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(54) **TGC CONTROLS FOR AN ULTRASONIC DIAGNOSTIC IMAGING SYSTEM**

TGC-STEUERUNGEN FÜR EIN DIAGNOSTISCHES ULTRASCHALLBILDGEBUNGSSYSTEM

COMMANDES TGC POUR SYSTÈME D’IMAGERIE DE DIAGNOSTIC PAR ULTRASONS

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(56) References cited:
JP-A- 2012 061 239
US-A- 5 482 045
US-A1- 2003 187 353

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Description

[0001] This invention relates to medical diagnostic ultrasound systems and, in particular, to ultrasound systems with controls for time gain compensation of received ultrasonic echo signals.

[0002] When ultrasound signals are transmitted into the body by an ultrasound imaging probe, the waves are continuously attenuated during their passage through tissue, and the returning echoes are further attenuated as they travel back to the transducer. As a consequence echoes are increasingly attenuated as a function of the depth in the body from which they return. The time-honored solution to this attenuation problem is to amplify the received echo signals as a function of the time at which they are received: echoes returning later from the time of transmit are amplified more greatly than those received earlier from shallower depths. The circuitry which performs this amplification is known as time gain compensation (TGC) circuitry, also referred to as sensitivity time control (STC). But the relationship between time and attenuation is not a purely linear one. The echoes experience different degrees of attenuation depending upon the tissue through which they travel. For instance, when imaging the heart relatively little attenuation is experienced as echoes travel through the blood in the heart chamber, and greater attenuation is experienced as echoes travel through the heart muscle, the myocardium. Accordingly the controls for TGC are a series of switches which affect the gain applied at different depths over the depth of the ultrasound image. Typically the switches are slide switches arranged in a column on the ultrasound system control panel. The columnar orientation is immediately seen to correspond to successively greater depths of the image. The switches are generally slide switches with a center position which sets a nominal gain for the corresponding image depth. The slide switches can be moved laterally in either direction to apply more or less than the nominal gain at each depth. Thus the gain profile can be set nonlinearly to vary the gain in relation to the anatomical makeup of the region of the body being imaged. In modern ultrasound systems gain profiles can be stored for particular imaging applications and recalled, applied, and adjusted by the slide switches as appropriate to produce an image of uniform brightness and grey shades over the depth of the image as described in US Pat. 5,482,045 (Rust et al.)

[0003] Ultrasound exams are often performed in a darkened room so that the sonographer can most easily discern the appearance of the images and subtle structures and functions (e.g., blood flow) being images. To enable the sonographer to readily see the controls of the system control panel, the control are often back-lit to aid visibility. The TGC controls can be lighted in various ways. But even with effective back-lighting, the sonographer is often not able to distinguish the specific positions of the TGC switches. In particular, it is frequently difficult for the sonographer to see whether the TGC switches are still set in their nominal center positions or have been adjusted to a different gain setting. Accordingly it is desirable to provide TGC controls which are easily discernible and their setting readily visualized in a darkened exam room.

[0004] In accordance with the principles of the present invention, a diagnostic ultrasound system is described with illumination provided for the individual switches of the TCG control. The illumination is uniquely controlled or modulated when a switch is in its center position as by color or brightness modulation or control. The sonographer is thereby readily able to visualize the gain setting of the switches from their orientation pattern and to immediately discern those switches which are set in their nominal center positions.

[0005] In the drawings:

FIGURE 1 illustrates the control panel of an ultrasonic diagnostic imaging system.

FIGURE 2 is a detailed view of the TGC control of the ultrasound system of FIGURE 1 constructed in accordance with the principles of the present invention.

FIGURE 3 illustrates in block diagram form the major components of an ultrasound system including TGC circuitry.

FIGURES 4a and 4b illustrate illuminated TGC controls of the present invention when viewed in a darkened room.

FIGURES 5a and 5b illustrate implementations of the present invention by pulse width modulation and color control of an LED on a TGC control.

[0006] Referring first to FIGURE 1, an ultrasound system control panel 28 is shown in a perspective view. When a user desires to perform a particular ultrasonic examination such as imaging the liver, the user selects the desired procedure by using the controls on the control panel 28. This may involve interaction with a menu of parameters and performance choices shown on the display monitor 62 using the trackball and a select button on the control panel to select the desired parameters. Upon selection of an imaging procedure the system will select an optimal TGC characteristic stored in the system memory for the procedure and apply it to the TGC circuitry as described below. The TGC circuitry will then control the gain of the TGC amplifier in the system's signal path in accordance with this optimal TGC characteristic. The system will also supply graphical information to the image display so that a visual representation of the optimal TGC characteristic will be shown on the image display 62 adjacent to the image. This TGC curve then illustrates the relative amounts of gain applied to echoes returning from progressively deeper depth of the image region.

[0007] The optimal, predetermined TGC characteristic will be displayed and used to control the amplifier of the TGC circuitry when the slide switches 20 on the control panel are vertically aligned in their central position 36 as shown in FIG. 2. If the clinician finds that variation from the predetermined characteristic is needed to better image a particular patient, the clinician will move the slide switches to the right or left to reset the slope segments of the TGC gain characteristic. As the switches are moved the changes are communicated from the control panel 28 to the TGC circuitry, which applies the incremental changes to the predetermined characteristic. The effects of these changes are shown by visual changes to the displayed TGC characteristic on the display screen. When the clinician is finished adjusting the TGC switches 20 the variation from the predetermined characteristic is indicated by the new physical positions of the switches on the control panel and the final TGC characteristic is shown on the display screen. A uniform gain adjustment over the full image depth is applied by adjusting a gain control adjustment 26.

[0008] Referring to FIGURE 3, an ultrasound system constructed in accordance with the principles of the present invention is shown in block diagram form. In this implementation the ultrasound probe includes a two dimensional array transducer 500 and a micro-beamformer 502. The present invention may be used with probes employing either one dimensional or two dimensional transducer arrays. The micro-beamformer contains circuitry which controls the signals applied to groups of elements ("patches") of the array transducer 500 and does some combining of the echo signals received by elements of each group. Micro-beamforming in the probe advantageously reduces the number of conductors in the cable 503 between the probe and the ultrasound system and is described in U.S. Pat. No. 5,997,479 (Savord et al.) and in U.S. Pat. No. 6,436,048 (Pesque).

[0009] The probe is coupled to the scanner 310 of the ultrasound system. The scanner includes a beamform controller 312 which is responsive to a user control on the control panel, such as a probe select control, and provides control signals to the microbeamformer 502 instructing the probe as to the timing, frequency, direction and focusing of transmit beams for the desired image and the selected probe. The beamform controller also control the beamforming of received echo signals by its coupling to the analog-to-digital (A/D) converters 316 and a beamformer 116. Echo signals received by the probe are amplified by preamplifier and an amplifier of the TGC (time gain control) circuitry 314, then digitized by the A/D converters 316. The digitized echo signals are then formed into beams by the beamformer 116. The echo signals from individual elements or patches of elements of the array 500 are then processed by an image processor 318 which performs digital filtering, B mode detection, and/or Doppler processing, and can also perform other signal processing such as harmonic separation, speckle reduction through frequency compounding, digital gain (including digital TGC) and other desired image or signal processing.

[0010] The echo signals produced by the scanner 310 are coupled to a display subsystem 320 which processes the echo signals for display in the desired image format. The echo signals are processed by an image line processor 322 which is capable of sampling the echo signals, splicing segments of beams into complete line signals, and averaging line signals for signal-to-noise improvement or flow persistence. The image lines of each image are scan converted into the desired image format by a scan converter 324 which performs R-theta conversion as is known in the art. The images are then stored in an image memory 328 from which they can be displayed on the display 150. The images in memory are also overlayed with graphics to be displayed with the images, such as the TGC characteristic described above, which are generated by a graphics generator 330 which is responsive to a user control. Individual image frames or image frame sequences can be stored in a cine memory 326 during capture of image loops.

[0011] In accordance with the principles of the present invention, each slider switch 22 of the TGC controls is lighted with an LED 10 mounted on the slider of the switch as shown in FIGURE 2. Each slider has a range of control dictated by the extent of a cutout 24 in the control panel along which the slider can travel laterally. Thus, if the uppermost slider (corresponding to the shallowest depth) is moved to the left it will appear to the left of the column of the LEDs of the other switches. The sonographer can see at a glance that at the shallowest depth a low gain setting is in place, while the gains applied at the deeper depths are all nominal gain settings. The illuminated LEDs on the switch sliders will make this visibly clear even in a darkened room.

[0012] In accordance with a further aspect of the present invention, each LED 10 produces a distinguishing illumination when it is set in its nominal central position 36. A variety of different illumination differentiation techniques may be used. One is to illuminate the LED brightly when the slider 22 is in its center position, and dimmer when the slider is moved away from the center position. FIGURE 5a illustrates a potentiometer 12 of a TGC slider switch with a slider arm 14. When the slider is centered, the differential amplifier 16 switches to a low output, which disables the input of a pulse width modulator 17. In this null state, the LED 10 is driven by a steady voltage, producing a bright illumination. But when the slider arm 14 is moved off center, the differential amplifier 16 switches to a high output, enabling the pulse width modulator 17, which drives the LED 10 with a pulse width modulated pulse train. The LED illumination is then dimmer.

[0013] Another approach to illumination variation is to vary the color of the light of the LED when the slider 22 is in its center position. In FIGURE 5b when the slider arm 14 is centered the differential amplifier 16 causes the LED to be illuminated with a predetermined color such as red. This can be done with a color controller 17 that selects the color of an RGB LED, or by varying the color temperature of the LED 10. When the slider arm is moved off center, the color controller 17 selects a different color for an RGB LED, white instead of red, for instance, or changes the color temperature to a different one than used in the centered position.

[0014] Each TGC control will produce a value (digital or analog) depending upon its setting, which is coupled to an illumination controller. The illumination controller compares the digital value against the known value of the center position setting. If the two values are not equal the difference value is used to control the pulse width modulation duty cycle and/or frequency to dim the illumination. For the color modulation implementation three independent pulse width modulators are used to control the duty cycle or frequency of each color of an RGB LED to produce virtually any desired color.

[0015] FIGURES 4a and 4b illustrate the effect of such color modulation. FIGURE 4a illustrates a series of lights on eight TGC sliders. The settings range from a low gain at the shallow depths by the top sliders, which are set to the left of center, and ranging down to greater than nominal gains at the deepest depths where it is seen that the lower-most sliders have been moved to the right. This curved pattern of white LEDs gives little indication of which sliders were untouched and remain in their nominal gain positions. But in the example of FIGURE 4b, the LEDs for the third, fifth, and sixth sliders 26, 27, and 28 are modulated to produce a reddish color (as represented by the dotted patterns), which clearly stand out in relation to the other white LEDs. The sonographer can see at a glance that no adjustment has been made to the nominal gains at these depths.

[0016] Other illumination schemes will readily occur to those skilled in the art. The LEDs could be illuminated red when moved to a higher gain setting (to the right), green when moved to a lower gain setting (to the left), and white when set in the nominal center position, for instance. Another alternative is to use the pulse width modulator to blink the LEDs on and off to indicate by the blinking those that are in the center position or those that have been moved.

Claims

1. A diagnostic ultrasound system with time gain compensation comprising:

an ultrasound system control panel (28);
a plurality of time gain compensation (TGC) controls, located on the ultrasound system control panel, which may be set in a nominal position or adjusted to other positions to control time gain compensation;

characterized in that the system further comprises

a plurality of lighting devices, each located on one of the TGC controls; and
an illumination controller, responsive to the setting of a TGC control in its nominal position and coupled to the lighting device of the TGC control, which is arranged to visibly distinguish illumination by the lighting device when its TGC control is set in the nominal position.

2. The diagnostic ultrasound system of Claim 1, wherein the TGC controls further comprise slide switches (22).

3. The diagnostic ultrasound system of Claim 2, wherein the lighting devices further comprise light emitting diodes (LEDs) (10);
wherein the slide switches each further comprise a user-operable slider;
wherein an LED is mounted on each slider.

4. The diagnostic ultrasound system of Claim 3, wherein each slider can be moved along a lateral range of adjustment;
wherein the nominal position is the center of the lateral range.

5. The diagnostic ultrasound system of Claim 4, further comprising a slider position sensor responsive to movement of a slider along its range of adjustment which is arranged to sense when the slider is in the center of the lateral range.

6. The diagnostic ultrasound system of Claim 5, wherein the illumination controller is further responsive to the slider position sensor.

7. The diagnostic ultrasound system of Claim 6, wherein the slider position sensor further comprises a differential amplifier (16).

8. The diagnostic ultrasound system of Claim 1, wherein the illumination controller is further arranged to visibly distinguish illumination by the lighting device by changing the color of light produced.

9. The diagnostic ultrasound system of Claim 1, wherein the illumination controller is further arranged to visibly distinguish illumination by the lighting device by changing the brightness of light produced.

10. The diagnostic ultrasound system of Claim 9, wherein the illumination controller further comprises a pulse width modulator.

11. The diagnostic ultrasound system of Claim 10, wherein the lighting devices further comprise LEDs (10);
wherein the pulse width modulator is arranged to drive an LED with a width-modulated pulse to reduce the brightness of light produced by the LED.

12. The diagnostic ultrasound system of Claim 8, wherein the lighting devices further comprise LEDs; wherein the illumination controller is further arranged to change the color of light produced by an LED by changing the color temperature of the LED.

13. The diagnostic ultrasound system of Claim 12, wherein the color of light produced by an LED is set to a reddish color when a TGC control is set in its nominal position.

14. The diagnostic ultrasound system of Claim 8, wherein the lighting devices further comprise RGB LEDs; wherein the illumination controller further comprises an LED color controller (17).

15. The diagnostic ultrasound system of Claim 1, wherein the TGC controls further act to control time gain compensation by enabling user adjustment of the amplification applied to ultrasonic echo signals received from different depths of imaging.

Patentansprüche

1. Diagnostisches Ultraschallsystem mit Zeitgewinnkompensation (engl. time gain compensation, TGC), umfassend:

ein Ultraschallsystem-Bedienfeld (28);
eine Vielzahl von TGC-Steuerungen am Ultraschall-Bedienfeld, die auf eine nominale Position oder auf andere Positionen eingestellt werden können, um die Zeitgewinnkompensation zu steuern;

dadurch gekennzeichnet, dass das System weiterhin Folgendes umfasst:

eine Vielzahl von Beleuchtungsvorrichtungen, jede angeordnet an einer der TGC-Steuerungen; und
einen Illuminationssteuereinheit, die auf die Einstellung einer TGC-Steuerung auf ihre nominale Position reagiert, mit der Beleuchtungsvorrichtung der TGC-Steuerung gekoppelt ist und dafür ausgelegt ist, die Illumination durch die Beleuchtungsvorrichtung sichtbar kenntlich zu machen, wenn ihre TGC-Steuerung auf die nominale Position eingestellt ist.

2. Diagnostisches Ultraschallsystem nach Anspruch 1, wobei die TGC-Steuerungen weiterhin Schiebeschalter (22) umfasst.

3. Diagnostisches Ultraschallsystem nach Anspruch 2, wobei die Beleuchtungsvorrichtungen weiterhin Leuchtdioden (LEDs) (10) umfassen;
wobei die Schiebeschalter jeweils weiterhin einen durch einen Benutzer bedienbaren Schieber umfassen;
wobei an jedem Schieber eine LED montiert ist.

4. Diagnostisches Ultraschallsystem nach Anspruch 3, wobei jeder Schieber entlang eines lateralen Einstellbereichs bewegt werden kann;
wobei die nominale Position die Mitte des lateralen Einstellbereichs ist.

5. Diagnostisches Ultraschallsystem nach Anspruch 4, weiterhin umfassend einen Schieberpositionssensor, der auf die Bewegung eines Schiebers entlang seines Einstellbereichs reagiert und vorgesehen ist, um zu erfassen, wenn sich der Schieber in der Mitte des Einstellbereichs befindet.

6. Diagnostisches Ultraschallsystem nach Anspruch 5, wobei die Illuminationssteuereinheit weiterhin auf den Schieberpositionssensor reagiert.

7. Diagnostisches Ultraschallsystem nach Anspruch 6, wobei der Schieberpositionssensor weiterhin einen Differenzverstärker (16) umfasst.

8. Diagnostisches Ultraschallsystem nach Anspruch 1, wobei die Illuminationssteuereinheit weiterhin dafür ausgelegt ist, die Illumination durch die Beleuchtungsvorrichtung sichtbar kenntlich zu machen, indem die Farbe des erzeugten Lichts geändert wird.

9. Diagnostisches Ultraschallsystem nach Anspruch 1, wobei die Illuminationssteuereinheit weiterhin dafür ausgelegt ist, die Illumination durch die Beleuchtungsvorrichtung sichtbar kenntlich zu machen, indem die Helligkeit des erzeugten Lichts geändert wird.

10. Diagnostisches Ultraschallsystem nach Anspruch 9, wobei die Illuminationssteuereinheit weiterhin einen Pulsbreitenmodulator umfasst.

11. Diagnostisches Ultraschallsystem nach Anspruch 10, wobei die Beleuchtungsvorrichtungen weiterhin LEDs (10) umfassen;
wobei der Pulsbreitemodulator dafür ausgelegt ist, eine LED mit einem breitenmodulierten Puls anzusteuern, um die Helligkeit des durch die LED erzeugten Lichts zu reduzieren.

12. Diagnostisches Ultraschallsystem nach Anspruch 8, wobei die Beleuchtungsvorrichtungen weiterhin LEDs umfassen;
wobei die Illuminationssteuereinheit weiterhin dafür ausgelegt ist, die Farbe des durch eine LED erzeugten Lichts zu ändern, indem sie die Farbtemperatur der LED ändert.

13. Diagnostisches Ultraschallsystem nach Anspruch 12, wobei die Farbe des durch eine LED erzeugten Lichts auf eine rötliche Farbe eingestellt wird, wenn eine TGC-Steuerung auf ihre nominale Position gestellt wird.

14. Diagnostisches Ultraschallsystem nach Anspruch 8, wobei die Beleuchtungsvorrichtungen weiterhin RGB-LEDs umfassen;
wobei die Illuminationssteuereinheit weiterhin eine LED-Farbsteuereinheit (17) umfasst.

15. Diagnostisches Ultraschallsystem nach Anspruch 1, wobei die TGC-Steuerungen weiterhin agieren, um die Zeitgewinnkompensation zu steuern, indem eine Benutzereinstellung der Verstärkung ermöglicht wird, die auf die aus verschiedenen Bildgebungstiefen empfangenen Ultraschallsignale angewendet wird.

Revendications

1. Système ultrasonore de diagnostic avec compensation de gain de temps comprenant :

un panneau de commande de système ultrasonore (28) ;
une pluralité de commandes de compensation de gain de temps (TGC), situées sur le panneau de commande de système ultrasonore, qui peuvent être réglées à une position nominale ou ajustées à d'autres positions pour commander une compensation de gain de temps ;
caractérisé en ce que le système comprend en outre :

une pluralité de dispositifs lumineux, chacun d'eux étant situé sur l'une des commandes de TGC ; et
un organe de commande d'illumination, réactif au réglage d'une commande de TGC à sa position nominale et couplé au dispositif lumineux de la commande de TGC, qui est agencé pour distinguer visuellement l'illumination par le dispositif lumineux lorsque sa commande de TGC est réglée à la position nominale.

2. Système ultrasonore de diagnostic selon la revendication 1, dans lequel les commandes de TGC comprennent en outre des commutateurs coulissants (22).

3. Système ultrasonore de diagnostic selon la revendication 2, dans lequel les dispositifs lumineux comprennent en outre des diodes électroluminescentes (LED) (10) ;
dans lequel chacun des commutateurs coulissants comprend en outre un curseur utilisable par un utilisateur ;
dans lequel une LED est montée sur chaque curseur.

4. Système ultrasonore de diagnostic selon la revendication 3, dans lequel chaque curseur peut être déplacé le long d'une plage latérale d'ajustement ;
dans lequel la position nominale est le centre de la plage latérale.

5. Système ultrasonore de diagnostic selon la revendication 4, comprenant en outre un capteur de position de curseur en réponse à un mouvement d'un curseur le long de sa plage d'ajustement, qui est agencé pour détecter quand le curseur se trouve au centre de la plage latérale.

6. Système ultrasonore de diagnostic selon la revendication 5, dans lequel l'organe de commande d'illumination est en outre réactif au capteur de position de curseur.

7. Système ultrasonore de diagnostic selon la revendication 6, dans lequel le capteur de position de curseur comprend en outre un amplificateur différentiel (16).

8. Système ultrasonore de diagnostic selon la revendication 1, dans lequel l'organe de commande d'illumination est en outre agencé pour distinguer visuellement une illumination par le dispositif lumineux en changeant la couleur de la lumière produite.

9. Système ultrasonore de diagnostic selon la revendication 1, dans lequel l'organe de commande d'illumination est en outre agencé pour distinguer visuellement une élimination par le dispositif lumineux en changeant la luminosité de la lumière produite.

10. Système ultrasonore de diagnostic selon la revendication 9, dans lequel l'organe de commande d'illumination comprend en outre un modulateur de largeur d'impulsion.

11. Système ultrasonore de diagnostic selon la revendication 10, dans lequel les dispositifs lumineux comprennent en outre des LED (10) ;
dans lequel le modulateur de largeur d'impulsion est agencé pour la régulation d'une LED avec une impulsion de largeur modulée afin de réduire la luminosité de la lumière produite par la LED.

12. Système ultrasonore de diagnostic selon la revendication 8, dans lequel les dispositifs lumineux comprennent en outre des LED ;
dans lequel l'organe de commande d'illumination est en outre agencé pour changer la couleur de la lu-

mière produite par une LED en changeant la température de couleur de la LED.

13. Système ultrasonore de diagnostic selon la revendication 12, dans lequel la couleur de la lumière produite par une LED est réglée à une couleur rougeâtre lorsqu'une commande de TGC est réglée à sa position nominale.

14. Système ultrasonore de diagnostic selon la revendication 8, dans lequel les dispositifs lumineux comprennent en outre des LED RVB ;
dans lequel l'organe de commande d'illumination comprend en outre un organe de commande de couleur de LED (17).

15. Système ultrasonore de diagnostic selon la revendication 1, dans lequel les commandes de TGC servent en outre à commander une compensation de gain de temps en permettant un ajustement par un utilisateur de l'amplification appliquée à des signaux d'échos ultrasonores reçus depuis différentes profondeurs d'imagerie.

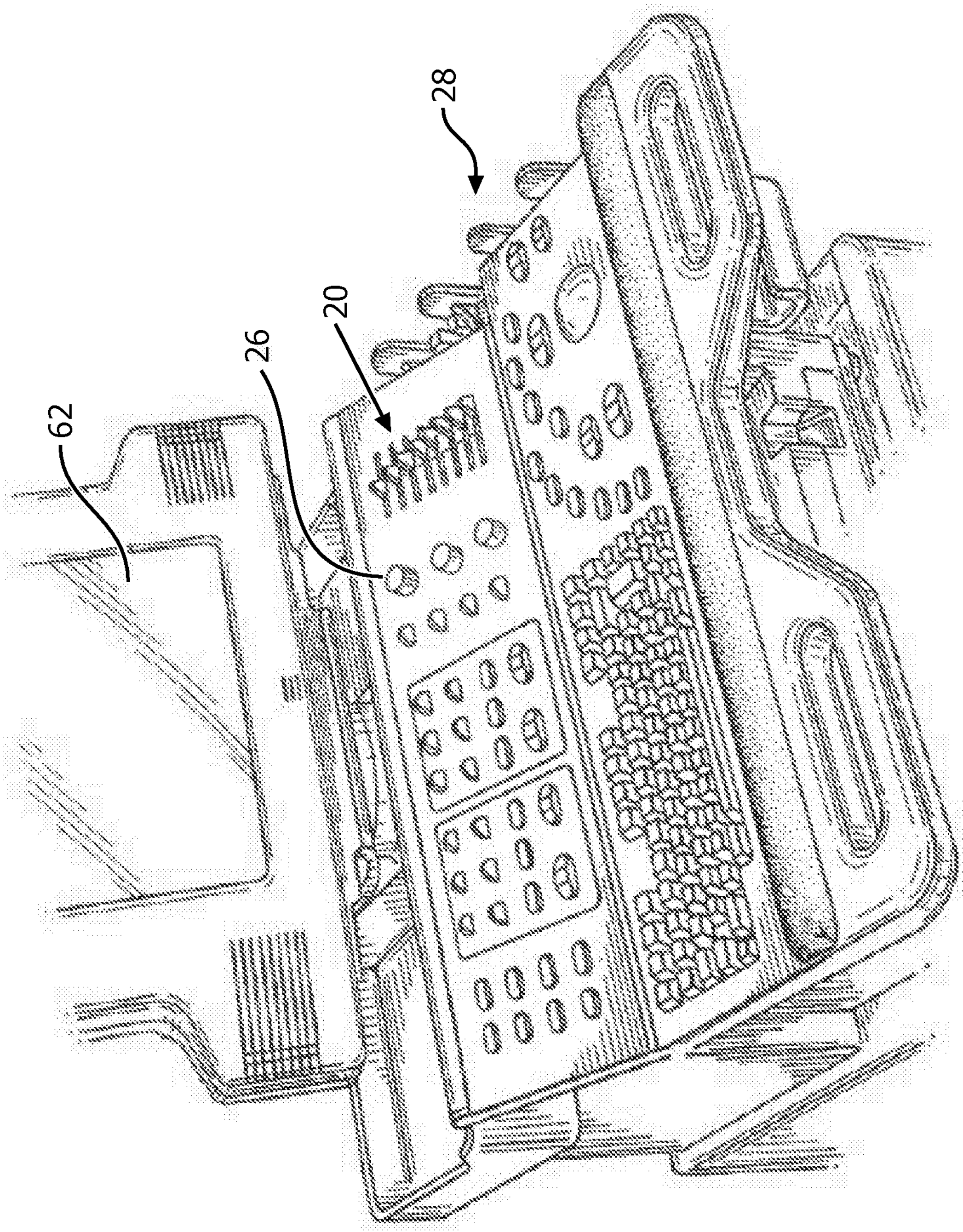

FIG. 1

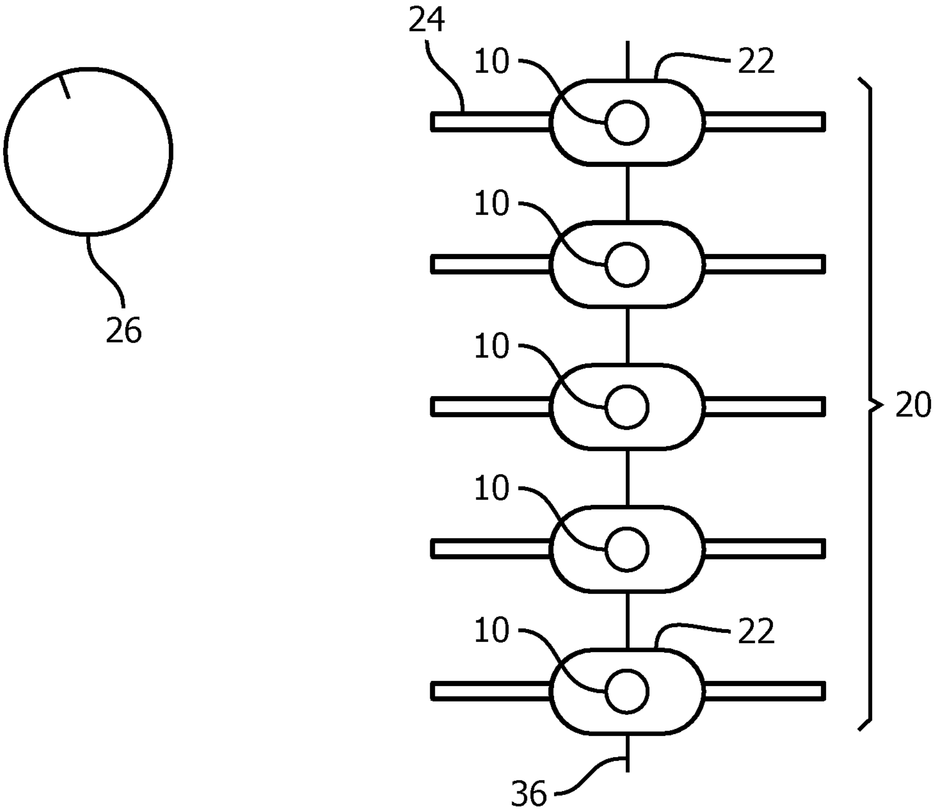

FIG. 2

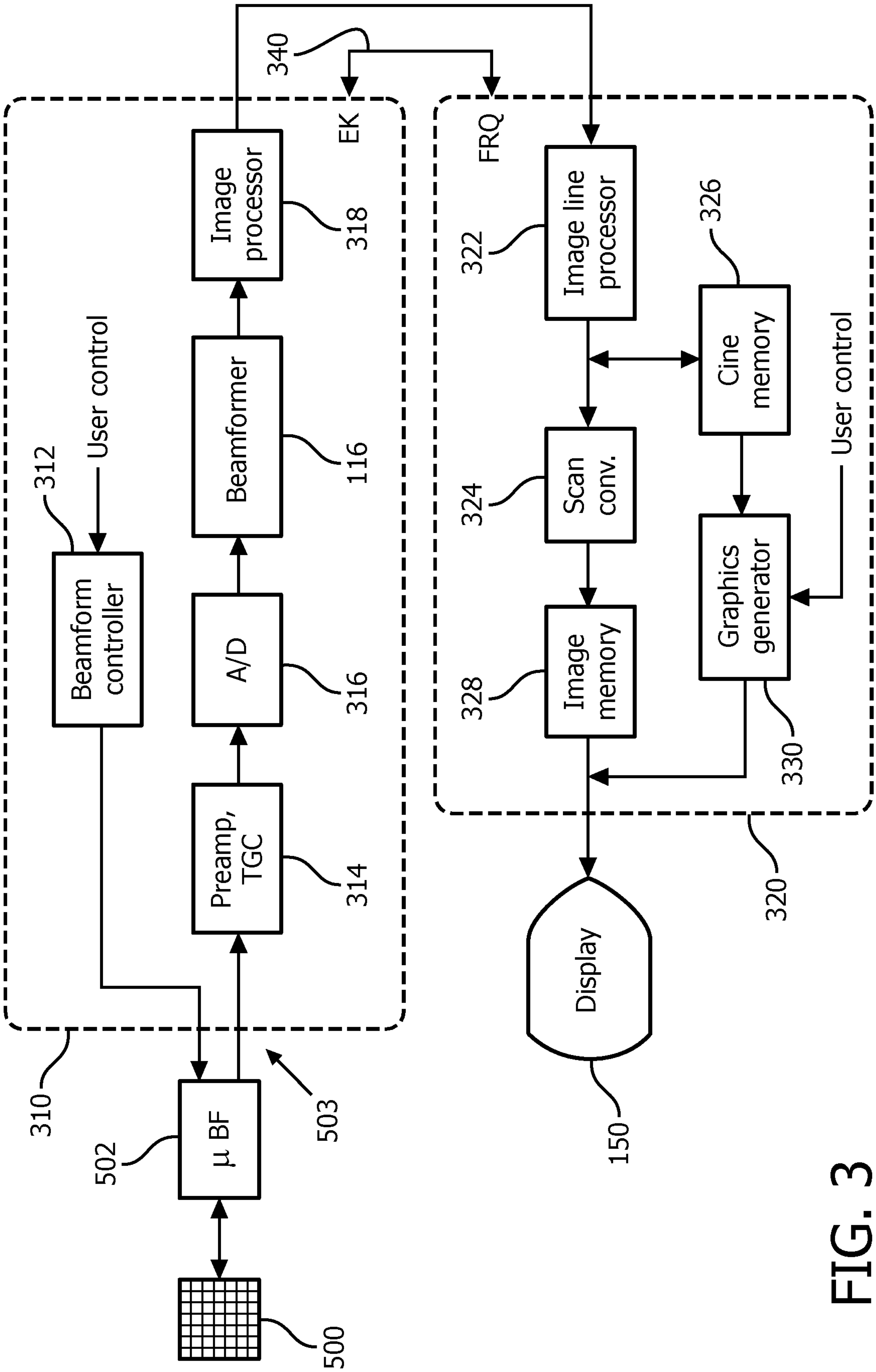
340
EK
FRQ
Image processor
318
User control
312
Beamform controller
Beamformer
116
A/D
316
Preamp, TGC
314
310
μ BF
502
503
500
322
Image line processor
326
Cine memory
User control
324
Scan conv.
Graphics generator
328
Image memory
330
320
Display
150

FIG. 3

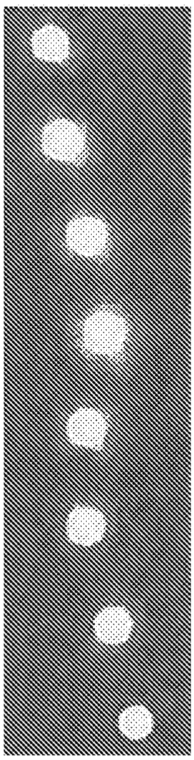

FIG. 4a

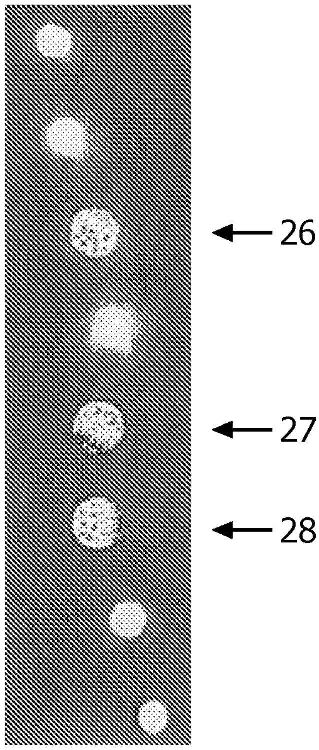

FIG. 4b

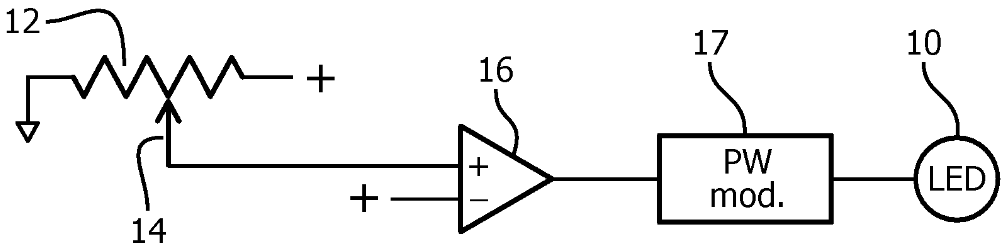

FIG. 5a

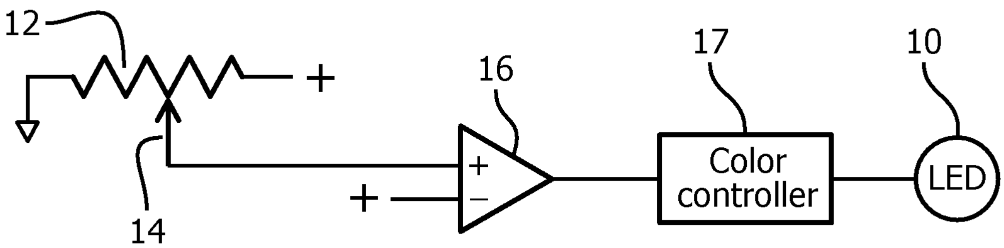

FIG. 5b

REFERENCES CITED IN THE DESCRIPTION

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- US 5997479 A, Savord **[0008]**
- US 6436048 B, Pesque **[0008]**

专利名称(译)	TGC控制超声诊断成像系统		
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[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	MATSUMURA TOWA		
发明人	MATSUMURA, TOWA		
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外部链接	Espacenet		

摘要(译)

提供超声诊断成像系统的TGC控制的TGC滑动开关（20）具有安装在滑动开关的滑动器（22）上的LED（10），使得可以在黑暗的房间中容易地看到开关。当开关的滑块设置在其默认位置（36）时，由开关的LED发出的光变为指示颜色或亮度，以便对从给定深度接收的回波信号施加标称增益。

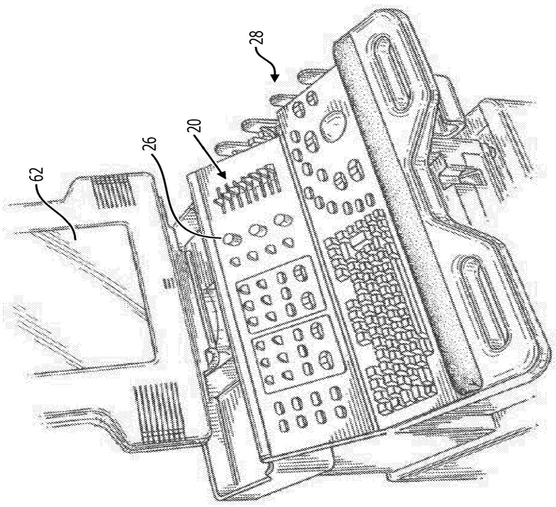

FIG. 1