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(54) **HUMAN INTERFACE AND DEVICE FOR ULTRASOUND GUIDED TREATMENT**

MENSCHLICHE SCHNITTSTELLE UND VORRICHTUNG FÜR ULTRASCHALLGEFÜHRTE BEHANDLUNG

INTERFACE HUMAINE ET DISPOSITIF DE TRAITEMENT GUIDÉ PAR ULTRASONS

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Description

BACKGROUND

[0001] The use of focused ultrasound for treating tissues is a relatively new field. Devices providing ultrasound therapy are being developed and new ways are being found for users to interact with such devices.

[0002] There is increasing interest in devices that provide image-guided focused ultrasound therapy. With an image-guided ultrasound device, the general principle is to provide the user sufficient information so they can safely and effectively target and treat tissues. Various devices described herein for illustrative purposes use ultrasound imaging for visualization and high-intensity focused ultrasound for treatment.

[0003] US 2009/0326372 A1 is directed to a medical imaging and therapy applicator that can image target tissue of a patient with ultrasound imaging transducers, and display the imaging information and provide therapeutic energy to the target tissue.

SUMMARY

[0004] The following summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0005] This disclosure describes unique ways in which a user may interact with an ultrasound device. It also describes ways in which the device may automatically respond or behave as an alternative to the user interaction.

[0006] High intensity focused ultrasound (HIFU) systems described herein provide real-time, image-guided HIFU treatment of tissue. In a first embodiment, the present invention provides a high intensity focused ultrasound, HIFU, system for real-time, image-guided HIFU treatment of tissue of a patient, the system comprising: a HIFU applicator configured to deliver HIFU energy to the tissue; a HIFU generator configured to control and transmit the HIFU energy to the HIFU applicator; an ultrasound imaging device configured to control imaging of the tissue so as to provide, during operation of the HIFU system, 1) a real-time view of a first image plane that is parallel to a line passing through a feature of the HIFU applicator, and 2) a real-time view of a second image plane that is orthogonal to the first image plane, wherein the feature of the HIFU applicator visually provides to a user of the HIFU system a corresponding indication that correlates an orientation of a displayed image plane to the patient; and a user interface including a display, wherein the user interface is configured to display images of the tissue on the display which provide three-dimensional visualization of the tissue, wherein the display simultaneously includes an active parallel frame depicting the real-time view of the first image plane parallel to the feature of the HIFU applicator and an active orthogonal frame depicting the real-time view of the second image plane orthogonal to the first image plane depicted in the active parallel frame.

[0007] The user interface may be further configured to display reference frames in addition to the active parallel frame and the active orthogonal frame, wherein the reference frames include a reference parallel frame and a reference orthogonal frame. In at least one embodiment, the reference parallel frame provides a static view of the active parallel frame and the reference orthogonal frame provides a static view of the active orthogonal frame.

[0008] The user interface may be further configured to display reference lines added to the reference parallel frame and the reference orthogonal frame, and duplicate the reference lines on the active parallel frame and the active orthogonal frame. The user interface may include device controls, which may be one or more control icons accessible via the display, for controlling the ultrasound imaging device. In at least one embodiment, the system is configured to automatically set and adjust one or more of the device controls.

[0009] The system may be further configured to detect and mark tissue boundaries, calculate and adjust treatment parameters based on the detected tissue boundaries, and display the marked tissue boundaries on the display. The user interface may be configured to display a 360 degree sweep view of the tissue volume. The ultrasound imaging device may be connected to the system via a docketing interface.

[0010] Methods of interacting with a high intensity focused ultrasound (HIFU) system during real-time, image-guided HIFU treatment of tissue are also described herein. In a second embodiment, the present invention provides a method of operation of a high intensity focused ultrasound, HIFU, system that includes a HIFU applicator, an ultrasound imaging device, and a user interface including a display, the method comprising: operating the ultrasound imaging device to acquire ultrasound images that include 1) a real-time view of a first image plane that is parallel to a line passing through a feature of the HIFU applicator, and 2) a real-time view of a second image plane that is orthogonal to the first image plane, wherein the feature of the HIFU applicator visually provides to a user of the HIFU system a corresponding indication that correlates an orientation of a displayed image plane to a patient being imaged; and displaying the ultrasound images on the display of the user interface, wherein the display simultaneously includes an active parallel frame depicting the real-time view of the first image plane parallel to the feature of the HIFU applicator and an active orthogonal frame depicting the real-time view of the second image plane orthogonal to the first image plane depicted in the active parallel frame.

[0011] The method may further include displaying reference frames in addition to the active parallel frame and the active orthogonal frame during treatment, wherein the reference frames include a reference parallel frame and a reference orthogonal frame. In at least one embodiment, the reference parallel frame provides a static view of the active parallel frame and the reference orthogonal frame provides a static view of the active orthogonal frame.

[0012] The method may further include adding reference lines to the reference parallel frame and the reference orthogonal frame, and duplicating the reference lines on the active parallel and active orthogonal frames.

[0013] The method may further include controlling an ultrasound imaging device through device controls, which may be one or more control icons accessible on a display. In at least one embodiment, the method includes automatically setting and adjusting one or more of the device controls.

[0014] The method may further include detecting, marking, and displaying tissue boundaries, as well as calculating and adjusting treatment parameters based on the detected tissue boundaries. In at least one embodiment, the method includes automatically detecting, marking, and displaying tissue boundaries, and automatically calculating and adjusting treatment parameters based on the detected tissue boundaries. The method may further include displaying a 360 degree sweep view of the tissue volume.

DESCRIPTION OF THE DRAWINGS

[0015] The foregoing aspects and many of the attendant advantages of this disclosure will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 illustrates a therapeutic ultrasound device in accordance with at least one embodiment;

FIGURE 2 illustrates a user interface layout including an initial screen with two orthogonal image planes depicted in accordance with at least one embodiment;

FIGURE 3 illustrates a user interface layout including a screen with a graphical overlay of the embodiment illustrated in FIGURE 2;

FIGURE 4 illustrates a user interface layout including a screen with a layout with a full volume mode;

FIGURE 5 illustrates a user interface layout including a screen with a scanplane position manual control;

FIGURE 6 illustrates a user interface layout including a pretreatment screen showing reference and active images;

FIGURE 7 illustrates a user interface layout including a screen with user controls in a targeting mode;

FIGURE 8 illustrates a user interface layout including a screen displaying sketched reference lines;

FIGURE 9 illustrates a user interface layout including a screen with an ultrasound imager control panel;

FIGURE 10 illustrates a user interface layout including a pretreatment screen with a footswitch control;

FIGURE 11 illustrates a therapeutic ultrasound device in accordance with at least one embodiment;

FIGURE 12 illustrates a user interface layout including a screen layout with two active image planes and two reference planes;

FIGURE 13 illustrates a user interface layout including a screen layout with two image planes;

FIGURE 14 illustrates a user interface layout including a screen layout with an alternative quad-view with critical controls section identified; and

FIGURE 15 illustrates a user interface layout including reference images overlaid on the screen.

DETAILED DESCRIPTION

[0016] This section describes various embodiments of therapeutic ultrasound devices that include user interfaces in accordance with the present disclosure.

[0017] The primary components of at least one embodiment of a device described herein (see FIGURE 1) are listed in Table 1.

Table 1: Device primary components

Number	Description
10	HIFU device
12	Ultrasound imaging component (preferably, commercial grade)
14	HIFU generator that controls and outputs the power waveform to the HIFU transducer
30	User interface that includes a video/image display with touchscreen for input, and a footswitch
16	Computer for interfacing the primary device components
18	Connector and associated cabling to interconnect the HIFU generator and imaging components to the HIFU applicator
20	HIFU applicator that houses the HIFU transducer, imaging transducer, high bandwidth ultrasound receiver, and motors/mechanisms for steering the HIFU energy

[0018] In at least one embodiment, an image-guided focused ultrasound device 10 includes a user interface 30 that gives a user the ability to visualize patient tissues in real time both while targeting and treating the tissues. In at least one embodiment, the user interface 30 provides the user with images for visualizing three-dimensional tissue volumes. The user is provided with two real-time orthogonal views 42, 44 (e.g., x-z and y-z planes, or from the user's perspective in this particular embodiment, transverse and sagittal planes), preferably simultaneously, to allow basic three-dimensional visualization of the patient's tissue and tracking of ultrasound therapy applied to the tissue (see FIGURE 2). An active parallel frame 42 provides the real-time view of the sagittal image. When appropriately positioning the applicator, the parallel plane passes through the long axis of the applicator and is parallel to a line passing through a feature of the applicator, such as both handles (this plane is typically parallel to the user). An active orthogonal frame 44 provides the real-time view of the transverse plane, which is orthogonal to the active parallel frame 42, as shown in FIGURE 2.

[0019] The user interface 30, as described herein, may include a variety of icons that allow the user to select certain functionality and otherwise interact with the ultrasound device 10. In the embodiment shown in FIGURE 2, for example, an icon 40 is shown in the upper left corner of each image 42, 44 to indicate the orientation (position) of the respective image plane within the patient's tissue. To correlate the image plane to the patient, a corresponding indication on the ultrasound applicator 20 may be provided in the form of a color, shape, or other markings or features. The implementation described herein is intuitive. For an applicator 20 with two handles spaced at 180 degrees apart, one image aligns with the user's hands (handles), and the other image aligns orthogonal to a plane through the user's hands. The corresponding applicator motion is also intuitive as well, since a left motion along the plane through the handles may result in the tissue "sliding" through the ultrasound image (as if one were looking though a scope or view finder). The orthogonal plane can be programmable or selectable as to whether pushing the applicator 20 away results in a "left slide" or a "right slide" of the applicator 20 over the tissue. In addition, there is a provision for displaying a graphic of the applicator 20 moving over the patient on the screen of the user interface 30. The device 10 may use accelerometer data from the applicator 20 (or other input information, such as image data) to determine the motion of the applicator 20 and reflect that motion on the screen of the user interface 30. The orientation of the patient relative to the applicator 20 is settable by the user (e.g., head to the left or right). This mode would primarily be available in a training mode, but could be available during treatment. This data would also be available for motion detection during treatment, could be used independently or combined with processed ultrasound image data to detect motion, and may inform or alarm the user during treatment (e.g., regarding a shift during treatment).

[0020] With regard to identifying target tissue, a graphical overlay 50 on the screen of the user interface 30 may be used to show the target volume 52, a safety margin 54, and pre focal and post focal field lines 56, 58 (see FIGURE 3). The target volume 52 indicates the tissue to be treated. The safety margin lines 54 indicate the distance away from the target volume 52 to keep critical tissue away such as the serosa, bowel, etc. The pre focal and post focal lines 56, 58 indicate the boundaries of the overall HIFU field for the entire treatment (e.g., as the focus is moved about). The overlay 50 can be turned off or disabled with overlay on/off icon 92 for unobstructed viewing, then re-enabled when desired, e.g., for treatment (see FIGURE 7).

[0021] In addition, the device 10 may provide the user with a full-volume scanning mode (see icon 100 of FIGURE 7), where the scanplane is rotated about a vertical axis, e.g., a full 180 degrees, to allow the user to visualize some portion or an entire volume of tissue. The relative angle of rotation is either automated or manually positioned via the user interface 30 (see FIGURE 4).

[0022] The scanplane position (angle) of the ultrasound image, specifically relative to the applicator and indirectly relative to the patient, may be indicated to the user via the same icon 40 used to reference the orientation of the aforementioned orthogonal scanplanes (see FIGURE 4). In addition, the user may pause the automatic sweeping of the scanplane position and manually position the scanplane using controls 60, 62, 64, for example, as shown in FIGURE 5.

[0023] In at least one embodiment, the user can rotate the image plane in either a clockwise or counterclockwise direction by momentarily, repeatedly, or continuously selecting the respective step icons 62, 63. To restart the automated sweeping, the user selects the Sweep/Pause icon 64.

[0024] Upon exiting the targeting mode, the user is provided two targeting image frames. Reference parallel frame 46 and reference orthogonal frame 48 are maintained for reference (left), and two additional image frames (right) become active, namely active parallel frame 42 and active orthogonal frame 44 (see FIGURE 6). In the active parallel and orthogonal frames 42, 44, the tissue can be observed in real time, while in the reference parallel and orthogonal frames 46, 48, the image of the tissue is captured at one point in time, for example.

[0025] The right-side active image planes (active parallel frame 42 and active orthogonal frame 44) are used for real-time tracking of tissue treatment throughout the treatment session, with the reference image planes (reference parallel frame 46 and reference orthogonal frame 48) remaining constant on the left side. Also shown on the screen of the user interface 30 is an icon 70 used for selecting between various image filters. These image filters include, but are not limited to, filters that remove image reverb artifacts using various techniques and/or edge, boundary, or tissue-enhancing filters. In the illustrated embodiment, most controls are available in both the targeting and pretreatment modes (see FIGURE 7).

[0026] The user can modify treatment parameters, initiate treatment, or exit/power off. The characteristics of these controls and other interactions or features of the device 10 will be discussed below.

[0027] The device 10 may incorporate multiple features that assist the user in tracking the patient's tissue during treatment. First, the reference planes (reference parallel frame 46 and reference orthogonal frame 48) on the left side of the screen of the user interface 30, which show the targeted tissue, stay consistent throughout treatment (FIGURE 6). The intent is to keep the applicator 20 positioned such that the active images (active parallel frame 42 and active orthogonal frame 44) on the right side of the screen of the user interface 30 consistently appear like the reference images. The reference planes are used to ensure that the position of the applicator 20 relative to the patient remains consistent during treatment. In addition, in cases where the user moves the applicator 20 in an unintended direction, the patient moves, or the applicator 20 is otherwise not on target, the user can pause the treatment, reposition the applicator 20 such that the active images are aligned similar to the reference images, and then restart treatment.

[0028] Second, the user has tools 80, 82, 84 for drawing or sketching reference lines 110 on the reference plane images (see FIGURES 7 and 8). These reference lines 110 are typically used to mark tissue boundaries. The reference lines 110 can be drawn with finger, stylus, mouse, trackball, touchpad, or other suitable device on the touchscreen display of the user interface 30. These reference lines 110 are thereafter duplicated 112 on the active plane images, which assist the user in keeping the applicator 20 on target (FIGURE 8). In addition to the drawing tool 80, there is an eraser tool 82 for erasing part or all of a reference line, and an erase function 84 for erasing all reference lines. The eraser tool data may be input via finger, stylus, and/or other tools similar to the line-drawing tool. As with the overlay 50, the lines 110, 112 can be visible or hidden for unobstructed viewing of the ultrasound image.

[0029] Reference lines 110 could also be generated automatically using common signal and image-processing techniques that can detect dominant features, such as boundaries or edges, in the reference images. Upon activation by the user (or automatically), the device 10 may present the user with proposed reference lines based on detected features, from which the user can choose to accept all, some, or none as reference lines on the screen of the user interface 30. In addition, an embodiment of the device 10 may enhance the tissue boundaries (edges) using currently known signal and image-processing techniques (e.g., enhancing steep gradients across the image data).

[0030] The device 10 may incorporate an ultrasound imaging system for visualizing the patient's tissues. The ultrasound imaging system may be a commercially available system. As described herein, controls for a commercial ultrasound system may be included in the user interface 30 of the HIFU device 10 (see FIGURE 9) by activating icon 96 (see FIGURE 7).

[0031] The ultrasound imaging controls presented to the user may include Time Gain Control (TGC) 120, enabling or disabling harmonic imaging 122, and adjusting the overall gain 124. In other embodiments, the user interface 30 may be further enhanced with additional or different imaging ultrasound controls that are presented to the user. In addition to the user controls, there are controls that may be automatically adjusted by the device 10, such as overall gain and TGC presets, and automatic gain change as depth is varied.

[0032] The distance between the imaging transducer and the patient interface may vary as a function of the HIFU treatment depth, since the imaging transducer is moved along with the HIFU transducer within a transducer fluid volume.

The transducer fluid path increases and the tissue path decreases as the depth of treatment decreases. The device may reduce overall gain of the ultrasound imaging system to account for the reduced tissue path between the transducer and the target volume. For some imaging systems, the device 10 can also adjust the output power as the transducer fluid path length is varied.

[0033] In addition, the device 10 may provide the user with options for edge-enhancing filters (e.g., enhancing steep gradients in the image), reverb and motion filtering (via Doppler and/or minimum filtering), elastography methods to enhance differences in tissue stiffness, and other ultrasound imaging enhancements that assist the user with differentiating between tissue types (e.g., clearer identification of fibroid boundaries).

[0034] The device 10 may include multiple features by which the user can set or adjust the treatment regimen for affecting treatment parameters. For example, in at least one embodiment, the user first operates the device 10 to choose a target volume. The device 10 may provide an icon on the user interface 30 that, when selected, brings up a menu of treatment volume options (using, for example, a scrolling, mouse, or touch screen selection). Alternatively, the target volume shown on the screen of the user interface 30 could change size or shape each time the user selects the icon 94 on the screen of the user interface 30 (see FIGURE 7). The icon 94 could also change (e.g., by way of text or graphic) with each target volume selection, providing feedback to the user. Alternatively, in other embodiments, the device 10 iteration(s) may allow the user to change the size of the volume simply by touching or clicking on the target volume boundary on the user interface 30 and dragging the boundary to the desired target volume size and/or shape.

[0035] Every target volume may have associated with it a unique set of treatment parameters, such as peak acoustic power, duty cycle, and motion pattern. In at least one embodiment, an overall target volume is made up of multiple unit volumes and the treatment parameter(s) set for each unit volume is/are dependent on where the unit is located relative to the other unit volume(s). In an embodiment, the device 10 is implemented using predetermined treatment volumes (e.g., spherical shapes), though other embodiments may include an interface that allows the user to sketch arbitrary shapes on the orthogonal planes (or more than two planes), if desired. In such embodiments, the device 10 is configured to interpolate between the sketched lines and create a volume based on the sketched boundaries. The created target volume is displayed for the user to modify or accept. The device 10 then uses one or more algorithms to determine the appropriate treatment parameters for treating the target volume as displayed.

[0036] Second, the treatment regimen may be affected by the depth of treatment, due to the attenuation of the ultrasound as it passes through the tissue. In at least one embodiment of the device 10, the user chooses a target depth for the tissue volume via arrows 98 on the screen of the user interface 30 (see FIGURE 7). The arrows 98 could be replaced with similar functions such as a slide bar or entered numeric value. Further device 10 enhancements may include the ability to touch or click on the target volume and drag the volume to a new target depth on the touchscreen of the user interface 30.

[0037] Third, the treatment regimen may be dependent on the presence of other physiological aspects of the patient, such as bladder fluid, in the acoustic path. In at least one embodiment, the device 10 provides cursors on the screen of the user interface 30 to mark upper and lower boundaries of the bladder. In cases where bladder fluid is in the acoustic path, the user may select one or more icons 90 on the screen of the user interface 30 to make the cursors visible and then mark the bladder upper and lower boundaries. The user may adjust the cursor positions by dragging them via the touch screen of the user interface 30, though one could use a stylus, mouse, arrow keys, entered value, or other means to adjust the positions.

[0038] The user may be presented with simple line cursors. In other embodiments, the user interface 30 is enhanced to include curved or arbitrary lines for more complex and more precise calculation of the treatment parameters. In addition, embodiments of the ultrasound device 10 may automatically detect the boundaries of the bladder using known boundary detection algorithms on the image data, and use subsequent calculations to determine the treatment parameters based on the detected boundaries, thus eliminating the need for the user to interact with this parameter.

[0039] Fourth, the treatment parameters may be influenced by the thickness of the patient's abdominal wall. Similar to the bladder, in at least one embodiment, the user can enable a cursor on the screen of the user interface 30 and use the cursor to identify the abdominal wall depth as well as adjust the position of the cursor to mark the lower wall boundary. Methods of adjusting the cursor utilize icon 88 and are similar to the aforementioned methods for adjusting the bladder wall cursors (see FIGURE 7). In addition, similar to the bladder wall detection, embodiments of the device 10 may use currently known (or future developed) methods to automatically determine the abdominal wall boundary and subsequently calculate and adjust the treatment parameters. In both cases, the automatically determined boundaries could be presented to the user (e.g., via the screen of the user interface 30) for verification and/or modification.

[0040] In case the patient interface cap is flexible and the transducer fluid path length between the transducer and the patient tissue is dependent on the volume of transducer fluid in the system, the device 10 may be configured to account for the fluid standoff in the process of calculating the output power of the ultrasound signals. The position of the patient interface relative to the transducer may be adjusted by the user (e.g., using the screen of the user interface 30) or may be automatically determined by the device 10. In the example above, the "skinline marker" icon 86 (see FIGURE 7) activates a blue line marker (cursor) on the image that is used to mark the surface of the patient's tissue (skin). This manual feature is implemented and used in at least one embodiment of the device 10, though the feature may be automated in other embodiments of the device 10. In an automated embodiment, the device 10 processes the image data to identify the boundary of the patient's tissue by looking for the transition from the foreground dark or low amplitude reflection data to the first bright or high amplitude reflection data. Other processing techniques may be used to detect this transition, such as processing raw RF data for the first significant reflection. This first transition is the patient's skin, which is then used for calculating the standoff distance.

[0041] When in pretreatment mode, the user is presented with the option of enabling the footswitch (see FIGURE 10), in at least one embodiment. Upon activation of the footswitch, the Activate Footswitch icon 130 may be configured to change to an Activate Treatment icon, and the device 10 programs the HIFU parameters and positions the transducer to start treatment. The device 10 is in Treatment Mode while the footswitch is enabled and the device 10 is either ready to treat or actively outputting HIFU signals.

[0042] When the user presses the footswitch, the icon changes from the Activate Treatment icon to a Stop/Pause Treatment icon, and the device 10 implements a regimen to treat the targeted treatment volume. The device 10 disables the footswitch and notifies the user when treatment is complete, at which time the icon changes back to indicate a pretreatment state. If the user releases the footswitch before the device 10 completes treatment, the icon may be configured to change to an inactive Treatment Paused icon, and the device 10 enters a Treatment Paused state.

[0043] In the Treatment Paused state, the device 10 may be configured to display options to the user. The user may choose to cancel the treatment and return to the pretreatment state, or simply re-press the footswitch to continue treating the target volume using the previously determined treatment regimen. While in the Treatment Paused state, the user may also choose to enter an imaging state and conduct a full volume sweep of the target volume to verify the conditions of the target volume and acoustic path, return to the Treatment Paused state, and then choose to cancel or return to providing treatment to the patient's tissue.

[0044] While outputting therapeutic ultrasound signals, the device 10 may include multiple indicators to the user that treatment is active. The device 10 may emit a sound, show an icon on the screen of the user interface 30 (e.g., the treatment icon changes to a stop treatment icon, and/or other indications), and/or illuminate the applicator 20 while outputting treatment. In addition, there may be a treatment timer on the screen of the user interface 30 indicating progress of the treatment regimen to the user. This treatment progress indicator could also be implemented with a progress bar, shading the target volume, or other relevant means of indication.

[0045] Although the examples of the device 10 discussed above are implemented with a footswitch, other examples of the device 10 could incorporate one or more control switches on the applicator 20, voice commands, proximity sensors, combinations of the aforementioned, or other means for the user to activate the output of HIFU signals.

[0046] While outputting treatment, an uncoupled applicator 20 (relative to the patient) would not harm the patient, though it would not result in effective treatment and such conditions could potentially harm the applicator 20. In at least one embodiment, the device 10 monitors the HIFU signal reflected from the patient interface and compares it to a predetermined threshold. If the reflected signal is greater than the threshold, the device 10 assumes the applicator 20 is not fully coupled to the patient and notifies the user. A value lower than the threshold would indicate the device 10 is coupled to the patient. In other examples, the thresholds and comparisons may be configured differently such that a value lower than the threshold indicates the applicator 20 is not fully coupled, and a value higher than the threshold indicates the device 10 is coupled to the patient. In addition, the device 10 may be configured to monitor the HIFU signal(s) reflected from tissues deeper than skinline (e.g., near focus) and compares these with expected values. This data may be combined with other data to enhance the coupling detection algorithm.

[0047] While in some examples, the device 10 allows the entry of patient data (e.g., name, etc.) and stores device data during treatment (for analysis, etc.), other examples of the device 10 may not provide the user with an option to enter patient data and device 10 does not store data during treatment. Further embodiments of the device 10 may allow the user to input patient data, treatment planning information from past, current, or future treatments, or other related data. In addition, the device 10 could also store treatment data (values, video, and images) from a given treatment session or sessions for later use by the user or others.

[0048] The device 10 may incorporate multiple features that enhance the safety of the device 10. The device 10 may detect and inform the user in case of insufficient coupling, as discussed above. The energy reflected off the patient interface from the HIFU waveform is monitored, and if it is too high (or too low) of a value, the device 10 may determine that the device 10 is not properly coupled, cease outputting treatment, and inform the user to check the patient coupling.

[0049] Moreover, the device 10 may include monitoring the tissue boundaries in the active image(s) and comparing them to the position of the tissue boundaries in the reference image(s). If the boundaries are not found to be within a predetermined value (threshold), a warning may be displayed or communicated to the user to check the alignment of the applicator relative to the patient. The user could pause treatment, realign the applicator 20 over the target tissue, or choose to ignore the warning. If the boundaries are not found to be within a second predetermined threshold (value), the device 10 may automatically pause treatment and an error may be displayed or communicated to the user indicating the treatment is paused and to check the alignment. The user would then reposition the applicator 20, clear the error, and reinitiate treatment, thereby continuing to treat the target volume. As a secondary means of ensuring an aligned applicator 20 is on target (where the primary means is the user monitoring the ultrasound images), the user may have the option to set the two thresholds and enable or disable the feature. Additional configurations include an accelerometer that can be used independently or combined with the image data to determine motion of the applicator 20 and accordingly inform the user.

[0050] The device 10 may include the ability to use independent ultrasound imaging for general ultrasound imaging. For example, there are two implementations of this feature described below. Table 2 below sets forth various ultrasound imaging components shown in the accompanying figures and described herein.

Table 2: General ultrasound imaging components

Number	Description
10	Therapeutic ultrasound device
12	Imaging ultrasound component
22	Connection between the imaging ultrasound component and the rest of the therapeutic ultrasound device
24	Hand-held ultrasound imaging probe
26	Connector between the ultrasound imaging probe and the therapeutic ultrasound device

[0051] In at least one configuration of integrated diagnostic imaging ultrasound, the HIFU device 10 may incorporate one or more connection(s) 26 for hand-held ultrasound imaging transducer(s) 24 (see FIGURE 11). The HIFU device 10 is then used as a diagnostic ultrasound imaging system.

[0052] In a dockable portable ultrasound configuration, the ultrasound imaging component 12 is disconnected via a docking interface 22 by the user from the HIFU device 10. The ultrasound imaging component 12 is then connected via connector 26 directly to the imaging transducer 24 and used as a stand-alone diagnostic ultrasound imaging system.

[0053] Alternative user interface layouts include multiple screen layouts for alternative user interaction with the device 10. The screen of the user interface 30 may have two active image planes and two reference image planes (see FIGURE 12).

[0054] The right-side screens display two orthogonal images (active parallel frame 42 and active orthogonal frame 44) and are always active (imaging). The left-side screens (reference parallel frame 46 and reference orthogonal frame 48) are blank on first entry to the user interface, and are populated with images from the right side when the user chooses (e.g., selects capture image) or when the user selects to start treating (e.g., activates the footswitch). The feature of capturing the images may be selected via a variety of modes, including, but not limited to, a footswitch, switch/sensor on the applicator 20, voice command, or through a touchscreen of the user interface 30. If the user has preselected captured images prior to activating the footswitch, the user may be prompted to choose whether the previously captured images are to be replaced. Once the device 10 is in treatment mode, the reference images (reference parallel frame 46 and reference orthogonal frame 48) are static and do not change. Alternatively, the static images, namely reference parallel frame 46 and reference orthogonal frame 48, may be replaced while in treatment mode.

[0055] The screen of the user interface 30 may have only two active image planes that are visible, namely active parallel frame 42 and active orthogonal frame 44 (see FIGURE 13), and the image planes have a larger format than that with four image planes (see FIGURE 12).

[0056] In this case, the two orthogonal image planes (active parallel frame 42 and active orthogonal frame 44) are always active and continually updated. Upon entry to the treatment mode (e.g., by activating the footswitch), the device 10 stores captured reference images in memory. If the user chooses to view the reference images (e.g., in case the user pauses treatment and needs to reposition), the user may select an icon to make the reference images visible. The screen format of the user interface 30 may change to the aforementioned quad-view mode (see FIGURE 14), with the critical control functions 140 remaining consistently placed and visible between the two formats. Alternatively, the screen format of the user interface 30 may remain constant and reference parallel frame 46 and reference orthogonal frame 48 may be overlaid on the screen of the user interface 30 (see FIGURE 15).

[0057] In another example, the user may select more than two active image planes. For example, one may choose to view four image planes equally spaced about the volume (e.g., 0, 45, 90, and 135 degrees) or about two opposing quadrants (e.g., 0, 22.5, 67.5, and 90 degrees), etc. In yet another example, the display may include more than four image planes, for example with a relay out of the screen of the user interface 30 and/or with a larger display.

[0058] In the aforementioned image display formats, the user may have the option to also display the 360 degrees sweep view. This may be accomplished by replacing the biplane view layout with a single-view 360 degrees sweep layout. Alternatively, the image display format may have a third view that is included with the two orthogonal views. This third view may have, in one embodiment, the 360 degrees sweep view. In another embodiment, the third view could display a rendered 3D volume. The third view could display a coronal plane view. In another embodiment, four images could be displayed with two orthogonal active images, an active 360 degrees sweep, and the coronal view. It is recognized and appreciated that one can display four or more live images simultaneously where the displayed images are any combination of the aforementioned views (e.g., two orthogonal views, 360 degrees swept view, coronal view, rendered 3D image, Doppler image, strain imaging image, and/or other standard imaging mode views).

[0059] As may be appreciated from the various implementations described herein, there are a variety of features and advantages obtained when constructing a device in accordance with the present disclosure. Furthermore, although the present disclosure has been described in connection with certain depicted implementations, those of ordinary skill will recognize that one or more features of a particular implementation described herein may be used in another implementation for similar advantage. Accordingly, it is not intended that the scope of the present disclosure in any way be limited by the precise forms described above, but instead be determined by reference to the claims that follow and equivalents thereto.

Claims

1. A high intensity focused ultrasound, HIFU, system (10) for real-time, image-guided HIFU treatment of tissue of a patient, the system comprising:

    a HIFU applicator (20) configured to deliver HIFU energy to the tissue;
    a HIFU generator (14) configured to control and transmit the HIFU energy to the HIFU applicator (20);
    an ultrasound imaging device configured to control imaging of the tissue so as to provide, during operation of the HIFU system (10), 1) a real-time view of a first image plane that is parallel to a line passing through a feature of the HIFU applicator (20), and 2) a real-time view of a second image plane that is orthogonal to the first image plane, wherein the feature of the HIFU applicator (20) visually provides to a user of the HIFU system (10) a corresponding indication that correlates an orientation of a displayed image plane to the patient; and
    a user interface (30) including a display, wherein the user interface (30) is configured to display images of the tissue on the display which provide three-dimensional visualization of the tissue, wherein the display simultaneously includes an active parallel frame (42) depicting the real-time view of the first image plane parallel to the feature of the HIFU applicator (20) and an active orthogonal frame (44) depicting the real-time view of the second image plane orthogonal to the first image plane depicted in the active parallel frame (42).

2. The system of Claim 1, wherein the user interface (30) is further configured to display reference frames simultaneously with the display of the active parallel frame (42) and the active orthogonal frame (44), wherein the reference frames include a reference parallel frame (46) and a reference orthogonal frame (48), and wherein the reference parallel frame (46) corresponds to the active parallel frame (42) and provides a static view of the image plane depicted in the active parallel frame (42), and the reference orthogonal frame (48) corresponds to the active orthogonal frame (44) and provides a static view of the image plane depicted in the active orthogonal frame (44).

3. The system of Claim 2, wherein the user interface (30) is further configured to display reference lines (110) added to the image in the reference parallel frame (46) and the reference orthogonal frame (48), and duplicate the reference lines (110) on the image in the corresponding active parallel frame (42) and the corresponding active orthogonal frame (44), respectively.

4. The system of Claim 1, wherein the user interface (30) includes device controls for controlling the ultrasound imaging device, wherein at least one of the device controls is a control icon accessible via the display, optionally wherein the system is configured to automatically set and adjust one or more of the device controls.

5. The system of Claim 1, wherein the system is further configured to:

    detect and mark tissue boundaries;
    calculate and adjust treatment parameters based on the detected tissue boundaries; and
    display the marked tissue boundaries in one or more of the images on the display.

6. The system of Claim 5, wherein the system is configured to automatically detect and mark the tissue boundaries, and calculate and adjust the treatment parameters based on the detected tissue boundaries.

7. The system of Claim 1, wherein the user interface (30) is configured to display a 360 degree sweep view of the tissue.

8. The system of Claim 1, wherein the ultrasound imaging device is connected to the system via a docking interface.

9. The system of Claim 1, wherein the feature of the HIFU applicator (20) includes handles that are operable by the user of the HIFU system (10) to move the HIFU applicator (20), and wherein during motion of the HIFU applicator (20) the first image plane remains parallel to the handles of the HIFU applicator (20).

10. A method of operation of a high intensity focused ultrasound, HIFU, system (10) according to any of claims 1-9 the method comprising:

operating the ultrasound imaging device to acquire ultrasound images that include 1) a real-time view of a first image plane that is parallel to a line passing through a feature of the HIFU applicator (20), and 2) a real-time view of a second image plane that is orthogonal to the first image plane, wherein the feature of the HIFU applicator (20) visually provides to a user of the HIFU system (10) a corresponding indication that correlates an orientation of a displayed image plane to a patient being imaged; and
displaying the ultrasound images on the display of the user interface (30), wherein the display simultaneously includes an active parallel frame (42) depicting the real-time view of the first image plane parallel to the feature of the HIFU applicator and an active orthogonal frame (44) depicting the real-time view of the second image plane orthogonal to the first image plane depicted in the active parallel frame (42).

11. The method of Claim 10, the method further comprising displaying reference frames simultaneously with the display of the active parallel frame (42) and the active orthogonal frame (44), wherein the reference frames include a reference parallel frame (46) and a reference orthogonal frame (48), and wherein the reference parallel frame (46) corresponds to the active parallel frame (42) and provides a static view of the image plane depicted in the active parallel frame (42), and the reference orthogonal frame (48) corresponds to the active orthogonal frame (44) and provides a static view of the image depicted in the active orthogonal frame (44).

12. The method of Claim 11, the method further comprising adding reference lines (110) to the image in the reference parallel frame (46) and the reference orthogonal frame (48), and duplicating the reference lines (110) on the image in the corresponding active parallel frame (42) and the corresponding active orthogonal frame (44).

13. The method of Claim 10, the method further comprising controlling an ultrasound imaging device through device controls, wherein the ultrasound imaging device is used to display ultrasound images of the tissue on the user interface (30), and wherein at least one of the device controls is a control icon accessible on a display of the user interface (30), optionally wherein the method further comprising automatically setting and adjusting one or more of the device controls.

14. The method of Claim 10, the method further comprising detecting, marking, and displaying tissue boundaries, and calculating and adjusting treatment parameters based on the detected tissue boundaries, optionally wherein the method further comprising automatically detecting, marking, and displaying tissue boundaries, and automatically calculating and adjusting treatment parameters based on the detected tissue boundaries.

15. The method of Claim 10, the method further comprising:
selecting an icon on the user interface to cause reference images stored in a memory to be displayed, wherein the active parallel frame (42) becomes a reference parallel frame (46) that depicts a static image of the first image plane parallel to the feature of the HIFU applicator (20) and the active orthogonal frame (44) becomes a reference orthogonal frame (48) that depicts a static image of the second image plane orthogonal to the image plane depicted in the reference parallel frame (46).

Patentansprüche

1. Hochintensives fokussiertes Ultraschall (HIFU)-System (10) zur bildgesteuerten HIFU-Behandlung von Gewebe eines Patienten in Echtzeit, wobei das System umfasst:

einen HIFU-Applikator (20), der so konfiguriert ist, dass er HIFU-Energie an das Gewebe abgibt;
einen HIFU-Generator (14), der so konfiguriert ist, dass er die HIFU-Energie an den HIFU-Applikator (20) steuert

und überträgt;
eine Ultraschallbildgebungseinrichtung, die so konfiguriert ist, dass sie die Bildgebung des Gewebes so steuert, dass sie während des Betriebs des HIFU-Systems (10) 1) eine Echtzeitansicht einer ersten Bildebene, die parallel zu einer Linie ist, die durch ein Element des HIFU-Applikators (20) verläuft, und 2) eine Echtzeitansicht einer zweiten Bildebene liefert, die orthogonal zur ersten Bildebene ist, wobei das Element des HIFU-Applikators (20) einem Benutzer des HIFU-Systems (10) visuell eine entsprechende Anzeige liefert, die eine Ausrichtung einer abgebildeten Bildebene mit dem Patienten in Übereinstimmung bringt; und
eine Benutzerschnittstelle (30) mit einer Anzeige, wobei die Benutzerschnittstelle (30) so konfiguriert ist, dass sie Bilder des Gewebes auf der Anzeige abbildet, die eine dreidimensionale Veranschaulichung des Gewebes liefern, wobei die Anzeige gleichzeitig einen aktiven parallelen Rahmen (42), der die Echtzeitansicht der ersten Bildebene parallel zum Element des HIFU-Applikators (20) darstellt, und einen aktiven orthogonalen Rahmen (44) aufweist, der die Echtzeitansicht der zweiten Bildebene orthogonal zur ersten Bildebene darstellt, die im aktiven parallelen Rahmen (42) dargestellt ist.

2. System nach Anspruch 1, wobei die Benutzerschnittstelle (30) weiter so konfiguriert ist, dass sie Bezugsrahmen gleichzeitig mit der Anzeige des aktiven parallelen Rahmens (42) und des aktiven orthogonalen Rahmens (44) anzeigt, wobei die Bezugsrahmen einen parallelen Bezugsrahmen (46) und einen orthogonalen Bezugsrahmen (48) aufweisen und wobei der parallele Bezugsrahmen (46) dem aktiven parallelen Rahmen (42) entspricht und eine statische Ansicht der im aktiven parallelen Rahmen (42) dargestellten Bildebene liefert und der orthogonale Bezugsrahmen (48) dem aktiven orthogonalen Rahmen (44) entspricht und eine statische Ansicht der im aktiven orthogonalen Rahmen (44) dargestellten Bildebene liefert.

3. System nach Anspruch 2, wobei die Benutzerschnittstelle (30) weiter so konfiguriert ist, dass sie Bezugslinien (110) anzeigt, die dem Bild in dem parallelen Bezugsrahmen (46) und dem orthogonalen Bezugsrahmen (48) hinzugefügt wurden, und die Bezugslinien (110) auf dem Bild in dem entsprechenden aktiven parallelen Rahmen (42) bzw. dem entsprechenden aktiven orthogonalen Rahmen (44) dupliziert.

4. System nach Anspruch 1, wobei die Benutzerschnittstelle (30) Einrichtungssteuerungen zum Steuern der Ultraschallabbildungseinrichtung aufweist, wobei mindestens eine der Einrichtungssteuerungen ein über die Anzeige zugängliches Steuersymbol ist, wobei das System wahlweise so konfiguriert ist, dass es eine oder mehrere der Einrichtungssteuerungen automatisch einstellt und anpasst.

5. System nach Anspruch 1, wobei das System weiter so konfiguriert ist, dass es:

Gewebegrenzen erfasst und markiert;
Behandlungsparameter auf der Grundlage der erfassten Gewebegrenzen berechnet und anpasst; und
die markierten Gewebegrenzen in einem oder mehreren der Bilder auf der Anzeige abbildet.

6. System nach Anspruch 5, wobei das System so konfiguriert ist, dass es die Gewebegrenzen automatisch erfasst und markiert und die Behandlungsparameter auf der Grundlage der erfassten Gewebegrenzen berechnet und anpasst.

7. System nach Anspruch 1, wobei die Benutzerschnittstelle (30) so konfiguriert ist, dass sie eine 360-Grad-Abtastansicht des Gewebes abbildet.

8. System nach Anspruch 1, wobei die Ultraschallabbildungseinrichtung über eine Andockschnittstelle mit dem System verbunden ist.

9. System nach Anspruch 1, wobei das Element des HIFU-Applikators (20) Griffe aufweist, die vom Benutzer des HIFU-Systems (10) betätigt werden können, um den HIFU-Applikator (20) zu bewegen, und wobei während der Bewegung des HIFU-Applikators (20) die erste Bildebene parallel zu den Griffen des HIFU-Applikators (20) bleibt.

10. Verfahren zum Betrieb eines hochintensiven, fokussierten Ultraschall (HIFU)-Systems nach einem der Ansprüche 1-9, wobei das Verfahren umfasst:

Betreiben der Ultraschallabbildungseinrichtung zum Erhalten von Ultraschallbildern, die 1) eine Echtzeitansicht einer ersten Bildebene, die parallel zu einer Linie ist, die durch ein Element des HIFU-Applikators (20) verläuft, und 2) eine Echtzeitansicht einer zweiten Bildebene aufweisen, die orthogonal zur ersten Bildebene ist, wobei das Element des HIFU-Applikators (20) einem Benutzer des HIFU-Systems (10) visuell eine entsprechende Anzeige liefert, die eine Ausrichtung einer abgebildeten Bildebene mit einem abgebildeten Patienten in Übereinstimmung gebracht wird; und

Abbilden der Ultraschallbilder auf der Anzeige der Benutzerschnittstelle (30), wobei die Anzeige gleichzeitig einen aktiven parallelen Rahmen (42), der die Echtzeitansicht der ersten Bildebene parallel zum Element des HIFU-Applikators darstellt, und einen aktiven orthogonalen Rahmen (44) aufweist, der die Echtzeitansicht der zweiten Bildebene orthogonal zur ersten Bildebene darstellt, die im aktiven parallelen Rahmen (42) dargestellt ist.

11. Verfahren nach Anspruch 10, wobei das Verfahren weiter umfasst:

Abbilden von Bezugsrahmen gleichzeitig mit der Anzeige des aktiven parallelen Rahmens (42) und des aktiven orthogonalen Rahmens (44),

wobei die Bezugsrahmen einen parallelen Bezugsrahmen (46) und einen orthogonalen Bezugsrahmen (48) umfassen und wobei der parallele Bezugsrahmen (46) dem aktiven parallelen Rahmen (42) entspricht und eine statische Ansicht der im aktiven parallelen Rahmen (42) dargestellten Bildebene liefert und der orthogonale Bezugsrahmen (48) dem aktiven orthogonalen Rahmen (44) entspricht und eine statische Ansicht des Bilds liefert, das im aktiven orthogonalen Rahmen (44) dargestellt ist.

12. Verfahren nach Anspruch 11, wobei das Verfahren weiter umfasst:
Hinzufügen von Bezugslinien (110) zu dem Bild in dem parallelen Bezugsrahmen (46) und dem orthogonalen Bezugsrahmen (48) und Duplizieren der Bezugslinien (110) auf dem Bild in dem entsprechenden aktiven parallelen Rahmen (42) und dem entsprechenden aktiven orthogonalen Rahmen (44).

13. Verfahren nach Anspruch 10, wobei das Verfahren weiter umfasst:
Steuern einer Ultraschallabbildungseinrichtung durch Einrichtungssteuerungen, wobei die Ultraschallabbildungseinrichtung verwendet wird, um Ultraschallbilder des Gewebes auf der Benutzerschnittstelle (30) abzubilden und wobei mindestens eine der Einrichtungssteuerungen ein Steuersymbol ist, das auf einer Anzeige der Benutzerschnittstelle (30) zugänglich ist, wobei das Verfahren wahlweise weiter das automatische Einstellen und Anpassen einer oder mehrerer der Einrichtungssteuerungen umfasst.

14. Verfahren nach Anspruch 10, wobei das Verfahren weiter umfasst:
Erfassen, Markieren und Abbilden von Gewebegrenzen sowie Berechnen und Anpassen von Behandlungsparametern auf der Grundlage der erfassten Gewebegrenzen, wobei das Verfahren wahlweise weiter das automatische Erfassen, Markieren und Abbilden von Gewebegrenzen sowie das automatische Berechnen und Anpassen von Behandlungsparametern auf der Grundlage der erfassten Gewebegrenzen umfasst.

15. Verfahren nach Anspruch 10, wobei das Verfahren weiter umfasst:
Auswählen eines Symbols auf der Benutzerschnittstelle, um zu bewirken, dass in einem Speicher gespeicherte Referenzbilder abgebildet werden, wobei der aktive parallele Rahmen (42) zu einem parallelen Referenzrahmen (46) wird, der ein statisches Bild der ersten Bildebene parallel zum Element des HIFU-Applikators (20) darstellt, und der aktive orthogonale Rahmen (44) zu einem orthogonalen Referenzrahmen (48) wird, der ein statisches Bild der zweiten Bildebene orthogonal zu der in dem parallelen automatische Referenzrahmen (46) dargestellten Bildebene darstellt.

Revendications

1. Système à ultra-sons focalisés haute intensité (HIFU) (10) pour le traitement HIFU temps réel à guidage par imagerie des tissus d'un patient, le système comprenant :

un applicateur HIFU (20) configuré pour délivrer une énergie HIFU au tissu ;

un générateur HIFU (14) configuré pour contrôler et transmettre l'énergie HIFU à l'applicateur HIFU (20) ;

un dispositif d'imagerie par ultrasons configuré pour contrôler l'imagerie des tissus de façon à fournir, pendant l'utilisation du système HIFU (10), 1) une vue temps réel d'un premier plan d'image qui est parallèle à une ligne passant au travers d'une caractéristique de l'applicateur HIFU (20) et 2) une vue temps réel d'un second plan d'image qui est orthogonal au premier plan d'image, dans lequel la caractéristique de l'applicateur HIFU (20) fournit visuellement à un utilisateur du système HIFU (10) une indication correspondante qui corrèle une orientation d'un plan d'image affichée avec le patient ; et une interface utilisateur (30) incluant un affichage, dans laquelle l'interface utilisateur (30) est configurée pour afficher des images des tissus sur l'affichage qui procure une visualisation tridimensionnelle des tissus, dans laquelle l'affichage inclut simultanément une trame parallèle active (42) décrivant la vue temps réel du premier plan d'image parallèle à la caractéristique de l'applicateur HIFU (20) et une trame orthogonale active (44) décrivant la vue temps réel du second plan d'image orthogonal au premier plan d'image décrit dans la trame parallèle active (42).

2. Système selon la revendication 1, dans lequel l'interface utilisateur (30) est en outre configurée pour afficher des trames de référence simultanément avec l'affichage de la trame parallèle active (42) et la trame orthogonale active (44), dans lequel les trames de référence incluent une trame parallèle de référence (46) et une trame orthogonale de référence (48) et dans lequel la trame parallèle de référence (46) correspond à la trame parallèle active (42) et la trame orthogonale de référence (48) correspond à la trame orthogonale active (44) et fournit une vue statique du plan d'image décrit dans la trame orthogonale active (44).

3. Système selon la revendication 2, dans lequel l'interface utilisateur (30) est en outre configurée pour afficher des lignes de référence (110) ajoutées à l'image dans la trame parallèle de référence (46) et la trame orthogonale de référence (48), et dupliquer les lignes de référence (110) sur l'image dans la trame parallèle active correspondante (42) et la trame orthogonale active correspondante (44), respectivement.

4. Système selon la revendication 1, dans lequel l'interface utilisateur (30) inclut des contrôles de dispositif pour contrôler le dispositif d'imagerie par ultrasons, dans lequel au moins l'un des contrôles de dispositif est une icône de contrôle accessible via l'affichage, optionnellement dans lequel le système est configuré pour automatiquement régler et ajuster un ou plusieurs des contrôles de dispositif.

5. Système selon la revendication 1, dans lequel le système est en outre configuré pour :

détecter et marquer les limites des tissus ;
calculer et ajuster les paramètres de traitement sur la base des limites des tissus détectées ; et
afficher les limites des tissus marquées dans une ou plusieurs des images sur l'affichage.

6. Système selon la revendication 5, dans lequel le système est configuré pour détecter et marquer automatiquement les limites des tissus et calculer et ajuster les paramètres de traitement sur la base des limites de tissus détectées.

7. Système selon la revendication 5, dans lequel l'interface utilisateur (30) est configurée pour afficher une vue balayante sur 360 degrés des tissus.

8. Système selon la revendication 1, dans lequel le dispositif d'imagerie par ultrasons est connecté au système via une interface de station d'accueil.

9. Système selon la revendication 1 dans lequel la caractéristique de l'applicateur HIFU (20) inclut des poignées qui sont actionnables par l'utilisateur du système HIFU (10) pour déplacer l'applicateur HIFU (20) et dans lequel pendant le mouvement de l'applicateur HIFU (20), le premier plan d'image reste parallèle aux poignées de l'applicateur HIFU (20).

10. Procédé d'exploitation d'un système HIFU à ultrasons focalisés haute intensité (20) selon l'une quelconque des revendications 1-9, le procédé comprenant les opérations consistant à :

exploiter le dispositif d'imagerie par ultrasons pour acquérir des images par ultrasons qui incluent 1) une vue temps réel d'un premier plan d'image qui est parallèle à une ligne passant au travers d'une caractéristique de l'applicateur HIFU (20), et 2) une vue temps réel d'un second plan d'image orthogonal au premier plan d'image, dans lequel la caractéristique de l'applicateur HIFU (20) fournit visuellement à un utilisateur du système HIFU (10) une indication correspondante qui corrèle une orientation d'un plan d'image affiché à un patient imagé ; et
afficher les images par ultrasons sur l'affichage de l'interface utilisateur (30) dans lequel l'affichage inclut simultanément une trame parallèle active (42) décrivant la vue temps réel du premier plan d'image parallèle à la caractéristique de l'applicateur HIFU et une trame orthogonale active (44) décrivant la vue temps réel du second plan d'image orthogonal au premier plan d'image décrit dans la trame parallèle active (42).

11. Procédé selon la revendication 10, le procédé comprenant en outre l'affichage de trames de référence simultanément à l'affichage de la trame parallèle active (42) et de la trame orthogonale active (44) dans lequel les trames de référence incluent une trame parallèle de référence (46) et une trame orthogonale de référence (48) et dans lequel la trame parallèle de référence (46) correspond à la trame parallèle active (42) et fournit une vue statique du plan d'image décrit dans la trame parallèle active (42), et la trame orthogonale de référence (48) correspond à la trame orthogonale active (44) et fournit une vue statique de l'image décrite dans la trame orthogonale active (44).

12. Procédé selon la revendication 11, le procédé comprenant en outre les opérations consistant à ajouter des lignes de référence (110) à l'image dans la trame parallèle de référence (46) et la trame orthogonale de référence (48) et à dupliquer les lignes de référence (110) sur l'image dans la trame parallèle active (42) et la trame orthogonale active correspondante (44).

13. Procédé selon la revendication 10, le procédé comprenant en outre le contrôle d'un dispositif d'imagerie à ultrasons par des contrôles de dispositif, dans lequel le dispositif d'imagerie par ultrasons est utilisé pour afficher des images par ultrasons du tissu sur l'interface utilisateur (30) et dans lequel au moins un des contrôles de dispositif est une icône de contrôle accessible sur un affichage de l'interface utilisateur (30), optionnellement dans lequel le procédé comprend le réglage et l'ajustement automatique d'un ou de plusieurs des dispositifs de contrôle.

14. Procédé selon la revendication 10, le procédé comprenant en outre la détection, le marquage et l'affichage de limites de tissus et le calcul et l'ajustement de paramètres de traitement sur la base des limites des tissus détectées, optionnellement dans lequel le procédé comprend en outre la détection, le marquage et l'affichage automatiques des limites de tissus et le calcul et l'ajustement automatiques des paramètres de traitement sur la base des limites de tissus détectées.

15. Procédé selon la revendication 10, le procédé comprenant en outre l'opération consistant à :
sélectionner une icône sur l'interface utilisateur pour faire que les images de référence stockées dans une mémoire soient affichées, dans lequel la trame parallèle active (42) devient une trame parallèle de référence (46) qui dépeint une image statique du premier plan d'image parallèle à la caractéristique de l'applicateur HIFU (20) et la trame orthogonale active (44) devient une trame orthogonale de référence (48) qui décrit une image statique du second plan d'image orthogonal au plan d'image décrit dans la trame parallèle de référence (46).

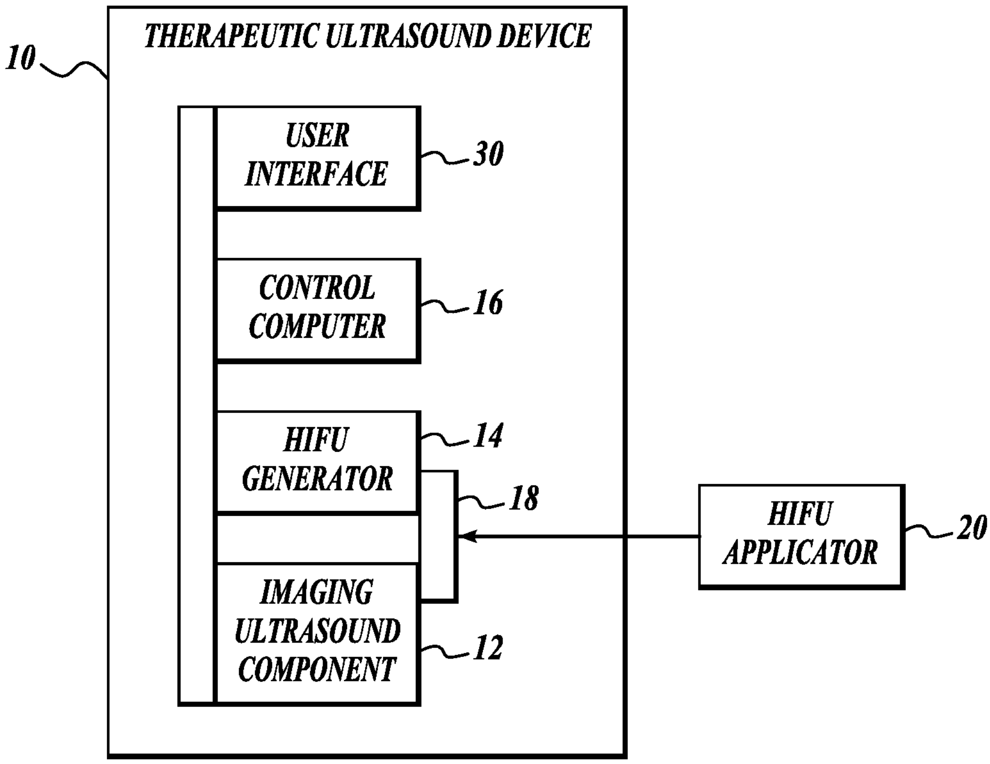

10
THERAPEUTIC ULTRASOUND DEVICE
USER INTERFACE
30
CONTROL COMPUTER
16
HIFU GENERATOR
14
18
HIFU APPLICATOR
20
IMAGING ULTRASOUND COMPONENT
12

Fig.1.

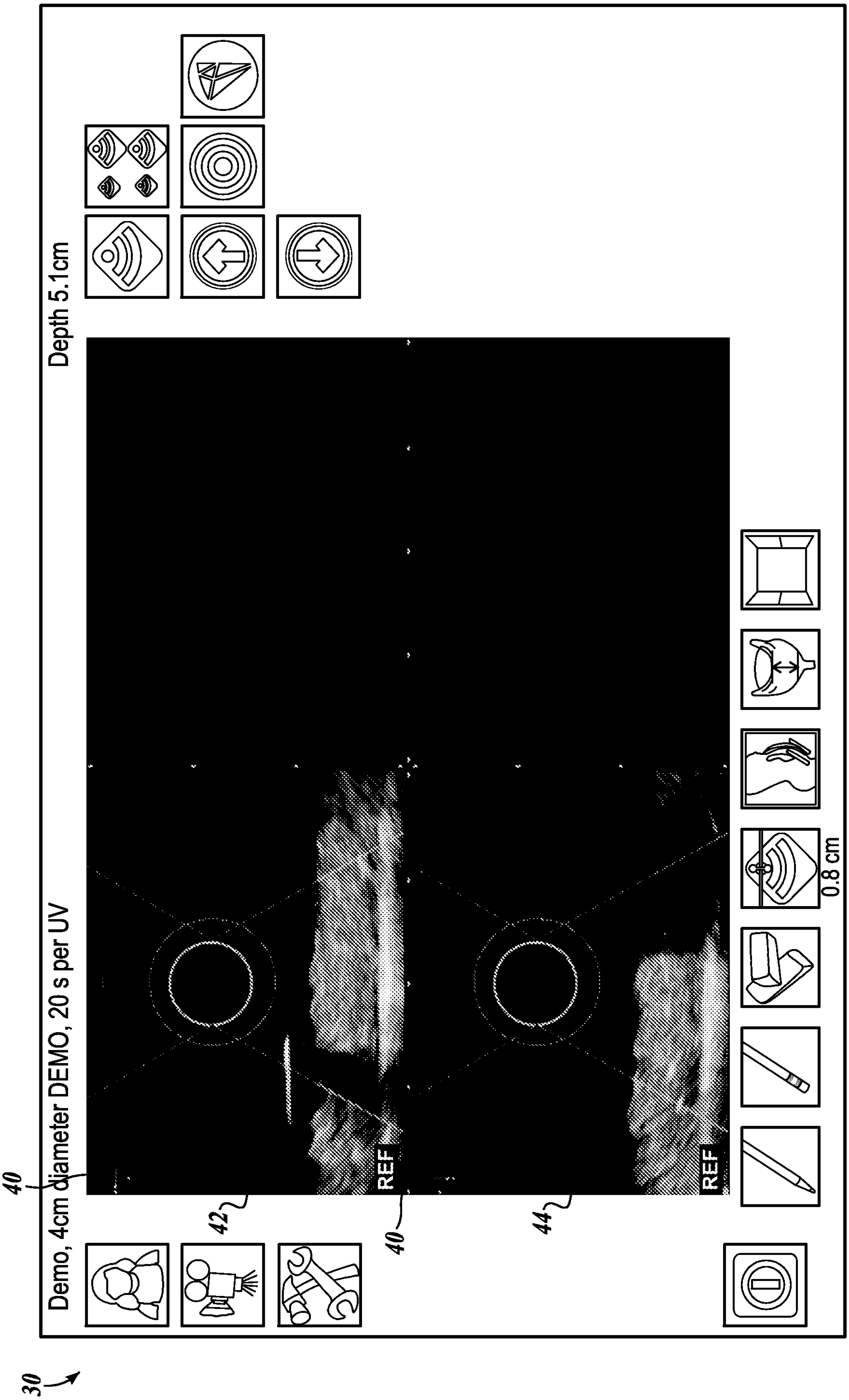
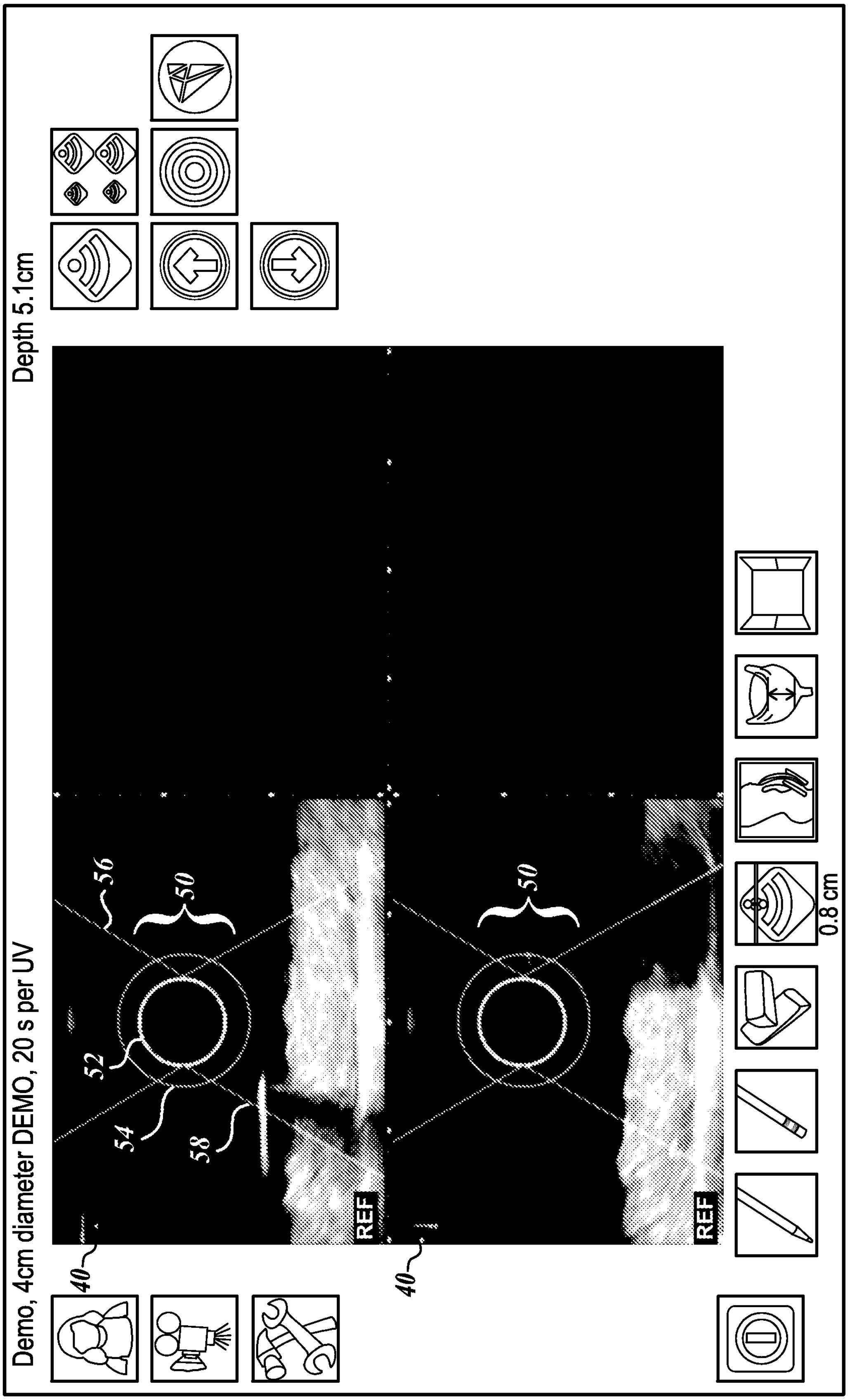

Demo, 4cm diameter DEMO, 20 s per UV
Depth 5.1cm
REF
REF
0.8 cm
40
42
40
44
30

Fig.2.


Demo, 4cm diameter DEMO, 20 s per UV
Depth 5.1cm
REF
REF
0.8 cm
40
40
50
50
52
54
56
58

30

Fig.3.

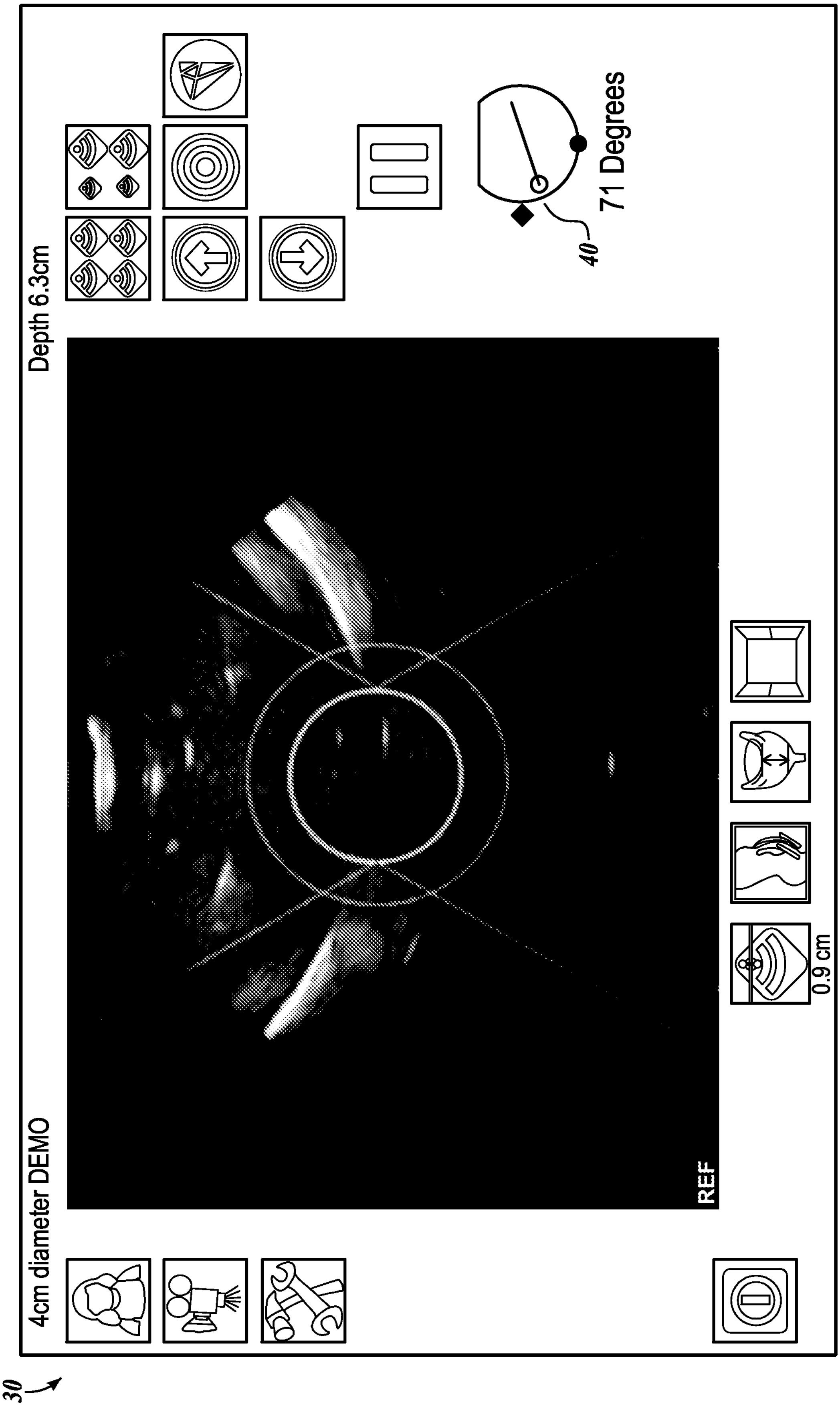


Fig. 4.

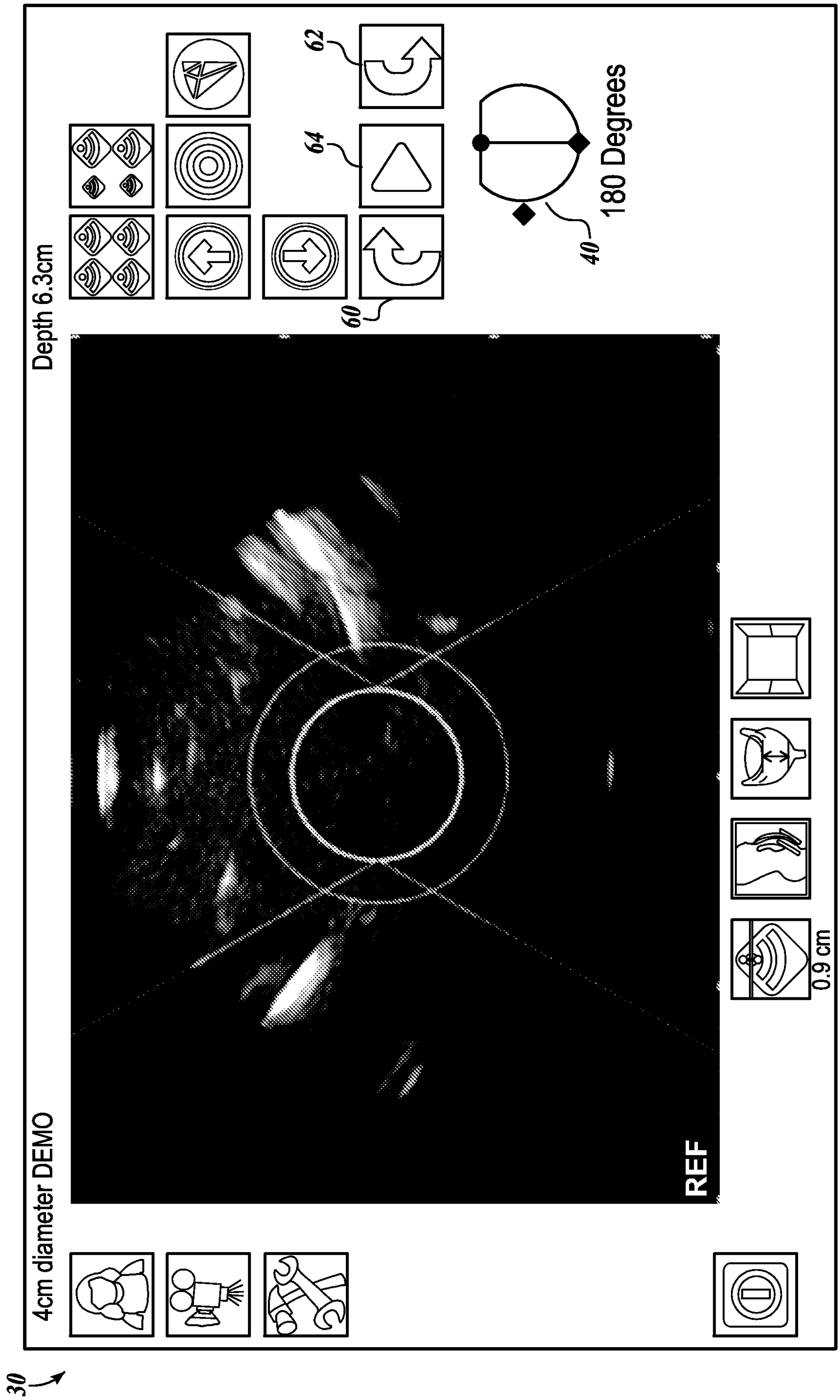

4cm diameter DEMO
Depth 6.3cm
REF
0.9 cm
180 Degrees
60
62
64
40
30

Fig.5.

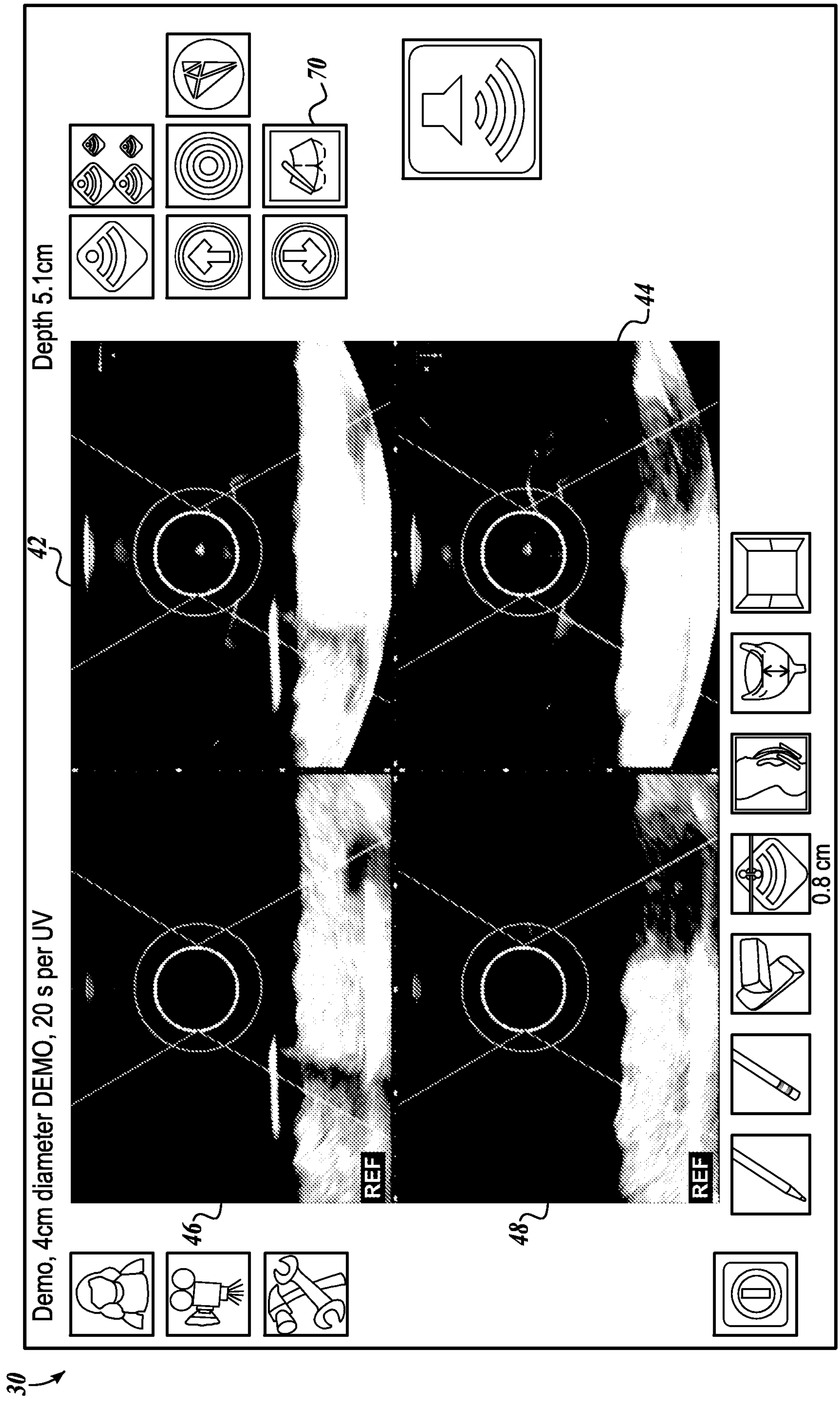

Demo, 4cm diameter DEMO, 20 s per UV
Depth 5.1cm
REF
REF
0.8 cm
42
44
46
48
70
30

Fig.6.

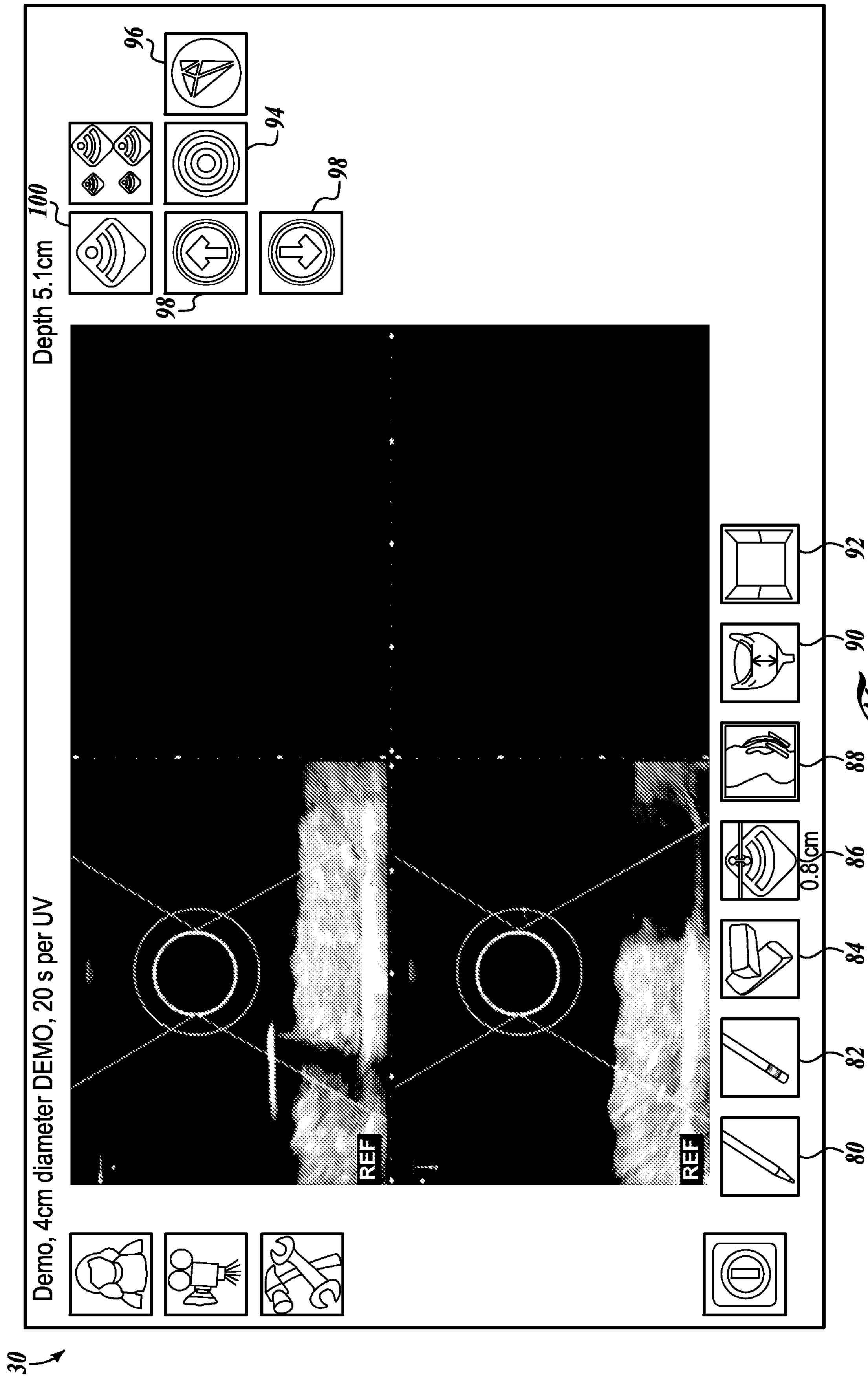

Demo, 4cm diameter DEMO, 20 s per UV
Depth 5.1cm
REF
REF
0.8cm
30
80
82
84
86
88
90
92
94
96
98
98
100

Fig. 7.

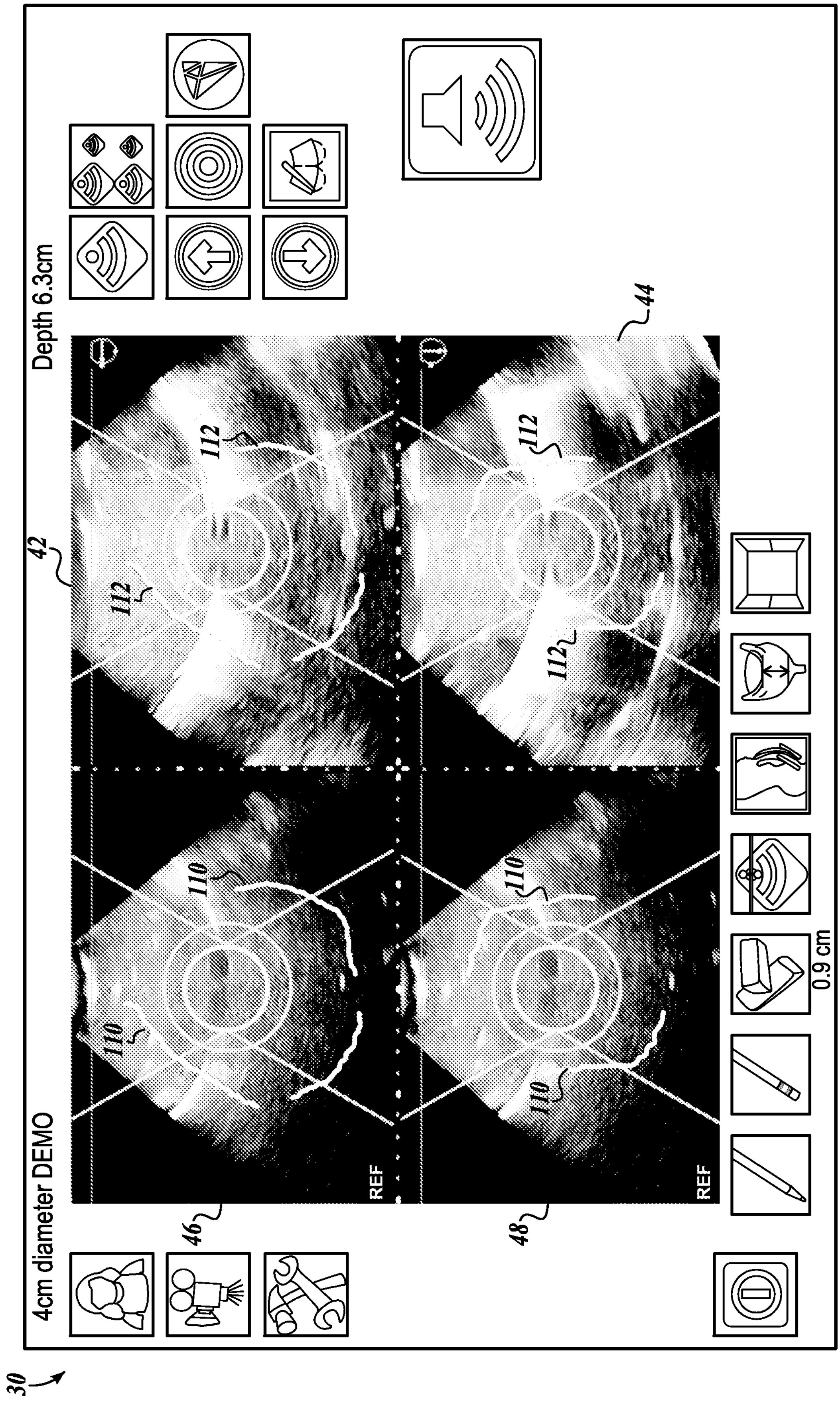

4cm diameter DEMO
Depth 6.3cm
REF
REF
0.9 cm
30
42
44
46
48
110
110
110
110
112
112
112
112

Fig. 8.

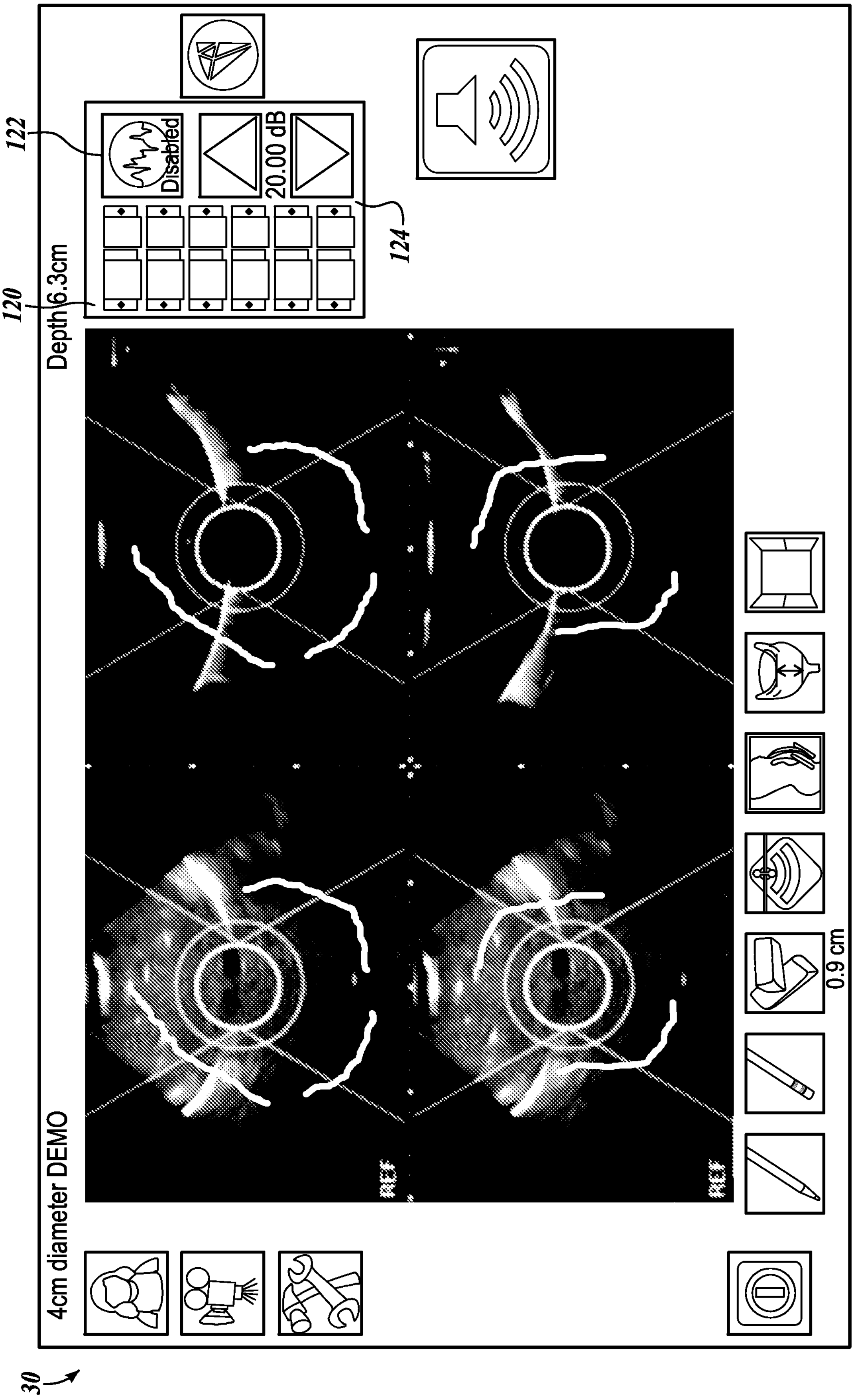

4cm diameter DEMO
Depth 6.3cm
Disabled
20.00 dB
0.9 cm
REF
REF
120
122
124
30

Fig.9.

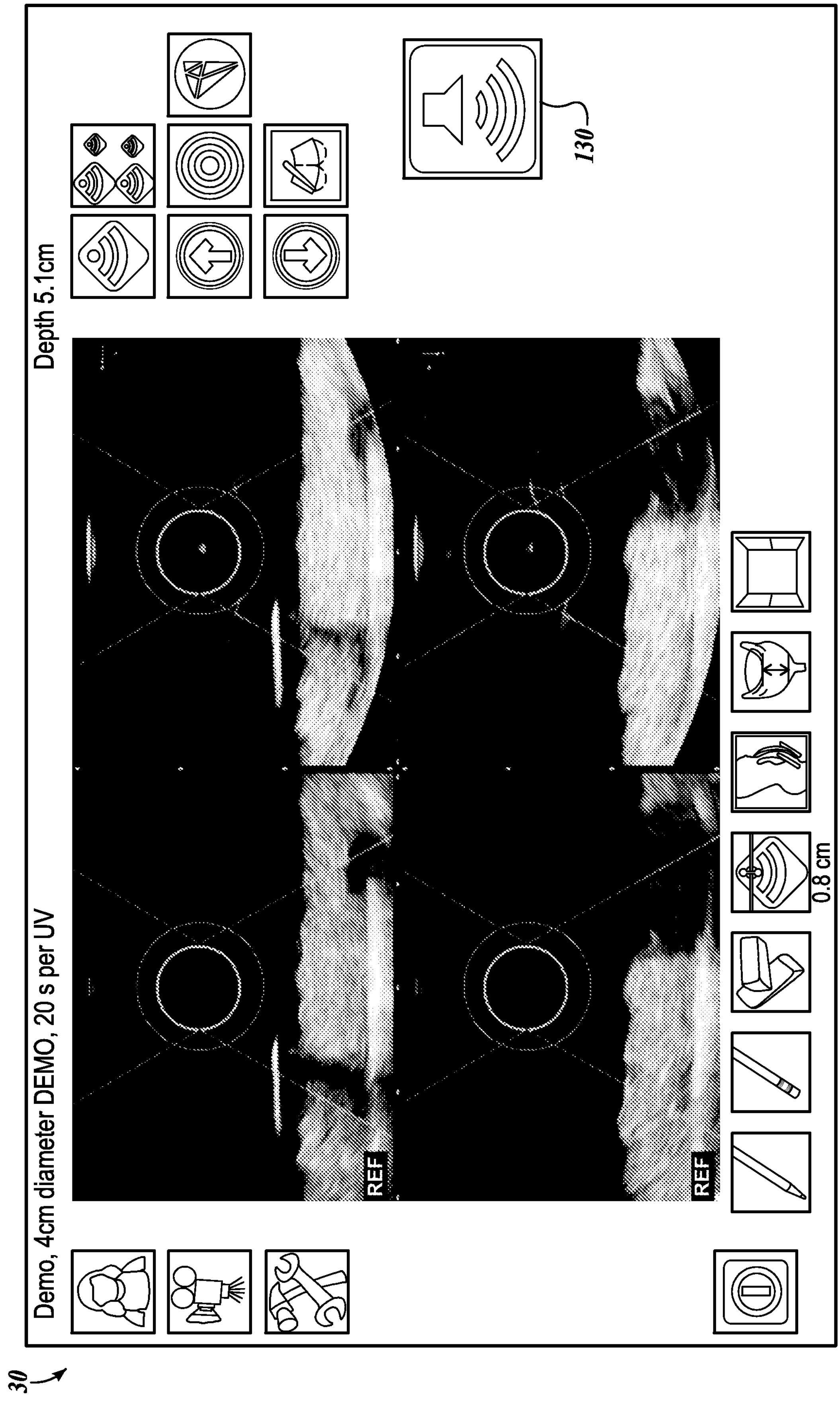

Demo, 4cm diameter DEMO, 20 s per UV
Depth 5.1cm
REF
REF
0.8 cm
130
30

Fig. 10.

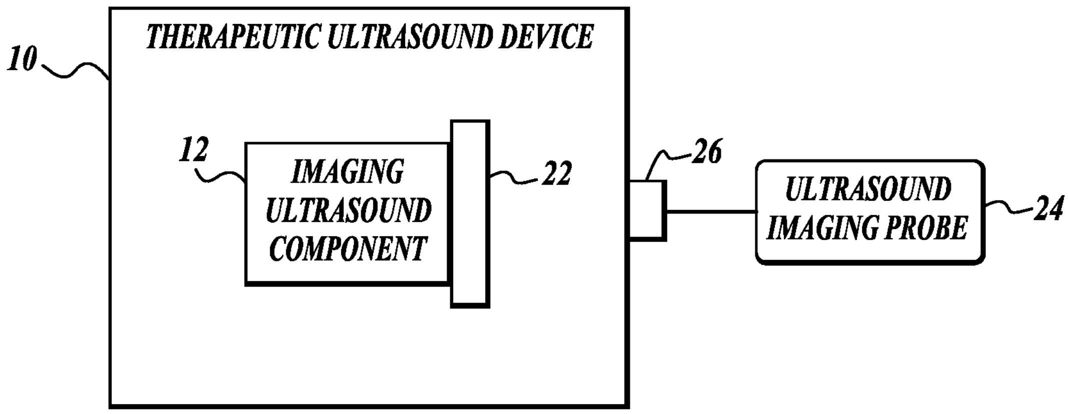

THERAPEUTIC ULTRASOUND DEVICE
10
12
IMAGING
ULTRASOUND
COMPONENT
22
26
ULTRASOUND
IMAGING PROBE
24

Fig.11.

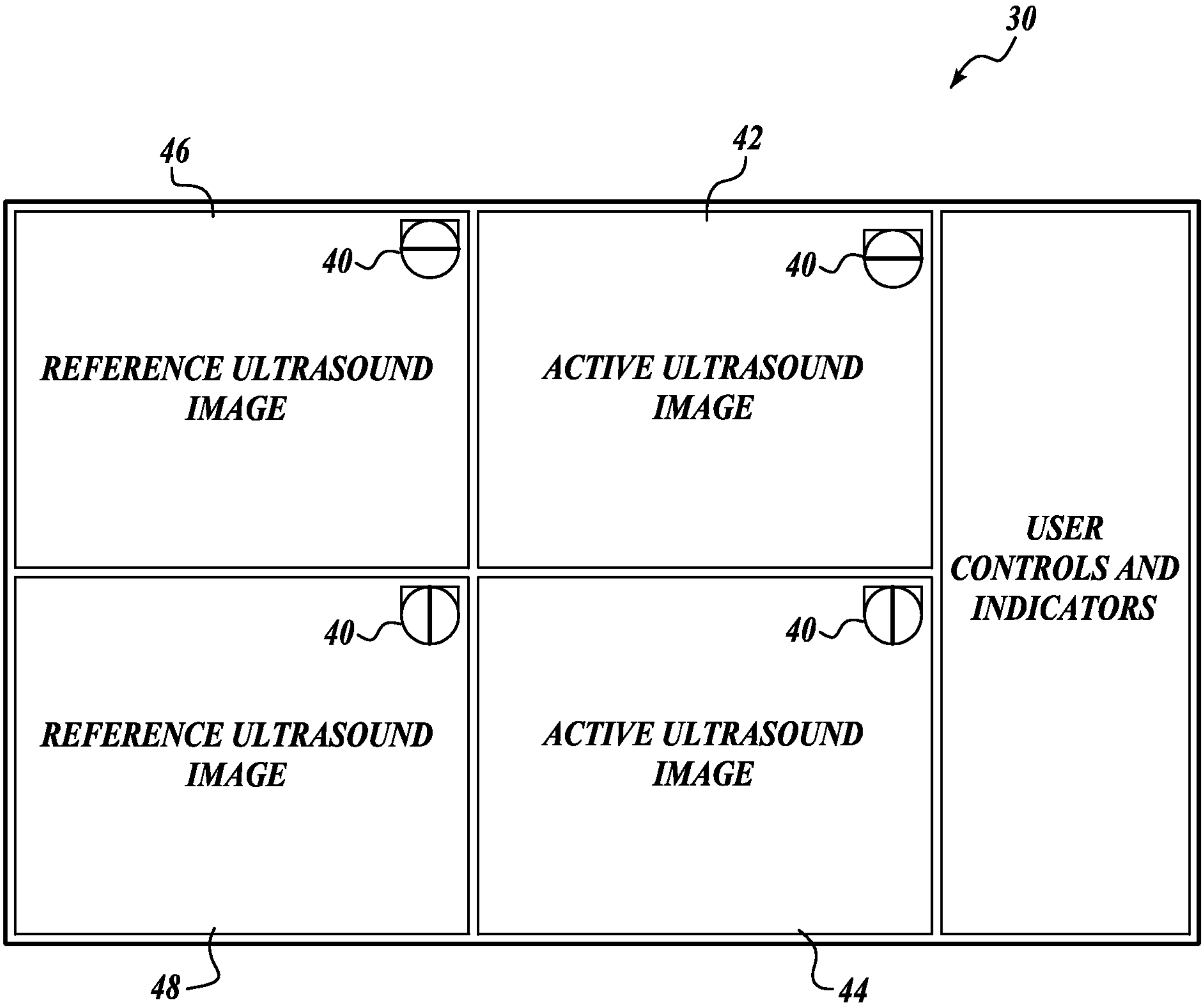

30
46
42
40
40
REFERENCE ULTRASOUND IMAGE
ACTIVE ULTRASOUND IMAGE
USER CONTROLS AND INDICATORS
40
40
REFERENCE ULTRASOUND IMAGE
ACTIVE ULTRASOUND IMAGE
48
44

Fig.12.

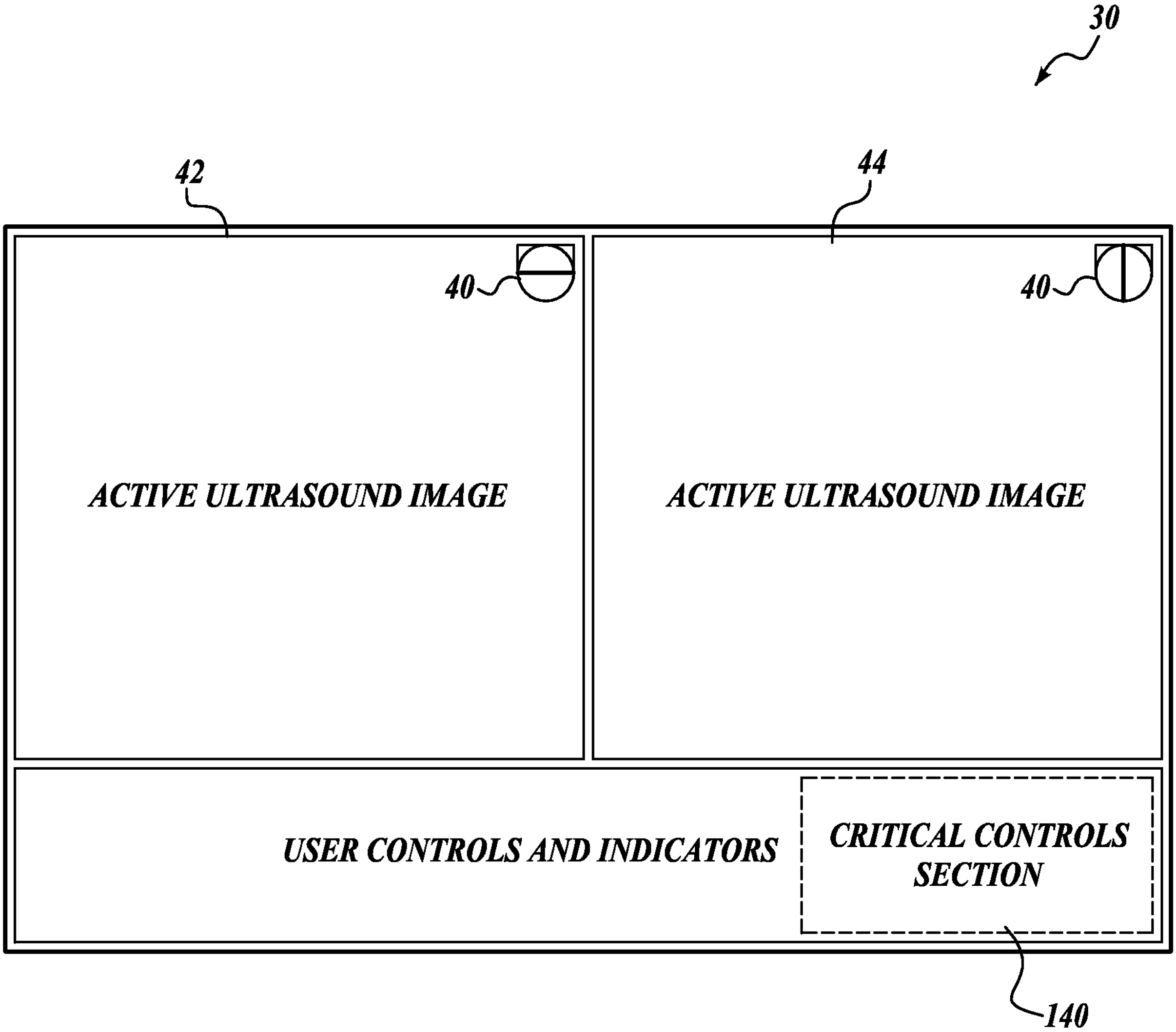

30
42
44
40
40
ACTIVE ULTRASOUND IMAGE
ACTIVE ULTRASOUND IMAGE
USER CONTROLS AND INDICATORS
CRITICAL CONTROLS SECTION
140

Fig.13.

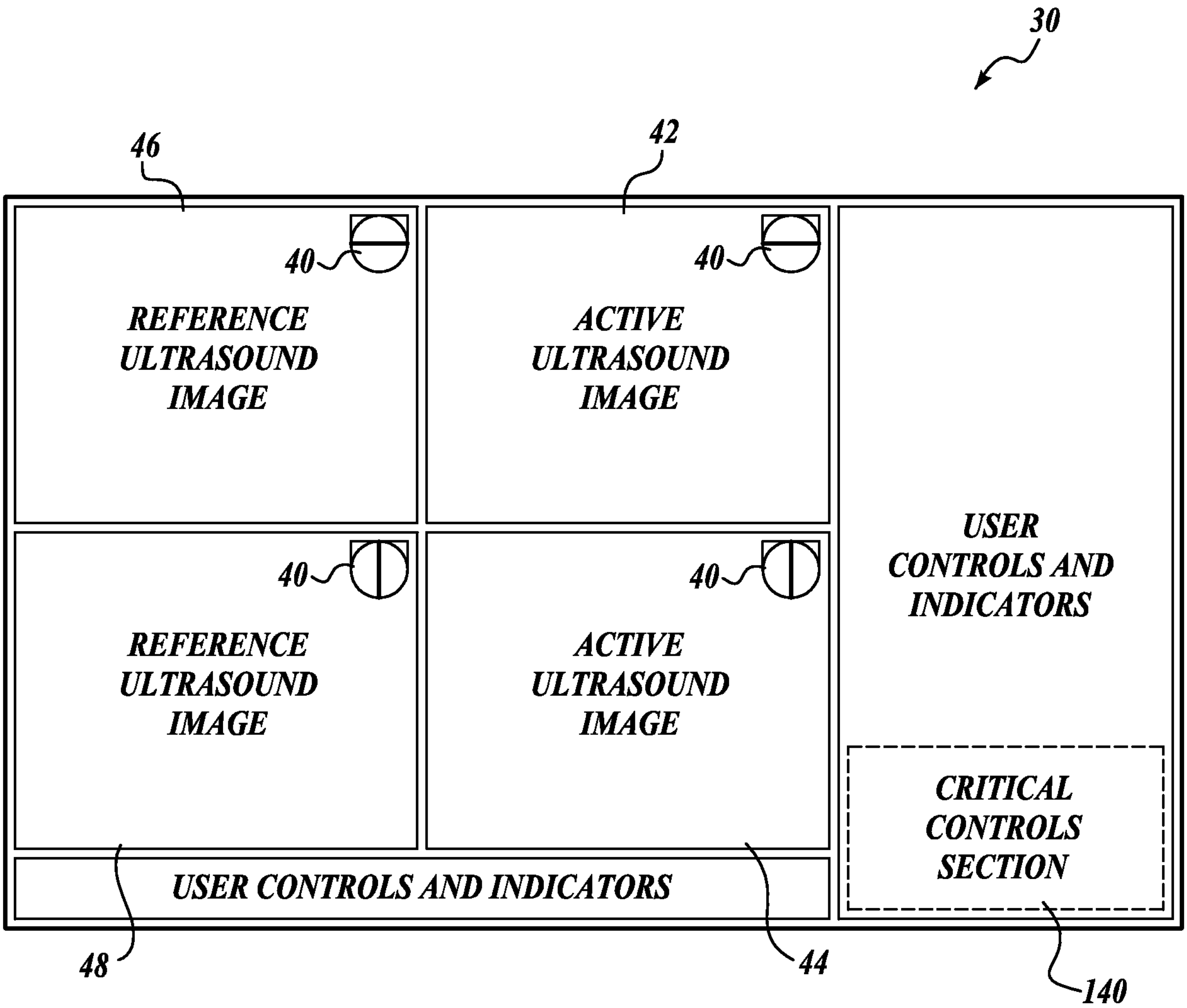

30
46
42
40
REFERENCE ULTRASOUND IMAGE
40
ACTIVE ULTRASOUND IMAGE
40
REFERENCE ULTRASOUND IMAGE
40
ACTIVE ULTRASOUND IMAGE
USER CONTROLS AND INDICATORS
CRITICAL CONTROLS SECTION
USER CONTROLS AND INDICATORS
48
44
140

Fig.14.

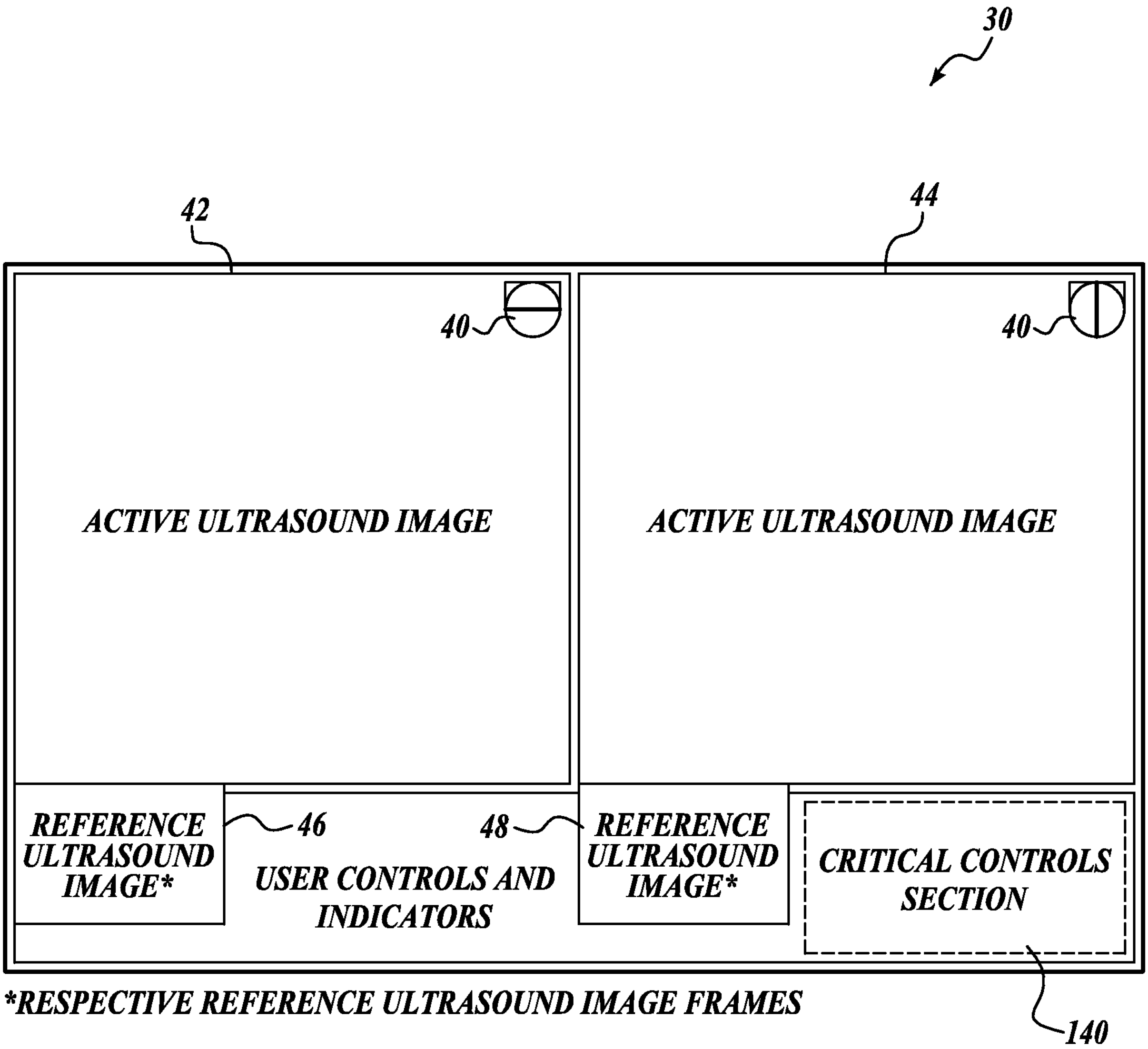

30
42
44
40
40
ACTIVE ULTRASOUND IMAGE
ACTIVE ULTRASOUND IMAGE
REFERENCE ULTRASOUND IMAGE*
46
48
REFERENCE ULTRASOUND IMAGE*
USER CONTROLS AND INDICATORS
CRITICAL CONTROLS SECTION
*RESPECTIVE REFERENCE ULTRASOUND IMAGE FRAMES
140

Fig.15.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20090326372 A1 **[0003]**

专利名称(译)	用于超声引导治疗的人体界面和装置		
公开(公告)号	EP2872044B1	公开(公告)日	2019-03-13
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外部链接	Espacenet		

摘要(译)

一种用于提供实时，图像引导的高强度聚焦超声（HIFU）靶向和组织治疗的系统和方法。在一个实施例中，该系统包括HIFU施加器和具有触摸屏显示器的用户界面，用于组织的三维可视化。在用户界面上显示的图像帧描绘了组织的实时图像，包括平行于涂抹器的特征的图像和与平行图像正交的图像。可以使用触摸屏绘制参考线并绘制在图像帧上。在一个实施例中，组织边界由用户检测并在图像帧上标记，或由系统自动标记。在另一个实施例中，用户界面包括脚踏开关，供用户与系统交互。在另一个实施例中，该系统包括超声成像部件，该超声成像部件被配置成从系统移除以用作独立的超声成像设备。

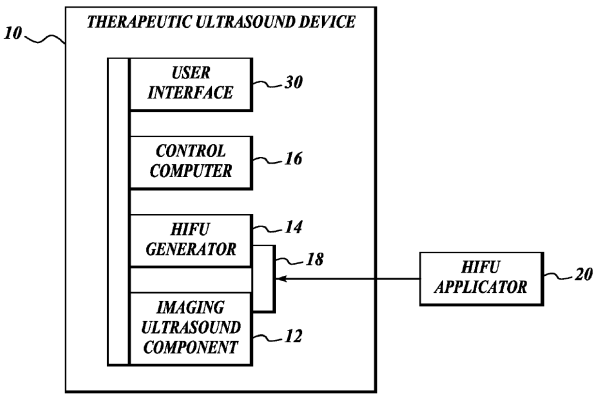

Fig. 1.