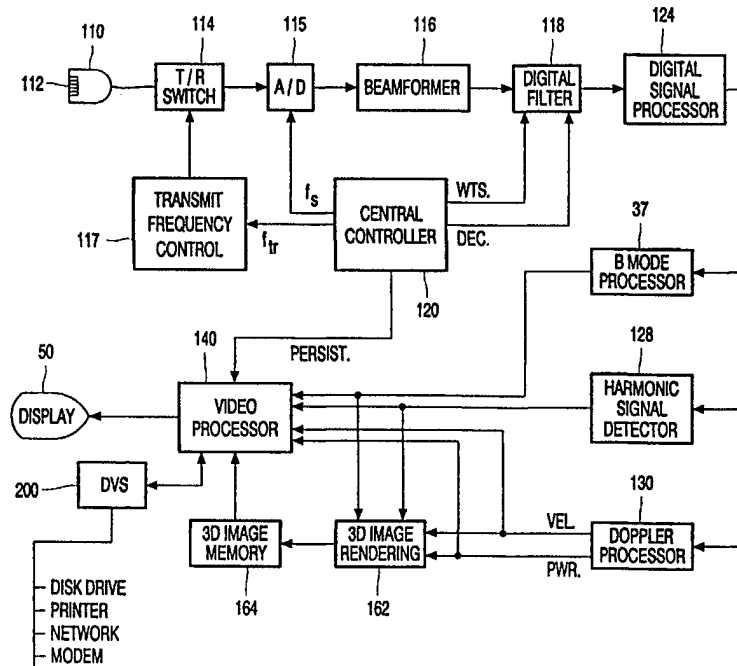




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification ⁷ : H04N 9/804</p>	<p>A1</p>	<p>(11) International Publication Number: WO 00/54517 (43) International Publication Date: 14 September 2000 (14.09.00)</p>
<p>(21) International Application Number: PCT/EP00/01171 (22) International Filing Date: 14 February 2000 (14.02.00) (30) Priority Data: 60/123,040 5 March 1999 (05.03.99) US 09/293,370 16 April 1999 (16.04.99) US (71) Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (72) Inventors: NEGRIN, Irv, D.; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). RICHBOURG, Jack, H.; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). (74) Agent: CHARPAIL, François; Internationaal Octrooibureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).</p>		<p>(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i></p>

(54) Title: ULTRASONIC DIAGNOSTIC IMAGING SYSTEM WITH DIGITAL VIDEO RECORDER



(57) Abstract

A digital video recorder (200) is provided which provides digital storage of real time ultrasonic image sequences, replacing the conventional VCR with a recorder which does not degrade digital ultrasound images by analog conversion and recording. The capacity of the digital video recorder (200) is extended by the ability of the digital video recorder to compress ultrasound image data prior to storage and the ability to decompress compressed image data retrieved from storage for realtime display.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

Ultrasonic diagnostic imaging system with digital video recorder.

This application claims the benefit of U.S. Provisional application no. 60/123,040, filed March 5, 1999.

This invention relates to ultrasonic diagnostic imaging systems and, in particular, to ultrasonic diagnostic imaging systems which digitally store and retrieve
5 ultrasonic image information.

One of the advantages that diagnostic ultrasound has had over many other diagnostic imaging modalities is the ability to produce realtime images. The advantage has been especially significant in cardiology where the physiology of a continually moving organ, the heart, are the subject of study. Realtime imaging has been a virtual necessity in
10 echocardiography as compared with abdominal and obstetrical applications where the tissues and organs being studied are stationary and may be readily examined by static imaging. Echocardiologists, like other practitioners of diagnostic ultrasound, make records of their ultrasound examinations for subsequent diagnosis, review, and comparison. Since
15 echocardiography studies use realtime ultrasonic imaging, they are conventionally recorded on videotape with a VCR, rather than being recorded statically on film or as photographic prints. A VCR has been an essential accessory for an echocardiography system for many years.

Over time ultrasonic imaging systems have become increasingly digital, whereas VCRs have remained recorders of analog video signals. Thus it has been necessary to convert the digital ultrasound images produced by the digital scan converter of an ultrasound
20 system into modulated and synchronized video signals before the images can be recorded by a VCR. This conversion does not contribute to the quality of the image, and often is detrimental to image resolution. This detriment has been viewed as one which must be accepted, however, since the VCR has traditionally provided the only efficient means for recording many minutes of live, realtime echocardiographic image sequences.

The present invention is directed to replacing the VCR with an all-digital means
25 for storing realtime ultrasonic image sequences, a true digital video replacement of the VCR. The present invention allows many minutes of realtime ultrasonic image sequences to be stored on a nonvolatile, high capacity digital storage medium such as a hard disk, CD-RW, magneto-optical or floppy disk. In a preferred embodiment the user has the ability to control

the degree of compression of the image data. A high degree of compression enables an increased number of images to be stored on a given digital storage medium. A constructed embodiment of the present invention provides virtual VCR controls whereby the user can operate the digital video recorder similar to the manner in which he is accustomed to operating a VCR.

In the drawings:

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

FIGURE 2 illustrates in greater detail the digital video storage system and the video processor of the ultrasound system of FIGURE 1;

FIGURE 3 illustrates in greater detail the codec processor of the digital video storage system of FIGURE 2; and

FIGURE 4 illustrates a quad screen ultrasound display and the virtual controls of an embodiment of the digital video recorder of the present invention.

Referring first to FIGURE 1, an ultrasonic diagnostic imaging system constructed in accordance with the principles of the present invention is shown in block diagram form. A central controller 120 commands a transmit frequency control 117 to transmit ultrasonic scanning beams of a desired transmit frequency band. The parameters of the transmit frequency band, f_{tr} , are coupled to the transmit frequency control 117, which causes the transducer 112 of ultrasonic probe 110 to transmit the desired ultrasonic waves. The array transducer 112 of the probe 110 transmits ultrasonic energy and receives echoes returned in response to this transmission. In FIGURE 1 these echoes are received by the transducer array 112, coupled through the T/R switch 114 and digitized by analog to digital converters 115. The sampling frequency f_s of the A/D converters 115 is controlled by the central controller. The desired sampling rate dictated by sampling theory is at least twice the highest frequency f_c of the received passband. Sampling rates higher than the minimum requirement are also desirable.

The echo signal samples from the individual transducer elements are delayed and summed by a digital beamformer 116 to form coherent echo signals. The digital coherent echo signals are then filtered by a digital filter 118. In this embodiment, the transmit frequency f_t is not tied to the receiver, and hence the receiver is free to receive a band of frequencies which is different from the transmitted band. The digital filter 118 can thus pass harmonic frequency signals of a fundamental transmit band of frequencies. A preferred technique for separating harmonic signals is described in U.S. Patents 5,706,819 and (appl. SN

08/986,383). The received echo signals may then be further processed, for instance by processing to remove artifacts such as speckle, by a digital signal processor 124.

The echo signals are detected and processed by either a B mode processor 37 or a harmonic signal detector 128 for display as a two dimensional ultrasonic image on the display 50. The echo signals are also coupled to a Doppler processor 130 for conventional Doppler processing to produce velocity and power Doppler signals which may be used to produce a colorflow or power Doppler 2D image. The outputs of these processors are also coupled to a 3D image rendering processor 162 for the rendering of three dimensional images, which are stored in a 3D image memory 164. Three dimensional rendering may be performed as described in U.S. Pat. 5,720,291, and in U.S. Pats. 5,474,073 and 5,485,842, the latter two patents illustrating three dimensional power Doppler ultrasonic imaging techniques. The signals from the harmonic signal detector 128, the processors 37 and 130, and the three dimensional image signals are coupled to a video processor 140 where they may be selected for two or three dimensional display on an image display 50 as dictated by user selection.

In accordance with the principles of the present invention, the video processor 140 is coupled to a digital video storage (DVS) system 200 which processes digital video signals and audio in realtime for recording, transmission, or reproduction. As FIGURE 1 shows, the DVS system is coupled to storage, transmission and reproduction media such as disk drives, printers, networks and modems. The DVS system processes this information while the user is simultaneously observing the realtime image sequence on the display 50. The DVS system also replays recorded digital video information on the display 50 when commanded to do so. The DVS system operates as a digital video recorder which replaces the conventional VCR with a realtime, all-digital recorder and player without the analog conversion degradation of the VCR.

Referring to FIGURE 2, portions of the video processor 140, the 3D image memory 164, and the DVS system 200 are shown in greater detail. Digital image data produced by any of the aforementioned processors or detectors is coupled to the input of a digital scan converter 142, which processes and converts received echo information into an ultrasound image of the desired format, e.g., sector-shaped or rectangular. The image data can also be stored in a Cineloop® memory 164'. The Cineloop memory is a random access memory (RAM) temporary storage buffer which can hold a number of still or realtime images for immediate review or processing. For example, a typical Cineloop memory can hold a loop (realtime sequence which is replayed) of 400 images for continual replay and review. At a realtime frame rate of 30 frames per second, the Cineloop memory can hold a twelve second

loop, for instance. At lower realtime frame rates, e.g., 15 frames per second, the loop will play for a greater duration. An image or loop stored in the Cineloop memory is replayed through the scan converter and a video display processor & D/A converter 144, which processes the digital video signals into analog video signals with synchronizing pulses for display on a display monitor 50. The Cineloop memory can also receive scan converted digital images by way of the video display processor & D/A 144, which is useful for assembling and storing a 3D image sequence, as explained in the aforementioned U.S. Patent 5,485,842.

In accordance with the principles of the present invention, digital video signals are coupled to a codec (compression/decompression) processor 202 of the DVS system 200.

In a constructed embodiment the digital video signals are digital RGB (red, green, blue) signals. The codec processor assembles received images into formats determined by user selected protocols, optionally compresses the image data as selected by the user, and puts the processed data onto a host system bus 218. The data on the host system bus is directed to the desired storage, transmission or reproduction medium by a CPU 204. The data can be stored on nonvolatile digital storage media, including a hard disk 210, a magneto-optical disk 212, a CD-RW disk 214, or a digital disk 216. A preferred digital storage device is one using a high density removable disk media which is capable of holding the data from several ultrasound studies such as an LS 120 floppy disk. The ultrasound data can also be transmitted over a fiber optic network by way of a fiber coupler to printers and other reproduction and storage devices over a 10/100 base-T network connection, by modem, or by wireless transmitter. In a constructed embodiment the DVS system is integrated into the ultrasound system and is operated by the ultrasound system's user interface 64 (keyboard, control keys, trackball, softkeys, and displayed controls and hand controller).

The DVS system 200 includes a conventional computer sound card 206 to digitize and reproduce audio signals such as audio Doppler ultrasound, and a conventional computer VGA card 208 for the processing of ultrasound image graphics such as patient name and image depth markers. Preferably the CPU 204, sound card 206, and VGA card 208 share the same motherboard, and a portion of the host system bus 218 is provided by the motherboard. These modules may be connected to the DVS system by various bus architectures which may be compatible with the specific module. For example, the VGA card may be connected to an AGP bus, the sound card and floppy disk may be connected to an ISA bus, and the hard disk and codec may be connected to a PCI bus, all of which comprise the host system bus.

Turning to FIGURE 3, the codec processor 202 is shown in greater detail. Digital RGB video is received by the processor 202 at the input of an LVDS (low voltage differential signal) receiver 302. At the output of the LVDS receiver 302 the digital RGB signals comprise three bytes (red, green and blue) of eight bits each and in a constructed embodiment are received at a rate of 24.5 MHz for NTSC signals and 29.5 MHz for PAL signals. The digital video signals are then assembled into a full image frame in an acquisition frame buffer 306 under control of an acquisition FPGA (field programmable gate array) controller 304. The acquisition FPGA controller can also crop an incoming image frame so that only a specified region of interest of the full image is retained. The assembled image frame is coupled to a color space converter 310, which converts the 24 bit RGB signals into 24 bit YUV signals. The YUV signals then may be compressed if directed by the user under control of a compression FPGA controller 314. Compression is performed by a high speed compression/decompression FPGA 312, which may perform various levels of lossy compression such as JPEG, MPEG or wavelet, or lossless compression such as RLE. The compressed data is stored in a frame buffer 316 by the compression controller 314. RLE compression, an interframe compression technique, will operate separately on the Y,U, and V components of a single image frame. Other compression techniques such as MPEG operate on multiple frames simultaneously. The compressed data is transmitted through a bi-directional FIFO 318 and put on a local bus 320 in four-byte words. The compressed frame data is then transferred to CPU memory by way of a PCI bus 218' by a DMA controller residing in the PCI bridge 324. At this point the frame data is stored on one of the digital storage devices or transmitted or reproduced under control of the CPU 204.

When an image sequence is to be stored without compression the acquisition FPGA controller 304 transmits the image frames directly to biFIFO 330 and onto the local bus 320, from which the image frames are stored under control of the CPU 204. Incoming image sequences may also be processed and then stored or displayed without compression. In this alternative the incoming image frames are transferred from the acquisition FPGA controller 304 to the lookup table 332 and the scalar 334 which can, for example, colorize the images and then scale them to a dual or quad screen format size. The image frames are then transferred by the display FPGA controller 336 to the local bus 320 by way of the biFIFO 330, from which the images can be stored, or to the graphic overlay buffer 340 for transmission by the LVDS transmitter 344 to the ultrasound system for display.

The components of the codec processor are all operated under control of a local processor 322, which transmits control words to the various controllers by way of biFIFOs 318

and 330. The local processor provides realtime control of the various codec operations as commanded by the CPU 204. A memory controller 324 is under control of the local processor and directs control messages through the biFIFOs to the various controllers.

When video data is to be replayed from one of the storage media and displayed,
5 the data retraces its compression path and is decompressed. Under command of the CPU 204 video data retrieved from the storage device and transferred over the PCI bus 218', where it is put on the local bus 320 by the DMA controller residing in the PCI bridge 324. The digital video data on the local bus 320 is coupled to the compression controller 314 by way of the biFIFO 318, under control of the local processor 322. This time the compression controller
10 314 sends the compressed data to the compression/decompression FPGA 312 where the data is decompressed and the decompressed YUV data is stored in a frame buffer 316. The controller 314 sends the decompressed data to the color space converter 310 where it is reconverted into RGB video. Frames of RGB video are coupled by way of the acquisition FPGA controller 304 to a lookup table 332 which performs operations such as gamma correction and color
15 mapping. The output of the lookup table 332 is coupled to a scalar 334 which performs magnification or minimization of image frames as requested by the user. The frame data is then assembled into a desired display frame format such as full, dual or quad screen in a display frame buffer 338 under control of display FPGA controller 336. The controller 336 synchronizes the previously stored ultrasound image frame to the timing of the ultrasound
20 system's video display processor & D/A 144, so that the user can switch seamlessly back and forth between stored image sequences and live image sequences currently being produced by the ultrasound system. Graphic data is stored in a graphic overlay buffer 340 from which it is synchronized to the timing of the stored ultrasound image frame so that the ultrasound image can be overlaid with graphical information as needed. Stored physiological data such as ECG
25 traces are also synchronized and combined with the ultrasound image in this manner. The graphical and video physio information is retrieved from the storage or transmission medium by the VGA card 208 under control of the CPU 204, is stored in a graphics memory 342, then combined with the ultrasound image frame in the graphic overlay buffer. The final display frame in 24 bit RGB bytes is applied to an LVDS transmitter 344 and then to the video display
30 processor & D/A 144 for display on the display monitor 50.

When uncompressed images are retrieved from storage for display, they retrace the path by which they were stored. Uncompressed image data is transferred by the biFIFO 330 to the acquisition FPGA controller 304, from which it can be colorized or mapped by the lookup table 332, scaled by the scalar 334, and put into the desired display format by the

display FPGA controller 336. Alternatively the biFIFO 330 can transfer the image data directly to the display FPGA controller 336 for display.

5 The codec processor 202 also has the ability to combine stored and live image sequences in a single realtime display frame. A realtime image sequence can be stored on one of the digital storage devices, then retrieved in synchronism with a live realtime image sequence that is currently being produced by the ultrasound system. The retrieved image sequence data is decompressed if necessary, transferred to the acquisition FPGA controller 304, then scaled and formatted by the display FPGA controller for display in one area of a multi-image (dual or quad screen) display. The live image sequence is synchronously
10 transferred by the LVDS receiver 302 to the acquisition FPGA controller 304, then scaled and formatted by the display FPGA controller for display in another area of the multi-image display. The multi-image frame is overlaid with graphic data as needed, then transferred for display on the system display 50 by the LVDS transmitter 344.

The ability of the digital video system 200 to record extended durations of
15 digital ultrasound images approaching that of a VCR is a function of the digital information of an image, the capacity of the digital storage media, and the speed (bandwidth) and performance of the digital processors used, in particular the CPU 204 which mediates the PCI bus. A fourth factor which has a very significant impact on storage capacities is the level of compression selected by the user. In a constructed embodiment an NTSC format image is
20 composed of 480 lines of 640 pixels per line. With each RGB pixel comprising three bytes, a full image is seen to comprise just under one megabyte of data. Using a 200 MHz CPU, the constructed DVS system 200 can store data on a disk drive at rates of 10-17 megabytes per second, which translates to the storage of realtime image sequences having frame rates of 10-15 Hz. This rate for uncompressed images can be increased appreciably through compression.
25 The constructed embodiment performs lossless RLE compression at levels up to 4-6:1, and lossy compression such as JPEG at levels up to 25-30:1. The user is provided choices of lossless, low, medium, or high compression. These choices connote a quality factor of the compressed and then uncompressed images, since the compression is a function of the image data itself and cannot be quantitatively specified with great precision. At these compression
30 levels frame rates of 30 Hz are readily attainable. Storage of five, ten, or twenty minutes of realtime images are possible depending upon the level of compression used. An 8 Gigabyte hard disk can thus store many minutes of realtime images and serve the purpose of a VCR for many echocardiography exams.

Echocardiography images are frequently accompanied by scrolling traces of physiological functions displayed on the ultrasound image display such as a QRS cardiac waveform. To further enable high speed digital storage, the present invention digitizes physiological information such as ECG, pulse and phono signals and transmits the digital data for storage in one of the last lines of the 480 lines of image data, lines which are not used for ultrasonic image display data. Thus, the physiological information is simultaneously stored with the image data to which it relates with no increase in the size of the block of image data. Audio signals such as Doppler sounds which are produced concurrently during imaging are digitized by the sound card 206 and stored in synchronization with the concurrent image data. During replay the digital audio data is routed back over the PCI bus 218 to the sound card, is converted to an analog signal and reproduced through the speakers of the ultrasound system during display of the accompanying image sequence.

FIGURE 4 illustrates a quad display as it would appear on a monitor screen when replayed by a digital video storage system of the present invention. Since the present invention can replace the standard VCR, a preferred embodiment uses virtual recorder controls 400 displayed on the monitor screen, which the user would intuitively operate much in the manner of the controls or remote control buttons of a VCR. The virtual buttons of the virtual controls are arranged in a softkey toolbar 400 and take advantage of the versatility of direct digital recording by providing functions not available on the standard VCR. When the user clicks on the first button 402, the user can scan through consecutive frames in an image sequence, one frame at a time. The user can scan through all four image sequences in the quad display simultaneously, or can click on one of the quad images to highlight it and scan through only that sequence of images. In a constructed embodiment the user uses the select key of the ultrasound system's user interface to select a quad display or virtual button, and then uses the trackball of the user interface to scan through the image sequence.

The virtual button 404, when clicked on by the user, plays the image sequences in realtime. When the button 404 is clicked during realtime replay, the realtime display will pause. Repeatedly clicking virtual button 406 will increment the play speed of the images and repeatedly clicking virtual button 408 will decrement the play speed of the images. Virtual buttons 410 and 412 will skip back to a previous mark in a sequence and skip forward to a later mark in the sequence. Marks are placed at points in sequences when long sequences are trimmed to one or more short sequences such as a single cardiac cycle which is of particular interest to a clinician. Such immediate access of points in a sequence of images is not possible with a VCR, since the user must serially advance or rewind the tape to get to other points in a

sequence or earlier or later sequences. These virtual buttons enable the user to directly access and instantly replay a trimmed sequence from an editing mark.

An embodiment of the DVS system of the present invention, with its own CPU and digital storage and response to the user interface of the ultrasound system, can execute stored protocols on the ultrasound system. For instance, the constructed embodiment stores protocols for stress echo exams which are carried out in the following manner. Using the ultrasound system user interface including selections displayed on the monitor, the user selects the desired protocol. The stages to be performed are selected and defined, which for stress echo are the initial rest stage and the post-exercise stage. The views of the heart to be acquired are selected, such as 2D long axis, 2D short axis, apical 4 chamber and apical 2 chamber views. The capture format such as quad screen is selected, and the compression level is chosen. The capture length is also chosen, which can be denominated in time, e.g., 1 second to 5 minutes for each view, or it can be denominated in the number of cardiac cycles or number of images per view. As these choices are made the ultrasound system displays the disk capacity and the number of sequences that can be stored on the selected storage medium at the specified capture length and compression level. Patient images are then acquired one view at a time both pre- and post-stress.

The acquired sequences are then replayed on the display and arranged in the chosen quad format by the display controller 336. The user can edit the image sequences to select out images or heart cycles that are of particular interest. As described above, the user can select one of the four images of the quad display and select the "trim" toolbar. The user can manipulate the trackball to scroll through the full image sequence and mark the first and last frames of portions of a full sequence that are of particular interest. The trimmed sequence can then be stored as a new image sequence. The user can then replay the quad screen display in realtime for only the trimmed sequence intervals, continually replaying the image sequences as image loops.

The versatility and flexibility of the digital recorder makes possible diagnostic tools not previously known. For instance, a dual or quad screen display can be formed from one or more previously stored image sequences together with a live image sequence which is just being acquired. Such a capability is useful when performing a stress echo examination, for instance. An image sequence of the patient's heart can be acquired and stored by the DVS system when the patient is initially at rest. An image loop of one cardiac cycle of the at-rest heart can be trimmed and prepared for replay. When the heart rate is accelerated by exercise or a cardiotonic adrenergic agent such as dobutamine, the live heartbeat is displayed alongside

the at-rest heartbeat. Display of the at-rest cardiac loop is repetitively triggered by the ECG trigger of the live heartbeat image sequence. Thus, live realtime images of the accelerating heart are viewed alongside and in physiological synchronism with the stored at-rest beating heart loop. The clinician can thereby observe the effect of the adrenergic agent by comparing
5 the live heartbeat with the heartbeat of the at-rest heart. When the clinician notes the onset of the effect of the agent, he can stop administering the drug so that the patient will not undergo an undue amount of pharmacological stress.

Different sequences in a dual or quad screen display can be replayed at different rates at the same time, enabling images of the heart cycle at resting pulse rate to be played in moving
10 synchronism with images of the heart after exercise. The clinician can thus assess the side-by-side performance of the resting and stressed heart with the two realtime sequences of different heart rates apparently moving in synchronism.

CLAIMS:

1. A digital ultrasound video storage system for storing and retrieving realtime ultrasonic image sequences in real time comprising:
 - a user control;
 - a high capacity nonvolatile digital storage medium;
 - 5 an image display device;
 - a source of realtime digital ultrasonic image frame data;
 - an ultrasonic digital image frame data processor, coupled to said source and responsive to said user control, for directing digital ultrasonic image frame data to said digital disk storage medium for digital storage in substantially real time, and for retrieving said digital ultrasonic image frame data from said storage medium for display on said image display device in substantially real time.
- 15 2. The digital ultrasound video storage system of Claim 1, wherein said image frame data processor further comprises a video data compression and decompression circuit for compressing digital ultrasonic image frame data prior to storage, and for decompressing compressed digital ultrasonic image frame data after retrieval from storage.
- 20 3. The digital ultrasound video storage system of Claim 2, wherein said video data compression and decompression circuit utilizes one of a lossy compression algorithm or a lossless compression algorithm.
4. The digital ultrasound video storage system of Claim 3, wherein said video data compression and decompression circuit utilizes one or more of the following compression protocols: JPEG, MPEG, RLE or wavelet.
- 25 5. The digital ultrasound video storage system of Claim 1, wherein said source of realtime digital ultrasonic image frame data comprises a source of digital ultrasonic color image frame data.

6. The digital ultrasound video storage system of Claim 5, wherein said digital ultrasonic color image frame data has a red-green-blue data format.

7. The digital ultrasound video storage system of Claim 6, wherein said image frame data processor further comprises a video data compression circuit, and further comprising a YUV conversion circuit for converting said RGB data to YUV data prior to compression.

8. The digital ultrasound video storage system of Claim 7, wherein said image frame data processor further comprises an acquisition frame buffer for storing a full frame of digital ultrasonic image frame data prior to YUV conversion.

9. The digital ultrasound video storage system of Claim 1, wherein said high capacity digital storage medium comprises one or more of the following: a hard disk, a magneto-optical disk, a digital compact disk, and a high density floppy disk.

10. The digital ultrasound video storage system of Claim 1, further comprising a video display processor, coupled between said ultrasonic digital image frame data processor and said image display device, for converting retrieved digital ultrasonic image frame data into a form suitable for use by said image display device.

11. The digital ultrasound video storage system of Claim 10, wherein said video display processor includes a digital to analog converter for converting digital ultrasonic image frame data to analog signals for use by said image display device.

12. The digital ultrasound video storage system of Claim 1, further comprising means for arranging retrieved digital ultrasonic image frame data for display in full, dual or quad screen format.

13. The digital ultrasound video storage system of Claim 1, further comprising means for digitally storing and retrieving audio ultrasound data.

14. The digital ultrasound video storage system of Claim 13, wherein said means for digitally storing and retrieving audio ultrasound data includes a sound card.

15. The digital ultrasound video storage system of Claim 1, further comprising means for digitally storing graphic ultrasound image information, and for retrieving said stored graphic ultrasound image data for display with stored ultrasonic image frame data.

5 16. The digital ultrasound video storage system of Claim 15, wherein said means for digitally storing and retrieving graphic ultrasound image information includes a VGA card.

17. The digital ultrasound video storage system of Claim 15, wherein said stored graphic ultrasound image data includes physiological data.

10

18. The digital ultrasound video storage system of Claim 1, wherein said user control further comprises means for controlling an ultrasonic diagnostic imaging system.

19. An ultrasound system with realtime digital video storage capability comprising:
15 an array transducer for acquiring ultrasonic signals from a region of the body being imaged;
a beamformer, coupled to said transducer, for producing coherent ultrasonic image signals of said region in a sequence of realtime image frames;
a digital signal processor, coupled to said beamformer, for producing frames of digital ultrasonic image data in real time;
20 an image display, coupled to said digital signal processor, for displaying frames of said digital ultrasonic image data in real time;
a high capacity nonvolatile digital storage medium; and
a digital video storage and retrieval system, coupled to said digital storage
25 medium, said digital signal processor, and said image display, for storing said digital ultrasonic image data on said digital storage medium in substantially real time and for retrieving digital ultrasonic image data from said digital storage medium for display on said image display in substantially real time.

20. The ultrasound system of Claim 19, wherein said high capacity digital storage
30 medium has a capacity which able to store in excess of 400 ultrasound frames.

21. The ultrasound system of Claim 19, wherein said high capacity digital storage medium has a capacity which is able to store a realtime ultrasonic image sequence which has a display duration on replay of greater than either 30 seconds or one minute or five minutes.

22. The ultrasound system of Claim 19, wherein said digital video storage and retrieval system includes a compression/decompression processor which compresses ultrasound images prior to storage and decompresses stored compressed ultrasound images prior to display.

5

23. The ultrasound system of Claim 22, wherein the degree of compression effected by said compression/ decompression processor is variable and selectable.

24. The ultrasound system of Claim 22, wherein said compression/ decompression processor can execute a plurality of selectable compression algorithms.

10

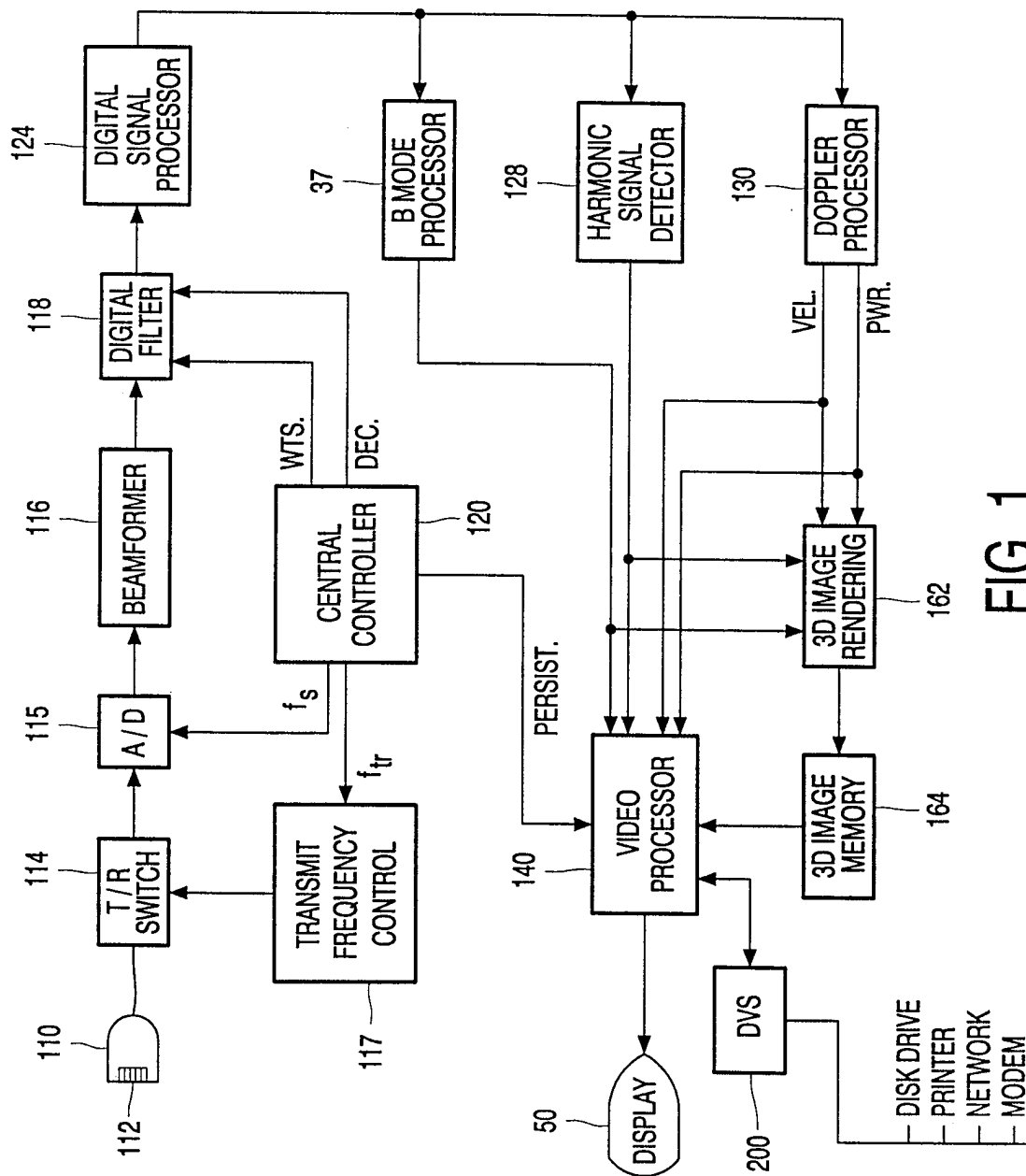


FIG. 1

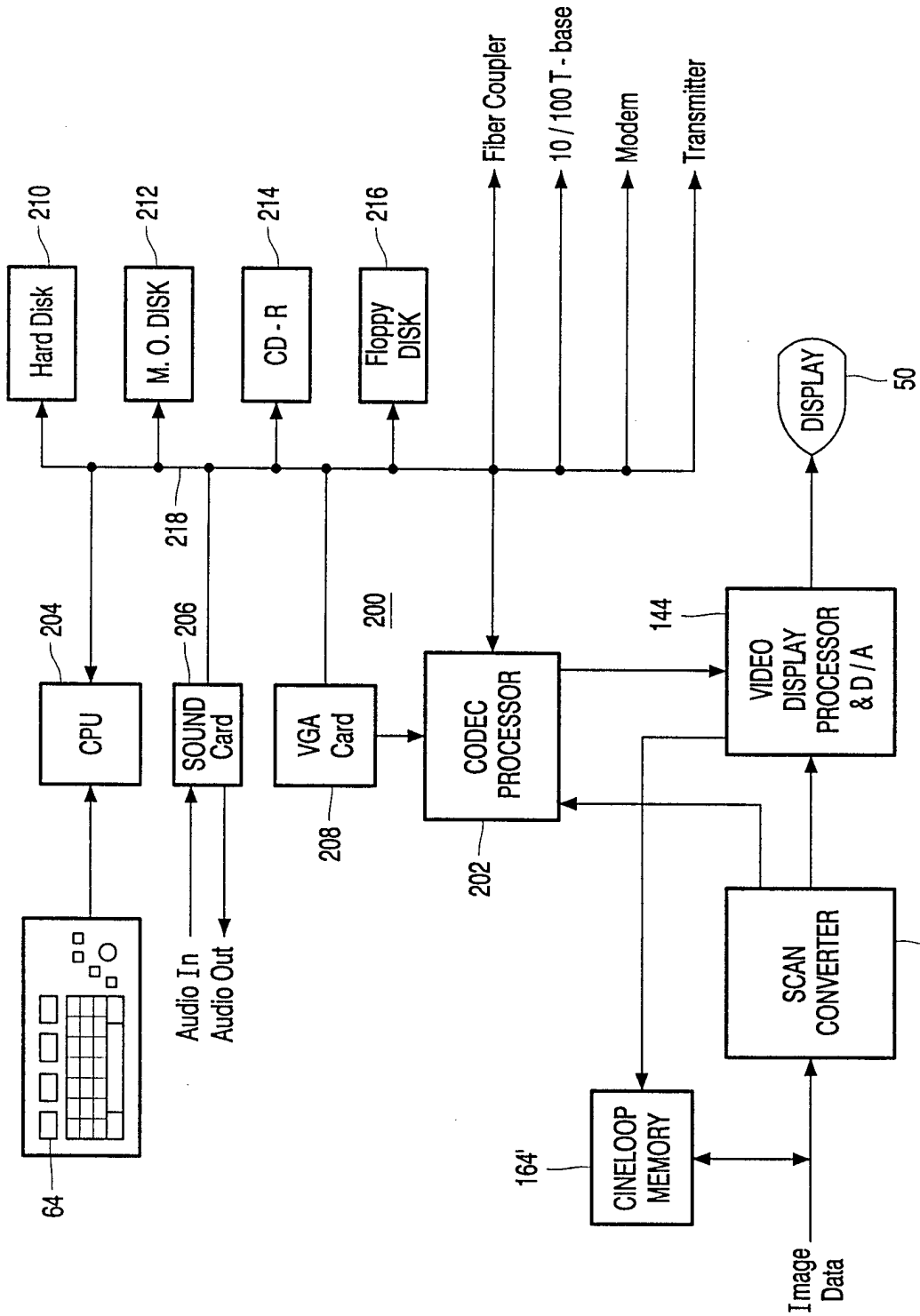


FIG. 2

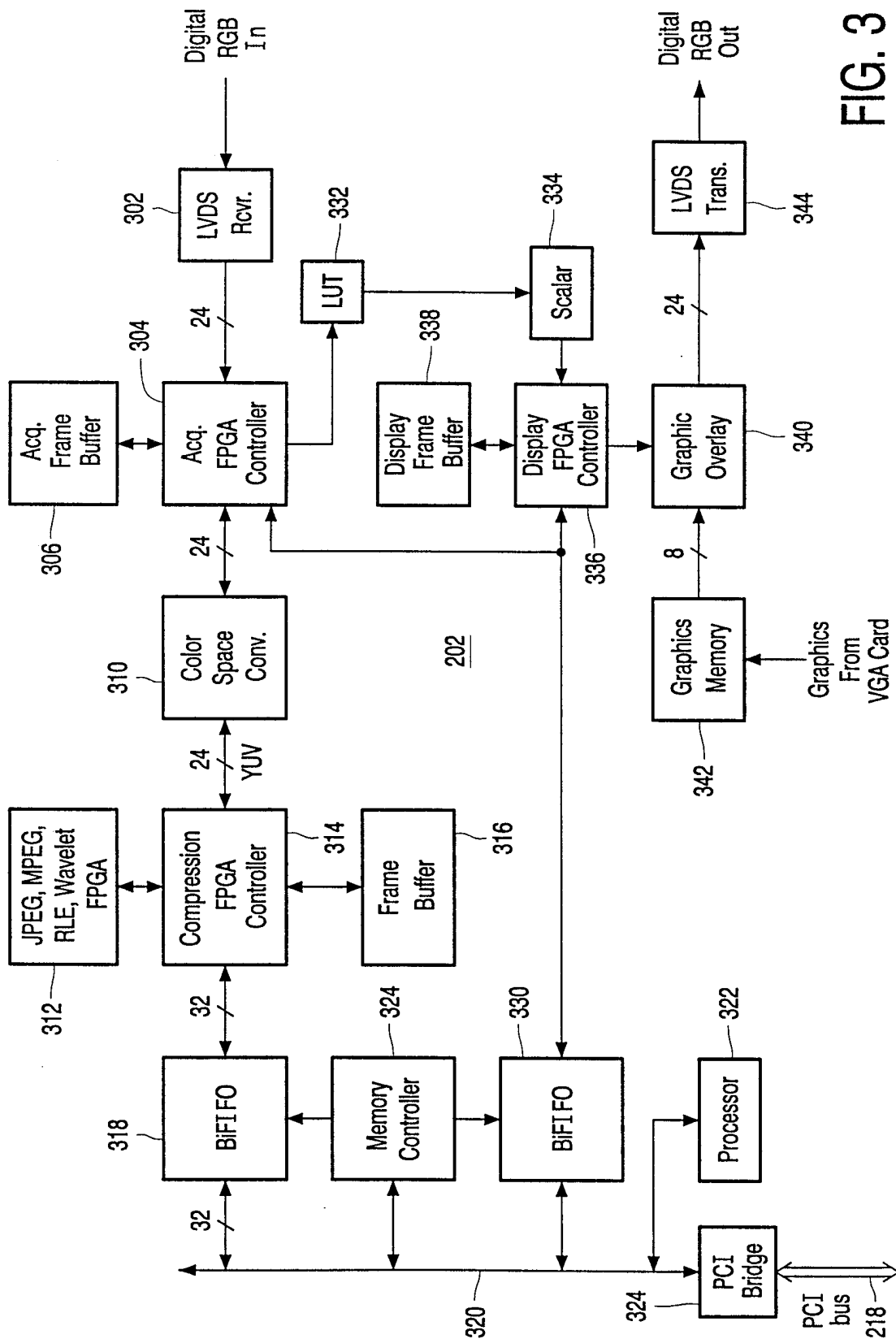


FIG. 3

4/4

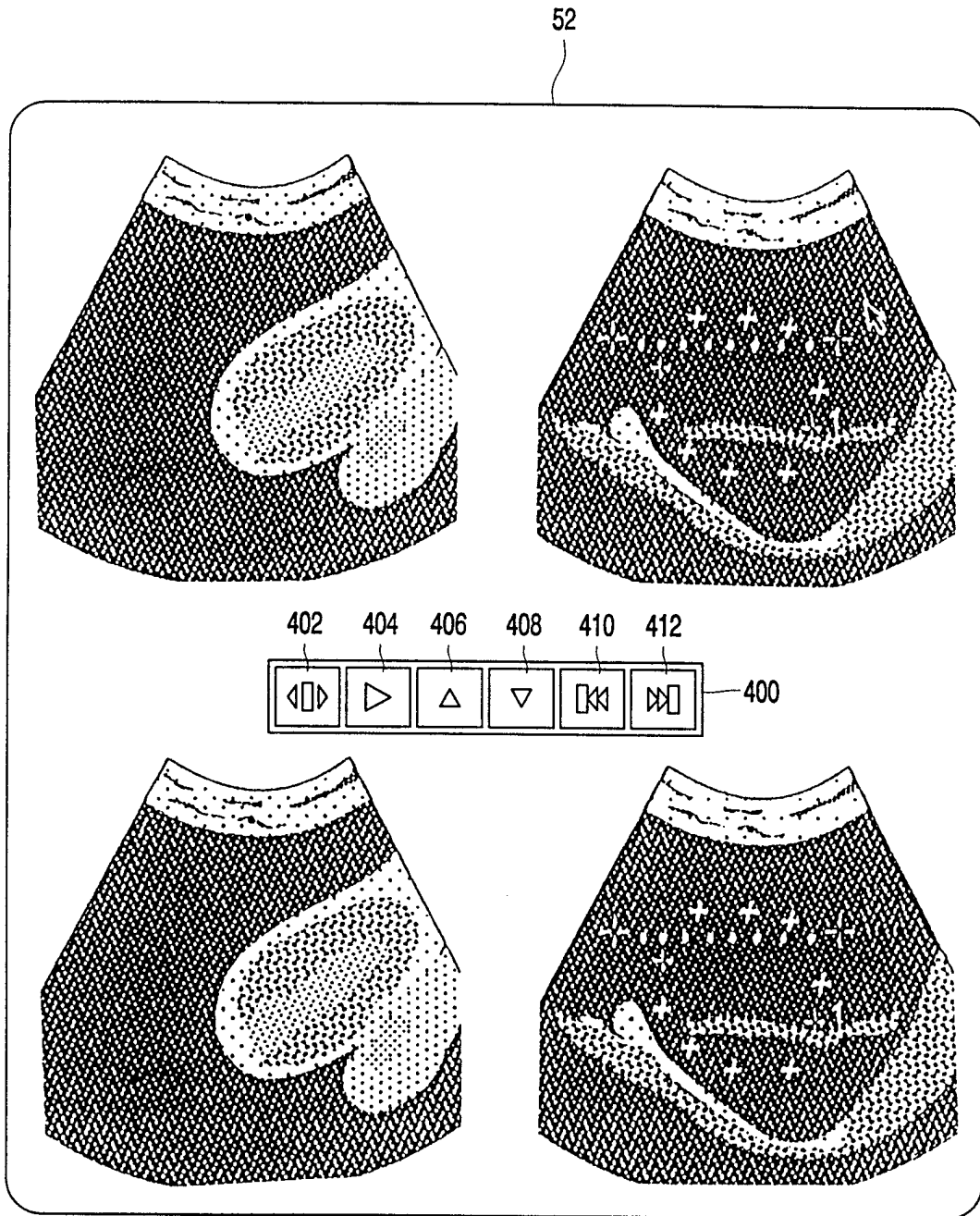


FIG. 4

INTERNATIONAL SEARCH REPORT

Inte: onal Application No

PCT/EP 00/01171

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 H04N9/804

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 H04N

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 619 995 A (LOBODZINSKI) 15 April 1997 (1997-04-15)	1-6, 9, 10, 12-15, 17-19, 22-24
Y	the whole document	11
Y	----- WO 82 01784 A (WISCONSIN ALUMNI RESEARCH FOUNDATION) 27 May 1982 (1982-05-27)	11
A	the whole document ----- -/--	1, 5, 9, 10, 18, 19

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

7 June 2000

14/06/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Verleye, J

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/01171

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 474 073 A (SCHWARTZ ET AL.) 12 December 1995 (1995-12-12) cited in the application column 2, line 60 -column 4, line 14; figure 1	1,5,9, 10,18,19
A	US 5 583 566 A (KANNO ET AL.) 10 December 1996 (1996-12-10) column 6, line 48 -column 13, line 60 column 14, line 31 -column 17, line 44; figures 4-11,14-18	1,5,6, 8-12,18, 19

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/EP 00/01171

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5619995 A	15-04-1997	NONE	
WO 8201784 A	27-05-1982	CA 1164581 A EP 0064539 A	27-03-1984 17-11-1982
US 5474073 A	12-12-1995	CA 2157313 A,C EP 0714036 A JP 10309279 A JP 2812670 B JP 8229038 A US RE36564 E	23-05-1996 29-05-1996 24-11-1998 22-10-1998 10-09-1996 08-02-2000
US 5583566 A	10-12-1996	JP 2299070 A JP 2659240 B JP 3159490 A	11-12-1990 30-09-1997 09-07-1991

专利名称(译)	具有数字录像机的超声诊断成像系统		
公开(公告)号	EP1078534A1	公开(公告)日	2001-02-28
申请号	EP2000916830	申请日	2000-02-14
[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)	皇家飞利浦电子N.V.		
当前申请(专利权)人(译)	皇家飞利浦电子N.V.		
[标]发明人	NEGRIN IRV D		
发明人	NEGRIN, IRV, D. RICHBOURG, JACK, H.		
IPC分类号	A61B8/14 A61B8/08 G01S7/52 G01S15/89 H04N5/781 H04N5/85 H04N5/907 H04N5/91 H04N9/804 H04N9/82 H04N9/87		
CPC分类号	G01S7/52087 A61B8/565 G01S7/52073 G01S15/899 G01S15/8993 H04N5/781 H04N5/85 H04N5/907 H04N9/8042 H04N9/8216 H04N9/8227 H04N9/8715		
优先权	60/123040 1999-03-05 US 09/293370 1999-04-16 US		
外部链接	Espacenet		

摘要(译)

提供一种数字视频记录器 (200) , 其提供实时超声图像序列的数字存储, 用记录器代替传统的VCR, 该记录器不通过模拟转换和记录降低数字超声图像。数字视频记录器 (200) 的容量通过数字视频记录器在存储之前压缩超声图像数据的能力以及解压缩从存储器检索的压缩图像数据以进行实时显示的能力而得以扩展。