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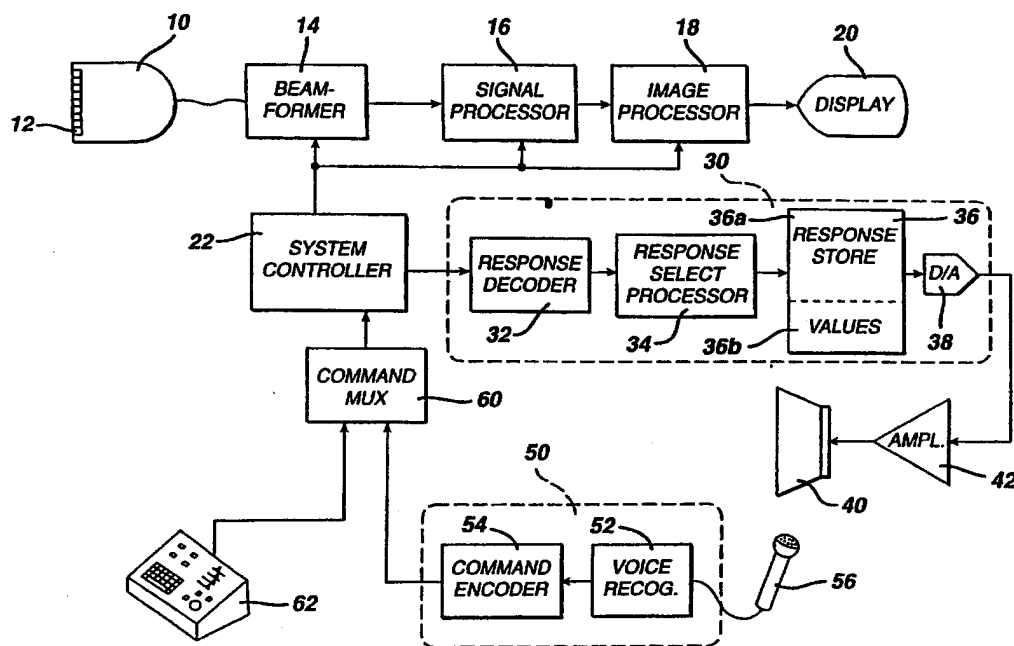
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(54) Title: **ULTRASONIC DIAGNOSTIC IMAGING SYSTEM WITH VOICE COMMUNICATION**



(57) Abstract: An ultrasonic diagnostic imaging system is responsive to oral command for changing the state of the system or carrying out an instruction. In response to an oral command the system produces an audible response which assures a user that the oral command has been properly executed. Commands which may be carried out in this manner include those which change the operating state of the ultrasound system, measure and annotate images, produce diagnostic reports, control the signals which are used to form an ultrasound image, and control the quality of an ultrasound image.

## Ultrasonic diagnostic imaging system with voice communication

This invention relates to ultrasonic diagnostic imaging systems and, in particular, to ultrasonic diagnostic imaging systems with voice response to audibly communicate with a user.

In recent years the development of voice recognition technology has advanced the day when hands-free control of an ultrasound system will be effective as users control their ultrasound systems audibly. A number of ultrasound system manufacturers including the assignee of the present application have developed and demonstrated prototype voice-controlled ultrasound systems. One such system is described in U.S. patent number 5,544,654, in which over seventy ultrasound system commands are arranged in groups called sub-vocabularies which are activated depending upon the state of the system.

While a voice-controlled ultrasound system allows the user a certain degree of hands-free operation of the system, voice control adds a new set of problems. One is that total accuracy of voice control has not yet been achieved. While relatively infallible voice recognition technology will no doubt evolve with time, today's technology must cope with this shortcoming, and usually does so by requiring a user to "train" the voice recognition system to his or her voice. In the system described in the aforementioned patent, a user would be required to train the voice recognition system to recognize over seventy voice commands, a substantial burden on the user. A corollary of this problem is that, since voice recognition is not yet infallible, the user must be constantly alert to commands which the voice-controlled ultrasound system erroneously received or missed entirely. The freedom of hands-free operation comes at the price of a loss of the confidence that pushing a button or setting a switch previously provided.

The present inventor has recognized that an ultrasound system that a user can talk to provides one-half of a human behavior, the behavior of conversation. A conversation is a two-way flow of information: one person asks a question, and a second person provides an answer. Or, one person makes a statement and a second person responds to the statement. In accordance with the principles of the present invention, the present inventor has imbued an ultrasound system with the characteristic of human conversation by providing an ultrasound system with the ability to produce audible responses to audible commands. The

audible responses provide information which is relevant to the audible command or query posed by the operator. In one embodiment audible responses are given to voice control commands to inform the ultrasound system operator that the requested command has been (or has not been) carried out. In another embodiment ultrasound images are analyzed in response to voice commands as by labeling images, making measurements, and/or audibly providing the response of such analysis. In yet another embodiment diagnostic reports are prepared or edited by voice control. In yet a further embodiment the type of signals which are processed to form an ultrasound image is audibly controlled. The audible responses provided by the ultrasound system can give qualitative audible affirmation that voice commands have been responded to or can give quantitative audible information on requested actions or results.

In the drawings:

FIGURE 1 illustrates in block diagram form an ultrasonic diagnostic imaging system with a voice synthesizer constructed in accordance with the principles of the present invention;

FIGURES 2a and 2b illustrate further details of the voice synthesizer of FIGURE 1;

FIGURES 3a and 3b illustrate ultrasound image measurements performed in accordance with the present invention;

FIGURES 4a and 4b illustrate ultrasound image labeling performed in accordance with the present invention;

FIGURES 5a and 5b illustrate voice control of the signal frequencies used to form an ultrasound image; and

FIGURES 6a and 6b illustrate voice control of ultrasonic image compounding.

The invention relates to an ultrasonic diagnostic imaging system which communicates with a user in a conversational manner.

In a first embodiment, this system comprises a voice controller responsive to an oral user command to produce a command signal; an ultrasound system controller, responsive to the command signal, which causes the ultrasonic imaging system to respond as requested by said oral user command; and a voice synthesizer, responsive to said command signal to produce an audible response. In this system, said controller produces a response signal in response to said command signal; and said voice synthesizer is responsive to said response signal to produce said audible response.

In particular embodiments of said first embodiment:

Said controller receives a confirmation signal from said ultrasonic imaging system in response to a command; and wherein said voice synthesizer is responsive to said confirmation signal to produce said audible response;

5 The voice synthesizer comprises a response store in which audible responses are electronically stored and said response store is responsive to a command signal for the issuance of a desired audible response. In this particular embodiment, said voice synthesizer further comprises a conversion circuit, coupled to said response store, which converts electronically stored responses into audio signals; said response store may store textual and numeric response information and an audible response may be formed of textual and selected  
10 numeric response information; said response store may store a plurality of partial responses and said desired audible response may be compiled from a plurality of stored partial responses.

The voice synthesizer comprises a decoder, responsive to signals from said controller, for selecting a desired stored response; a response store, coupled to said decoder,  
15 for issuing a desired one of a plurality of stored responses; an analog to digital converter, coupled to receive responses from said response store, for producing analog audio signals; and a loudspeaker coupled to receive said analog audio signals for producing an audible response.

In a second embodiment, said ultrasonic diagnostic imaging system responds  
20 to oral instructions of a user and comprises a graphic generator which generates characters and/or graphic symbols which annotate an ultrasound image; a voice controller responsive to an oral user command to produce a graphic command signal; an ultrasound system controller, responsive to the graphic command signal, which causes the graphic generator to annotate an ultrasound image as requested by said oral user command; and a display, coupled to said  
25 graphic generator, which displays an annotated ultrasound image.

In particular embodiments of said second embodiment, said graphic generator may annotate an ultrasound image with a label, said graphic generator may annotate an ultrasound image with a measurement graphic; in said particular embodiment, the ultrasonic diagnostic imaging system may further comprise a voice synthesizer, responsive to the  
30 production of a graphic command signal, which produces an audible measurement result.

In a third embodiment, the ultrasonic diagnostic imaging system responds to oral instructions of a user and comprises a report generator which generates diagnostic reports containing information developed by said ultrasound system; a voice controller responsive to the voice of a user to produce information signals for a diagnostic report; and

an ultrasound system controller, responsive to the information signals and coupled to said report generator, which causes the information orally communicated by the user to be entered in a diagnostic report. Said ultrasonic diagnostic imaging system may further comprise a display coupled to said report generator which displays a diagnostic report, and said  
5 information orally communicated by said user appears in a displayed diagnostic report.

In a fourth embodiment, the ultrasonic diagnostic imaging system varies the type of signals used to form an ultrasound image in response to oral instructions and comprises a probe which receives fundamental and harmonic ultrasound signals; a signal separation circuit, responsive to signals produced by said probe, for separating fundamental  
10 and harmonic signals; an image processor coupled to said signal separation circuit which produces image signals in response to harmonic and/or fundamental signals; a display which displays said image signals; a voice controller responsive to an oral user command to produce a command signal; and an ultrasound system controller, coupled to said signal separation circuit, which causes said signal separation circuit to produce an output signal in which  
15 harmonic or fundamental signals are selectively emphasized in response to said command signal.

In particular embodiments of this fourth embodiment, said signal separation circuit may comprise a controllable filter circuit; said signal separation circuit may comprise a pulse inversion circuit; said command signal may control the relative proportions of  
20 fundamental and harmonic signals in a blended fundamental and harmonic signal image; said ultrasonic diagnostic imaging system may further comprise a voice synthesizer, coupled to said controller, which produces an audible indication of the type of signals which are emphasized in said displayed image signals.

In a fifth embodiment, the ultrasonic diagnostic imaging system varies the  
25 quality of an ultrasonic image in response to oral signals and comprises a probe which receives ultrasound signals from different look directions; a compound image processor, responsive to signals from different look directions, to produce a compound image; a display which displays said compound image; a voice controller responsive to an oral user command to produce an image compounding command signal; and an ultrasound system controller,  
30 coupled to said compound image processor and responsive to said image compounding command signal, which causes said compound image processor to change the quality of said compound image.

In particular embodiments of said fifth embodiment, said controller may be responsive to said image compounding command signal to vary the number of look

directions which are compounded; said controller may be responsive to said image compounding command signal to vary the operation of said compound image processor between survey and target modes; said ultrasonic diagnostic imaging system may further comprise a voice synthesizer, responsive to a change in the functioning of said compound  
5 image processor, for producing an audible indication of a new state of compound image processing by said ultrasonic diagnostic imaging system.

In a sixth embodiment, said ultrasonic diagnostic imaging system audibly communicates with a user and comprises an ultrasound system controller, coupled to a processor of said imaging system and responsive to a command signal, which causes the  
10 functioning of the ultrasonic imaging system to change; and a voice synthesizer, coupled to said controller and responsive to a change in said system functioning, which audibly informs a user of a change in said system functioning.

In particular embodiments of said sixth embodiment the ultrasonic diagnostic imaging system may further comprise a manually operated user control, coupled to said  
15 controller and responsive to oral commands, for commanding a change in the function of said ultrasonic imaging system; a voice recognition processor, coupled to said controller, for commanding a change in the function of said ultrasonic imaging system. In said last embodiment, said voice synthesizer may be responsive to a help request from a user to provide audible instructions on the use of said ultrasonic imaging system; said voice  
20 synthesizer may be responsive to an incomplete command signal to audibly assist the user in the operation of said ultrasonic imaging system; said voice synthesizer may be responsive to an incorrect command signal to audibly assist the user in the operation of said ultrasonic imaging system.

In any of those embodiments, the ultrasound system controller may retain a  
25 previous user command for modification by a subsequent user command; said subsequent user command may be a command to increment or decrement the result of a previous user command.

Referring first to FIGURE 1, an ultrasonic diagnostic imaging system  
30 constructed in accordance with the principles of the present invention is shown. An ultrasound probe 10 including an array transducer 12 is operated under control of a beamformer 14 which causes the array transducer to transmit ultrasonic beams into the body of a patient and receive echo signals in return. The received echo signals are formed into a receive beam of coherent echo signals by the beamformer 14 which is coupled to a signal

processor 16. The signal processor performs function such as filtering, demodulation, detection or Doppler estimation using the coherent echo signals. The processed echo signals are coupled to an image processor 18 where they are processed to form image information such as B or M mode image signals or color or spectral Doppler image signals in a two or three dimensional image format. The image information is then coupled to a display device 20 for display. The functioning of the beamformer and processors of the ultrasound system is directed by a system controller 22, which controls and coordinates the functioning of these elements, including initializing and changing their states of operation so that the display device will display the type of information desired by the ultrasound system operator.

10 In a conventional ultrasound system the system controller receives operator issued control commands from a user interface 62. The user interface can include both hardkey (buttons, switches, keyboard, trackball, etc.) and softkey (shown on the display device, plasma touch-panel, etc.) controls which, when activated by the operator, send control signals to the system controller 22.

15 In accordance with the principles of the present invention, the conventional user interface 62 is coupled to the system controller 22 by a command multiplexer (mux) 60. The command mux enables the system controller to receive input signals from the user interface 62, a voice controller 50, or both. The command mux 60 may also multiplex input signals from other control devices such as a footswitch. The voice controller 50 includes a voice recognition processor 52 which responds to voice input from a microphone 56 by producing digital output signals representing the audible information. A command encoder 54 converts the digital output signals of the voice recognition processor into digital command signals useable by the system controller. In a constructed embodiment the hardware and/or software of the voice recognition processor and the command encoder may be integrated into a single unit which receives audio input signals and produces ultrasound system control signals as output signals. The command mux is selectively conditioned to respond to signals from the conventional user interface 62, the voice controller 50, or both and to couple the signals to the system controller. The system controller responds to these inputs by effecting a change to the current state of the ultrasound system, such as changing a mode or displaying new or different information on the display.

30 In accordance with the principles of the present invention, the action being taken by the ultrasound system is audibly communicated to the user by a voice synthesizer 30. A signal indicative of the action taken by the ultrasound system is coupled to the input of the voice synthesizer 30. This signal can be or is derived from the command signal produced

by the voice controller, a command signal issued by the system controller to an ultrasound system processor or component, or a signal produced after the requested action has been carried out. A response decoder receives one of these input signal and produces an output signal identifying an audible response or class of responses from which an audible response is to be chosen. A response select processor 34 receives the identifying output signal from the response decoder and selects one or more stored responses in a response storage device 36 for audible delivery. In a constructed embodiment the response decoder 32 and the response select processor 34 may be integrated so that a state change signal received from the ultrasound system results in a signal which addresses the response storage device 36 in an integrated process. The response storage device may contain several types of responses which may be combined to form an integrated response, as indicated by response store section 36a and values section 36b. While the responses may be stored in any form or medium and can be stored in analog or digital form, the responses are preferably stored in digital form in which case they will be clocked out of the response storage device 36, converted to analog signals by a D/A converter 38, amplified by an amplifier 42, and reproduced by a speaker 40.

Examples of the types of responses which the response storage device 36 may contain are illustrated in FIGURES 2a and 2b. FIGURE 2a illustrates a series of responses which may be given in response to a change in the depth of the ultrasound image. For instance, the ultrasound system may be set to produce images down to a depth of 4 cm. The user may then command the system to change the image to a depth of 6 cm. In response to this command the response select processor 34 sends a response select signal to the response storage device 36 which causes the response store to play out the response "Depth set To 6 cm". In the conversational mode when the user gives the command orally, by saying "Increase depth to 6 cm." or "Increase depth by 2 cm.", the voice controller 50 receives the oral command and sends the proper command signal to the system controller 22. In response to the command or the depth change an input signal is sent to the voice synthesizer and the ultrasound system audibly responds, "Depth Set To 6 cm." The user is thereby assured that the oral command has been correctly received and executed in a fully conversational manner. Since there is no need for the user to visually confirm that the proper depth change has been made, the user can concentrate on the scanning process and the ultrasound image without averting his or her gaze from the diagnostic process.

FIGURE 2b illustrates a second embodiment of the response storage device 36 in which the audible response is formed from multiple response elements stored in the



storage device. In response to the same command the response select signal selects a first response element from response store section 36a which in this example is the words "Depth Set To." This response is followed by the issuance of a second response element from the value section 36b which in this example is "6 cm." The user thus hears the complete  
5 response "Depth Set To 6 cm." Again, the user can issue an oral command and receive an assuring audible response from the ultrasound system in a completely conversational manner.

FIGURES 3a-4b illustrate the use of a conversational ultrasound system to draw, measure and label an ultrasound image. In the example of FIGURE 3a the user locates two measurement cursors on the image 70. The user first issues a command to cause a cursor  
10 to appear, such as "Create New Cursor." The system responds by creating a cursor at a default location such as the center of the image and responds "Cursor A Created." The user then moves the cursor to a desired location with one or more commands. Any of a number of command methodologies may be used to move the cursor. For instance, the user may give the command "Cursor Up" or "Cursor Left" to move the cursor in predetermined increments  
15 each time a command is given. If the predetermined increment is insufficient, the user would give the command "More", and the cursor would be moved another increment in the desired direction. The command "More" is applied to the previous command, with the ultrasound system remembering the context (*i.e.*, cursor movement up, down, left, or right) of the previous command. In a similar manner, the command "Less" or "Too Much" would cause  
20 the previous increment of movement to be reversed by one-half and thereby reduced. As a second example the command "Cursor Up" may cause the cursor to move slowly upward until the user issues a command to stop it, such as "Stop Cursor." The ultrasound system would respond, "Cursor A Stopped." As a third example, if the ultrasound system includes an automatic border detection capability, the user could command, "Cursor Up To Tissue  
25 Boundary." The cursor would move upward to the next tissue boundary, as shown by tissue boundary 72 in FIGURE 3a. The user can then command the cursor to move along the tissue boundary until it is located at the desired position.

The user would create cursor B in a similar manner and move it to its desired location as shown by the cursor "+<sup>B</sup>" on the tissue boundary 74 in FIGURE 3a. Once the user  
30 has cursors A and B positioned as desired the user can issue a measurement command such as "Measure A to B." The system would then measure the distance from cursor A to cursor B and announce the result "2.6 centimeters." The measurement also appears on or adjacent to the image as shown in FIGURE 3b. The measurement could, for instance, appear in a sidebar to the image where measurements are displayed.

FIGURE 4a illustrates a scenario where the user is labeling an image 70. In FIGURE 4a the user has generated a new cursor indicated by the "+" symbol and moved it to the vicinity of a valve 76 in the image 70. The user then gives the command "Label Mitral Valve." The system responds by replacing the + cursor with the label "Mitral Valve" as shown in FIGURE 4b and audibly responds with the announcement "Mitral Valve Labeled." The user can give the image a label if desired. For example the user could give the command "Label Image Parasternal Long Axis." The system interprets this command as calling for an image label and displays the desired image label on or near the image 70 as shown at the bottom of FIGURE 4b. The system can audibly respond with the announcement "Image Labeled Parasternal Long Axis."

The ultrasound system conventionally can be operated to produce a report containing the results of image analysis such as the measurements and image labeling described above. In addition to the analytical result, such reports can also include commentary or diagnostic detail in text form. In accordance with a further aspect of the present invention, the system operator can use the same microphone and voice controller by which system commands are given to add commentary or textual detail to a diagnostic report. When the report is shown on the display 20, the user can manually move the cursor to the Comments field of the report, or move the cursor to the Comments field with an oral command such as "Comments Field." The user can then dictate comments or other text into the microphone for conversion to character data by the voice controller 50. The character data is coupled to the system controller for insertion into the report and display in the comments field of the displayed diagnostic report. Thus, the operator can quickly dictate comments into a diagnostic report immediately upon completion of the analysis of the image data, and can conclude the ultrasound exam with a finished diagnostic report.

FIGURES 5a and 5b illustrate another embodiment of the present invention in which the user audibly controls the type of ultrasound signals processed to form an ultrasound image. This type of control can if desired be done within the same imaging mode. For example a user can command the ultrasound system to use fundamental frequency signals to form a 2D image or to use harmonic frequency signals to form a 2D image, or to form an image which is a blend of the two types of signals. The user could give the same commands for 3D images also, if desired. FIGURES 5a and 5b illustrate two techniques for effecting such control. FIGURE 5a illustrates a filter 110 in the ultrasound signal path of the ultrasound system of FIGURE 1 which separates the type of signals desired for a particular image. The filter 110 is controlled by a control signal labeled "f select" to select either a

lower frequency band  $f_1$  or a higher frequency band  $f_2$ . The  $f_1$  band could be the fundamental frequency band and the  $f_2$  band could be the harmonic frequency band, for instance. The user can issue a command such as "Fundamental Image," which is received by the voice controller 50 which issues a command to the system controller 22 to select the fundamental frequency band. The system controller 22 applies the appropriate band select control signal to the filter 110 and a response signal is coupled to the voice synthesizer 30. The voice synthesizer issues the audible response "Fundamental Image Selected" to inform the user that the command has been carried out.

FIGURE 5b illustrates a second embodiment for controlling the type of signals used to form the 2D or 3D image. FIGURE 5b illustrates a pulse inversion circuit 120 in the ultrasound signal path of the ultrasound system in which the echoes  $S_{\phi 1}$  and  $S_{\phi 2}$  are combined to produce the type of signal used to form an image. The combining of signals is performed by a combining circuit 122 which can selectively additively combine or subtractively combine the  $S_{\phi 1}$  and  $S_{\phi 2}$  echo signals. When the  $S_{\phi 1}$  and  $S_{\phi 2}$  echo signals are derived from differently modulated transmit signals, the manner in which they are combined will determine the type of signals produced. For instance, additively combining the echoes from differently phased transmit signals can produce harmonic signal components and subtractively combining the echoes can produce fundamental frequency signals. Similar results can be obtained from other coded transmit pulses such as from amplitude modulated pulses, for instance. The combining circuit is controlled by a "+/- select" control signal as shown in FIGURE 5b which selects the manner in which the echo signals are to be combined. For example, when the user gives the command "Fundamental Image," the voice controller 50 issues a command to the system controller 22 which in turn applies a - select control signal to the pulse inversion circuit 120 and the circuit provides signals for a fundamental image. The system controller 22 notifies the voice synthesizer 30 of the selection and the voice synthesizer issues the audible response "Fundamental Image Selected." In a similar manner, when the user gives the command "Harmonic Image," the voice controller 50 issues a command to the system controller 22 which in turn applies a + select control signal to the pulse inversion circuit 120 and the circuit provides signals for a harmonic image. A notification of the selection is sent to the voice synthesizer 30 and the voice synthesizer issues the audible response "Harmonic Image Selected." Thus, the user is able to control the type of signals used to form the ultrasound image by audible command.

FIGURES 6a and 6b illustrate a further embodiment of the present invention in which the user is able to audibly control the quality of the ultrasound image. FIGURE 6a

illustrates a compound image processor 130 which may be employed in the ultrasound signal path of the ultrasound system of FIGURE 1. As explained in U.S. patent application serial number 09/335,058, image information 132 is acquired from different look directions, then combined to form a compound image with greatly improved image quality. FIGURE 6a

5 illustrates several operating parameters of the compound image processor which may be audibly controlled. One parameter is the target/survey mode control. As explained in the above patent application, when a user is scanning for pathology of interest the probe 10 is moved rapidly to survey the patient's anatomy. Since rapid movement can create blurring of compound images, the number of look directions which are compounded is reduced to a

10 single look direction or only a few look directions. But when the user has focused his or her attention on a particular point of the body and the probe is relatively stationary, the target mode can be selected to increase the number of look directions compounded and improve the quality of the image. This sequence of operation may be controlled audibly with the embodiment of FIGURE 6a. When the user gives the command "Survey Mode" the audible

15 command is interpreted by the voice controller 50, causing a "Survey" control signal to be applied to the compound image processor 130. The Survey control signal causes the processor 130 to compound one or only a few look directions to produce the display signals. The ultrasound system responds to the command by responding "Survey Mode," to assure the user that the compound image processor is operating in the desired mode. When the user

20 finds particular anatomy of interest the user gives the command "Target Mode," which is received by the voice controller 50 and used to switch the compound image processor 130 to the Target mode, in which an increased number of look directions are compounded to form the display signals for the display 20. The voice synthesizer 30 responds to the user by saying "Target Mode," confirming to the user that the ultrasound system has switched to the

25 target mode of compound imaging.

In the embodiment of FIGURE 6a the user also has the option of instructing the compound image processor 130 as to the desired degree of image quality provided by compound imaging. The user can audibly specify the number of look directions which the compound image processor combines by giving a command such as "Compound 5 Frames."

30 The voice controller 50 responds to this command by directing the system controller 22 to instruct the compound image processor to compound five frames or look directions to form the display data. The command to compound five look directions is applied to the "# frames compounded" input of the compound image processor, and the voice synthesizer responds by producing an audible response such as "Compounding 5 frames."

FIGURE 6b illustrates the data which may be stored in the response storage device 36 to issue these responses for changes in the state of the compound image processor.

When the compound image processor is directed to change to the survey mode or the target mode, the response select signal causes the response store section 36a to play out the  
5 response "Survey Mode" or (as appropriate) "Target Mode," which is converted to an analog signal by the D/A converter 38 and reproduced by the loudspeaker 40 to assure the user that the ultrasound system is operating in the desired compound imaging mode. When the user directs the compound image processor to compound a specific number of look directions the response select signal causes the response store section 36a to play out the response  
10 "Compounding," followed by reproduction of the number of look directions compounded from the value section 36b, such as "5 frames." The user hears the complete audible response "Compounding 5 frames," which assures the user that the compound image processor is producing image data with the desired number of look directions compounded. The ultrasound system is thereby producing the level of image quality requested by the user, and  
15 audibly assures the user that it is doing so.

In accordance with yet a further aspect of the present invention the voice synthesizer 30 responds to a user request for aid in operating the ultrasound system by providing information pertinent to the current operating state of the ultrasound system. In a first embodiment this capability takes the form of an online help functionality. Any time a  
20 user speaks the word "Help" to the ultrasound system, the voice synthesizer 30 responds by providing the user with information concerning current system operation or options. For example, the user may be trying to measure the volume of blood pumped by the heart, but, unbeknownst to him, he is be trying to do so with an improper cardiac image. The user would then say "Help" to the ultrasound system and the voice synthesizer would respond  
25 with audible assistance such as, "You are trying to measure ejection fraction from a short axis view of the heart. Ejection fraction can only be measured using a long axis view. Please obtain a long axis view image of the left ventricle if you want to measure ejection fraction." As a second example, a user may be trying to obtain an estimate of fetal age but has not taken a required measurement. In response to the word "Help" the ultrasound system might  
30 respond with "In order to estimate fetal age you must measure the biparietal diameter. Please obtain a biparietal diameter measurement if you would like to estimate fetal age." The user is thus guided with information enabling him to operate the ultrasound system properly.

In a second embodiment the voice synthesizer provides audible aid in completing a desired diagnostic or operating sequence. For example, the user might have

given an instruction to change the gain of the system without specifying the sense of the gain change. The voice synthesizer might respond with the query "Increase or Decrease?" while remembering the context of the initial command, that is, a gain change. When the user replies "Increase" or "Decrease", the ultrasound system would apply the desired change in gain. The change could be a predetermined increment as described previously, or a change to a requested gain setting such as 60 dB. Thus, the user has been audibly guided in the manner in which the ultrasound system is properly controlled in accordance with the desire of a user, and is assisted in completing incomplete commands and command sequences.

Finally, it will be appreciated that the voice synthesizer 30 can be used independently of the voice controller 50. The ultrasound system can be operated in the conventional manual manner by the user, with the voice synthesizer providing an audible response to manual system setting and control through the user interface 62. Even when the ultrasound system is being used in the conventional manner, the user can still have the benefit of being audibly assured that the ultrasound system is being controlled and operated as the user desires.

## CLAIMS:

1. An ultrasonic diagnostic imaging system which communicates with a user in a conversational manner comprising:
  - a voice controller (50) responsive to an oral user command to produce a command signal;
  - 5 an ultrasound system controller (22), responsive to the command signal, which causes the ultrasonic imaging system to respond as requested by said oral user command; and
  - a voice synthesizer (30), responsive to said command signal to produce an audible response.
- 10 2. The ultrasonic diagnostic imaging system of Claim 1, wherein said controller produces a response signal in response to said command signal; and
  - wherein said voice synthesizer is responsive to said response signal to produce said audible response.
- 15 3. The ultrasonic diagnostic imaging system of one of Claims 1 or 2, wherein said controller receives a confirmation signal from said ultrasonic imaging system in response to a command; and
  - wherein said voice synthesizer is responsive to said confirmation signal to produce said audible response.
- 20 4. The ultrasonic diagnostic imaging system of one of Claims 1 to 3, wherein voice synthesizer comprises a response store (36) in which audible responses are electronically stored;
  - wherein said response store is responsive to a command signal for the issuance
  - 25 of a desired audible response.
5. The ultrasonic diagnostic imaging system of Claim 4, wherein said voice synthesizer further comprises a conversion circuit (38), coupled to said response store, which converts electronically stored responses into audio signals.

6. The ultrasonic diagnostic imaging system of one of Claims 4 or 5, wherein said response store stores textual and numeric response information;  
wherein an audible response is formed of textual and selected numeric  
5 response information.
7. The ultrasonic diagnostic imaging system of one of Claims 1 to 6, wherein said voice synthesizer comprises:  
a decoder 32), responsive to signals from said controller, for selecting a  
10 desired stored response;  
a loudspeaker (40);  
wherein the response store is coupled to said decoder, for issuing a desired one of a plurality of stored responses;  
the conversion circuit (38) is an analog to digital converter, coupled to receive  
15 responses from said response store, for producing analog audio signals; and  
the loudspeaker receives said analog audio signals for producing an audible response.
8. An ultrasonic diagnostic imaging system as claimed in one of claims 1 to 7,  
20 which responds to oral instructions of a user further comprising:  
a display (20);  
a voice controller (50).
9. An ultrasonic diagnostic imaging system as claimed in claim 8, which  
25 responds to oral instructions of a user further comprising:  
a graphic generator which generates characters and/or graphic symbols which annotate an ultrasound image;  
wherein the voice controller (50) is responsive to an oral user command to produce a graphic command signal;  
30 the ultrasound system controller (22) is responsive to the graphic command signal, which causes the graphic generator to annotate an ultrasound image as requested by said oral user command; and  
and the display (20) is coupled to said graphic generator, which displays an annotated ultrasound image.



10. The ultrasonic diagnostic imaging system of Claim 9, wherein the voice synthesizer is responsive to the production of a graphic command signal and produces an audible measurement result.

5

11. An ultrasonic diagnostic imaging system as claimed in one of Claims 8 to 10, which responds to oral instructions of a user comprising:

a report generator which generates diagnostic reports containing information developed by said ultrasound system;

10

wherein the voice controller (50) is responsive to the voice of a user to produce information signals for a diagnostic report; and

the ultrasound system controller (22) is responsive to the information signals and coupled to said report generator, which causes the information orally communicated by the user to be entered in a diagnostic report.

15

12. The ultrasonic diagnostic imaging system of Claim 11, wherein the display (20) is coupled to said report generator which displays a diagnostic report,

and wherein said information orally communicated by said user appears in a displayed diagnostic report.

20

13. An ultrasonic diagnostic imaging system as claimed in one of Claims 8 to 12, which varies the type of signals used to form an ultrasound image in response to oral instructions comprising:

a probe (10) which receives fundamental and harmonic ultrasound signals;

25

a signal separation circuit (14' 16), responsive to signals produced by said probe, for separating fundamental and harmonic signals;

an image processor (18) coupled to said signal separation circuit which produces image signals in response to harmonic and/or fundamental signals;

wherein the display (20) displays said image signals;

30

the voice controller (50) is responsive to an oral user command to produce a command signal; and

and the ultrasound system controller (22) is coupled to said signal separation circuit, which causes said signal separation circuit to produce an output signal in which harmonic or fundamental signals are selectively emphasized in response to said command

signal, and wherein the voice synthesizer is coupled to said controller, and produces an audible indication of the type of signals which are emphasized in said displayed image signals.

- 5 14. An ultrasonic diagnostic imaging system as claimed in one of Claims 8 to 13, which varies the quality of an ultrasonic image in response to oral signals comprising:
- wherein the probe receives ultrasound signals from different look directions;
- the image processor (18) is responsive to signals from different look
- 10 directions, to produce a compound image;
- the display (20) displays said compound image;
- the voice controller (50) is responsive to an oral user command (62) to produce an image compounding command signal; and
- the ultrasound system controller (22), coupled to said compound image
- 15 processor and responsive to said image compounding command signal, which causes said compound image processor to change the quality of said compound image.

15. The ultrasonic diagnostic imaging system of one of Claims 1 to 14, further comprising a manually operated user control (62), coupled to said controller and responsive to oral commands, for commanding a change in the function of said ultrasonic imaging
- 20 system.

16. The ultrasonic diagnostic imaging system of one of Claims 1 to 15, wherein said voice synthesizer (30) is responsive to a help request from a user to provide audible instructions on the use of said ultrasonic imaging system.

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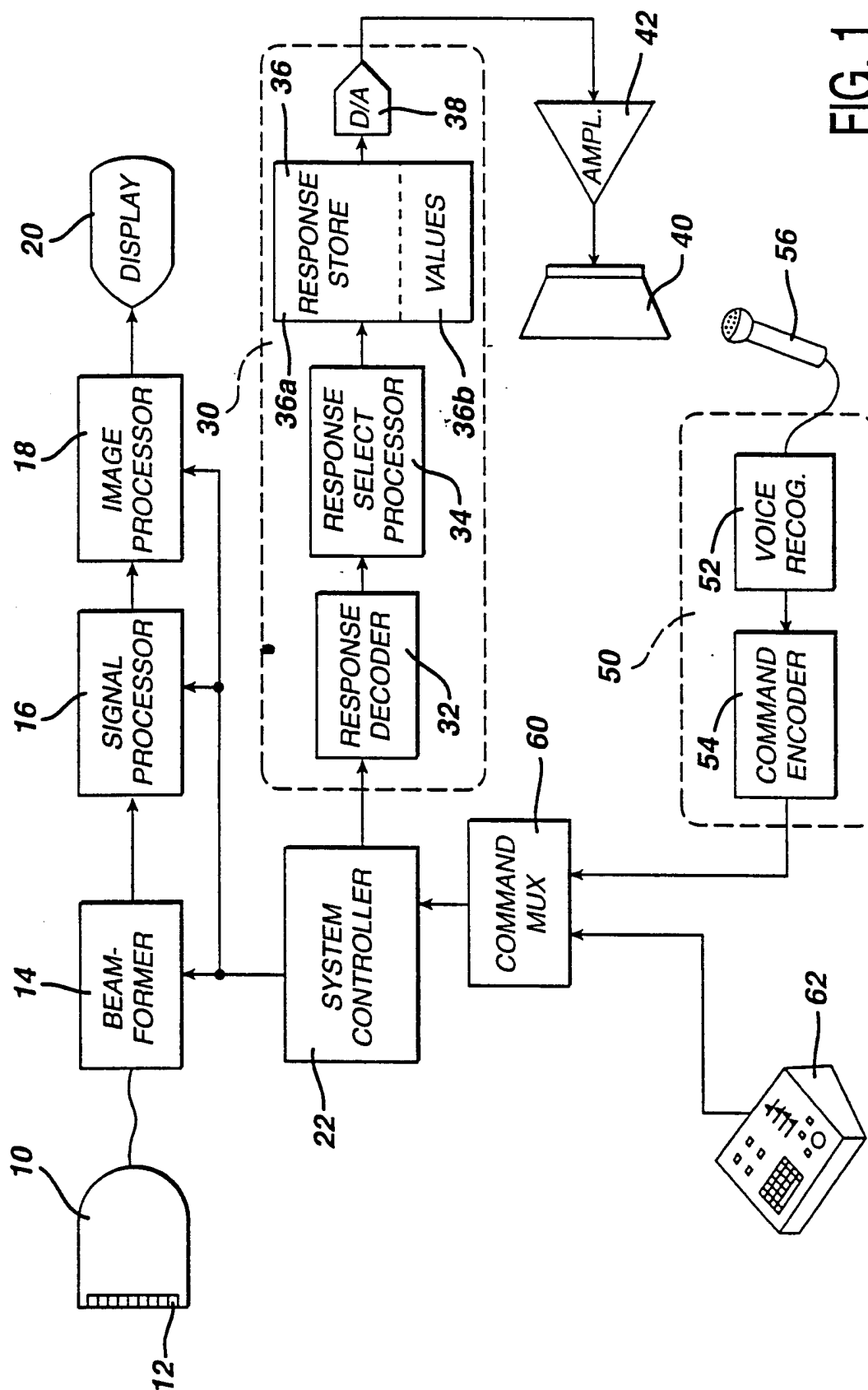


FIG. 1

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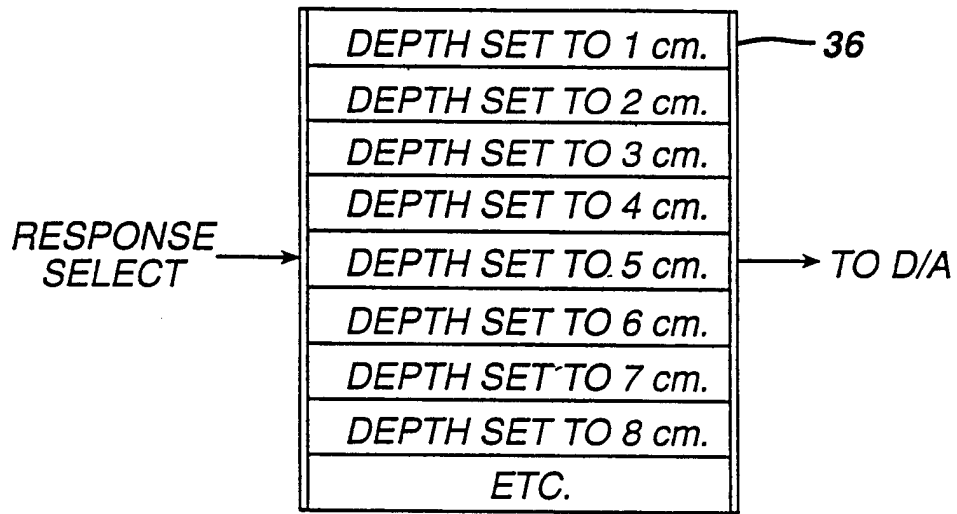


FIG. 2a

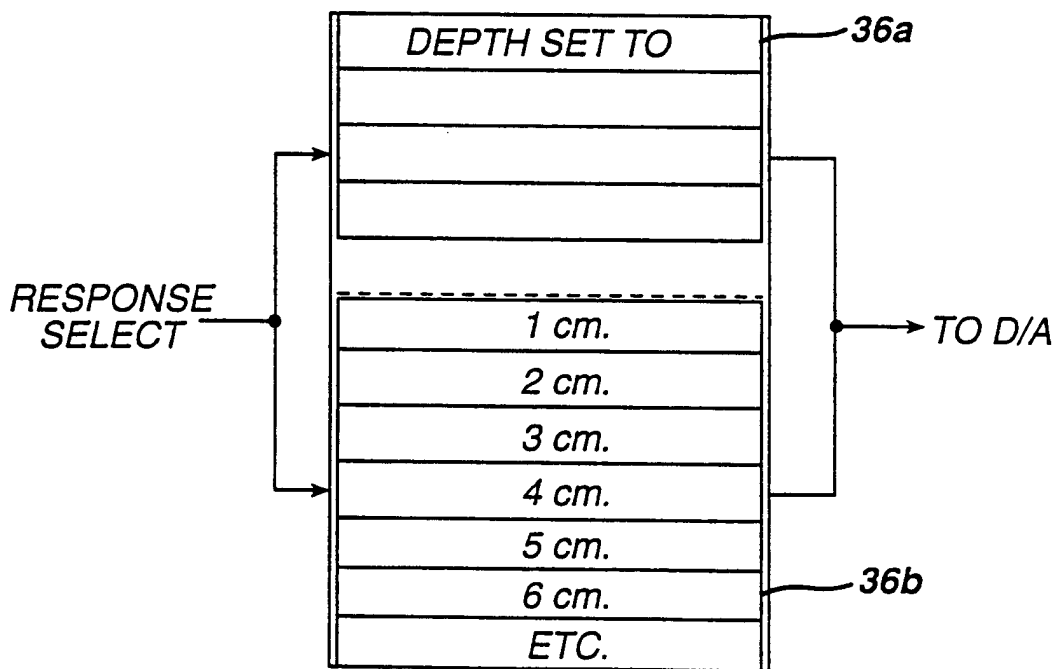


FIG. 2b

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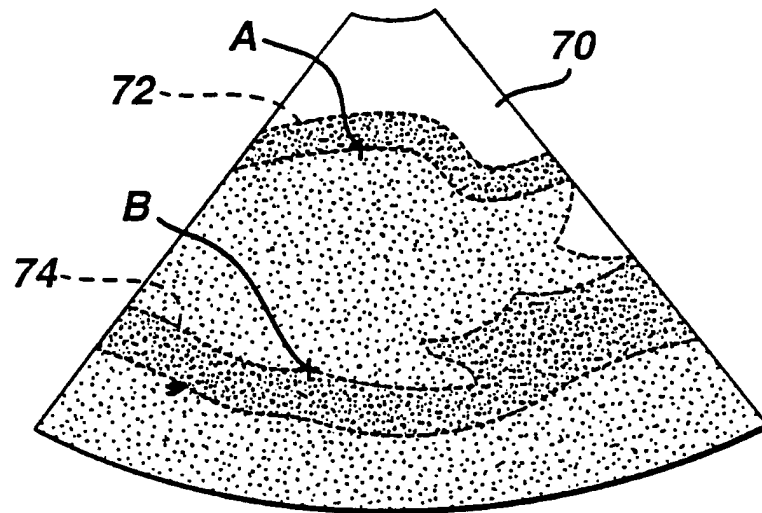


FIG. 3a

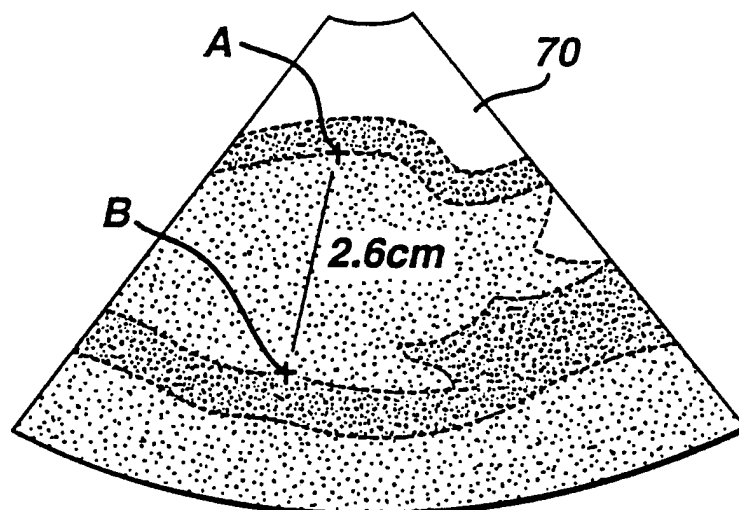


FIG. 3b

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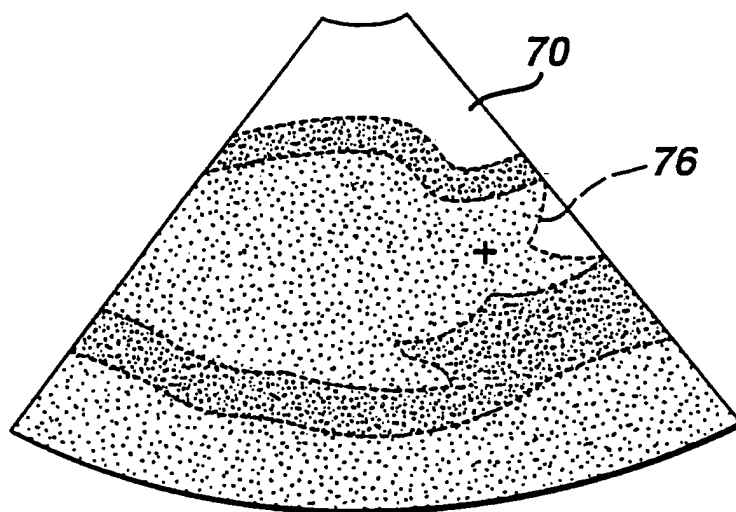


FIG. 4a

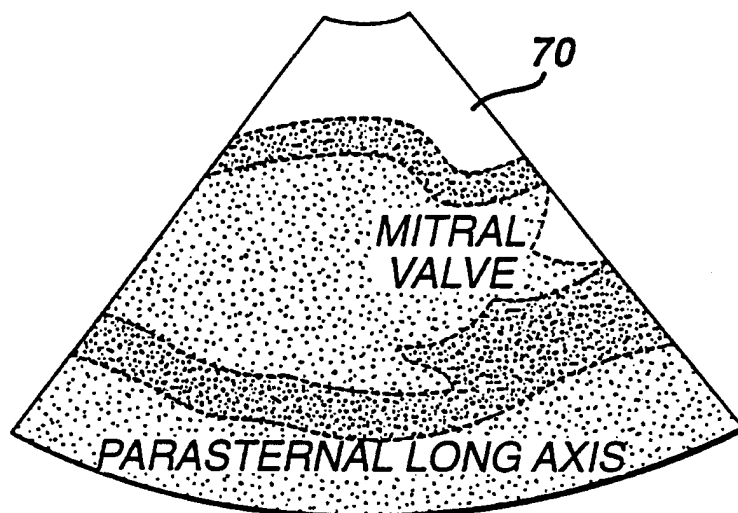


FIG. 4b

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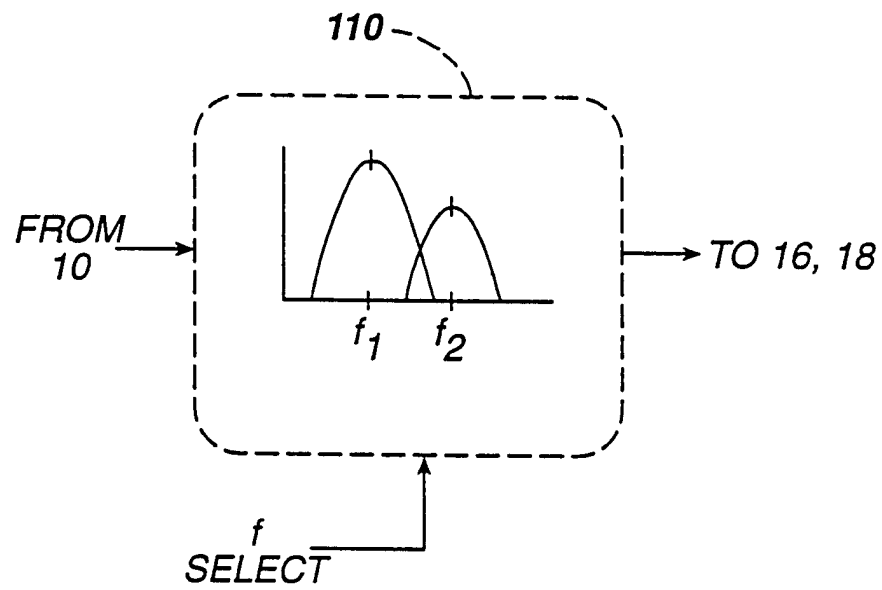


FIG. 5a

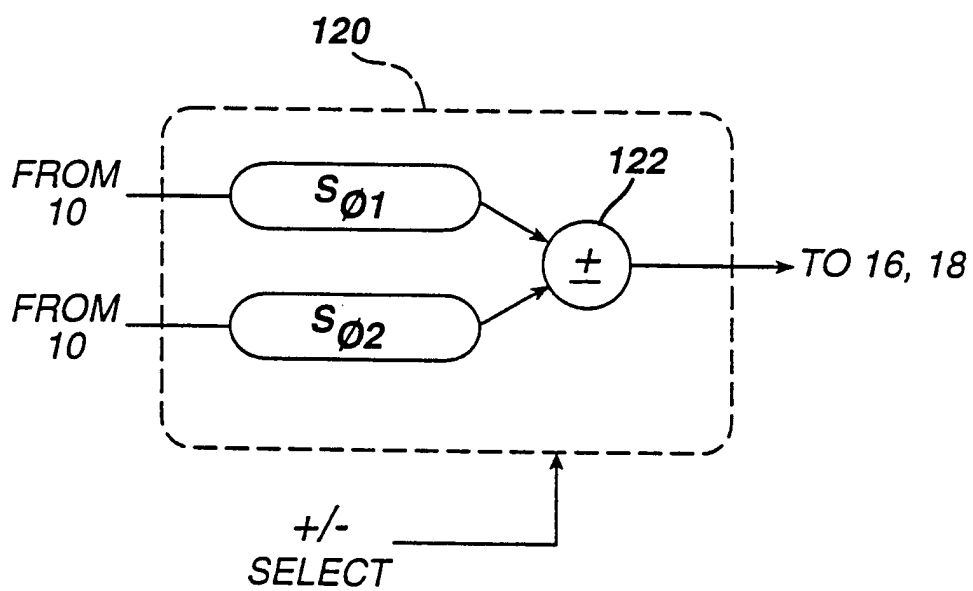


FIG. 5b

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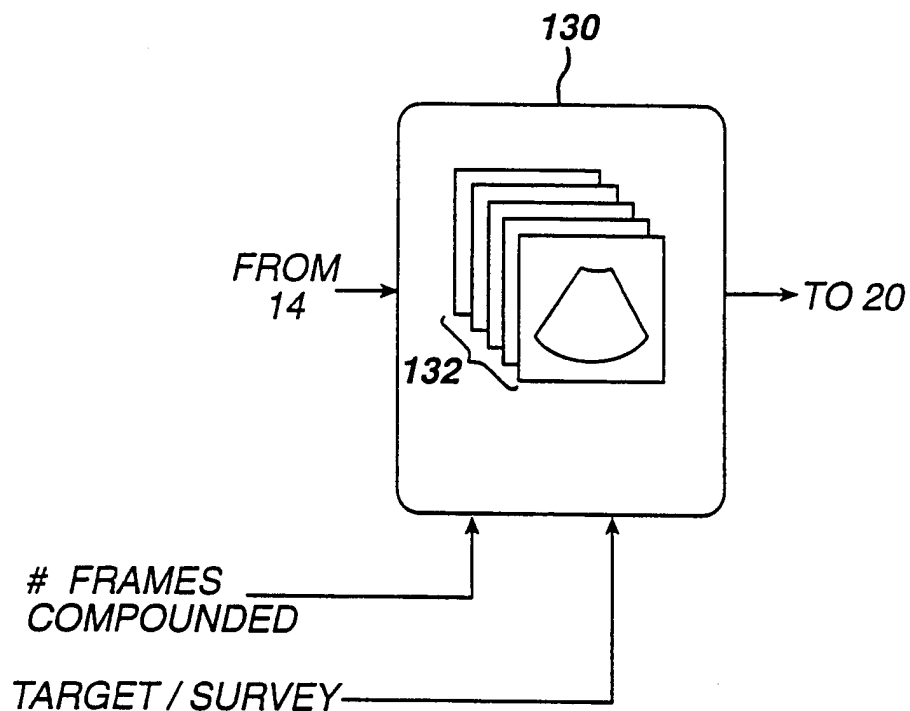


FIG. 6a

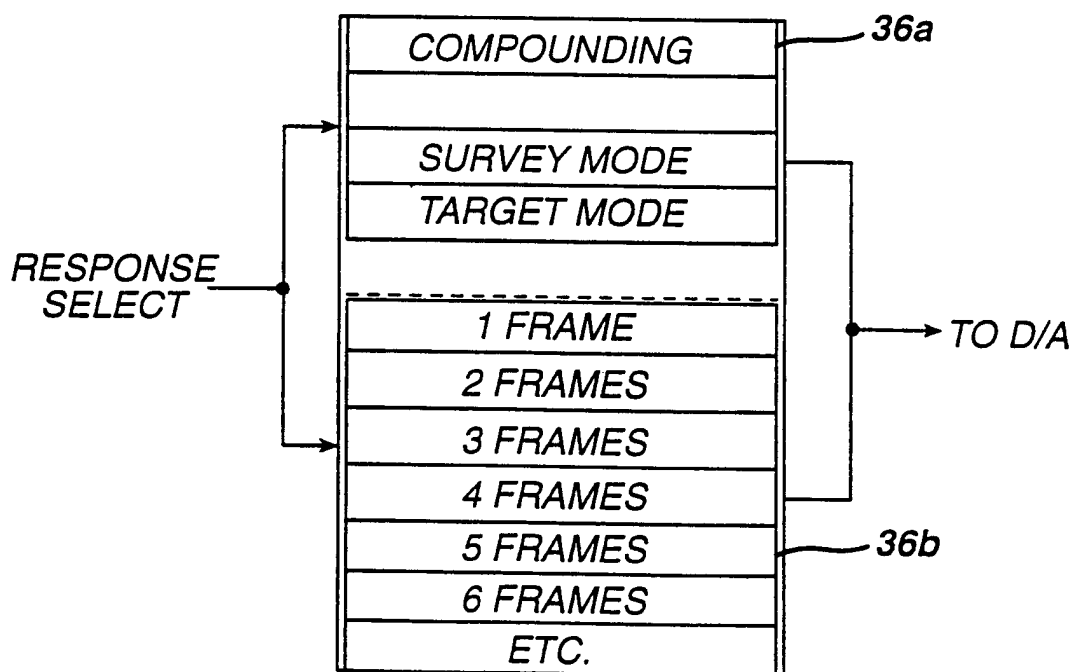


FIG. 6b



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/09506

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61B8/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61B G10L G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages                                                                                          | Relevant to claim No. |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y          | WO 94 01766 A (SIERRA MATRIX INC)<br>20 January 1994 (1994-01-20)<br>page 38, line 1 - line 26<br>page 12, line 4 -page 15, line 19; table 1<br>---                         | 1-8                   |
| Y          | PATENT ABSTRACTS OF JAPAN<br>vol. 1999, no. 12,<br>29 October 1999 (1999-10-29)<br>& JP 11 197142 A (HITACHI MEDICAL CORP),<br>27 July 1999 (1999-07-27)<br>abstract<br>--- | 1-8                   |
| P,A        | US 6 106 463 A (WILK PETER J)<br>22 August 2000 (2000-08-22)<br>column 2, line 55 -column 3, line 26<br>column 16, line 66 -column 18, line 15;<br>table 20<br>---<br>-/--  | 9-12,15,<br>16        |

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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- \*G\* document member of the same patent family

Date of the actual completion of the international search

19 February 2001

Date of mailing of the international search report

27/02/2001

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Weih, J

# INTERNATIONAL SEARCH REPORT

Int. Patent Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                     | Relevant to claim No. |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A          | US 5 544 654 A (MURPHY SEAN ET AL)<br>13 August 1996 (1996-08-13)<br>cited in the application<br>column 6, line 66 -column 7, line 67<br>column 9, line 19 -column 10, line 5;<br>tables 9-11<br>----- | 1-8                   |
| A          | WO 99 39628 A (UNIV EMORY)<br>12 August 1999 (1999-08-12)<br>abstract<br>page 11, line 4 -page 12, line 24; table 1<br>-----                                                                           | 1,15,16               |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/09506

| Patent document<br>cited in search report |   | Publication<br>date | Patent family<br>member(s) |   | Publication<br>date |
|-------------------------------------------|---|---------------------|----------------------------|---|---------------------|
| WO 9401766                                | A | 20-01-1994          | AU 4771893                 | A | 31-01-1994          |
|                                           |   |                     | US 5476010                 | A | 19-12-1995          |
| JP 11197142                               | A | 27-07-1999          | NONE                       |   |                     |
| US 6106463                                | A | 22-08-2000          | NONE                       |   |                     |
| US 5544654                                | A | 13-08-1996          | NONE                       |   |                     |
| WO 9939628                                | A | 12-08-1999          | US 6083167                 | A | 04-07-2000          |
|                                           |   |                     | AU 2579399                 | A | 23-08-1999          |
|                                           |   |                     | EP 1054616                 | A | 29-11-2000          |

|                |                              |         |            |
|----------------|------------------------------|---------|------------|
| 专利名称(译)        | 具有语音通信的超声诊断成像系统              |         |            |
| 公开(公告)号        | <a href="#">EP1152693A1</a>  | 公开(公告)日 | 2001-11-14 |
| 申请号            | EP2000969333                 | 申请日     | 2000-09-27 |
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| 当前申请(专利权)人(译)  | 皇家飞利浦电子N.V.                  |         |            |
| [标]发明人         | TAKATORI SONJA A             |         |            |
| 发明人            | TAKATORI, SONJA, A.          |         |            |
| IPC分类号         | A61B8/00                     |         |            |
| CPC分类号         | A61B8/467 A61B8/00 A61B8/461 |         |            |
| 代理机构(译)        | LOTTIN , CLAUDINE            |         |            |
| 优先权            | 09/411178 1999-10-01 US      |         |            |
| 外部链接           | <a href="#">Espacenet</a>    |         |            |

#### 摘要(译)

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