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(54) **REMOTE PRESENCE DISPLAY THROUGH REMOTELY CONTROLLED ROBOT**

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See application file for complete search history.

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(57) **ABSTRACT**

A robot system that includes a robot and a remote station. The robot and remote station contain monitors, cameras, speakers and microphones that allow for two-way videoconferencing between a physician at the remote station and a patient in the vicinity of the robot. The system also includes a patient monitor that displays patient information such as an x-ray. The patient monitor can be seen by the patient, and by the physician through the robot camera. The system allows for a physician to remotely review the medical information with the patient.

13 Claims, 8 Drawing Sheets

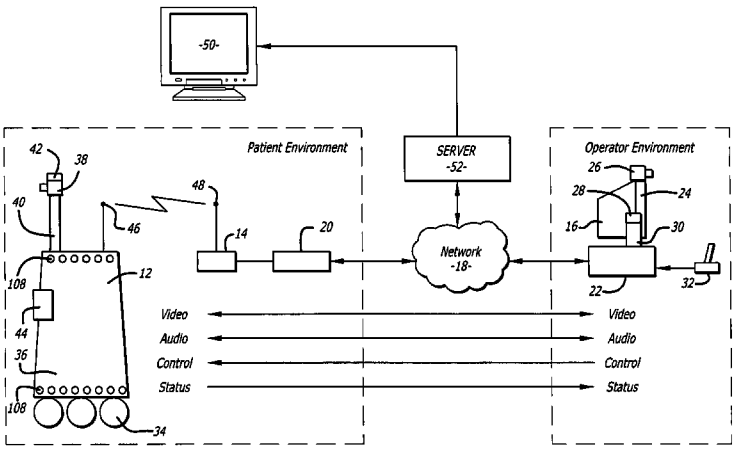

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FIG. 1

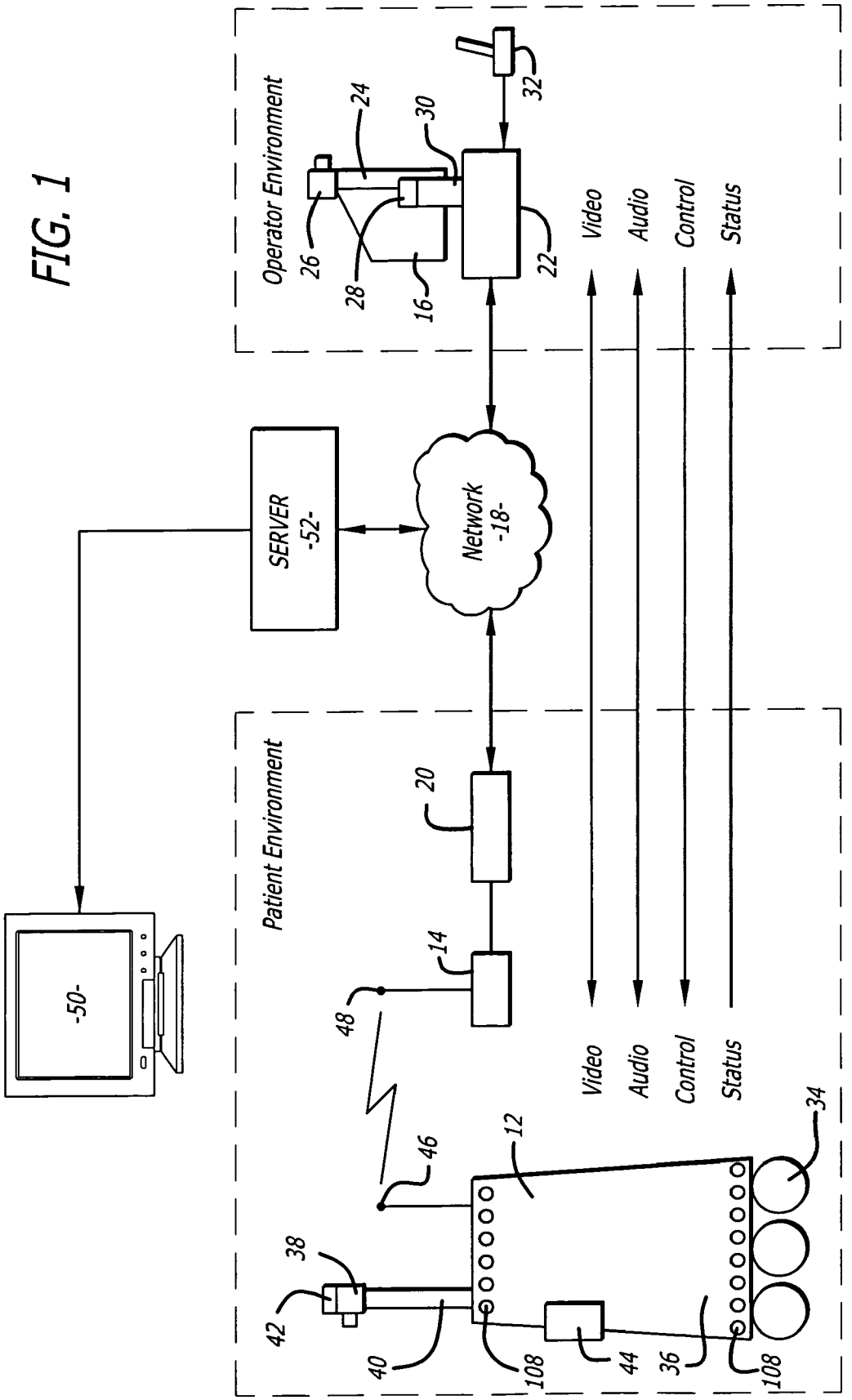
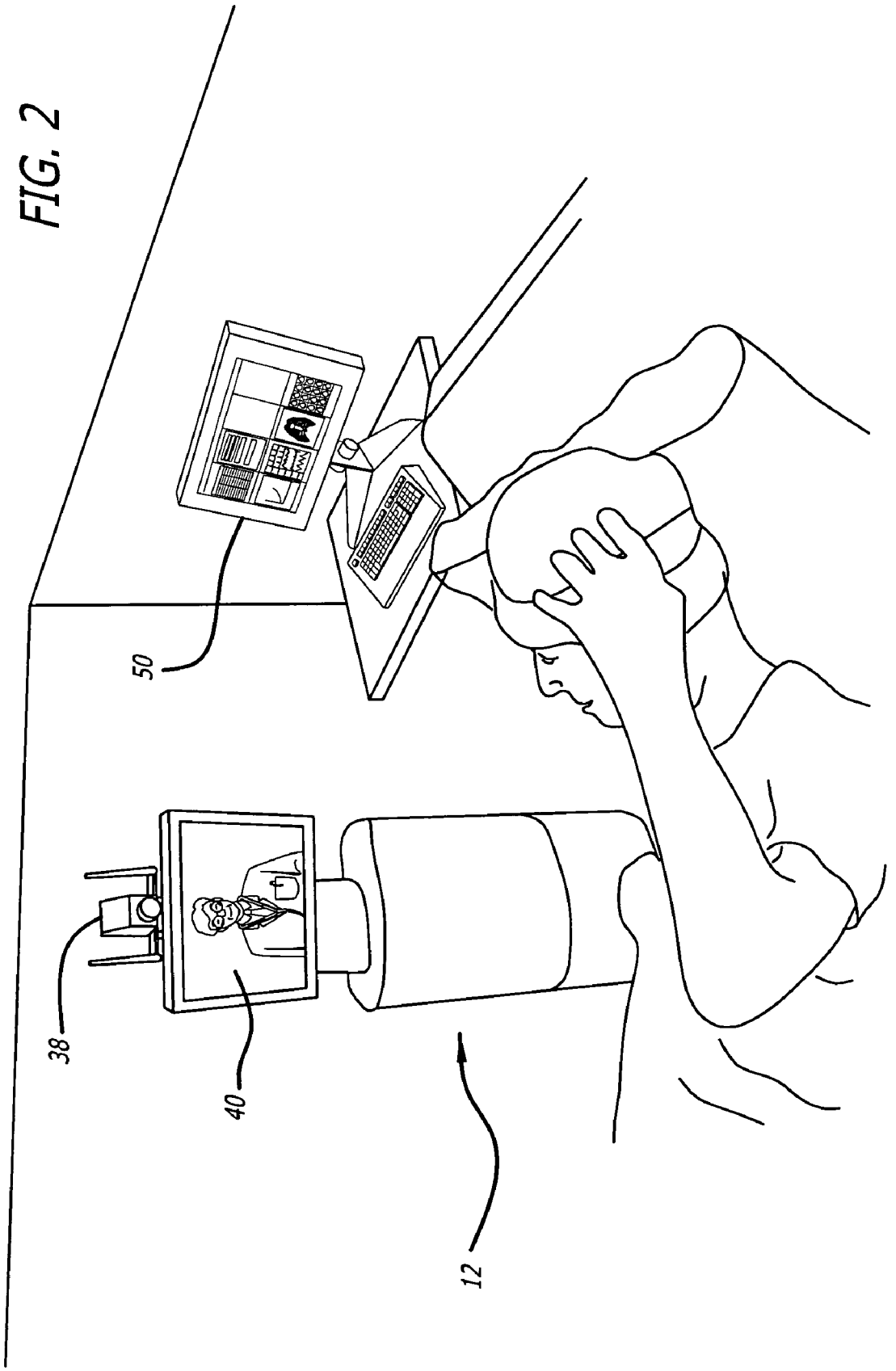

Operator Environment
Patient Environment
Network
-18-
SERVER
-52-
-50-
Video
Audio
Control
Status
Video
Audio
Control
Status
12
14
16
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
108
108

FIG. 2



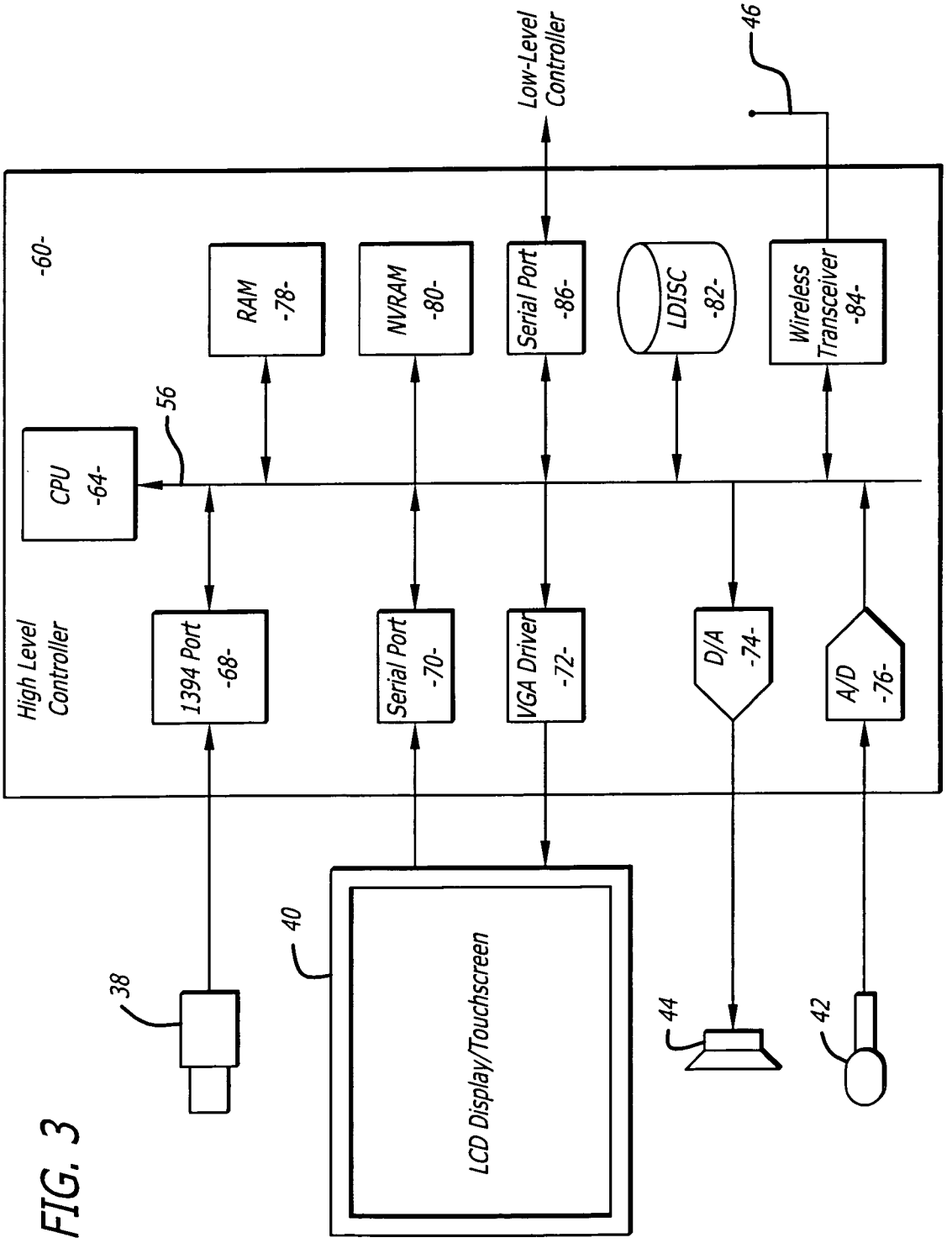

Low-Level Controller
46
-60-
RAM -78-
NVRAM -80-
Serial Port -86-
LDISC -82-
Wireless Transceiver -84-
56
CPU -64-
High Level Controller
1394 Port -68-
Serial Port -70-
VGA Driver -72-
D/A -74-
A/D -76-
38
40
LCD Display/Touchscreen
44
42

FIG. 3

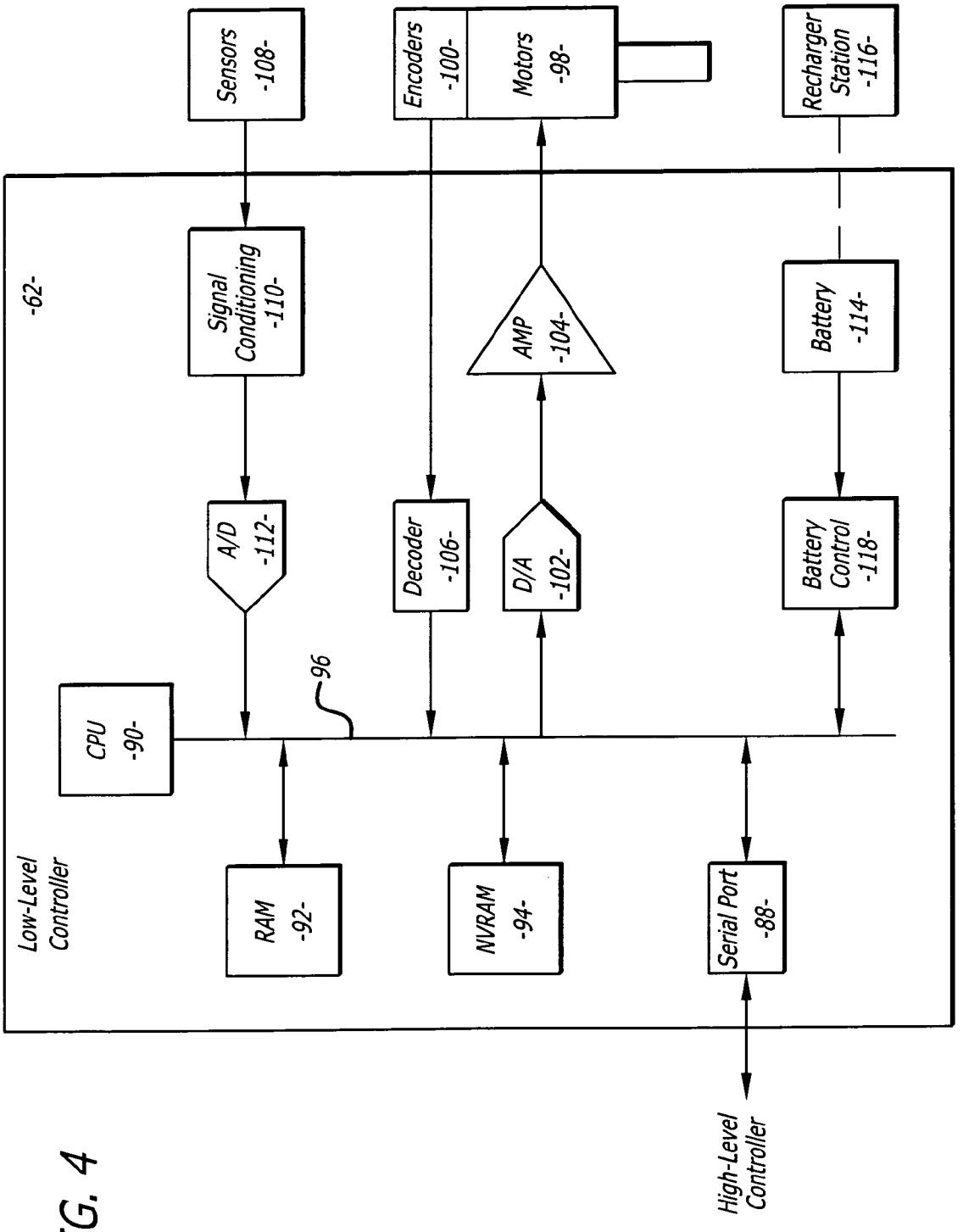

Sensors -108-
Encoders -100-
Motors -98-
Recharger Station -116-
-62-
Signal Conditioning -110-
AMP -104-
Battery -114-
A/D -112-
Decoder -106-
D/A -102-
Battery Control -118-
96
CPU -90-
Low-Level Controller
RAM -92-
NVRAM -94-
Serial Port -88-
High-Level Controller

FIG. 4

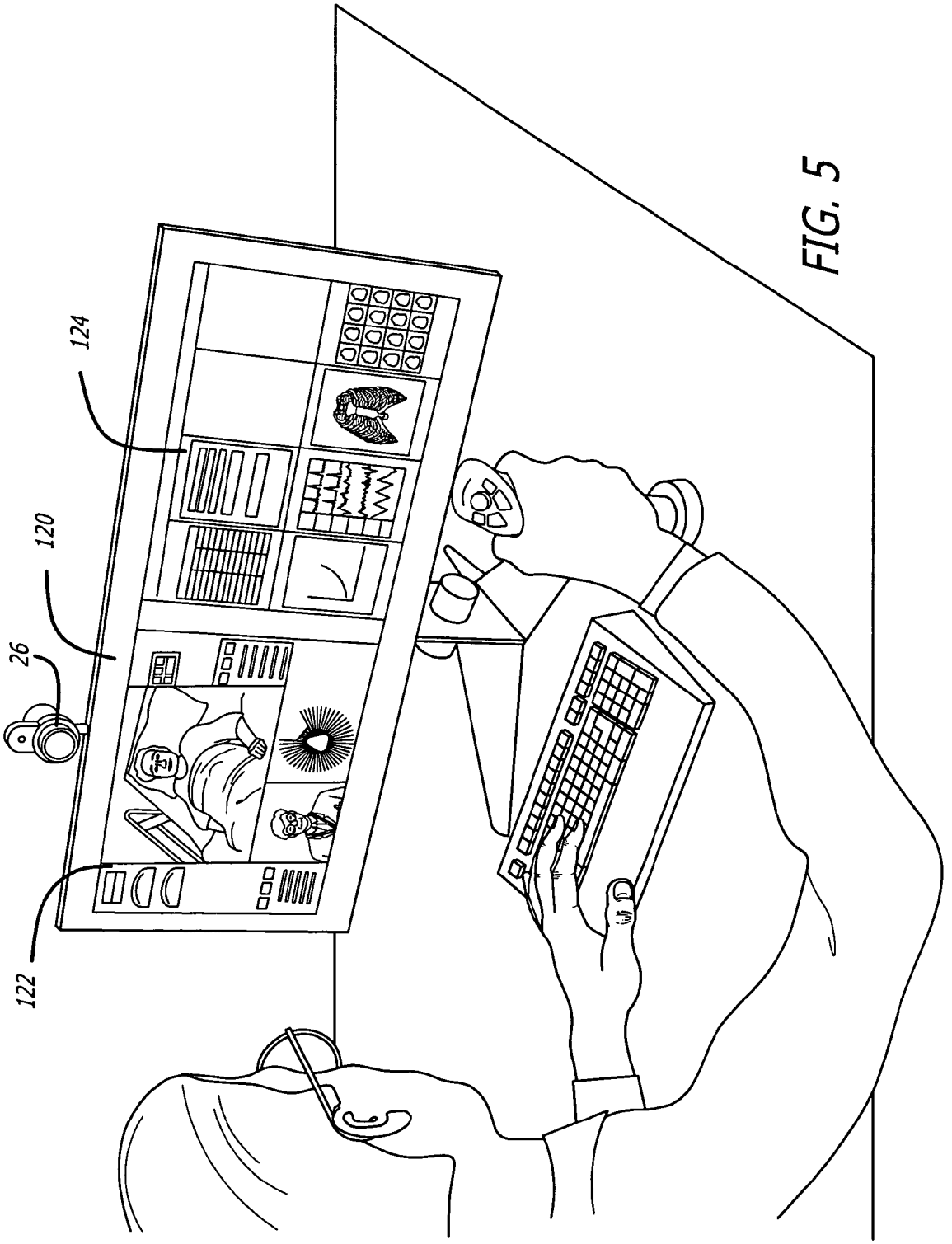


FIG. 5

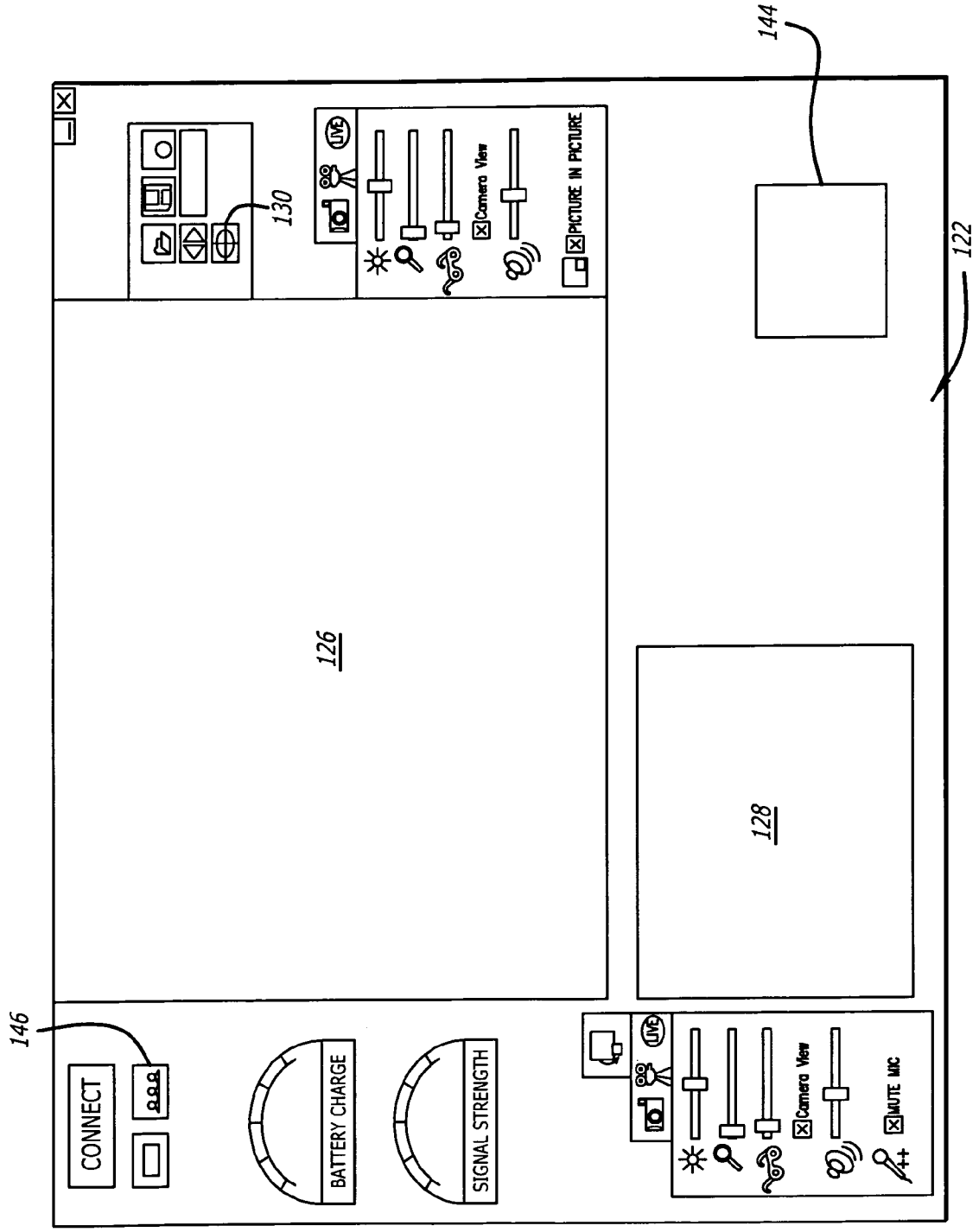

144
122
130
Camera View
PICTURE IN PICTURE
126
128
146
CONNECT
BATTERY CHARGE
SIGNAL STRENGTH
Camera View
MUTE MIC

FIG. 6

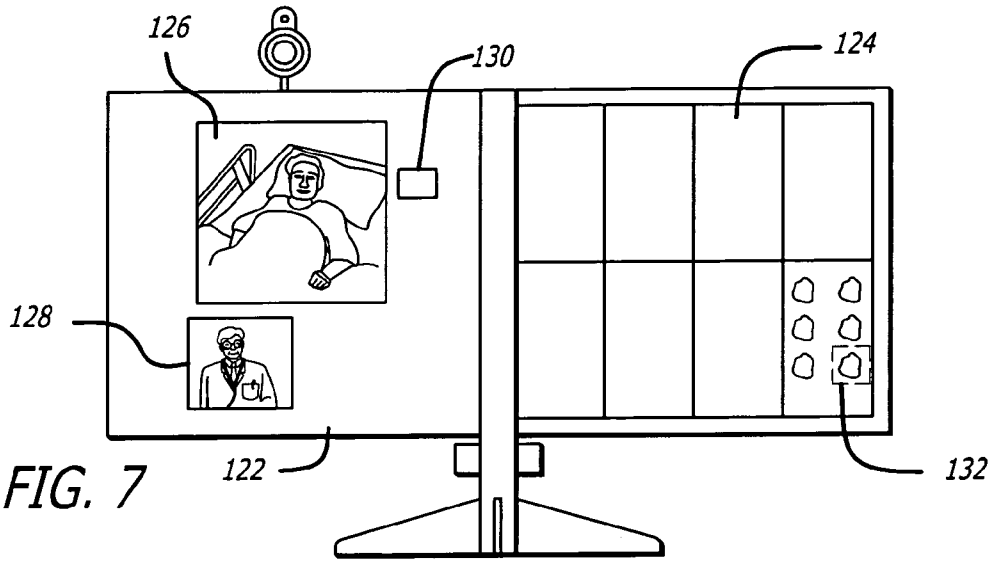


FIG. 7

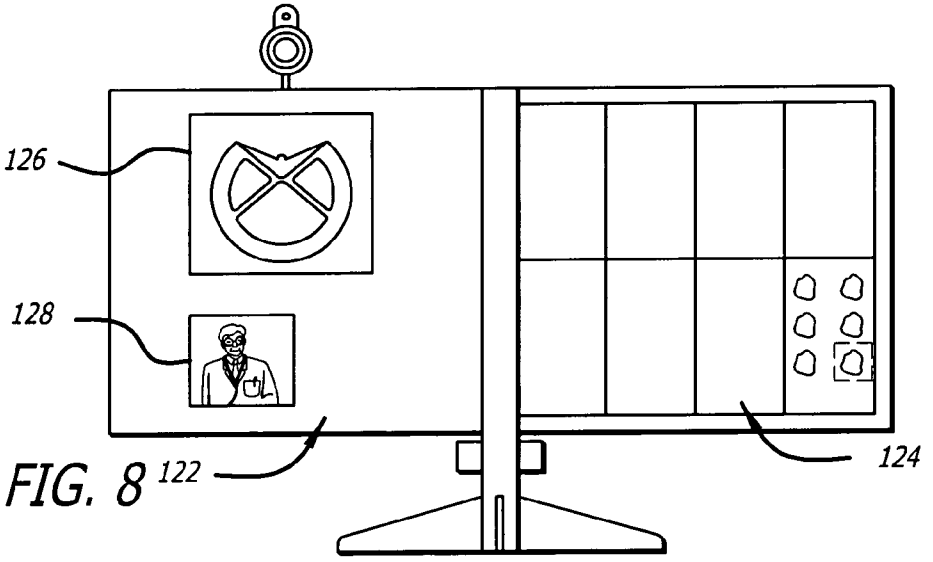


FIG. 8

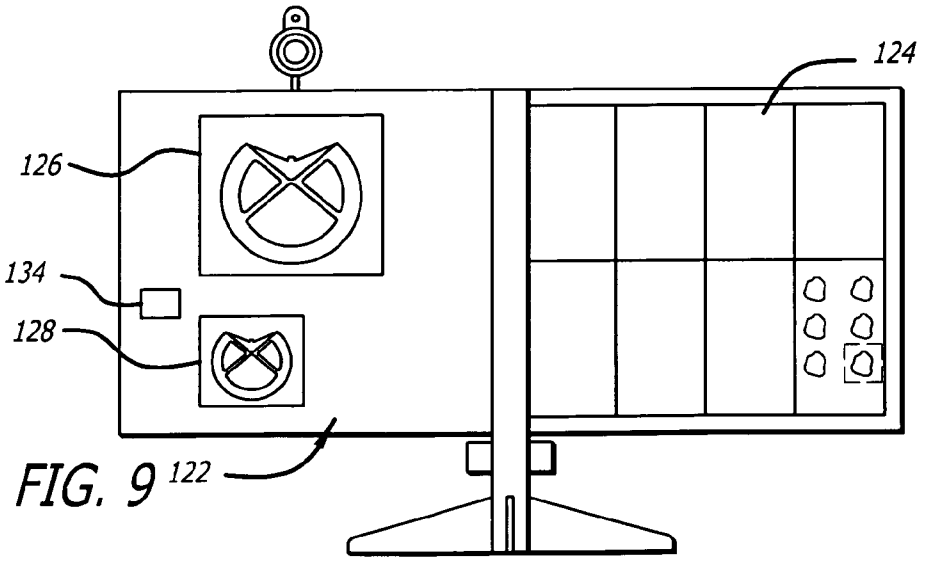


FIG. 9

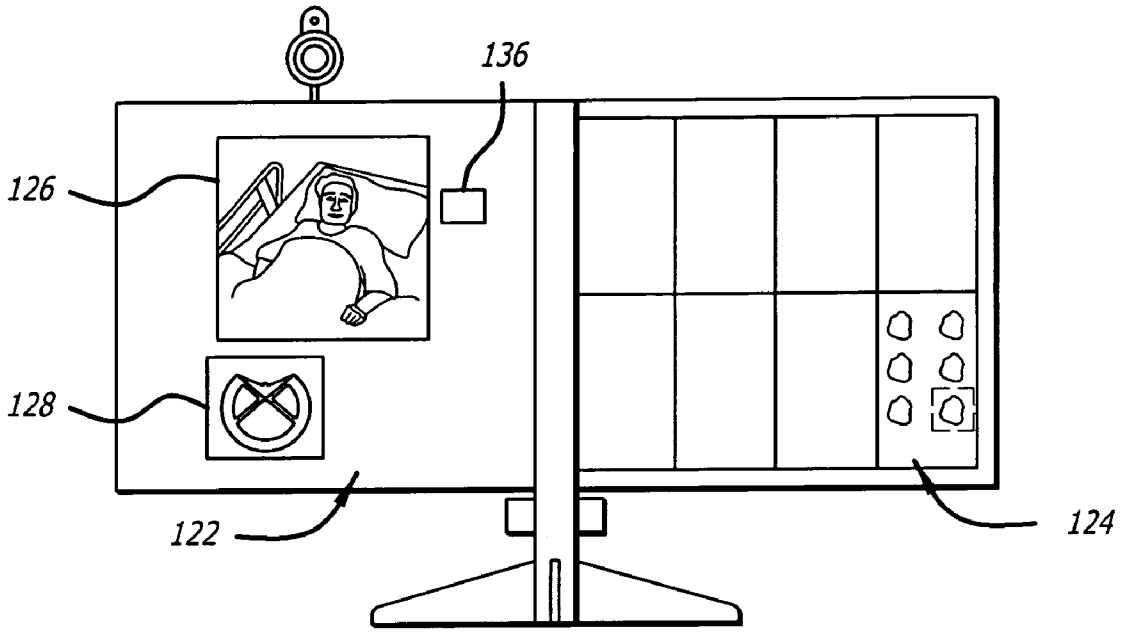


FIG. 10

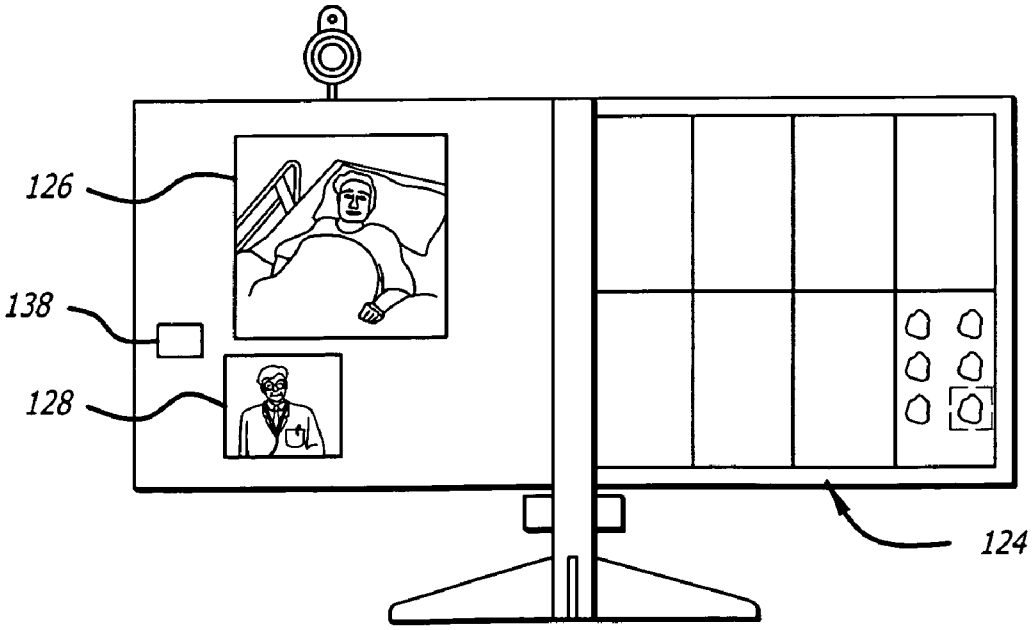


FIG. 11

REMOTE PRESENCE DISPLAY THROUGH REMOTELY CONTROLLED ROBOT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject matter disclosed generally relates to a system and method to provide patient consultation by a physician.

2. Background Information

There has been marketed a mobile robot introduced by InTouch-Health, Inc., the assignee of this application, under the trademarks COMPANION, RP-6 and RP-7. The InTouch robot is controlled by a user at a remote station. The remote station may be a personal computer with a joystick that allows the user to remotely control the movement of the robot. Both the robot and remote station have cameras, monitors, speakers and microphones to allow for two-way video/audio communication.

The InTouch robot has been used by physicians to remotely view and communicate with patients in healthcare facilities. The robot monitor displays an image of the doctor to create a tele-presence of the physician. A doctor can move the robot from room to room of the facility to provide consultation and care for the patient. The cameras, monitors, speakers and microphones of the robot and remote station allow the physician to communicate with the patient through speech and visual images.

It is sometimes desirable to review medical information with the patient. For example, it may be desirable to review an x-ray with a patient while providing consultation through the tele-presence robot. The medical information can be provided to the patient by a medical assistant who is present at the remote patient location. This requires that the assistant be present in the room. Alternatively, the robot monitor can display the medical information. Unfortunately, when the information is displayed by the robot monitor the physican's video image is no longer displayed and the robot does not provide a tele-presence of the doctor. It would be desirable to provide a system that allows a mobile robot to project a presence of a physician while reviewing medical information of a patient without requiring a medical assistant.

BRIEF SUMMARY OF THE INVENTION

A robot system that includes a remote station coupled to a mobile robot. The mobile robot has a robot monitor that displays an image captured by a remote station camera. Likewise, the remote station has a monitor that displays an image captured by a robot camera. The system further includes a patient monitor that displays patient information that can be captured by the robot camera.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration of a robotic system;

FIG. **2** is an illustration of the robotic system being used to provide physician consultation to a patient;

FIG. **3** is a schematic of an electrical system of a robot;

FIG. **4** is a further schematic of the electrical system of the robot;

FIG. **5** is a display user interface of a remote station having a first screen field and a second screen field;

FIG. **6** is a display user interface showing a first screen field;

FIG. **7** is a display user interface showing a portion of the second screen field being highlighted;

FIG. **8** is a display user interface showing the highlighted portion of the second screen transferred to the first screen;

FIG. **9** is a display user interface showing the highlighted portion of the screen shared with the robot monitor;

FIG. **10** is a display user interface showing a live robot camera feed;

FIG. **11** is a display user interface showing a live remote station camera feed.

DETAILED DESCRIPTION

Disclosed is a robot system that includes a robot and a remote station. The robot and remote station contain monitors, cameras, speakers and microphones that allow for two-way videoconferencing between a physician at the remote station and a patient in the vicinity of the robot. The system also includes a patient monitor that displays patient information such as an x-ray. The patient monitor can be seen by the patient, and by the physician through the robot camera. The system allows for a physician to remotely review the medical information with the patient.

Referring to the drawings more particularly by reference numbers, FIG. **1** shows a system **10**. The robotic system includes a robot **12**, a base station **14** and a remote control station **16**. The remote control station **16** may be coupled to the base station **14** through a network **18**. By way of example, the network **18** may be either a packet switched network such as the Internet, or a circuit switched network such has a Public Switched Telephone Network (PSTN) or other broadband system. The base station **14** may be coupled to the network **18** by a modem **20** or other broadband network interface device. By way of example, the base station **14** may be a wireless router. Alternatively, the robot **12** may have a direct connection to the network thru for example a satellite.

The remote control station **16** may include a computer **22** that has a monitor **24**, a camera **26**, a microphone **28** and a speaker **30**. The computer **22** may also contain an input device **32** such as a joystick or a mouse. The control station **16** is typically located in a place that is remote from the robot **12**. Although only one remote control station **16** is shown, the system **10** may include a plurality of remote stations. In general any number of robots **12** may be controlled by any number of remote stations **16** or other robots **12**. For example, one remote station **16** may be coupled to a plurality of robots **12**, or one robot **12** may be coupled to a plurality of remote stations **16**, or a plurality of robots **12**.

Each robot **12** includes a movement platform **34** that is attached to a robot housing **36**. Also attached to the robot housing **36** are a camera **38**, a monitor **40**, a microphone(s) **42** and a speaker(s) **44**. The microphone **42** and speaker **30** may create a stereophonic sound. The robot **12** may also have an antenna **46** that is wirelessly coupled to an antenna **48** of the base station **14**. The system **10** allows a user at the remote control station **16** to move the robot **12** through operation of the input device **32**. The robot camera **38** is coupled to the remote monitor **24** so that a user at the remote station **16** can view a patient. Likewise, the robot monitor **40** is coupled to the remote camera **26** so that the patient may view the user. The microphones **28** and **42**, and speakers **30** and **44**, allow for audible communication between the patient and the user. The monitor **40** and camera **38** may move together in two degrees of freedom such as pan and tilt.

The remote station computer **22** may operate Microsoft OS software and WINDOWS XP or other operating systems such as LINUX. The remote computer **22** may also operate a video driver, a camera driver, an audio driver and a joystick driver.

The video images may be transmitted and received with compression software such as MPEG CODEC.

The system **10** includes a patient monitor **50** that can display patient information. The patient monitor **50** is typically located within a patient's room at a healthcare facility. The patient monitor **50** can be any type of device that can display graphics, video images and text. By way of example, the patient monitor **50** may be a CRT monitor, flat screen, or a laptop computer.

The remote station **16** and patient monitor **50** may be coupled to a server **52** through the network **18**. The server **52** may contain electronic medical records of a patient. By way of example, the electronic medical records may include written records of treatment, patient history, medication information, a medical image, such as an x-ray, MRI or CT scan, EKGs, laboratory results, physician notes, etc. The medical records can be retrieved from the server **52** and displayed by the patient monitor **50**. The remote station **16** may allow the physician to modify the records and then store the modified records back in the server **52**. Although a server **52** is shown and described, it is to be understood that the information may be transferred directly from the remote station **16** to the patient monitor **50** without the server **52**. Although a medical application is described, it is to be understood that the system may be used in a non-medical application. For example, the monitor can be a computer monitor at an office or home, and the information can be business or personal in nature.

As shown in FIG. **2**, the system allows a physician to review medical information with a patient. The robot **12** displays an image of the physician so that the physician's presence is projected into a patient's room. The patient monitor **50** displays medical information that can be reviewed by the patient. The robot camera **38** allows the physician to see the patient and to view the medical information displayed by the patient monitor **50**. By way of example, the patient monitor **50** can display an x-ray of the patient and the physician can discuss the x-ray with the patient through the two-way video conferencing function of the system. The system may also allow the physician to highlight features of the x-ray with a tele-strating function.

FIGS. **3** and **4** show an embodiment of a robot **12**. Each robot **12** may include a high level control system **60** and a low level control system **62**. The high level control system **60** may include a processor **64** that is connected to a bus **66**. The bus is coupled to the camera **38** by an input/output (I/O) port **68**, and to the monitor **40** by a serial output port **70** and a VGA driver **72**. The monitor **40** may include a touchscreen function that allows the patient to enter input by touching the monitor screen.

The speaker **44** is coupled to the bus **66** by a digital to analog converter **74**. The microphone **42** is coupled to the bus **66** by an analog to digital converter **76**. The high level controller **60** may also contain random access memory (RAM) device **78**, a non-volatile RAM device **80** and a mass storage device **82** that are all coupled to the bus **72**. The mass storage device **82** may contain medical files of the patient that can be accessed by the user at the remote control station **16**. For example, the mass storage device **82** may contain a picture of the patient. The user, particularly a health care provider, can recall the old picture and make a side by side comparison on the monitor **24** with a present video image of the patient provided by the camera **38**. The robot antennae **46** may be coupled to a wireless transceiver **84**. By way of example, the transceiver **84** may transmit and receive information in accordance with IEEE 802.11b. The transceiver **84** may also process signals from the medical monitoring device in accordance with IEEE also known as Bluetooth. The robot may have a separate antennae to receive the wireless signals from the medical monitoring device.

The controller **64** may operate with a LINUX OS operating system. The controller **64** may also operate MS WINDOWS along with video, camera and audio drivers for communication with the remote control station **16**. Video information may be transceived using MPEG CODEC compression techniques. The software may allow the user to send e-mail to the patient and vice versa, or allow the patient to access the Internet. In general the high level controller **60** operates to control communication between the robot **12** and the remote control station **16**.

The high level controller **60** may be linked to the low level controller **62** by serial ports **86** and **88**. The low level controller **62** includes a processor **90** that is coupled to a RAM device **92** and non-volatile RAM device **94** by a bus **96**. Each robot **12** contains a plurality of motors **98** and motor encoders **100**. The motors **98** can activate the movement platform and move other parts of the robot such as the monitor and camera. The encoders **100** provide feedback information regarding the output of the motors **98**. The motors **98** can be coupled to the bus **96** by a digital to analog converter **102** and a driver amplifier **104**. The encoders **100** can be coupled to the bus **96** by a decoder **106**. Each robot **12** also has a number of proximity sensors **108** (see also FIG. **1**). The position sensors **108** can be coupled to the bus **96** by a signal conditioning circuit **110** and an analog to digital converter **112**.

The low level controller **62** runs software routines that mechanically actuate the robot **12**. For example, the low level controller **62** provides instructions to actuate the movement platform to move the robot **12**. The low level controller **62** may receive movement instructions from the high level controller **60**. The movement instructions may be received as movement commands from the remote control station or another robot. Although two controllers are shown, it is to be understood that each robot **12** may have one controller, or more than two controllers, controlling the high and low level functions.

The various electrical devices of each robot **12** may be powered by a battery(ies) **114**. The battery **114** may be recharged by a battery recharger station **116**. The low level controller **62** may include a battery control circuit **118** that senses the power level of the battery **114**. The low level controller **62** can sense when the power falls below a threshold and then send a message to the high level controller **60**.

The system may be the same or similar to a robotic system provided by the assignee InTouch-Health, Inc. of Santa Barbara, Calif. under the name RP-6 or RP-7, which is hereby incorporated by reference. The system may also be the same or similar to the system disclosed in application Ser. No. 10/206,457 published on Jan. 29, 2004, which is hereby incorporated by reference.

FIG. **5** shows a visual display **120** of the remote station. The visual display **120** displays a first screen field **122** and a second screen field **124**. The two screen fields may be created by two different monitors. Alternatively, the two screen fields may be displayed by one monitor. The first and second screen fields **122** and **124** may be part of an application program(s) stored and operated by the computer **22** of the remote station **16**.

FIG. **6** shows a first screen field **122**. The first screen field **122** may include a robot view field **126** that displays a video image captured by the camera of the robot. The first field **122** may also include a station view field **128** that displays a video image provided by the camera of the remote station. The first

field **122** may have a capture button **130** that can be selected to move at least a portion of the record field **124** into the robot view field **126**.

As shown in FIGS. **7** and **8**, the highlighted portion **132** of the second screen **124** may be copied to the robot view field **126**. By way of example, a graphical rectangle may be drawn around a portion of the second field through manipulation of a mouse. The ability to create the rectangle may be enabled by the selection of the capture button **130**. The highlighted portion of the second screen **132** may automatically populate the robot view field **126** when the rectangle is completed by the user.

As shown in FIG. **9**, the first screen field **122** may have a share button **134** that transfers the contents of the robot image field to the robot monitors. In this manner, the user can transfer the highlighted portion of the second screen field to the robot monitor. The transferred robot field contents are also displayed in the station view field **128**. The user can switch back to a live feed from the robot camera by selecting the live button **136**, as shown in FIG. **10**. Likewise, the robot monitor may display a live feed of the remote station operator by selecting the live button **138**, as shown in FIG. **11**.

Referring to FIG. **6**, the field **122** may have a button **144** that can be selected to transfer the contents of the second screen field **124** to the patient monitor **50**. The system may provide the ability to annotate the image displayed in field **126** and/or **128**. For example, a doctor at the remote station may annotate some portion of the image captured by the robot camera. The annotated image may be stored by the system. The system may also allow for annotation of images sent to the patient monitor **50** through the button **140**. For example, a doctor may send a medical image, such as an x-ray, MRI or CT scan to the patient monitor. The medical image is displayed by the patient monitor **50**. The doctor can annotate the medical image to point out a portion of the medical image to personnel located at the robot site. This allows the doctor to review the information with the patient as shown in FIG. **2**.

The second screen field may display a variety of different applications. For example, the second field **124** may display patient records, a medical image, etc. By way of example, the record field **124** may be a medical records program provided by Global Care Quest Corp. of Los Angeles, Calif.

While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art.

What is claimed is:

1. A medical system for a patient, comprising:
- a patient monitor that displays patient information;
- a mobile robot that has a robot monitor, and a robot camera that captures an image, said robot camera being capable of viewing the patient and said patient monitor; and
- a remote station that is coupled to said mobile robot, said remote station includes a remote station monitor that displays the image captured by said robot camera and a remote station camera that captures an image that is displayed by said robot monitor.

2. The system of claim **1**, further comprising a server that is coupled to said remote station and said patient monitor and provides said patient information.

3. The system of claim **1**, wherein said patient information is displayed by said remote station monitor.

4. The system of claim **1**, further comprising a broadband network that is coupled to said remote station and said mobile robot.

5. The system of claim **1**, wherein said robot monitor and said robot camera move together in at least one degree of freedom.

6. The system of claim **1**, wherein said patient information includes a medical image.

7. A method for interacting with a patient, comprising:
- moving a mobile robot that has a camera to view a patient and a patient monitor;
- displaying patient information on the patient monitor; and, conducting a two-way video conference between the patient, and a medical personnel at a remote station that controls movement of the robot.

8. The method of claim **7**, wherein the patient information is provided by the remote station.

9. The method of claim **7**, wherein the patient information is provided by a server.

10. The method of claim **7**, wherein the patient information is displayed by a remote station monitor.

11. The method of claim **7**, further comprising transmitting robot control commands from the remote station to the mobile robot through a broadband network.

12. The method of claim **7**, further comprising moving together a robot camera and a robot monitor in at least one degree of freedom.

13. The method of claim **7**, wherein the patient information includes a medical image.

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