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(54) CONTROL OF USER INTERFACES AND DISPLAYS FOR PORTABLE ULTRASOUND UNIT AND DOCKING STATION

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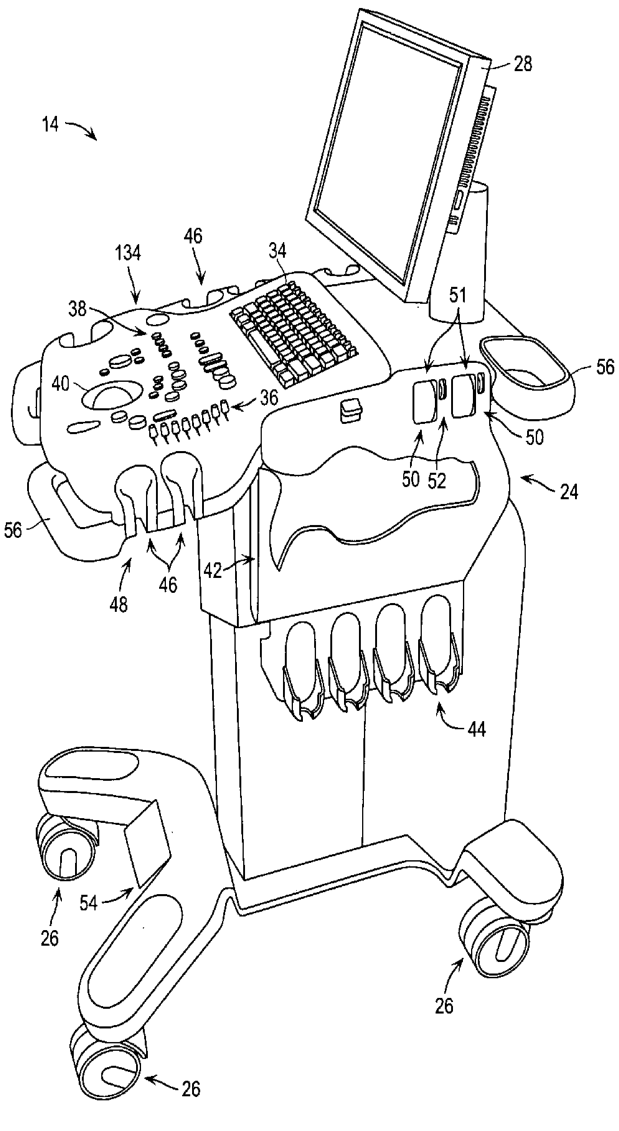
(57) **ABSTRACT**

Embodiments of the present invention provide ways for controlling a plurality of visual displays and a plurality of user interfaces for a portable ultrasound device which can be mounted to different docking stations or carts to provide and enhance different functionalities and features. In one embodiment, a portable ultrasound device comprises a portable housing; a display control module configured to control a plurality of visual displays, at least one of the visual displays being selectively configurable to provide a user interface display on the visual display for user interface control, at least one of the visual displays being selectively configurable to view an ultrasound image; and a plurality of user interfaces, at least one of the plurality of user interfaces being a separate user interface which is not integrally formed with the portable housing.



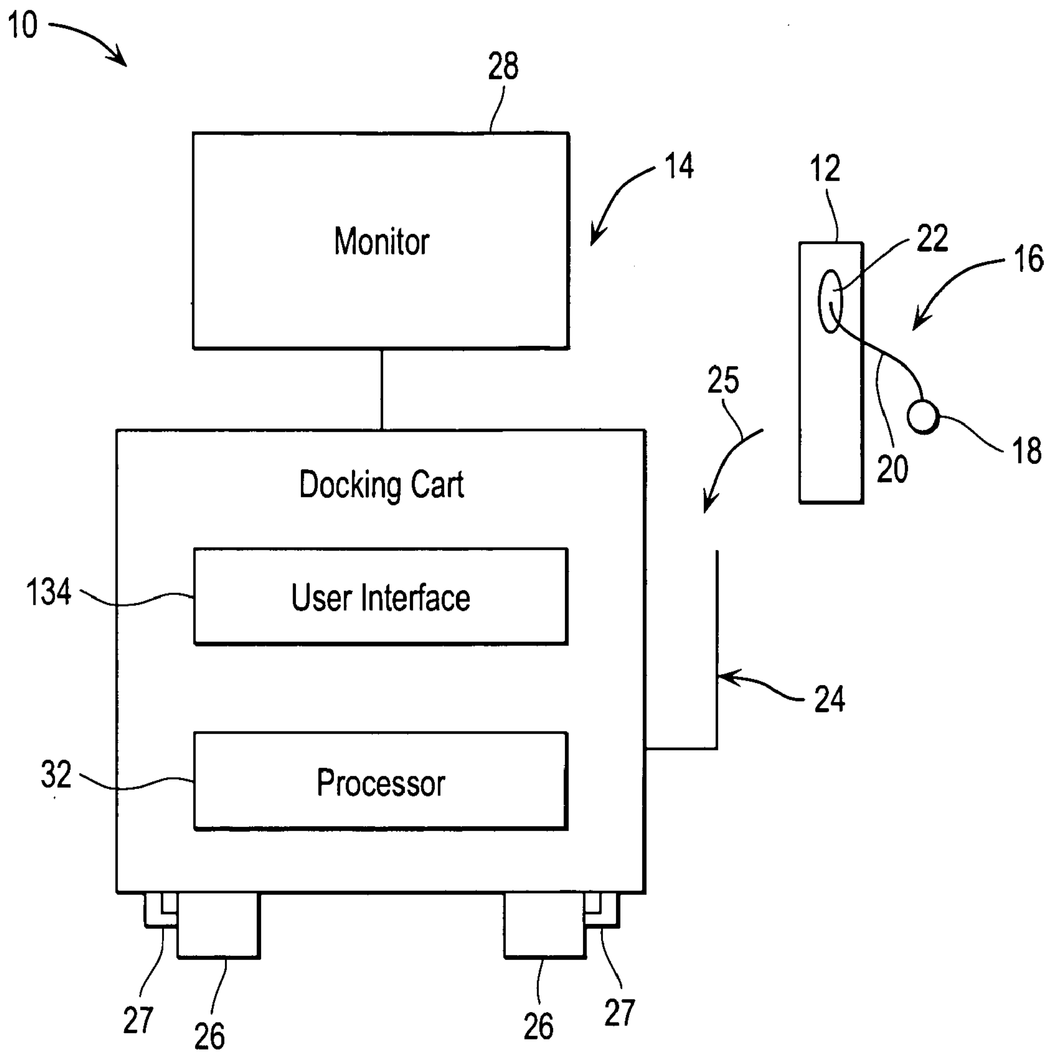

10
28
Monitor
14
12
22
16
25
20
18
Docking Cart
134
User Interface
24
32
Processor
27
26
26
27

FIG. 1

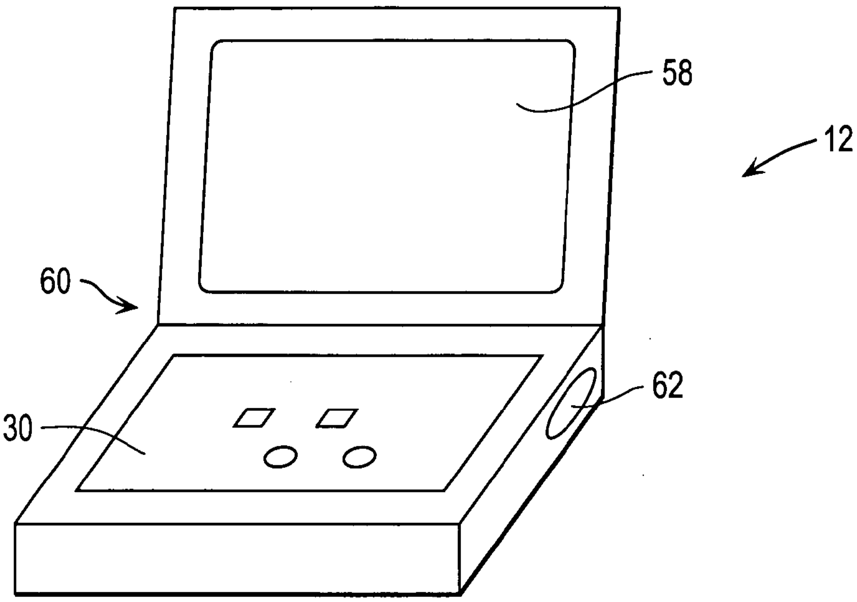


FIG. 2

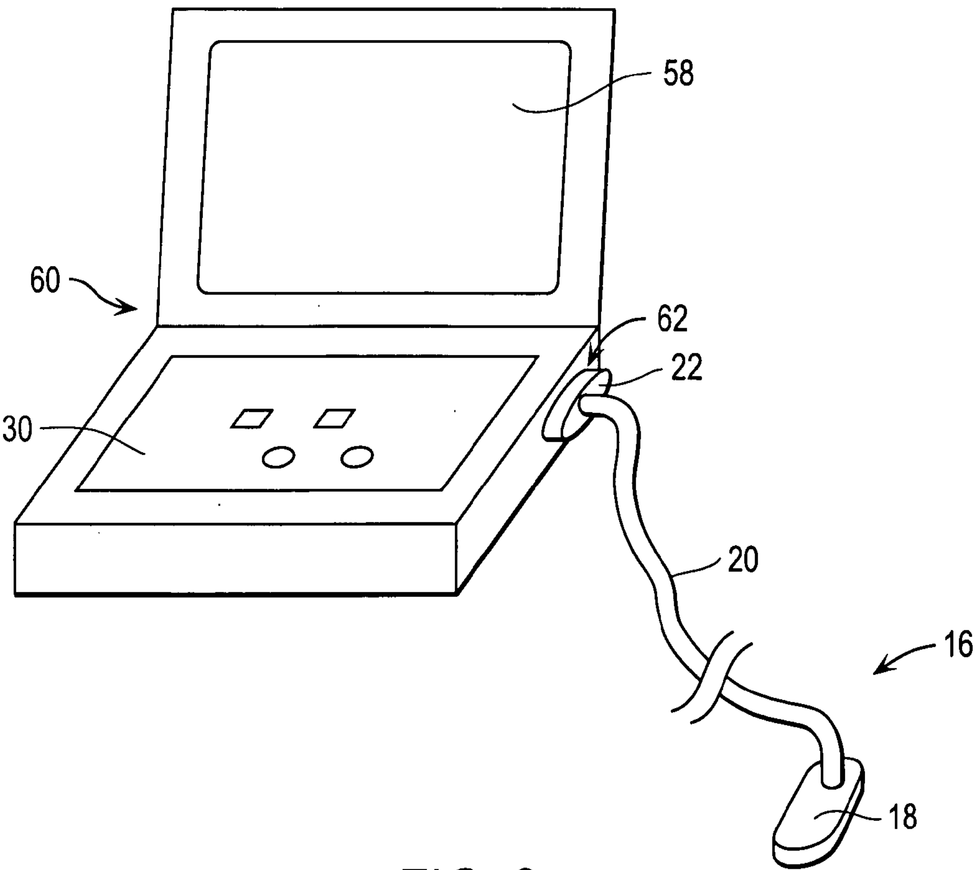


FIG. 3

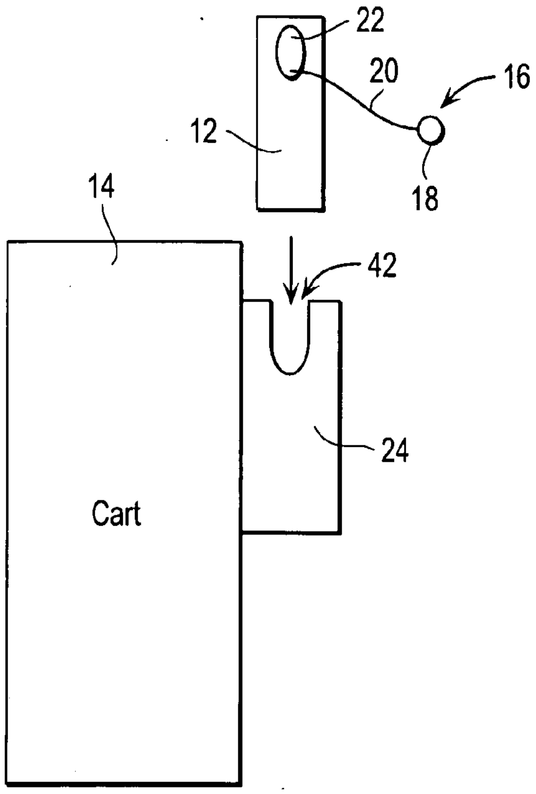


FIG. 4

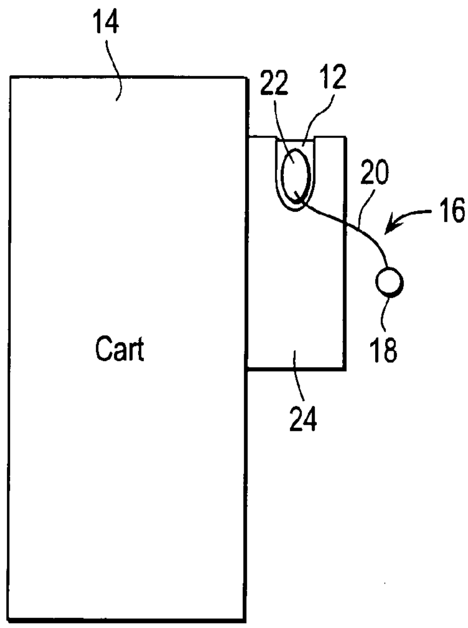


FIG. 5

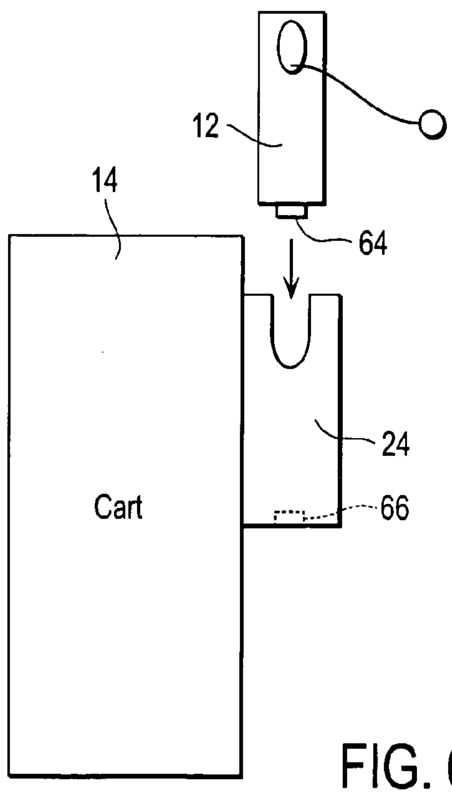
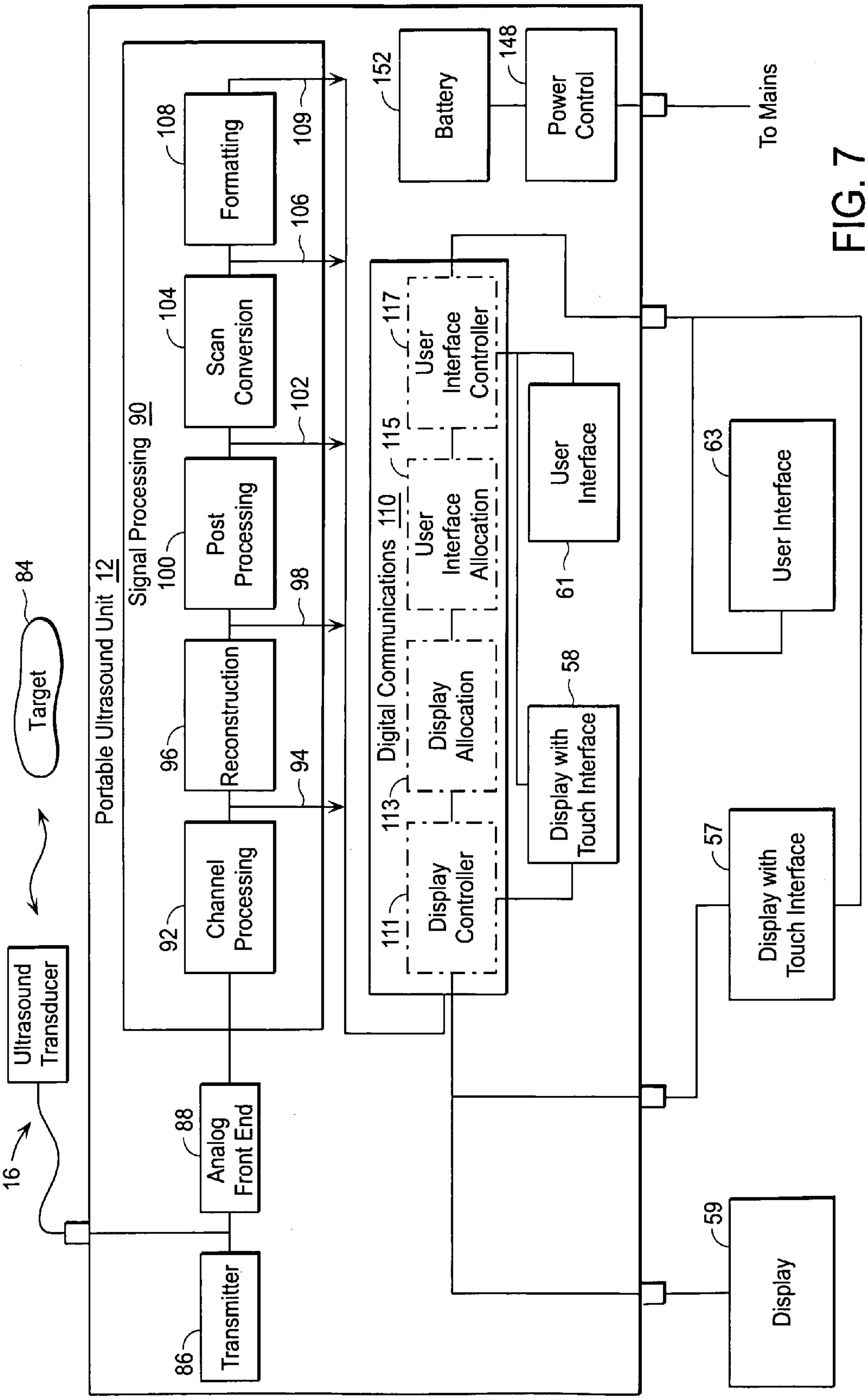


FIG. 6



Portable Ultrasound Unit 12
Signal Processing 90
Ultrasound Transducer
16
Target
84
Transmitter
86
Analog Front End
88
Channel Processing
92
94
Reconstruction
96
98
Post Processing
100
102
Scan Conversion
104
106
Formatting
108
109
Digital Communications 110
Display Controller
111
Display Allocation
113
User Interface Allocation
115
User Interface Controller
117
Display with Touch Interface
58
User Interface
61
Battery
152
Power Control
148
To Mains
Display
59
Display with Touch Interface
57
User Interface
63

FIG. 7

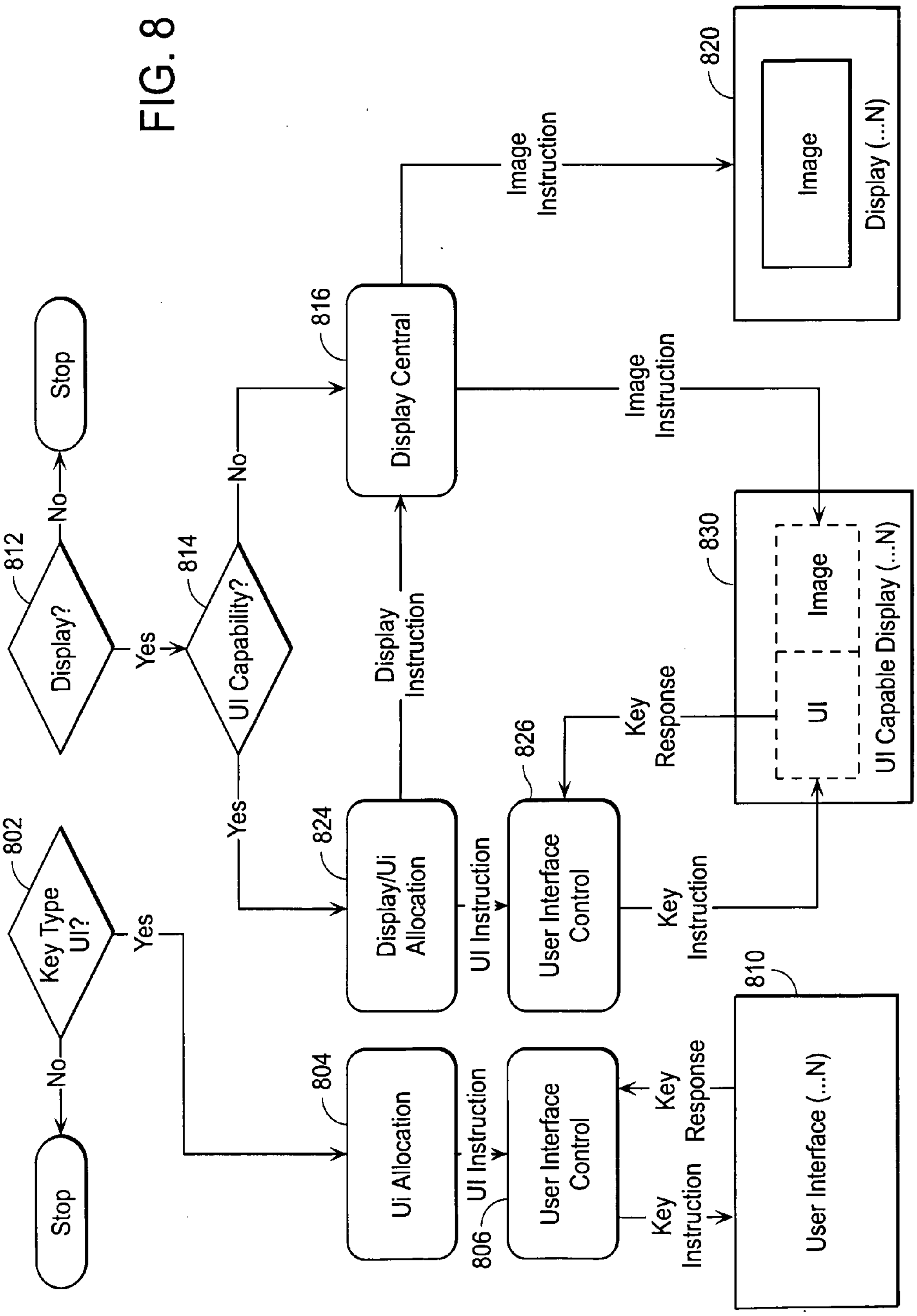

Key Type UI?
802
No
Stop
Yes
Ui Allocation
804
UI Instruction
User Interface Control
806
Key Instruction
Key Response
User Interface (...N)
810
Display?
812
No
Stop
Yes
UI Capability?
814
Yes
Display/Ui Allocation
824
UI Instruction
User Interface Control
826
Key Instruction
Key Response
UI
Image
UI Capable Display (...N)
830
No
Display Central
816
Display Instruction
Image Instruction
Image Instruction
Image
Display (...N)
820

FIG. 8

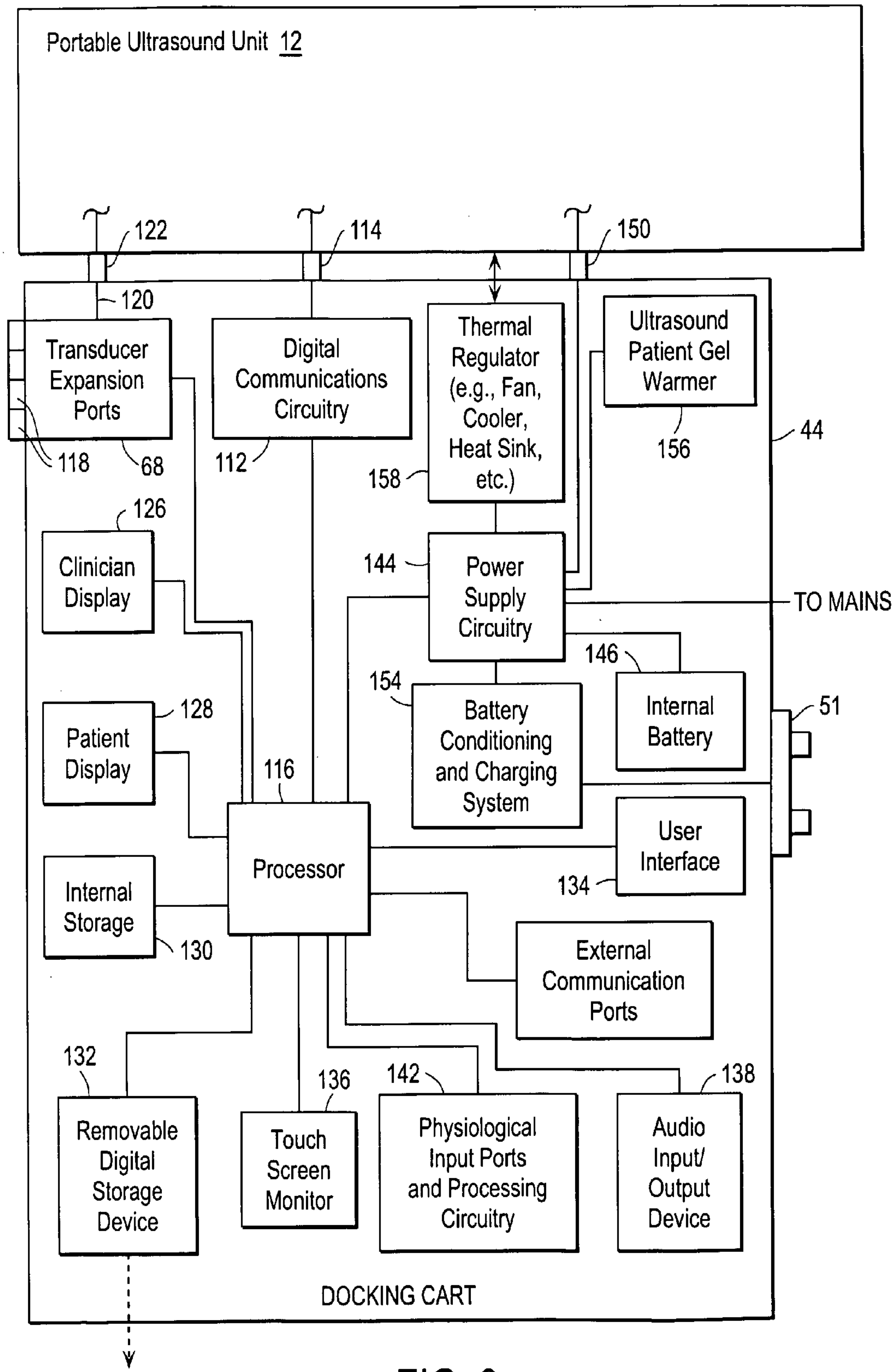

Portable Ultrasound Unit 12
122
114
150
120
Transducer Expansion Ports
Digital Communications Circuitry
Thermal Regulator (e.g., Fan, Cooler, Heat Sink, etc.)
Ultrasound Patient Gel Warmer
118
68
112
158
156
44
126
Clinician Display
144
Power Supply Circuitry
TO MAINS
146
154
Internal Battery
51
128
Patient Display
116
Battery Conditioning and Charging System
User Interface
Processor
134
Internal Storage
130
External Communication Ports
132
136
142
138
Removable Digital Storage Device
Touch Screen Monitor
Physiological Input Ports and Processing Circuitry
Audio Input/ Output Device
DOCKING CART

FIG. 9

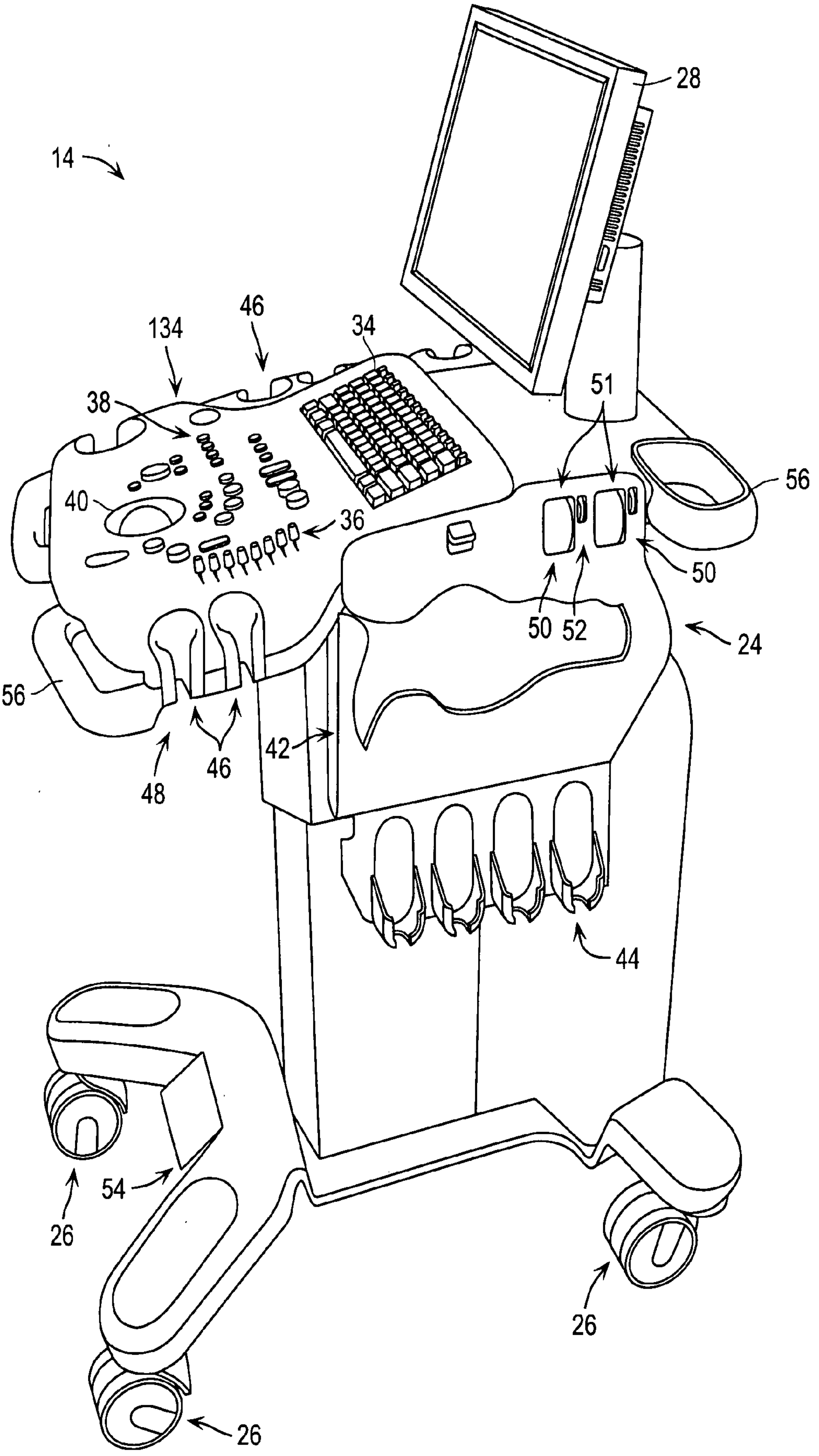


FIG. 10

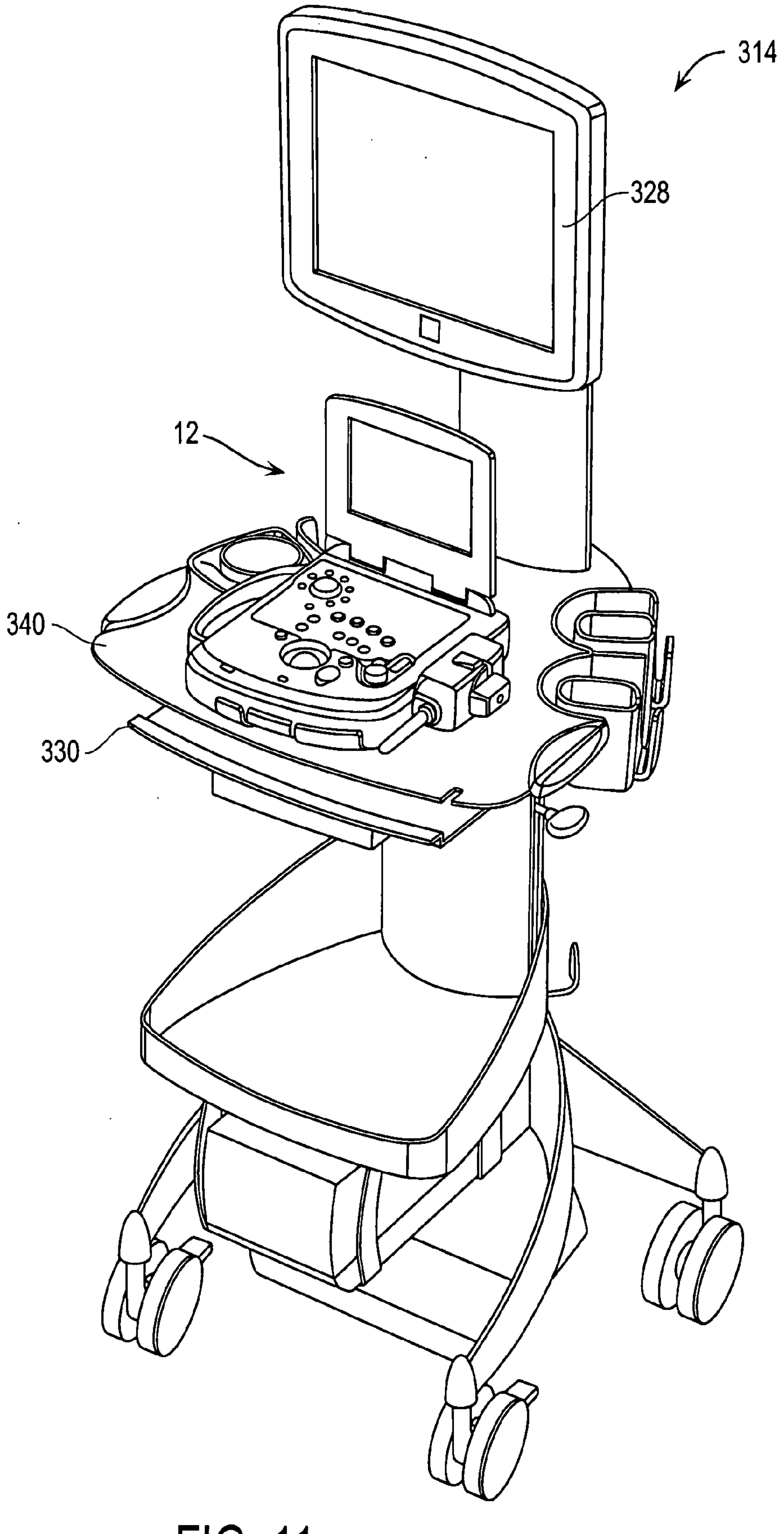


FIG. 11

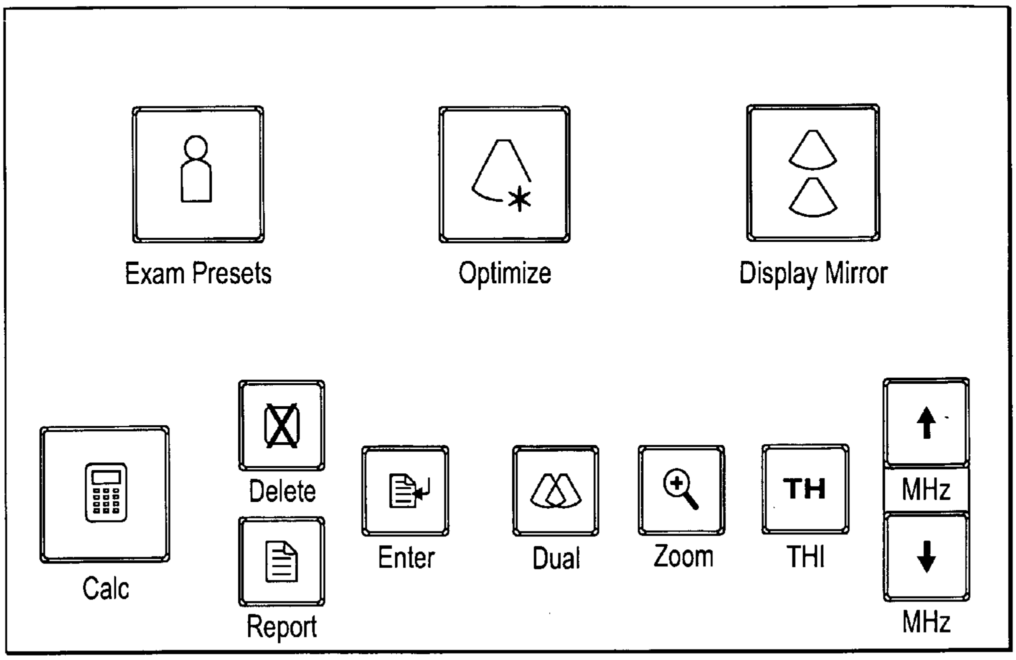

Exam Presets
Optimize
Display Mirror
Calc
Delete
Report
Enter
Dual
Zoom
TH
THI
MHz
MHz

FIG. 12

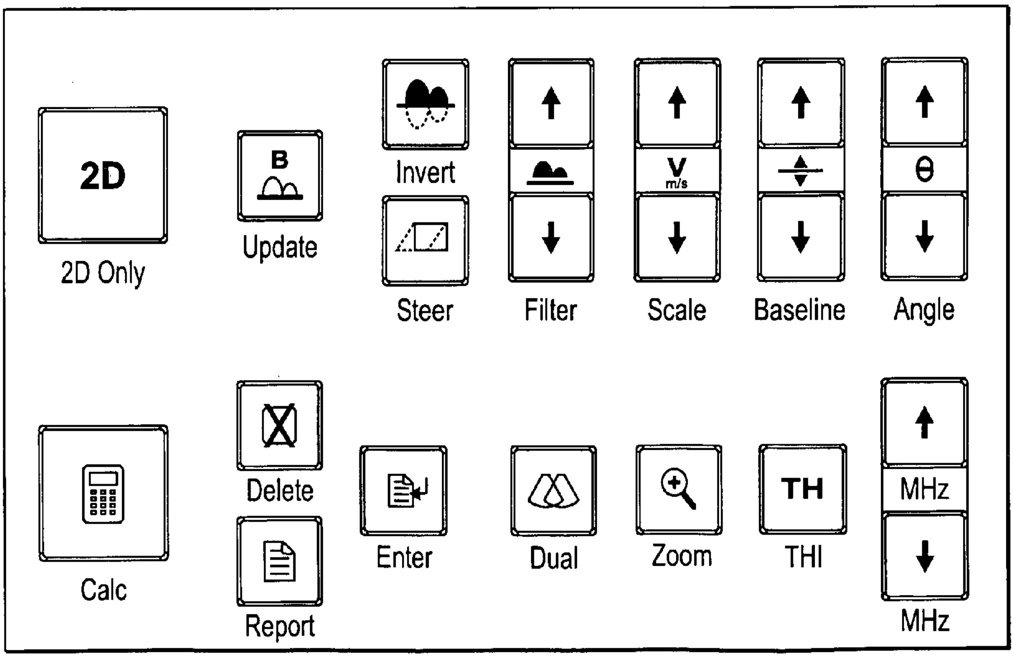

2D
2D Only
B
Update
Invert
Steer
Filter
V
m/s
Scale
Baseline
θ
Angle
Calc
Delete
Report
Enter
Dual
Zoom
TH
THI
MHz
MHz

FIG. 13

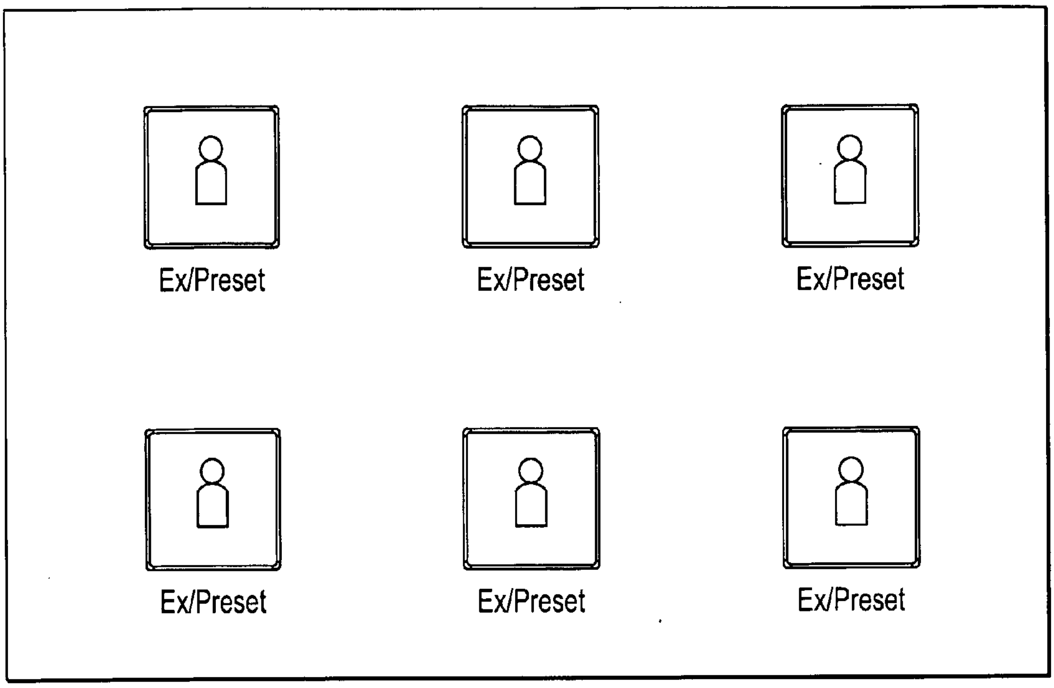

Ex/Preset
Ex/Preset
Ex/Preset
Ex/Preset
Ex/Preset
Ex/Preset

FIG. 14

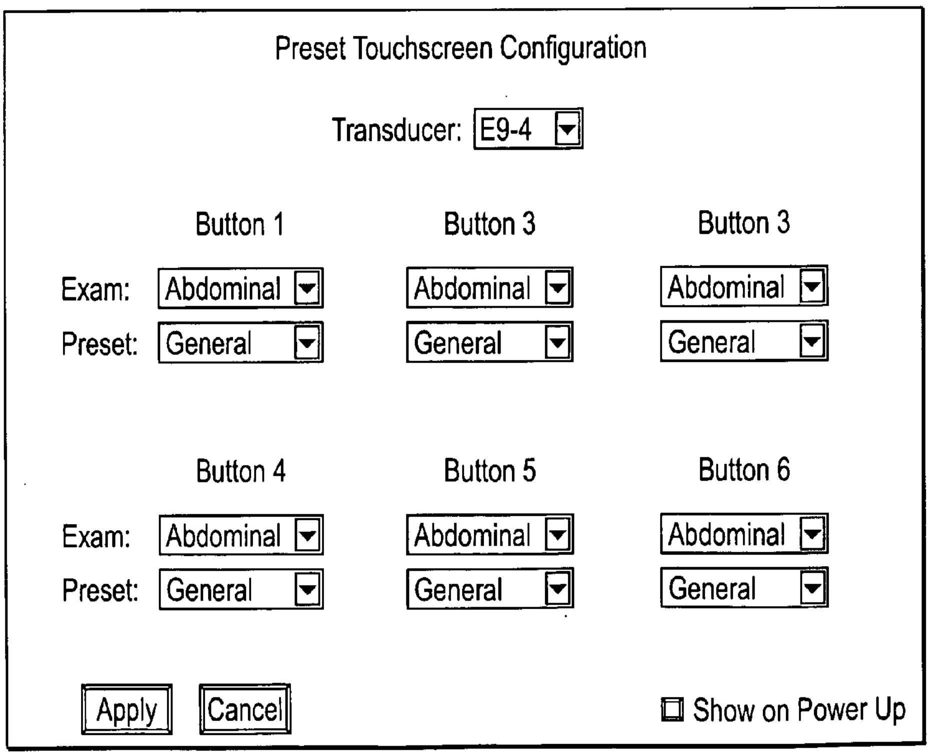

Preset Touchscreen Configuration
Transducer: E9-4
Button 1
Button 3
Button 3
Exam: Abdominal
Abdominal
Abdominal
Preset: General
General
General
Button 4
Button 5
Button 6
Exam: Abdominal
Abdominal
Abdominal
Preset: General
General
General
Apply
Cancel
Show on Power Up

FIG. 15

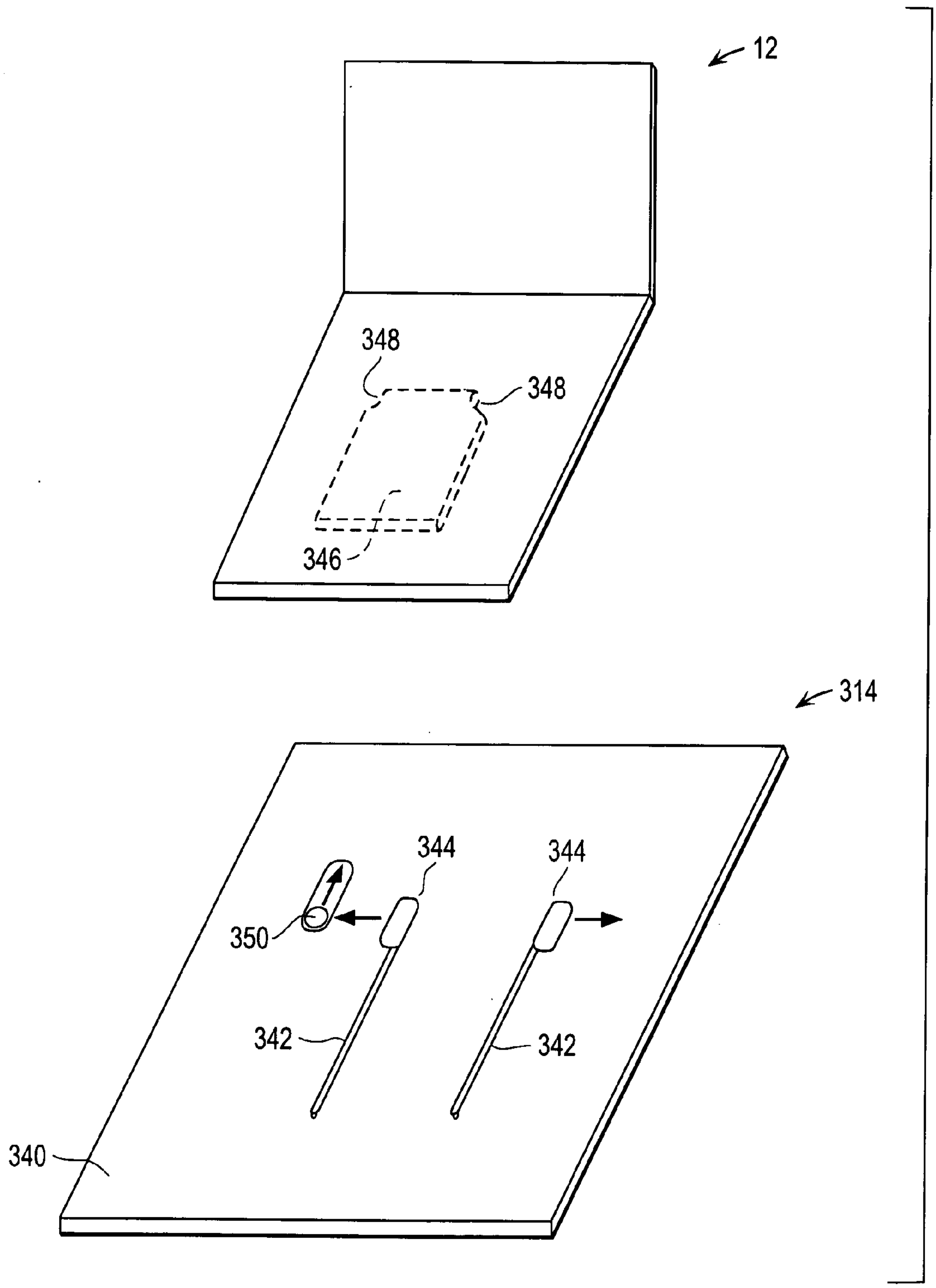


FIG. 16

CONTROL OF USER INTERFACES AND DISPLAYS FOR PORTABLE ULTRASOUND UNIT AND DOCKING STATION

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] NOT APPLICABLE

BACKGROUND OF THE INVENTION

[0002] This invention relates generally to ultrasound imaging systems and, more particularly, to control of user interfaces and displays for a portable ultrasound unit which is configured to mate with a docking station.

[0003] Ultrasound equipment is used in a variety of medical applications. Small hand-held ultrasound scanners are used for applications in which portability is at a premium. Such scanners, while portable, are not as full-featured as larger equipment. Accordingly, there remains a need for full-sized cart-based ultrasound scanners. Such cart-based ultrasound scanners, which typically weigh hundreds of pounds, have more capabilities than small portable units. These traditional cart-based scanners can be moved between different rooms in a medical establishment, but are not portable.

[0004] U.S. Pat. No. 6,980,419, the entire disclosures of which is incorporated herein by reference, discloses a portable ultrasound unit and docking cart. The portable ultrasound unit may be small enough to be carried in the hands of a medical professional or other user. When appropriate, the portable ultrasound unit may be used in conjunction with the docking cart. The docking cart may enhance the capabilities of the portable unit so that the portable unit's functionality rivals or exceeds the capabilities of traditional cart-based ultrasound equipment.

[0005] When the portable unit is mounted to the docking cart, the docking cart transforms the portable unit into a cart-based system with enhanced features and functionality such as improved ergonomics, ease of use, a larger display format, external communications connectivity, multiple transducer connections, and increased data processing capabilities. A clinician display and patient display may be provided on the cart. Communications circuitry in the docking cart may be used to support communications between the docking cart's processor and external networks and devices. The docking cart may receive physiological signals such as cardiac signals and may use this information to synchronize ultrasound imaging operations with a patient's physiological condition. Adjustable user interface controls, data handling features, security features, power control functions, and thermal management capabilities may be provided in the docking cart.

BRIEF SUMMARY OF THE INVENTION

[0006] Embodiments of the present invention provide ways for controlling a plurality of visual displays and a plurality of user interfaces for a portable ultrasound device which can be mounted to different docking stations or carts to provide and enhance different functionalities and features.

[0007] In accordance with an aspect of the present invention, a portable ultrasound device comprises a portable housing; a display control module configured to control a plurality of visual displays, at least one of the visual displays being selectively configurable to provide a user interface display on the visual display for user interface control, at least one of the visual displays being selectively configurable to view an ultrasound image; and a plurality of user interfaces, at least one of the plurality of user interfaces being a separate user interface which is not integrally formed with the portable housing.

[0008] In some embodiments, the display control module is configured to control visual displays having different sizes and/or resolutions. The portable ultrasound device includes a portable ultrasound device visual display. The portable ultrasound device visual display is selectively configurable to provide a user interface display on the portable ultrasound device visual display as a touch screen for user interface control of one or more of the user interfaces and selectively configurable to view an ultrasound image. At least one of the user interfaces is an integral user interface which is integrally formed with the portable housing. A communication module is configured to communicate with an auxiliary medical device for therapeutic application. The communication module is configured to send control signal to and/or receive control signal from the auxiliary medical device. A security mechanism is provided to lock the portable housing to a surface. A user interface allocation module is configured to allocate user interface functionalities among the plurality of user interfaces. A visual display allocation module is configured to allocate visual display functionalities among a plurality of visual displays.

[0009] In specific embodiments, a docking station comprises a docking station visual display which is configurable to view an ultrasound image. The portable ultrasound device comprises a transducer port configured to be coupled to a connector of an ultrasound transducer and a portable ultrasound device ultrasound processing circuitry that accepts first ultrasound image data from the transducer port and processes the first ultrasound image data to generate second ultrasound image data. The docking station comprises digital communications circuitry that supports communication between the docking station and the portable ultrasound device. The docking station visual display is configured to display an ultrasound image based on the second ultrasound image data received from the portable ultrasound device through the digital communications circuitry.

[0010] In some embodiments, the docking station comprises digital communications circuitry that supports communication between the docking station and the portable ultrasound device. The docking station comprises a docking station ultrasound processing circuitry that processes the second ultrasound image data received by the docking station from the portable ultrasound device through the digital communications circuitry. The docking station visual display is configured to display an ultrasound image based on processed data from the docking station ultrasound processing circuitry.

[0011] In specific embodiments, the docking station comprises a docking station user interface to receive user input of display instruction for the docking station visual display. At least one of the user interfaces of the portable ultrasound device receives user input of display instruction for the docking station visual display. The portable ultrasound device comprises a portable ultrasound device visual display, which is selectively configurable to provide a user interface display on the portable ultrasound device visual display, as a touch screen for user interface control to receive user input of display instruction for the docking station visual display.

[0012] In accordance with another aspect of the invention, an ultrasound system includes a portable ultrasound unit and a docking cart. The portable ultrasound unit comprises a portable housing, a portable ultrasound unit visual display, and a plurality of user interfaces. The portable ultrasound unit visual display is selectively configurable to provide a user interface display on the visual display for user interface control of one of more of the user interfaces and selectively configurable to view an ultrasound image. The docking cart comprises a docking cart visual display which is configurable to view an ultrasound image. The portable ultrasound unit further comprises a visual display allocation module configured to allocate visual display functionalities between the portable ultrasound unit visual display and the display cart visual display.

[0013] In some embodiments, the plurality of user interfaces include at least one of a separate user interface which is not integrally formed with the portable housing; or an integral user interface which is integrally formed with the portable housing. A security mechanism is provided to lock the portable housing of the portable ultrasound unit to the docking cart.

[0014] In some embodiments, the portable ultrasound unit comprises a transducer port configured to be coupled to a connector of an ultrasound transducer and a portable ultrasound unit ultrasound processing circuitry that accepts first ultrasound image data from the transducer port and processes the first ultrasound image data to generate second ultrasound image data. The docking cart comprises digital communications circuitry that supports communication between the docking cart and the portable ultrasound unit. The docking cart visual display is configured to display an ultrasound image based on the second ultrasound image data received from the portable ultrasound unit through the digital communications circuitry. In some other embodiments, the docking cart comprises digital communications circuitry that supports communication between the docking cart and the portable ultrasound unit. The docking cart comprises a docking cart ultrasound processing circuitry that processes the second ultrasound image data received by the docking cart from the portable ultrasound unit through the digital communications circuitry. The docking cart visual display is configured to display an ultrasound image based on processed data from the docking cart ultrasound processing circuitry.

[0015] In specific embodiments, at least one of the user interfaces of the portable ultrasound unit receives user input of display instruction for the docking cart visual display. The portable ultrasound unit visual display is selectively configurable to provide a user interface display on the portable ultrasound unit visual display, as a touch screen for user interface control to receive user input of display instruction for the docking cart visual display.

[0016] In accordance with another aspect of the present invention, a portable ultrasound device comprises a portable housing; a portable device processor; a portable device visual display; and at least one portable device user interface. The portable housing is configured to be mounted to any one of a plurality of docking stations. The portable device processor is configured to interface with a docking station processor of the docking station for allocating user interface functionalities and/or visual display functionalities between the portable ultrasound device and the docking station. The visual display functionalities include displaying an ultrasound image.

[0017] In some embodiments, the docking station has a docking station visual display, and wherein the visual display functionalities are allocated between the portable device visual display and the docking station visual display. The portable device visual display may be selectively configurable to provide a user interface display on the portable device visual display, as a touch screen for user interface control to receive user input of display instruction for the docking station visual display. The visual display functionalities may be fully allocated to the docking station visual display.

[0018] In specific embodiments, the docking station has at least one docking station user interface, and wherein the user interface functionalities are allocated between the at least one portable device user interface and the at least one docking station user interface. The user interface functionalities may be fully allocated to the at least one docking station user interface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** is a schematic diagram of an illustrative portable ultrasound unit and docking cart.

[0020] FIG. **2** is a perspective view of an illustrative portable ultrasound unit with an available ultrasound transducer port.

[0021] FIG. **3** is a perspective view of an illustrative portable ultrasound unit with an attached ultrasound transducer.

[0022] FIG. **4** is a diagram showing how a portable ultrasound unit may be inserted into a mating receptacle on a docking cart.

[0023] FIG. **5** is a diagram showing how a docking cart receptacle for the portable ultrasound unit may be configured so as not to block the transducer port of the portable ultrasound unit.

[0024] FIG. **6** is a diagram showing how a docking cart and portable ultrasound unit may have mating electrical connectors.

[0025] FIG. **7** is a schematic block diagram of an illustrative portable ultrasound unit in accordance with an embodiment of the present invention.

[0026] FIG. **8** is a flow diagram illustrating allocation and control of user interfaces and displays in the portable ultrasound unit according to an embodiment of the present invention.

[0027] FIG. **9** is a schematic block diagram of an illustrative docking cart in accordance with an embodiment of the present invention.

[0028] FIG. **10** is a perspective view of an illustrative docking cart in accordance with an embodiment of the present invention.

[0029] FIG. **11** is a perspective view of an illustrative docking cart in accordance with another embodiment of the present invention.

[0030] FIG. **12** shows a touch screen main panel example.

[0031] FIG. **13** shows a Doppler mode panel example.

[0032] FIG. **14** shows a preset sub-panel example.

[0033] FIG. **15** shows a preset touch screen configuration page example.

[0034] FIG. **16** is a simplified view of a latch mechanism for locking a portable unit to a surface of a cart.

DETAILED DESCRIPTION OF THE INVENTION

[0035] An exemplary embodiment of the present invention is directed to a portable ultrasound unit or device **12** and a docking cart **14** in an ultrasound system **10** as shown in FIG. **1**. The portable ultrasound unit **12** may be small and light enough to be easily carried by a user (e.g., a physician or other clinician in a medical setting or other suitable individual). The unit may, if desired, be small and lightweight enough to be carried in a single outstretched arm.

[0036] Standard cart-based ultrasound equipment generally weighs hundreds of pounds and is either stationary or is movable only with considerable effort. Accordingly, portable ultrasound units such as the unit **12** may often be much more appropriate to use than traditional cart-based ultrasound systems. For example, the portable ultrasound unit **12** may be used when ultrasound capabilities are needed in the field (e.g., in an ambulance) or even in a clinical setting such as a hospital in which the ability to easily transport the unit **12** from location to location is important. The weight of the portable unit **12** may be on the order of 5 to 10 pounds or less or may be any other suitable weight. The size of the portable unit **12** may be on the order of 4 inches times 10 inches by 12 inches or any other suitable size. These are merely illustrative weights and dimensions. The portable unit **12** may have any suitable size and weight as desired.

[0037] Ultrasound images may be gathered using an ultrasound transducer **16**. The transducer **16** may have a transducer head **18** and may be connected to the portable unit **12** using a cable **20** and connector **22** or other suitable interconnection arrangement. Different transducers may be used for making different types of ultrasound measurements. For example, medium frequency transducers with phased arrays may be particularly useful for applications in cardiology or abdominal imaging. High-frequency linear transducers may be used for muscular work. Curvilinear transducer heads may be preferred when making obstetrical measurements. Probe-based and catheter-based ultrasonic transducers may also be used with the portable unit **12** if desired. To allow different transducers to be used, the portable ultrasound unit **12** may have a transducer port to which different transducer connectors **22** may be attached, as needed.

[0038] The docking cart **14** may have a docking structure **24** that allows the portable unit **12** to be connected to the docking cart **14**. The docking structure **24** may be a shelf, receptacle, drawer, slot, recess, clasp, mating protrusion, or any other docking structure that facilitates attachment of the portable unit **12** to the docking cart **14**. In the example of FIG. **1**, the docking structure **24** is a vertically loaded receptacle into which the portable ultrasound unit **12** may be inserted as shown by arrow **25**. This is, however, merely one suitable arrangement for docking structure **24**. The docking structure **24** may have a different configuration if desired. Another example of connecting and locking the portable ultrasound unit **12** to a horizontal surface of the docking cart is described below.

[0039] The docking structure **24** may be used to physically secure the portable unit **12** to the cart **14**. Electrical connections between the portable ultrasound unit **12** and the docking cart **14** may also be made to allow information to be shared between the cart **14** and the portable unit **12**.

[0040] The cart **14** is preferably substantially larger than the portable unit **12**. For example, the cart **14** may be large enough to be pushed about on its wheels **26** by a standing user, without requiring that the user stoop or bend over excessively. Smaller or larger carts **14** may be provided if desired. Because the cart **14** has wheels **26**, the weight of the cart **14** may be considerably greater than that of the portable unit **12**. Each wheel **26** may be a swivel wheel that can be independently locked to prevent swivel movement, allowing the cart to be pushed down a corridor in a straight line. Wheels can also be locked to prevent rotation (e.g., to prevent the cart **14** from being stolen). The rotational or swivel motion of the wheels **26** may, if desired, be locked in unison (e.g., using a system of cables to mechanically actuated locks **27** together or by using electromagnetically actuated locks **27**). The cart **14** may have any suitable number of wheels **26** (e.g., 3-8 wheels).

[0041] Because the cart **14** is larger than the portable unit **12** and may weigh more than the portable unit **12**, the cart **14** may have features that can be used to supplement the capabilities of the portable unit **12**. When the portable unit is mounted to the docking cart, the docking cart in effect transforms the portable unit into a cart-based system with enhanced features and functionality. These enhanced capabilities may include improved ergonomics, ease of use, a larger display format, external communications connectivity, supplemental transducer ports, increased data processing capabilities, and the like.

[0042] The cart **14** may have one or more supplemental displays such as a monitor **28** that may be used to enhance or replace the display capabilities of the portable ultrasound unit **12**. The docking cart **14** may also have a user interface **134** and a processor **32** that can be used to supplement or replace the user interface and processing capabilities of the portable unit **12**. For example, the user interface **134** may include a full-size keyboard for data entry, which may be easier to use than the data entry arrangement of the portable unit **12**. As another example, the processor **32** may have more storage and greater or more flexible processing capabilities than the processor circuitry in the portable unit **12**.

[0043] The enhanced processing capabilities of the cart **14** may be used to provide features that would otherwise be difficult or impossible to implement using only the portable unit **12**. For example, the cart processor may be used to provide three-dimensional image rendering capabilities that are beyond the processing capabilities of the portable ultrasound unit operating alone. The cart's processor may also be used to implement powerful data processing packages. Large databases of ultrasound images or other patient data or reference-type medical data may be maintained by the cart's processor and associated storage devices. The cart's processor may help to coordinate access to network-based resources (e.g., medical data maintained on a hospital network).

[0044] A user may download patient data such as ultrasound image data or other data from the portable unit **12** to the cart **14**. The downloaded data may be stored on the cart (e.g., in an image database or archive implemented using a hard drive) or may be stored on a network connected to the cart. The cart processor may be used to compare recently gathered patient images from the portable unit with historical images of the same patient or with other patient images that are maintained in the cart's database.

[0045] The images may be obtained from the portable unit in real time while the portable unit is docked or may be downloaded from the unit at some time after the images are acquired. By using the cart's processor to make comparisons between a patient's current images and that patient's archived images, a clinician can track changes in the patient's medical condition and thereby detect trends in the patient's condition. The clinician may also use the cart processor and imaging database capabilities of the cart to compare a patient's images to images of other patients or standard images in the image database.

[0046] An illustrative portable ultrasound unit **12** is shown in FIG. **2**. The portable unit **12** may have a built-in flat panel display screen **58** (e.g., a color LCD display). This display, which may measure about 5-17 inches diagonally, may be used to display ultrasound images and other information when the portable unit **12** is in operation. A hinge **60** may be used to allow the upper portion of portable unit **12** to fold down over the portable unit's user interface **30** when the portable unit **12** is not being used. The user interface **30** may include a track ball, joystick, touch pad or other pointing device, and buttons, knobs, keys, sliders, LEDs, speakers, microphones, and other suitable user interface equipment. Only a subset of such user interface devices are typically used on the portable unit **12**, due to space and weight considerations. For example, the sliders can be omitted to save space.

[0047] The portable ultrasound unit **12** may have one or more transducer ports such as the transducer port **62**. As shown in FIG. **3**, an ultrasound transducer **16** may be attached to the portable ultrasound unit **12** by using the connector **22** to attach the cable **20** and the scanner head **18** to the port **62**. Different transducers **16** may be attached to the portable unit **12** as needed depending on the ultrasound imaging task to be performed.

[0048] As shown in FIGS. **4** and **5**, the docking structure **24** with which the portable ultrasound unit **12** is attached to the docking cart **14** may have a portion **42** that allows the connector **22** and the cable **20** of the transducer **16** to remain attached to the portable unit **12** even as the portable unit **12** is mated with the cart **14**. This type of arrangement may be advantageous because it allows a user to continue using the same transducer that is attached to the portable unit **12** without interruption, even as the user transitions from using the user interface, display and other capabilities of the portable unit **12** to using the corresponding capabilities of the docking cart **14**.

[0049] If desired, the portable ultrasound unit **12** and the docking cart **14** may have matching electrical connectors **64** and **66**, as shown in FIG. **6**. The connectors **64** and **66** may allow power and signals to be exchanged between the portable unit **12** and the docking cart **14**. For example, ultrasound image data may be provided to the docking cart **14** from the portable unit **12** and power may be provided from the docking cart **14** to the portable unit **12** using the connectors **64** and **66**. The connectors **64** and **66** may be provided using one connector or multiple connectors. When transferring ultrasound imaging data that is still in "channel" form, the connectors may include numerous parallel electrical connectors (differential and single-ended) for transmitted data to the cart **14** corresponding to each of the scanner array elements (channels) in the transducer head **18**. The communications functions provided by the connectors **64** and **66** and their associated communications circuitry may also be provided using optical communications or RF communications arrangements.

[0050] FIG. **7** is a schematic block diagram of an illustrative portable ultrasound unit **12** in accordance with an embodiment of the present invention. The ultrasound transducer **16** may be used to gather ultrasound images of a medical patient or other suitable image target **84**. The portable ultrasound unit **12** has electronic circuitry for generating ultrasonic acoustic waves that are launched into the target **84** and has electronic circuitry for gathering and analyzing reflected acoustic waves to form corresponding ultrasound images. A transmitter **86**, which may be a high-voltage transmitter, generates drive signals for the piezoelectric scanner elements in the ultrasound transducer **16**. The resulting acoustic waves are reflected from the structure of the target **84**. The scanner elements of the transducer **16** convert the reflected acoustic waves into electrical signals, which are processed by input circuitry in the portable unit **12**.

[0051] The input circuitry in the portable ultrasound unit **12** may include an analog front end **88** and other signal processing electronics **90**. The circuitry of the analog front end **88** helps to condition the analog signals from the transducer **16** prior to digitization of these signals by the signal processing electronics **90**. The transducer **16**, which may either be directly connected to the portable unit **12** or which may be connected to the unit **12** through the docking cart's expansion ports (**68** in FIG. **9**), may have numerous (e.g., 100 or more) individual scanner elements, each of which generates a signal on a separate "channel." Accordingly, the analog front end **88** may have circuitry that processes the analog input signals for each channel in parallel. The analog front end circuitry may include amplifier circuitry for amplifying signals detected by the transducer and may include analog filter circuitry for filtering out unwanted signals (e.g., based on their frequency). The conditioned analog signals from the analog front end **88** may be converted to digital signals by the digitization and channel processing circuitry **92**.

[0052] The digitization and channel processing circuitry **92** may have analog-to-digital converters, buffer circuitry, and processing circuitry that digitize each channel of data in parallel, resulting in a total digital data throughput of about 10-1000 Gbps (or other suitable rate). The digitization and channel processing circuitry **92** may enhance the signal-to-noise ratio of the ultrasound image data by performing channel-domain processing tasks such as deconvolving coded signals to filter out unwanted signals. Following processing by the digitization and channel processing block **92**, the ultrasound image signals may be provided at the output **94** as "channel data," so-called because the data at this stage is still available on individual channels, each corresponding to a respective transducer array piezoelectric element.

[0053] The channel data must be processed further before a displayable image is created. An image reconstruction block **96** of the signal processing electronics **90** may be used to perform image reconstruction tasks (also called "beam formation tasks"). The resulting data signals at the output **98** may be referred to as "RF data" (data at a processing point after beam-formation, but prior to sampling and detection). The RF data at the output **98** still has both amplitude and phase information.

[0054] Further processing of the image data may be carried out using the post-processing portion **100** of the processing electronics **90**. The resulting image data provided at the output **102** (called "detected data") contains amplitude information, but no longer contains independent phase information.

[0055] The "detected data" image data may be processed further by the scan conversion portion **104** of the processing electronics **90** to produce "scan-converted data" at the output **106**. The detected data processing performed by the scan conversion portion **104** may involve the use of acoustic-domain processing techniques that are based on a knowledge of the physical geometry of the transducer **16**. Scan-converted data may be displayed as an ultrasound image on a display such as the portable ultrasound unit display **58** or external display **57** or **59** (which may be the display **126** or **128** of the cart in FIG. **9**).

[0056] The scan-converted data produced at the output **106** of scan-conversion electronics **104** may be processed by formatting electronics **108** to produce corresponding "formatted image data" at the output **109**. The formatted image data may be in a format suitable for viewing on a display such as the display **58** or **57** or **59**. During formatting with the formatting electronics **108**, content such as text or graphic overlays (e.g., annotations such as physician-entered annotations, time/date stamps, etc.) may be merged with the image to be displayed.

[0057] The digital image data from the signal processing electronics **90** of portable ultrasound unit **12** may be displayed in the portable ultrasound unit display **58** or external displays **57** or **59**, or provided to the docking cart **14** in a number of different forms. As shown in FIG. **7**, the portable ultrasound unit **12** may have digital communications circuitry **110** for supporting communications with various displays **57**, **58**, **59** and with the cart **14**, as well as a portable ultrasound unit user interface **61** and an external user interface **63**. The external displays **57**, **59** and the external user interface **63** are optional. The portable unit **12** further includes an internal battery **152** and power control circuitry **148**.

[0058] In the embodiment shown in FIG. **7**, the digital communications circuitry **110** includes a display controller **111**, a display allocation module **113**, a user interface allocation module **115**, and a user interface controller **117**. The display allocation module **113** allocates display functionalities for a display with UI capability. The display controller **111** controls what display information or data goes to which display to perform the display functionalities. The user interface allocation module **115** allocates the user interface functionalities among the user interfaces. The user interface controller **117** controls what functionalities are performed by which user interface, for instance, by assigning a mapping of user interfaces and corresponding user interface functionalities.

[0059] FIG. **8** is a flow diagram illustrating allocation and control of user interfaces and displays in the portable ultrasound unit according to an embodiment of the present invention. When the portable ultrasound unit **12** is powered up, the digital communications circuitry **110** obtains information regarding the available user interfaces and displays. Block **802** determines whether a particular resource is a key type user interface. If so, allocation of user interface (UI) functionalities for the key type user interface takes place in block **804**. The UI allocation may be preprogrammed according to any desired criteria or scheme depending on what user interfaces are available to the portable unit **12**. User interface instruction is generated in block **804** and passed to block **806** for user interface control of the specific user interface among the available user interfaces **810** based on the allocated UI functionalities. Key instruction is provided to the user interface being controlled, and key response is returned from the user interface to provide UI input to the portable unit **12**.

[0060] The term "key type" user interface is used to distinguish it from a display-driven user interface (e.g., a touch screen display or graphical UI), and is not meant to limit the user interface to keys. The key type user interface may contain sliders (e.g., one or more sets of gain-depth-compensation sliders), knobs, buttons, keys (e.g., numeric keys, special functions keys, a full-size keyboard, etc.), and pointing devices (e.g., a mouse, trackball, joystick, keyboard-mounted pointing stick, touchpad, etc.). The keyboard of the user interface may be used for data entry (e.g., patient data entry) and image annotation. An advantage of providing a full-size keyboard either on the cart **14** or as an external keyboard connected to the portable unit **12** is that this allows easier data entry than the typically smaller user interface **61** of the portable unit **12** (see, e.g., FIG. **2**). The pointing device and other controls may be used to navigate among various on-screen options that are shown on displays such as displays **57** and **59**. Such on-screen options may, for example, allow the user to select which information is to be displayed on the cart's displays, to select which imaging modality is being used, to control settings, etc. Two sets of sliders may be used—a first one for adjusting the vertical gain/brightness of the display image and a second for adjusting the lateral gain/brightness of the display image. Special function keys may be used in the user interface to provide users with the ability to make single-key selections of options (e.g., to perform functions such as adjusting luminance curves, L/R invert, U/D invert, display format adjustment, sweep speed, acoustic output, Doppler gate size, etc.). These are merely illustrative user interface devices and ways in which such devices may be used to control the functions of the cart **14** and the portable unit **12**. Any suitable user interface arrangement may be used to allow one or more users to interact with the docking cart **14** and the portable unit **12** as desired.

[0061] As seen in FIG. **8**, block **812** determines whether a particular resource is a display. If so, block **814** determines whether the display has UI capability. If the display does not have UI capability, display control for the display takes place in block **816**. Image instruction is generated and provided to display an image in the particular display among all available displays **820**. If the display has UI capability, however, allocation of user interface (UI) functionalities for the display-driven user interface and allocation of display functionalities are performed, as seen in block **824**. The allocation of UI and display functionalities for the UI capable display may be preprogrammed according to any desired criteria or scheme depending on the capabilities of the UI capable display. User interface instruction is generated in block **824** and passed to block **826** for user interface control of the UI aspect of the specific UI capable display among the available UI capable displays **830**, such as touch screen displays. Display instruction is generated in block **824** and passed to block **816** for display control of the display aspect of the UI capable display. Key instruction is provided to the UI capable display being controlled, and key response is returned from the UI capable display to provide UI input to the portable unit **12**. Image instruction is provided to the UI capable display to display image.

[0062] If the UI capable display **830** is sufficiently large, the screen may be split between UI and image. In some cases, the screen is not split but is switched between UI and image. For example, the UI display may overlay the image when it is enabled to receive user input, and disappear or hidden when it is desired to view the image.

[0063] As shown in FIG. **1**, the cart **14** may include a user interface **134** and a processor **32** that can be used to supplement or replace the user interface and processing capabilities of the portable unit **12**. FIG. **9** shows an example of such a cart **14**. The cart **14** may have digital communications circuitry **112** for supporting communications with the portable unit **12**. A connector **114** (partly implemented using a connector on the portable unit **12** and partly implemented using a connector on the cart **14**) may be used to interconnect the circuitry **110** of the portable unit **12** and the circuitry **112** of the cart **14** (FIG. **7**). The digital communications circuitry **110** and **112**

may be used to support any suitable digital communications format. For example, data may be exchanged using serial protocols, parallel protocols, protocols for universal serial bus (USB) communications, IEEE 1394 (FireWire) communications, etc.

[0064] The image data supplied to the cart **14** by the portable ultrasound unit **12** may be provided in a relatively unprocessed form (e.g., as channel data at the output **94**), in a relatively processed form (e.g., as formatted data at the output **109**) as seen in FIG. **7**. Data may also be transferred from the portable unit **12** to the cart **14** after an intermediate level of processing has been performed (e.g., as data at one or more of the outputs **98**, **102**, and **106**). Providing image data to the cart **14** in a relatively unprocessed form may be advantageous when it is desired to retain a relatively large amount of flexibility for subsequent cart-based processing and when it is desired to avoid potentially irreversible losses of signal quality. Providing image data to the cart **14** in a relatively processed form may be advantageous when it is desired to reduce the processing burden on cart **14** and when this benefit outweighs the potential loss of flexibility in downstream signal processing that results from preprocessing the data.

[0065] The image data that is provided from the portable unit **12** to the cart **14** using the communications circuitry **110** and **112** may be provided in one format or only a few different formats (to simplify the processing circuitry in signal processing electronics **90**). This image data may also be provided in many formats (e.g., all of the formats shown in FIG. **7**).

[0066] If desired, the image data from the portable unit **12** may be provided to the cart **14** in the form of "channel data" at the output **94**. Channel data includes signal samples gathered from each of the active piezoelectric elements in the transducer **16**. The channel data is image data that has been digitized by the analog-to-digital converter circuitry of digitization and channel processing circuitry **92** of the processing electronics **90**, but which has not yet undergone the beam formation process implemented by the image reconstruction electronics **96**. An advantage of providing image data from the portable unit **12** to the cart **14** as channel data is that this allows the processing capabilities of the cart **14** to be used in handling the beam formation (image reconstruction) process.

[0067] Because the cart **14** may have a relatively powerful processor **116**, the cart may, if desired, use such processing capabilities to perform more accurate or complete beam formation processing operations than would be possible using only the processing capabilities of the portable unit **12**. Moreover, the beam formation operations of the cart may, if desired, be controlled by the user. For example, the cart may provide users with the ability to interact with on-screen options to make changes to the beam formation operation (e.g., through user-adjustable parameters). The user may, for example, make changes in the way the cart's processor handles velocity data, amplitude data, or other channel-based signal information.

[0068] If desired, the image data from the portable unit **12** may be provided to the cart **14** in the form of "RF data" at the output **98**. RF image data is the data that has been through the image reconstruction process, but has not been sampled and detected. (The sampling and detection processes are performed by post-processing electronics **100**.) RF image data still includes intact phase information. An advantage to providing image data to the cart **14** in the "RF data" format is that this allows the cart's processor to perform phase-related image-enhancement operations that are not possible once the phase information has been lost (as is the case with detected data). Substantially less bandwidth is required to transfer image data between the circuitry **110** and **112** in the form of RF data than in the form of channel data.

[0069] If desired, image data can be provided from the portable unit **12** to the cart **14** in the form of "detected data" at the output **102**. An advantage of providing data as detected data rather than as RF data is that less processing is required to make the detected data displayable for the user. The detected data output stage of signal processing electronics **90** is the last stage at which an image for the display screen (e.g., the cart's display) can be generated in any desired native resolution without risk of compromising image quality (e.g., through resolution or image content losses). Detected data may, however, still be processed using acoustic-domain image processing techniques. If image data is provided from the portable unit **12** to the cart **14** at the "detected data" stage, rather than after processing the data further, the cart **14** can still be used to implement image processing tasks that are based on considerations of scanner (transducer head) geometry.

[0070] An additional reduction in the processing burdens on the cart **14** can be attained by providing image data from the portable unit **12** to the cart **14** in the form of "scan-converted data" at the output **106**. Scan-converted data is data that has been converted from a format based on scanner geometry (detected data) to a user-display-oriented format. Image processing can still be performed on scan-converted data (if desired) using the amplitude information contained in the scan-converted data. For example, x-y filtering operations may be performed on the scan-converted data. The scan-converted data at the output **106** does not contain physician annotations or other overlay information. That information may be added by formatting electronics **108**. An advantage of providing image data to the cart **14** in the form of scan-converted data is that the cart need only annotate the data (if desired) and convert the data to the proper screen format before displaying the data on one of the cart's displays. Because scan-converted data does not include annotations, this arrangement preserves the ability of the cart to display unannotated data.

[0071] Image data may also be provided from the portable unit **12** to the cart **14** in the form of "formatted image data" at the output **109**. Formatted image data includes annotations (e.g., automatically generated annotations and annotations based on user input). Providing the image data to the cart as formatted image data reduces the image processing requirements of the cart to an extremely low level. Both scan-converted data and formatted image data have already been converted to a resolution that is specific to the screen format of the display **58** of the portable ultrasound unit **12**, so this data is preferably converted (e.g., by the processor **116**) to a format that is suitable for presentation on the display(s) of the cart **14**. Formatted image data may be formatted (by either the portable unit **12** or subsequently by the cart **14**) to accommodate standards such as DICOM, JPEG, TIFF, BMP, MPEG, or other suitable formats.

[0072] The processing capabilities of the cart **14** may be provided by the processor **116** and other components of the type shown in FIG. **9**. The processor **116** may be based on one or more integrated circuits and other components. The processor **116** may, for example, be based on devices such as microcontrollers, microprocessors, personal computer boards, digital signal processors, programmable logic devices, application specific integrated circuits, memory devices, etc. In general, the capabilities of the processor **116** may be used to enhance the processing capabilities of the portable ultrasound unit **12**, which are limited by size and weight considerations. The processor **116** may perform image processing tasks and may also serve as an embedded controller that controls the overall operation of the cart **14**. Functions controlled by the processor **116** include coordinating input and output operations involving the user, ultrasound transducers, internal components, and peripheral devices.

[0073] In FIG. **9**, the connectors **118** of the cart **14** that are used to attach the transducers **16** to the transducer expansion ports **68** are shown as being connected to the ports **68** from the exterior of the cart **14**. To use a given transducer **16** that is connected to one of the transducer expansion ports **68**, the processor **116** may activate multiplexer circuitry that switches a desired transducer **16** to the communications line **120**.

[0074] The communications line **120** may be connected to the transmitter **86** of the portable unit **12** by the connector **122**. High-voltage drive signals that are generated using the portable unit's transmitter **86** may be provided to a transducer **16** that is connected to one of the cart's expansion ports **68** via the connector **122** and line **120**. Input signals from the same transducer may be routed through the expansion port **68** to the analog front end **88** of the portable unit **12** via the communications line **120**, the connector **122**, and a communications line from the connector **122** to the analog front end **88**. The expansion port arrangement therefore allows the same high-voltage transmitter and analog front end (and some or all of the rest of the signal processing electronics **90** such as the digitization and channel processing circuitry **92**) to be used to handle signals from both the transducer **16** that is connected to the connector **62** of the portable unit **12** and a transducer **16** that is connected to the expansion port.

[0075] The connector **122** (which may be partly implemented in the portable unit **12** and partly implemented in the cart **14**) may be an electrical connector capable of passing numerous parallel channels of high-frequency signals having a large dynamic range (e.g., 160 dB or more). The connector **122** may, for example, be formed using the same types of electrical contacts and circuits used by the connector **62** (FIGS. **2** and **9**) when connecting the main transducer **16** to the portable unit **12**.

[0076] The expansion port capabilities of the cart **14** allow the larger size of the cart **14** to be used to overcome some of the size constraints faced by the portable ultrasound unit. With the expansion ports **68** of the cart **14**, a user may attach multiple transducers **16** to the portable unit **12**. The multiplexer circuitry that determines which of the transducers (main transducer **16** or one of the transducers connected via a given connector **118** attached to one of ports **68**) is connected to the input and output electronics of the portable unit (e.g., the transmitter **86** and the analog-front-end **88**) may be manually configured (e.g., through user interactions with the processor **116** through on-screen options) or may be automatically detected and configured (using mechanical or electronic detection of the presence or absence of a transducer at the ports **68**).

[0077] The docking cart **14** may have one or more displays that supplement or replace the display capabilities of the portable ultrasound unit **12**. For example, the docking cart **14** may have one or more clinician (user) displays **126**. Such displays may be larger than would be desired on a portable device due to the size, weight and power constraints imposed by portability. More information may be displayed on the cart's displays than on the display of the portable unit **12**. For example, additional information may be included on the cart display **126** (e.g., additional physician annotations, additional cart-generated annotations or overlay information, etc.). Additional image resolution and image content may be provided. The cart may, for example, display an image on a display **126** using the native resolution of that display (e.g., by using the cart's processor **116** to format the detected data from the portable unit into data in the desired native resolution).

[0078] The cart **14** may also include one or more patient displays such as a patient display **128**. A patient display is intended to be viewable by a patient during use of the cart **14** and the portable unit **12** in performing ultrasound procedures. Patients cannot always see the monitors of traditional ultrasound units and are often not encouraged to do so because the monitors are awkwardly placed and because the images displayed on the monitors contain potentially disturbing physician annotations. The patient display **128** may be placed on an articulating arm or other support that makes it easy for the patient to view the image on the monitor without hindering the ability of the clinician to perform the ultrasound procedure. Moreover, some or all of the supplemental information (e.g., text and graphic overlays such as clinician annotations) that are displayed for the user (e.g., the physician or other clinician) on the clinician display **126** may be suppressed (not displayed) by the processor **116** before displaying the image for the patient. The images displayed on the patient display **128** will therefore be less likely to cause undue concern on the part of the patient viewing the images.

[0079] The docking cart **14** may have an internal storage **130**. The internal storage may be formed using a hard drive, memory circuits (e.g., flash, RAM, ROM, EPROM, EEPROM), or any other suitable memory or storage device. The storage **130** may be used to store patient record data and image data (including stills and moving images) from the portable unit **12**.

[0080] The docking cart **14** may also have removable storage. The cart **14** may, for example, have one or more removable storage devices **132** such as magneto-optic drives, diskette drives, compact flash slots or other memory card readers, writable CD or DVD drives, tape drives, etc. Removable storage media may be used when it is desired to archive a patient record or other information (e.g., an ultrasound video clip and associated physician annotations, etc.).

[0081] The docking cart **14** may have one or more user interface devices (shown generally as user interface **134** in FIG. **9**). Displays such as the clinician display **126** and the patient display **128** may be used to display images and other information. If desired, one or more of the displays may be touch-sensitive, as shown by a touch-screen monitor **136**. When the cart **14** has a touch-screen monitor such as the monitor **136**, "soft menus" (e.g., user interface menus that processor **116** dynamically constructs out of on-screen options on the touch screen) can be used to provide a user of the cart **14** with user interface support. All or part of a given monitor may be provided with touch-screen capabilities.

[0082] An advantage of using a touch screen as a user interface for docking cart **14** is that this arrangement can help reduce clutter in the user console area. Ultrasound system operation can require many user adjustments. However, during certain modes of operation only a subset of the user controls are active. When the touch screen is used, inactive user control options can be hidden from view. Because inactive controls need not be displayed, they can either be hidden from view entirely (i.e., not displayed) or can be displayed in a way that indicates clearly to the user that those functions are currently inactive (e.g., by displaying the options with a reduced level of visibility on the screen relative to the options that remain active, by changing their color, etc.).

[0083] An audio input/output device **138**, which is shown separately in FIG. **9**, is a user interface device that may be used to present audio information to the user (e.g., the audio track associated with the spectral Doppler mode of operation of unit **12** that is picked up by a microphone associated with the portable unit **12** or a microphone associated with the cart **14**).

[0084] The docking cart **14** may have one or more external communications ports **140**. The communications circuitry of the ports **140** may be used to provide an interface between the processor **116** and the other components of the cart **14** and peripheral devices such as printers, plotters, recording devices (e.g., video recording devices such as VCRs or recordable DVD equipment), network equipment, telecommunications equipment, external displays, external storage devices, etc. Ports **140** may provide support for RS-232 signals and analog video.

[0085] The docking cart **14** may also have physiological input ports and processing circuitry **142**. The input capabilities and processing capabilities of the physiological input ports and processing circuitry **142** may be used to gather (and process) information from external medical equipment.

[0086] The physiological input ports and processing circuitry **142** of the cart **14** can handle cardiac information, information from blood oxygen sensors, information from pulse sensors, information from respiration sensors, or any other suitable physiological equipment. In general, some or all of the processing of the raw sensor signals can be performed in the external equipment and corresponding digital information signals can be provided to processor **116** via port **142**. If desired, the processing circuitry **142** may be used to handle signal conditioning and physiological data analysis tasks. Physiological data (or digital signals generated in response to processing the physiological data) may be shared with the portable ultrasound unit **12**.

[0087] The docking cart **14** may draw power from an AC wall outlet (mains) or from an internal battery **146**. The power supply circuitry **144** may be used to distribute power from the external supply or from the internal battery **146** to the components of cart **14**. Power supply circuitry **144** may also supply power (from an external AC supply or from internal battery **146**) to power control circuitry **148** of the portable ultrasound unit **12** via the connector **150**. The power control circuitry **148** of the portable ultrasound unit **12** may be used to distribute power from the cart **14** or from the internal battery **152** to the components of the portable unit **12**. The unit **12** may also use power from an AC source when not using power from the cart **14** or the battery **152**. The power supply circuitry **144** may sense which type of AC source is connected to the cart **14** (e.g., 110 V, 60 Hz or 220 V, 50 Hz) and may adjust automatically to accommodate the characteristics of the AC source.

[0088] When the cart **14** is not connected to a source of AC power, the cart's internal battery **146** may be used to operate the cart's components and may (if desired) be used to supplement or replace the power supplied by the unit's battery **152**. The cart's internal battery allows the cart to be readily transported from one room to another in a hospital or other establishment, without requiring that the user locate the cart near to an available wall outlet. The user can connect or disconnect the cart and AC power source at any time without interrupting the cart's operation.

[0089] The power supply circuitry **144** and power control circuitry **148** may be used to recharge the batteries **146** and **152** when AC power is available. The cart **14** may also have a battery conditioning and charging system **154** (and associated battery ports **156**). The system **154** may be used to condition and charge the portable ultrasound unit's batteries (i.e., batteries such as internal battery **152** that have been removed from the unit **12**). The battery charger of cart **14** may also be used to condition and charge other batteries (e.g., batteries for other portable medical equipment).

[0090] Ultrasound acoustic impedance matching gel is used to improve the efficiency of the acoustic impedance match between the face of transducer **16** and the target **84** (e.g., the tissue of the patient). The gel is typically applied directly to the skin of the patient. The docking cart **14** may have an ultrasound patient gel warmer **156** to warm the gel to a comfortable temperature before the gel is applied to the patient. The warmer **156** may warm the gel slightly above the ambient temperature of the room (e.g., to about 37° C. +/−5° C.). The gel warmer may be integrated into a cup-holder shaped structure (e.g., for holding plastic bottles of gel) or may have any other suitable shape. The gel warmer **156** may have a resistive or inductive heating element powered by power supply circuitry **144** or may use passive heating (e.g., the gel may be warmed by virtue of being located adjacent to a source of passive heating such as a warm portion of the cart's electronics, a heat sink, a fan outlet, etc.).

[0091] The portable ultrasound unit **12** is generally more exposed to the ambient atmosphere when used as a stand-alone unit than when the portable unit **12** is connected to the cart **14** and placed in a receptacle such as the holder **24** (FIG. **1**). Exposure to surrounding air tends to cool the unit **12**. The unit **12** may therefore experience a temperature rise when placed in a confined environment without supplemental cooling. Accordingly, the docking cart **14** may have a supplemental thermal regulator **158** that helps to control the temperature of portable ultrasound unit **12** when unit **12** is connected to cart **14**.

[0092] FIG. **10** is a perspective view of an illustrative docking cart in accordance with an embodiment of the present invention. The docking cart **14** has a large high-resolution monitor **28** such as a 19" color LCD flat panel display. The monitor **28** may be any suitable size, but a larger monitor may be preferable in some working environments, because it presents a larger easier-to-view image for the user.

[0093] The docking cart **14** has a user interface **134** that includes a full-size keyboard **34**, sliders **36** (e.g., for control of depth-gain compensation), various knobs and buttons **38**, and a trackball **40**. Other suitable user interface devices include touch pads, touch screens, voice recognition and audio equipment, a computer mouse, a joystick or other pointing device, etc.

[0094] The cart **14** has a docking structure or receptacle **24** into which the portable ultrasound unit **12** may be inserted. The receptacle **24** may have a cutout portion **42** that allows the transducer connector **22** and associated cable **20** of the transducer to protrude out of the portable ultrasound unit **12** while the unit **12** is attached to cart **14**. The transducer head **18** of the transducer attached to the portable unit **12** and the transducer heads of additional transducers **16** may be placed in the transducer holders **44** or one of the additional holders **46** on the main control panel portion **48** of the docking cart. Holders such as the holders **46** may be used for any desired purpose such as for holding ultrasound gel, tissues, transducers or other medical instruments, etc.

[0095] The portable ultrasound unit **12** and other devices used by the user may be powered (at least some of the time) using batteries. The cart **14** may have integral battery charging ports **51**. As shown in FIG. **2**, batteries **50** may be charged and conditioned in these receptacles. If desired, the battery ports may each have an accompanying battery release mechanism activated by a button **52**. The battery charging ports **51** may be used to recharge depleted batteries, may be used to recondition batteries in need of reconditioning, and may serve as a convenient storage location for charged fresh batteries.

[0096] The docking cart **14** may have wheels such as lockable swivel wheels **26** or any other suitable wheels or mechanisms for facilitating movement of docking cart **14**. The wheels **26** may be locked by depressing a foot pedal **54** (which may be connected to one or more of wheels **26** by internal cabling) or by using other manually controlled or electronically controlled electromechanical actuators such as the locks **27** of FIG. **1**. Other locking mechanisms may be used if desired. Handles such as front and rear handles **56** may be provided to allow the user to easily maneuver the cart.

[0097] FIG. **11** is a perspective view of an illustrative docking cart in accordance with another embodiment of the present invention. The cart **314** of FIG. **11** has a simpler construction and contains fewer features than the cart **14** of FIG. **10**. For example, while the cart **314** has a monitor **328**, it does not provide the user interface **134** of the cart **14**. Instead, the portable unit **12** provides the user interface capability. In such a system, the use of the display of the portable unit **12** as a touch screen interface or graphical UI, and/or operatively coupling a full-size keyboard to the portable unit, would be particularly advantageous. Such a keyboard as well as other user interface components may be connected to a USB port or the like of the portable unit, and be placed on a slidable tray **330** of the cart **314**. The portable unit **12** typically includes various connection ports in the back for coupling to external devices and to the cart. Examples of touch screen interface displays include a touch screen main panel of FIG. **12**, a Doppler mode panel of FIG. **13**, a preset sub-panel of FIG. **14**, and a preset touch screen configuration page of FIG. **15**. The processor of the cart **314** in FIG. **11** can be selected to provide the fewer capabilities and need not be as powerful as the processor of the more complex cart **14** in FIG. **10**.

[0098] As shown in FIG. **11**, the portable unit **12** is preferably supported on a generally horizontal surface **340** of the cart **314**. FIG. **16** is a simplified view of a latch mechanism for locking the portable unit **12** to the surface **340** of the cart **314**. A pair of rails **342** with locking tabs **344** are provided on the surface **340**. The portable unit **12** includes a skid plate **346** with slots **348** to receive the locking tabs **344** as the skid plate **346** slides along the rails **342**, thereby locking the skid plate **346** of the portable unit **12** to the rails **342** on the surface **340** of the cart **314**. A latch **350** is connected to the locking tabs **344** and is movable to release the locking tabs **344** from the slots **348** of the portable unit **12** by pulling the tabs **344** away from one another (see arrows in FIG. **16**), thereby allowing the portable unit **12** to be removed from the cart **314**. The removal of the portable unit **12** does not require sliding the skid plate **346** along the rails **342** in the reverse direction. The portable unit **12** can be lifted up from the surface **340** when the latch **350** is moved to release the locking tabs **344**.

[0099] As described above, the portable ultrasound unit **12** can operate on its own with the display screen **58**, user interface **30**, and, optionally, external user interface or similar components connected to the body of the portable unit **12**. The display screen **58** is used to display ultrasound images, and may also be used as a touch screen display or graphical user interface as well.

[0100] The portable unit **12** may be connected to a docking cart to enhance the capabilities of the portable unit so that the portable unit's functionality may even rival or exceed the capabilities of traditional cart-based ultrasound equipment. Two examples of docking carts are described above. In the first cart **14** of FIG. **10**, the docking cart **14** has a display monitor **28** and a full user interface **134**. When the portable unit **12** is mounted to the first docking cart **14**, the cart **14** may provide the full user interface and display capabilities, and there is no need to utilize the user interface and display capabilities of the portable unit **12**. In the second cart **314** of FIG. **11**, the docking cart **14** has a display monitor **328** but no user interface. When the portable unit **12** is mounted to the second docking cart **314**, the cart **314** may provide superior display capabilities as well as additional data processing capabilities if needed. User interface functionalities are provided by the user interface on the body of the portable unit **12**, external user interface components connected to the portable unit **12**, and/or the portable unit display **58** functioning as a touch screen display or graphical user interface.

[0101] The portable unit **12** can be adapted to different stations or carts in a modular construction based on the application environment and capabilities of the different stations or carts. The ultrasound data obtained and processed in the portable unit can be provided to the particular station or cart for further processing and/or viewing. For example, ultrasound image data may be provided to the docking cart from the portable unit in the form of "channel data," "RF data,", "detected data," scan-converted data," or "formatted image data," as discussed above. The respective processors of the portable unit and the particular cart communicate with one another and determine the data format and the respective user interface and display functions to be performed by the portable unit and the cart. In this way, a single portable unit can be used to collect and process ultrasound data, and be mounted to any suitable station or cart as a module to process and display the data as desired based on the application environment, programmed software, and the like.

[0102] It is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined not with reference to the above description, but instead should be determined with reference to the appended claims along with their full scope of equivalents.

What is claimed is:

1. A portable ultrasound device comprising:

a portable housing;

a display control module configured to control a plurality of visual displays, at least one of the visual displays being selectively configurable to provide a user interface display on the visual display for user interface control, at least one of the visual displays being selectively configurable to view an ultrasound image; and a plurality of user interfaces, at least one of the plurality of user interfaces being a separate user interface which is not integrally formed with the portable housing.

2. The portable ultrasound device of claim **1**, wherein the display control module is configured to control visual displays having different sizes and/or resolutions.

3. The portable ultrasound device of claim **1**, further comprising a portable ultrasound device visual display.

4. The portable ultrasound device of claim **3**, wherein the portable ultrasound device visual display is selectively configurable to provide a user interface display on the portable ultrasound device visual display as a touch screen for user interface control of one or more of the user interfaces and selectively configurable to view an ultrasound image.

5. The portable ultrasound device of claim **1**, wherein at least one of the user interfaces is an integral user interface which is integrally formed with the portable housing.

6. The portable ultrasound device of claim **1**, further comprising a communication module configured to communicate with an auxiliary medical device for therapeutic application.

7. The portable ultrasound device of claim **6**, wherein the communication module is configured to send control signal to and/or receive control signal from the auxiliary medical device.

8. The portable ultrasound device of claim **1**, further comprising a security mechanism to lock the portable housing to a surface.

9. The portable ultrasound device of claim **1**, further comprising a user interface allocation module configured to allocate user interface functionalities among the plurality of user interfaces.

10. The portable ultrasound device of claim **1**, further comprising a visual display allocation module configured to allocate visual display functionalities among a plurality of visual displays.

11. An ultrasound system including the portable ultrasound device of claim **1** and a docking station, wherein the docking station comprises:

a docking station visual display which is configurable to view an ultrasound image.

12. The ultrasound system of claim **11**,

wherein the portable ultrasound device comprises a transducer port configured to be coupled to a connector of an ultrasound transducer and a portable ultrasound device ultrasound processing circuitry that accepts first ultrasound image data from the transducer port and processes the first ultrasound image data to generate second ultrasound image data;

wherein the docking station comprises digital communications circuitry that supports communication between the docking station and the portable ultrasound device; and

wherein the docking station visual display is configured to display an ultrasound image based on the second ultrasound image data received from the portable ultrasound device through the digital communications circuitry.

13. The ultrasound system of claim **11**,

wherein the docking station comprises digital communications circuitry that supports communication between the docking station and the portable ultrasound device;

wherein the docking station comprises a docking station ultrasound processing circuitry that processes the second ultrasound image data received by the docking station from the portable ultrasound device through the digital communications circuitry; and

wherein the docking station visual display is configured to display an ultrasound image based on processed data from the docking station ultrasound processing circuitry.

14. The ultrasound system of claim **11**, wherein the docking station comprises a docking station user interface to receive user input of display instruction for the docking station visual display.

15. The ultrasound system of claim **11**, wherein at least one of the user interfaces of the portable ultrasound device receives user input of display instruction for the docking station visual display.

16. The ultrasound system of claim **11**, wherein the portable ultrasound device comprises a portable ultrasound device visual display, which is selectively configurable to provide a user interface display on the portable ultrasound device visual display, as a touch screen for user interface control to receive user input of display instruction for the docking station visual display.

17. An ultrasound system including a portable ultrasound unit and a docking cart,

wherein the portable ultrasound unit comprises a portable housing, a portable ultrasound unit visual display, and a plurality of user interfaces;

wherein the portable ultrasound unit visual display is selectively configurable to provide a user interface display on the visual display for user interface control of one of more of the user interfaces and selectively configurable to view an ultrasound image;

wherein the docking cart comprises a docking cart visual display which is configurable to view an ultrasound image; and

wherein the portable ultrasound unit further comprises a visual display allocation module configured to allocate visual display functionalities between the portable ultrasound unit visual display and the display cart visual display.

18. The ultrasound system of claim **17**, wherein the portable user interface comprises a user interface allocation module configured to allocate user interface functionalities among the plurality of user interfaces.

19. The ultrasound system of claim **17**, the plurality of user interfaces include at least one of:

a separate user interface which is not integrally formed with the portable housing; or

an integral user interface which is integrally formed with the portable housing.

20. The ultrasound system of claim **17**, further comprising a security mechanism to lock the portable housing of the portable ultrasound unit to the docking cart.

21. The ultrasound system of claim **17**,

wherein the portable ultrasound unit comprises a transducer port configured to be coupled to a connector of an ultrasound transducer and a portable ultrasound unit ultrasound processing circuitry that accepts first ultrasound image data from the transducer port and processes the first ultrasound image data to generate second ultrasound image data;

wherein the docking cart comprises digital communications circuitry that supports communication between the docking cart and the portable ultrasound unit; and

wherein the docking cart visual display is configured to display an ultrasound image based on the second ultrasound image data received from the portable ultrasound unit through the digital communications circuitry.

22. The ultrasound system of claim **17**,

wherein the docking cart comprises digital communications circuitry that supports communication between the docking cart and the portable ultrasound unit;

wherein the docking cart comprises a docking cart ultrasound processing circuitry that processes the second ultrasound image data received by the docking cart from the portable ultrasound unit through the digital communications circuitry; and

wherein the docking cart visual display is configured to display an ultrasound image based on processed data from the docking cart ultrasound processing circuitry.

23. The ultrasound system of claim **17**, wherein at least one of the user interfaces of the portable ultrasound unit receives user input of display instruction for the docking cart visual display.

24. The ultrasound system of claim **17**, wherein the portable ultrasound unit visual display is selectively configurable to provide a user interface display on the portable ultrasound unit visual display, as a touch screen for user interface control to receive user input of display instruction for the docking cart visual display.

25. A portable ultrasound device comprising:

a portable housing;

a portable device processor;

a portable device visual display; and

at least one portable device user interface;

wherein the portable housing is configured to be mounted to any one of a plurality of docking stations;

wherein the portable device processor is configured to interface with a docking station processor of the docking station for allocating user interface functionalities and/or visual display functionalities between the portable ultrasound device and the docking station; and

wherein the visual display functionalities include displaying an ultrasound image.

26. The portable ultrasound device of claim **25**, wherein the docking station has a docking station visual display, and wherein the visual display functionalities are allocated between the portable device visual display and the docking station visual display.

27. The portable ultrasound device of claim **26**, wherein the portable device visual display is selectively configurable to provide a user interface display on the portable device visual display, as a touch screen for user interface control to receive user input of display instruction for the docking station visual display.

28. The portable ultrasound device of claim **26**, wherein the visual display functionalities are fully allocated to the docking station visual display.

29. The portable ultrasound device of claim **25**, wherein the docking station has at least one docking station user interface, and wherein the user interface functionalities are allocated between the at least one portable device user interface and the at least one docking station user interface.

30. The portable ultrasound device of claim **29**, wherein the user interface functionalities are fully allocated to the at least one docking station user interface.

* * * * *

patsnap

专利名称(译)	控制便携式超声波单元和扩展坞的用户界面和显示器		
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[标]申请(专利权)人(译)	ZONARE医疗SYST		
申请(专利权)人(译)	ZONARE医疗系统，INC.		
当前申请(专利权)人(译)	深圳迈瑞生物医疗电子股份有限公司.		
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摘要(译)

本发明的实施例提供了用于控制便携式超声设备的多个视觉显示器和多个用户界面的方式，该便携式超声设备可以安装到不同的对接站或推车以提供和增强不同的功能和特征。在一个实施例中，便携式超声设备包括便携式外壳;显示控制模块，被配置为控制多个视觉显示器，至少一个视觉显示器可选择性地配置为在视觉显示器上提供用户界面显示以供用户界面控制，至少一个视觉显示器可选择性地配置为可视超声图像;多个用户界面，多个用户界面中的至少一个是独立的用户界面，其不与便携式外壳整体形成。