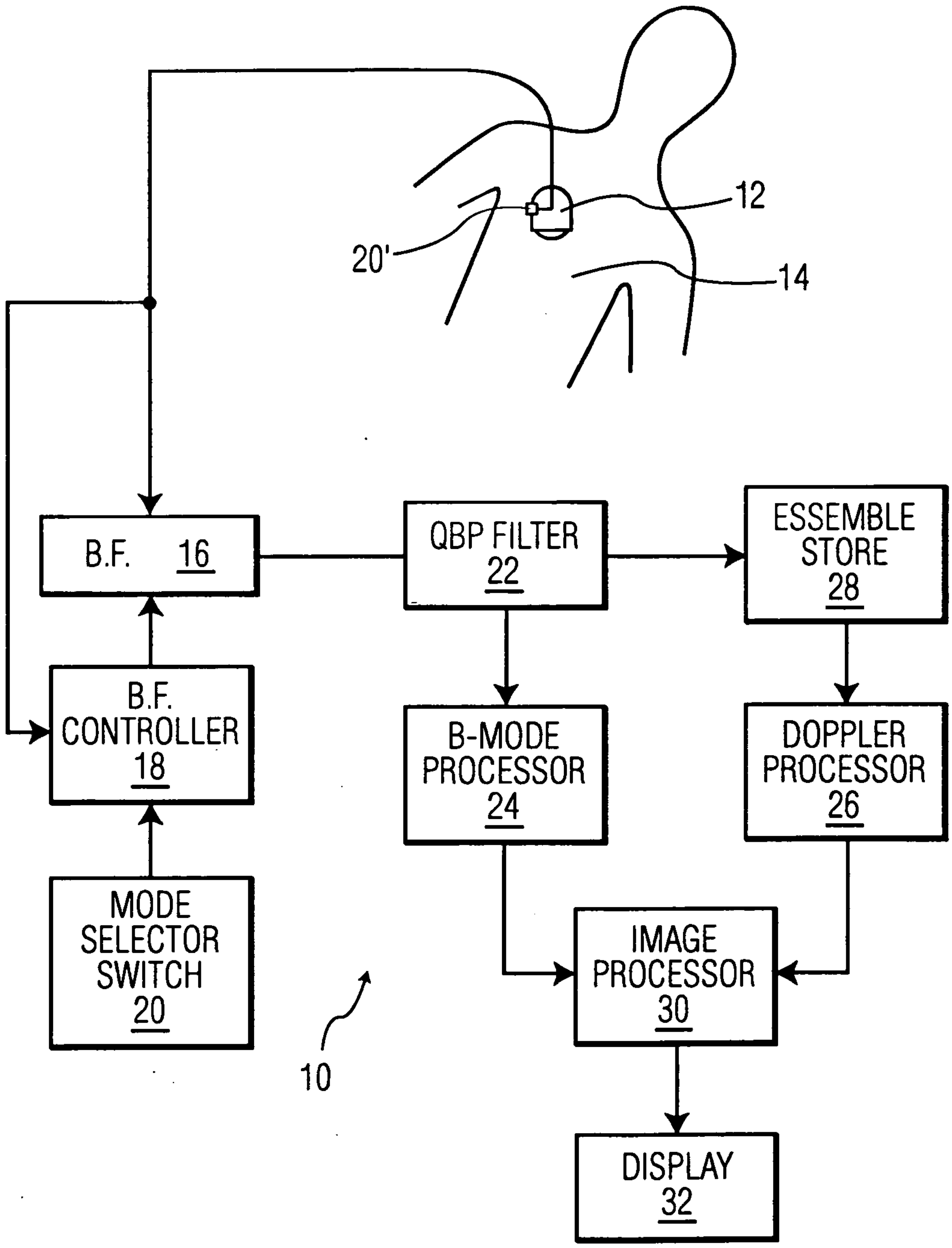
3. Système à ultrasons selon la revendication 2, dans lequel en mode linéaire, une ouverture active pour chaque faisceau est déplacée le long de la face du réseau de faisceau à faisceau, et en mode sectoriel, la même ouverture active d'éléments transducteurs est utilisée pour la commande de faisceau de réseau à commande de phase de chaque faisceau.

4. Système à ultrasons selon la revendication 1, dans lequel en mode sectoriel, les signaux provenant d'éléments qui ne sont pas couplés de manière acoustique à un patient ne participent pas à la formation de faisceaux.

5. Système à ultrasons selon la revendication 4, dans lequel des éléments qui ne sont pas couplés de manière acoustique à un patient sont identifiés par comparaison de signaux d'écho reçus par des éléments transducteurs à un seuil.

6. Système à ultrasons selon la revendication 4, comprenant en outre une commande d'ouverture permettant d'ajuster les éléments qui contribuent à l'ouverture active du transducteur.

7. Système à ultrasons selon la revendication 1, dans lequel en mode linéaire, les éléments transducteurs de la partie centrale fonctionnent par paires.



12
20'
14
B.F. 16
QBP FILTER 22
ESSEMBLE STORE 28
B.F. CONTROLLER 18
B-MODE PROCESSOR 24
DOPPLER PROCESSOR 26
MODE SELECTOR SWITCH 20
IMAGE PROCESSOR 30
10
DISPLAY 32

FIG. 1

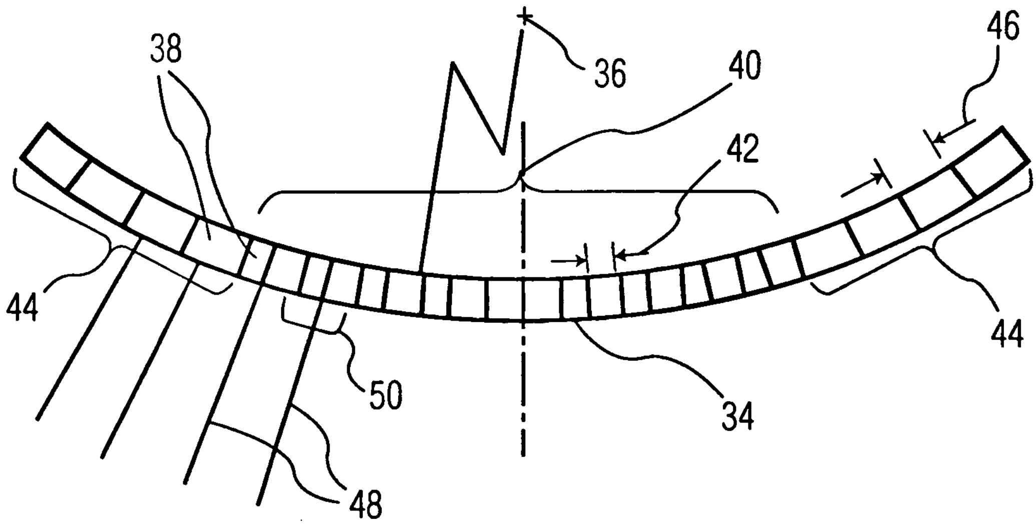


FIG. 2A

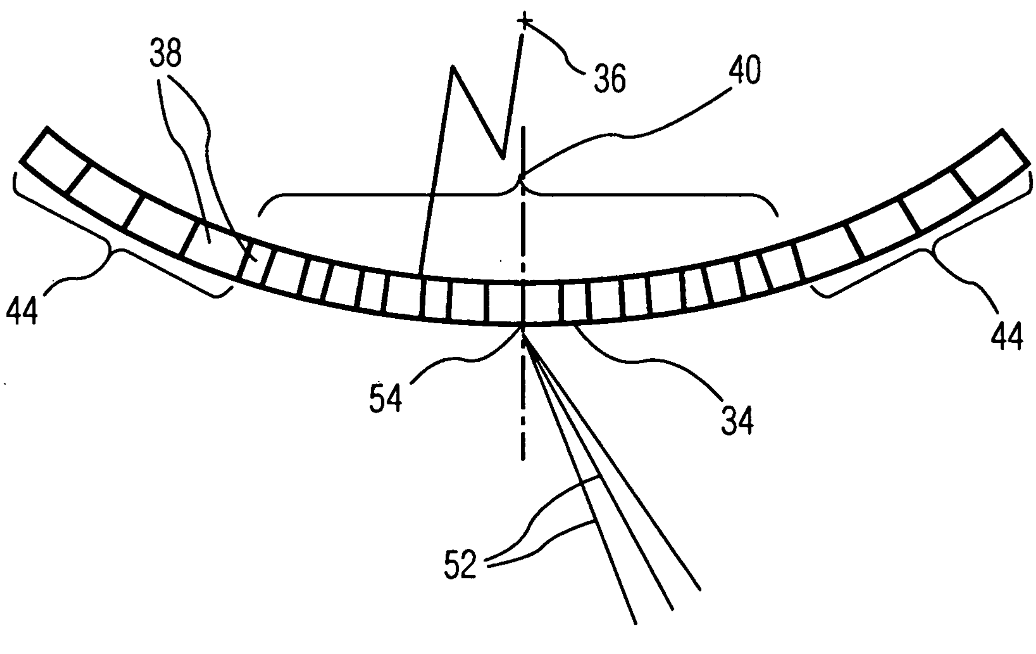


FIG. 2B

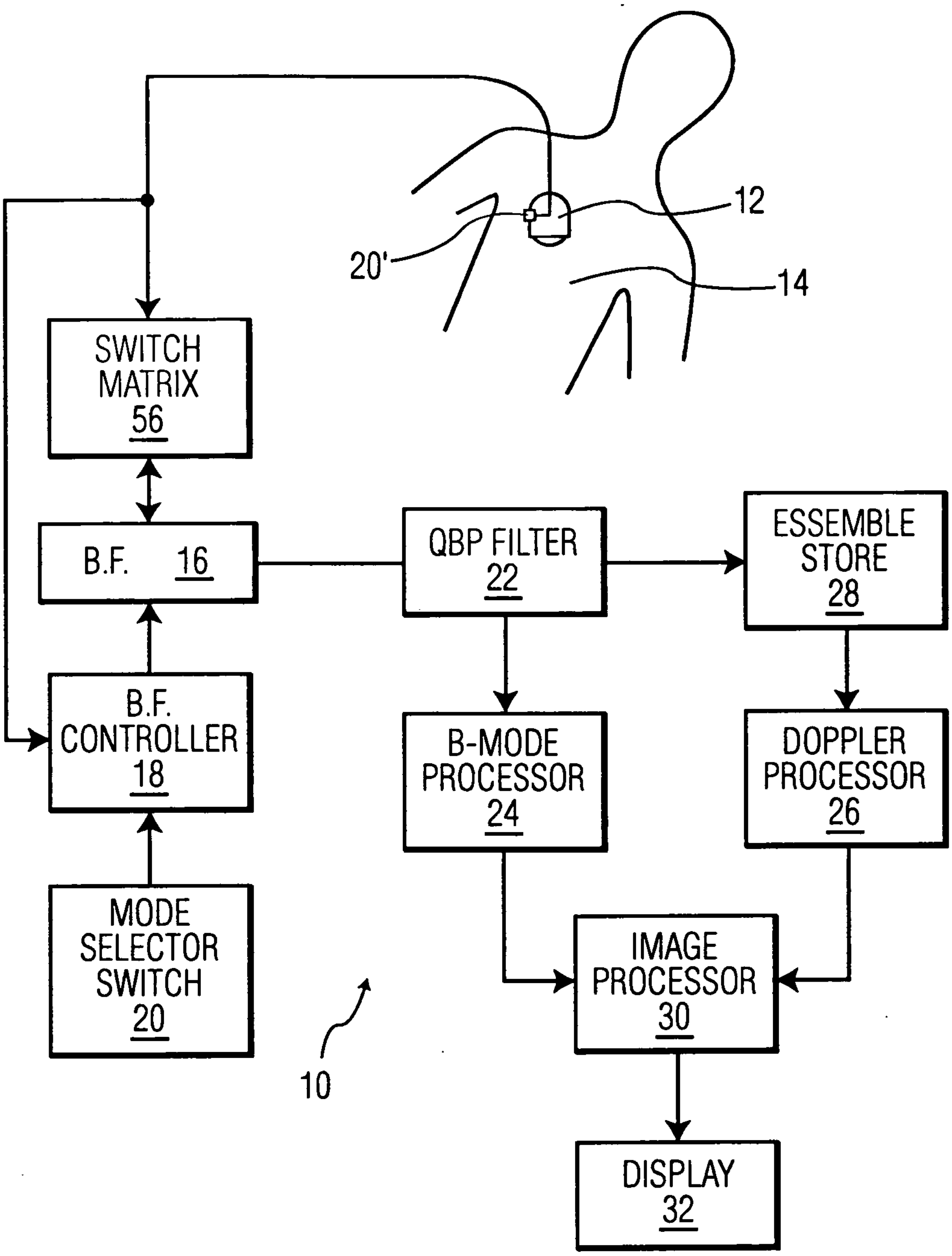

12
14
20'
SWITCH MATRIX 56
B.F. 16
B.F. CONTROLLER 18
MODE SELECTOR SWITCH 20
QBP FILTER 22
ESSEMBLE STORE 28
B-MODE PROCESSOR 24
DOPPLER PROCESSOR 26
IMAGE PROCESSOR 30
DISPLAY 32
10

FIG. 3

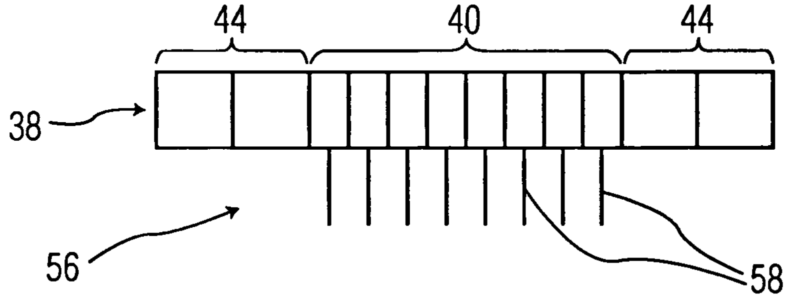


FIG. 4A

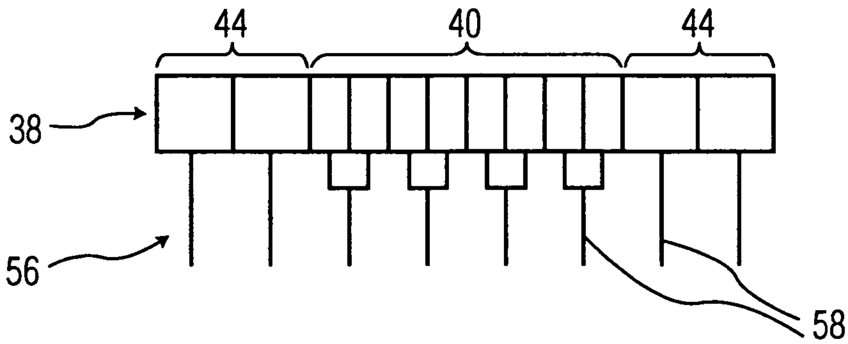


FIG. 4B

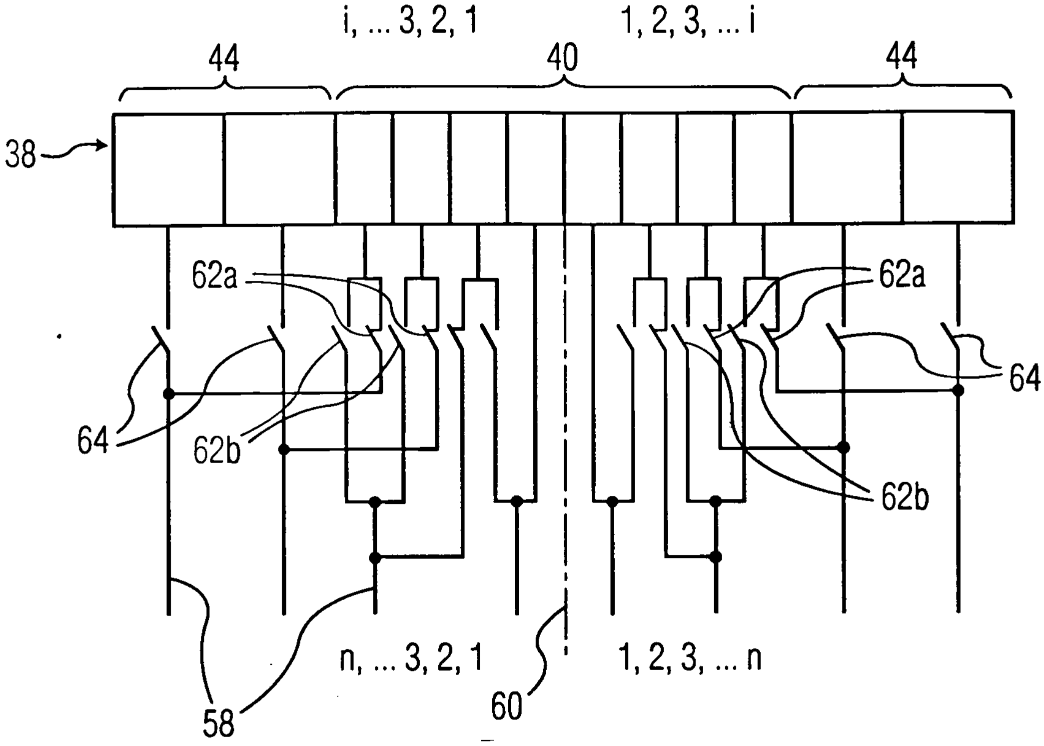
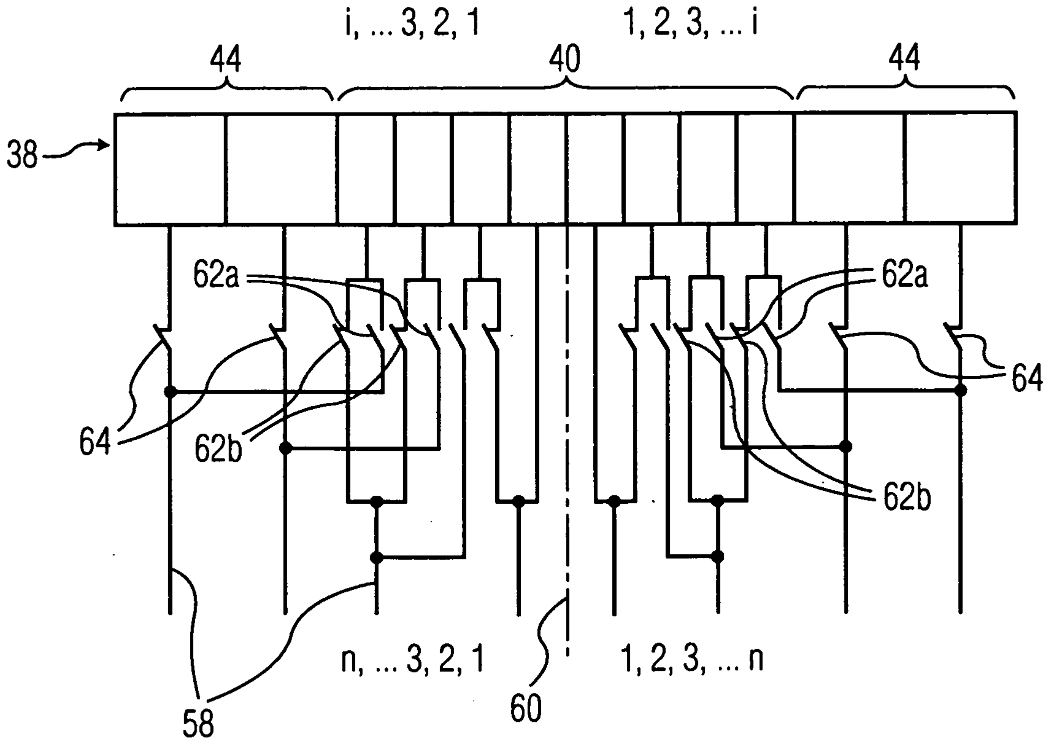

i, ... 3, 2, 1
1, 2, 3, ... i
44
40
44
38
62a
62a
64
64
62b
62b
n, ... 3, 2, 1
1, 2, 3, ... n
58
60

FIG. 5A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58
60

FIG. 5B

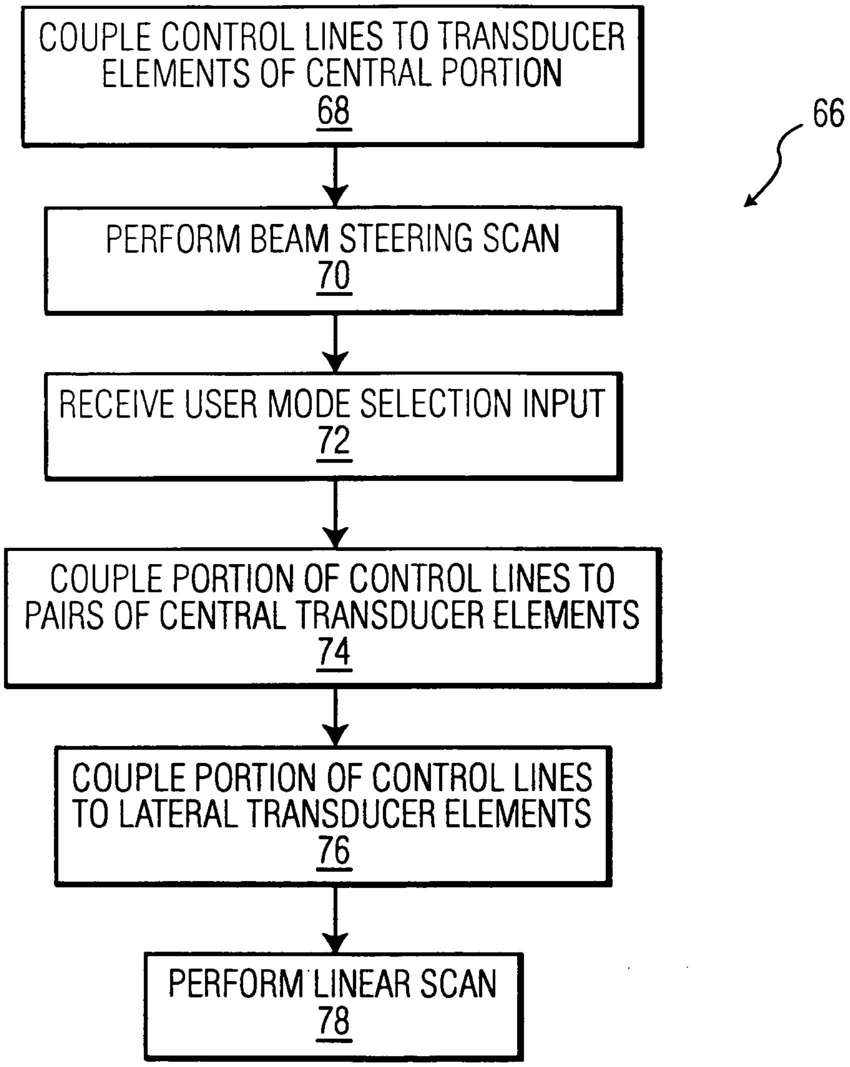
COUPLE CONTROL LINES TO TRANSDUCER ELEMENTS OF CENTRAL PORTION
68
PERFORM BEAM STEERING SCAN
70
RECEIVE USER MODE SELECTION INPUT
72
COUPLE PORTION OF CONTROL LINES TO PAIRS OF CENTRAL TRANSDUCER ELEMENTS
74
COUPLE PORTION OF CONTROL LINES TO LATERAL TRANSDUCER ELEMENTS
76
PERFORM LINEAR SCAN
78
66

FIG. 6

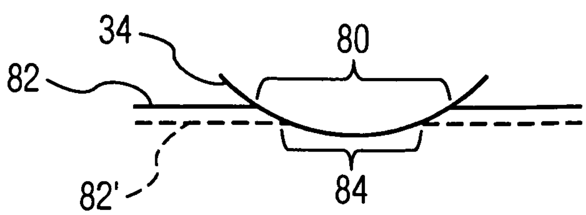
34
80
82
82'
84

FIG. 7

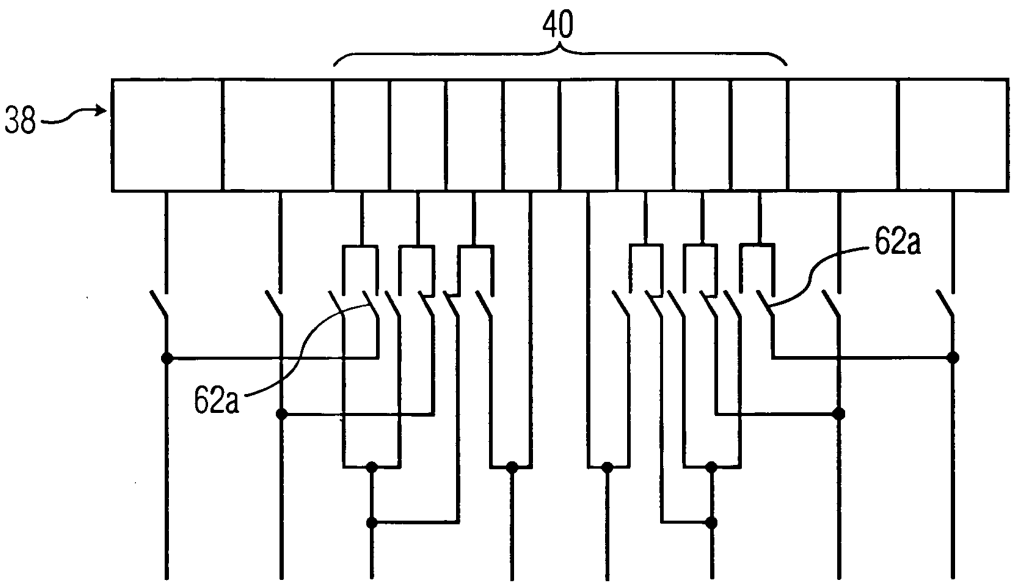
40
38
62a
62a

FIG. 8

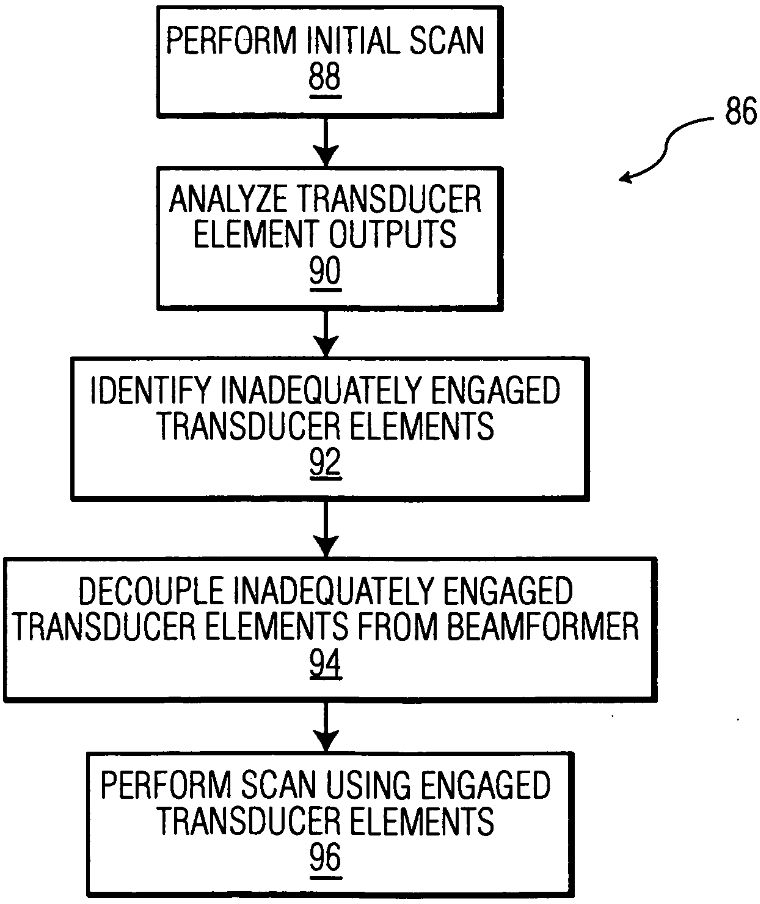
PERFORM INITIAL SCAN
88
86
ANALYZE TRANSDUCER ELEMENT OUTPUTS
90
IDENTIFY INADEQUATELY ENGAGED TRANSDUCER ELEMENTS
92
DECOUPLE INADEQUATELY ENGAGED TRANSDUCER ELEMENTS FROM BEAMFORMER
94
PERFORM SCAN USING ENGAGED TRANSDUCER ELEMENTS
96

FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6106472 A **[0009]**
- US 6104673 A **[0010]**
- US 2006058672 A **[0011]**

专利名称(译)	双模式超声系统		
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IPC分类号	G01S15/89 G10K11/34 A61B8/00 B06B1/06		
CPC分类号	A61B8/00 G01S15/8918 G01S15/892 G01S15/8927 G10K11/346		
优先权	60/969818 2007-09-04 US		
其他公开文献	EP2237070A1		
外部链接	Espacenet		

摘要(译)

描述了一种双模式超声系统，其包括模式选择开关（20），其可操作以选择线性扫描模式或扇形扫描模式，超声换能器包括具有正面的换能器元件的弯曲阵列，以及波束形成器响应于模式选择开关并耦合到弯曲阵列的元件，并且可在第一线性模式下操作以使得弯曲阵列发射和接收垂直于阵列面的光束，并且可在第二扇区模式下操作使弯曲的阵列发射和接收从共同的顶点发出的光束。

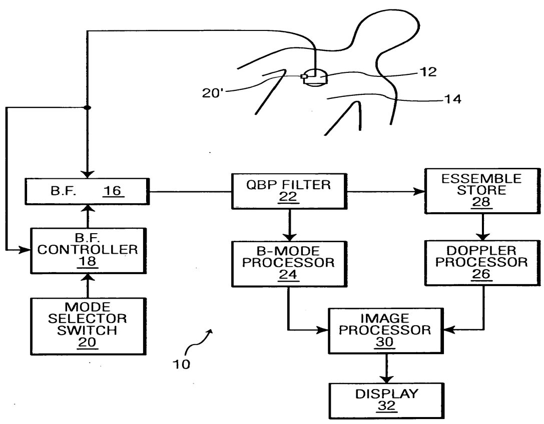

FIG. 1