



(12) **United States Patent**
Roman et al.

(10) **Patent No.:** **US 6,621,413 B1**
(45) **Date of Patent:** **Sep. 16, 2003**

(54) **WIRELESS MONITORING OF A MOBILE MAGNET**

(75) Inventors: **James P. Roman**, Nashota, WI (US);
Sean S. Josephson, Brookfield, WI (US);
David M. Davenport, Niskayuna, NY (US)

(73) Assignee: **GE Medical Systems Global Technology Company, LLC**, Waukesha, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 139 days.

(21) Appl. No.: **09/639,698**

(22) Filed: **Aug. 16, 2000**

(51) **Int. Cl.**⁷ **G08B 1/08**; A61B 5/00

(52) **U.S. Cl.** **340/539.12**; 340/539.18;
340/825.36; 701/29; 379/38; 455/426.1;
600/300; 600/411; 128/903; 324/307

(58) **Field of Search** 340/539, 531,
340/825.36, 825.49; 701/29, 30; 379/37,
38; 455/575, 426; 128/903, 904, 922; 430/39;
600/300, 410, 411; 324/318, 307, 309

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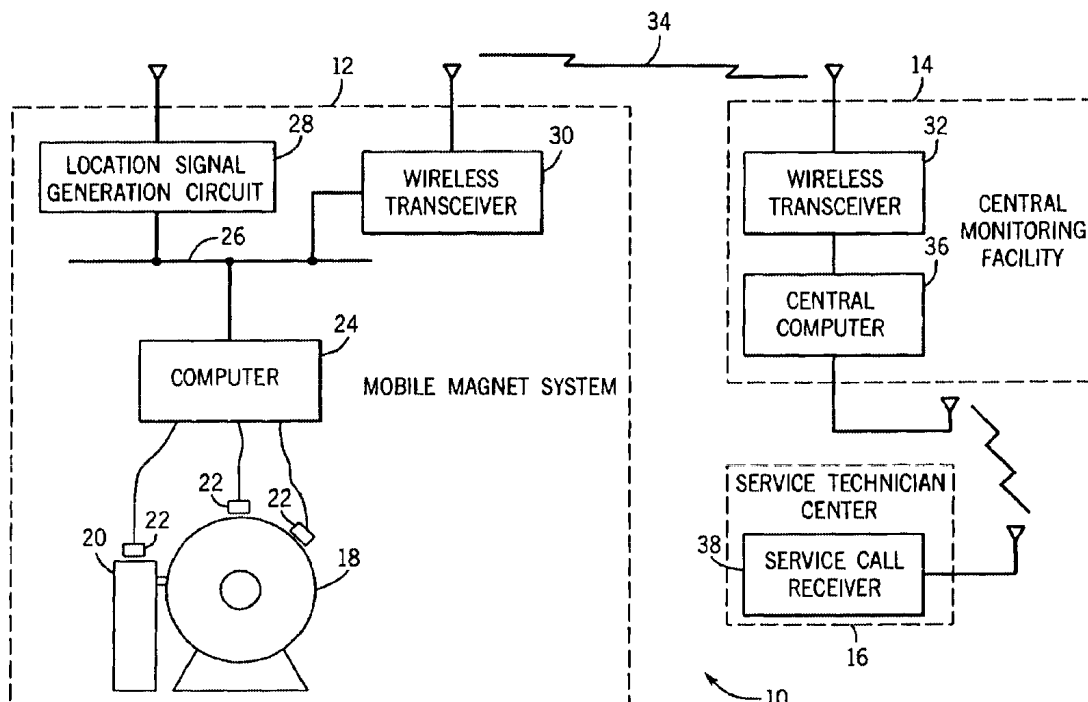
Primary Examiner—Donnie L. Crosland

(74) *Attorney, Agent, or Firm*—Foley & Lardner; Peter J. Vogel; Michael A. Della Penna

(57) **ABSTRACT**

A system and method of servicing a mobile magnet by wireless monitoring is provided. The mobile magnet has a sensor configured to sense a characteristic of the mobile magnet and a computer coupled to the sensor configured to receive sensor data representative of the sensed characteristic. The method includes receiving the sensor data at a remote monitoring station via a wireless communication link with the computer; determining whether the mobile magnet needs service based on the sensor data; and dispatching a service technician to the mobile magnet when the mobile magnet needs service.

22 Claims, 6 Drawing Sheets



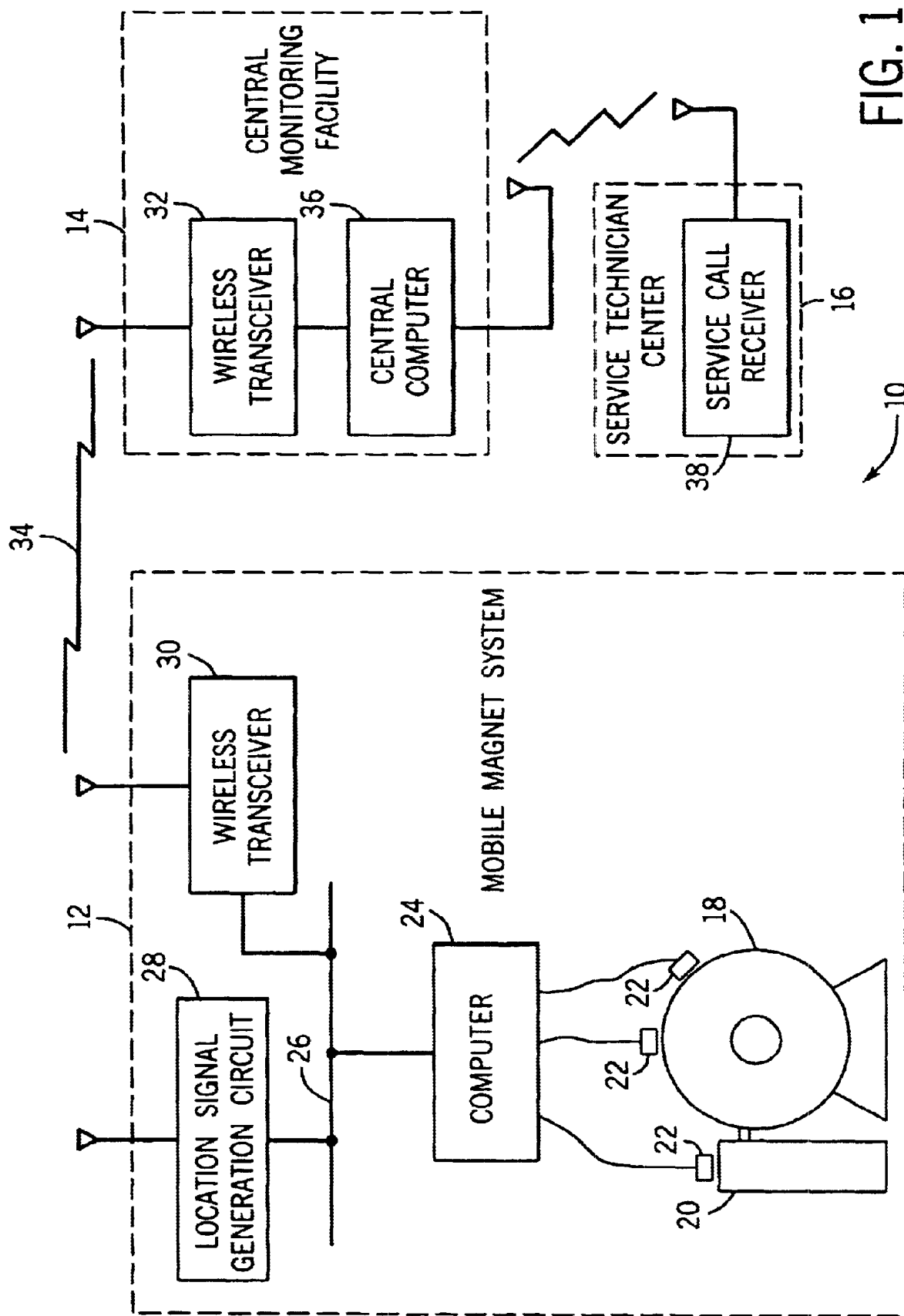


FIG. 1

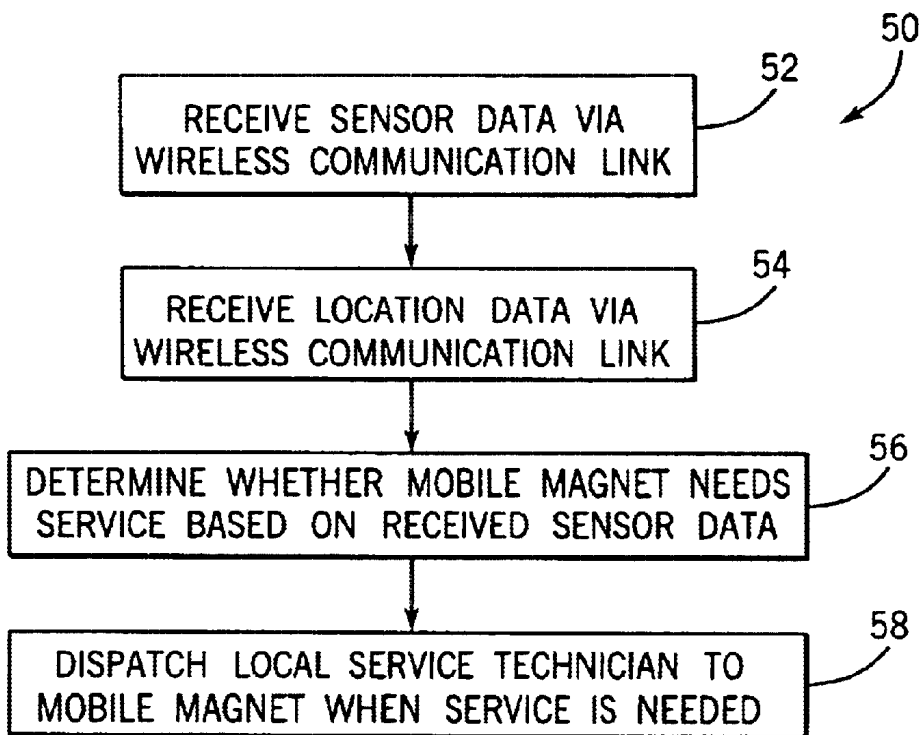


FIG. 2

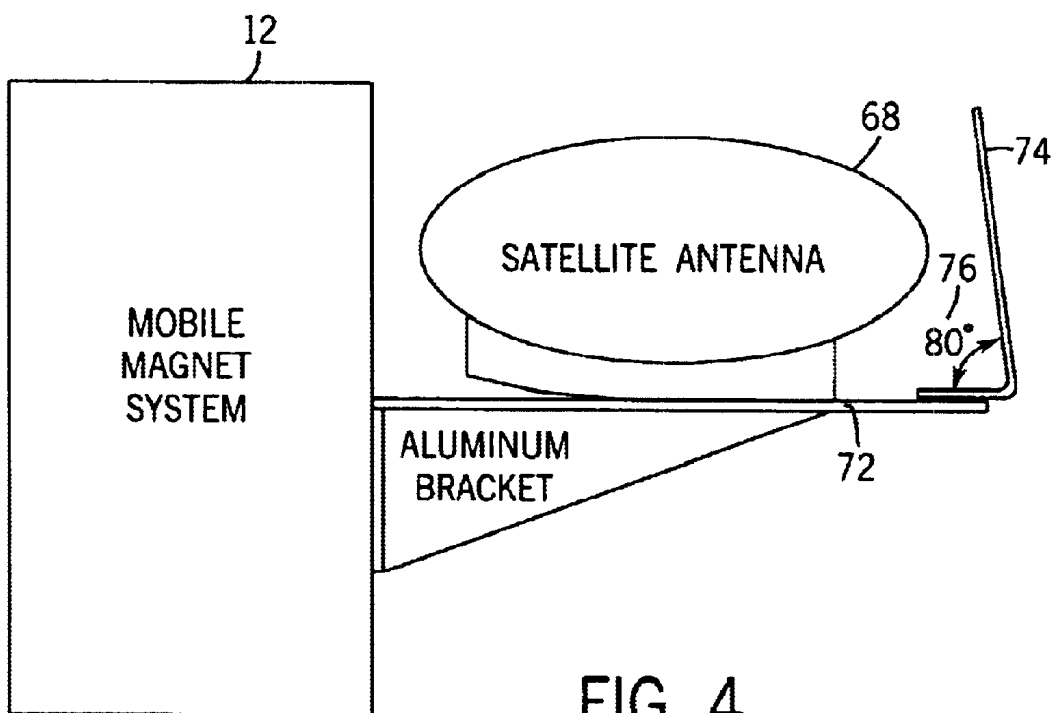


FIG. 4

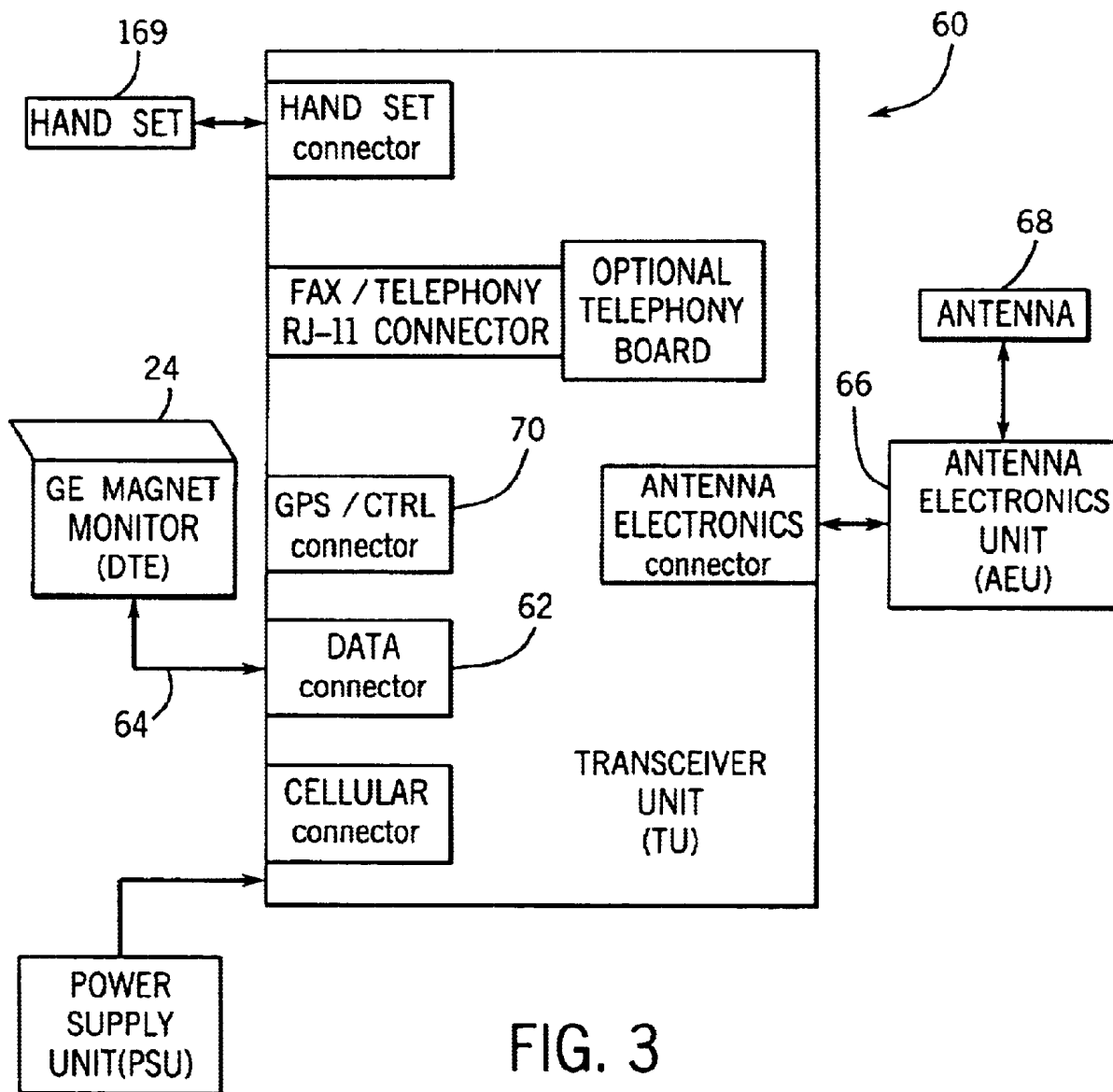


FIG. 3

The image shows a network configuration dialog box with three tabs: "GEMS MOBILE MR", "GEMS MOBILE MR", and "TCP/IP SETTINGS".

Tab 1: GEMS MOBILE MR

- Buttons: GENERAL, SERVER TYPES, SCRIPTING
- Section: PHONE NUMBER: 82
- AREA CODE: 877
- TELEPHONE NUMBER: 363-4925
- COUNTRY CODE: UNITED STATES OF AMERICA (1)
- Use Country Code and Area Code: 84
- Section: CONNECT USING:
- MEGAHERTZ CC3144 V.32BIS PCMCIA MO
- Buttons: CONFIGURE..., OK, CANCEL

Tab 2: GEMS MOBILE MR

- Buttons: GENERAL, SERVER TYPES, SCRIPTING
- Section: TYPE OF DIAL-UP SERVER
- PPP WINDOWS 95 WINDOWS NT 3.5 INTERNET
- Section: ADVANCED OPTIONS:
- Log on to network:
- Enable software compression:
- Require encrypted password:
- Section: ALLOWED NETWORK PROTOCOLS:
- NETBEUI:
- IPX/SPX COMPATIBLE:
- TCP/IP: (with sub-tab: TCP/IP SETTINGS...)
- Buttons: OK, CANCEL

Tab 3: TCP/IP SETTINGS

- Buttons: SERVER ASSIGNED IP ADDRESS, SPECIFY AN IP ADDRESS
- IP ADDRESS: 0 ^ 0 v 0 ^ 0
- Buttons: SERVER ASSIGNED NAME SERVER ADDRESS, SPECIFY NAME SERVER ADDRESS
- PRIMARY DNS: 0 v 0 ^ 0 v 0
- SECONDARY DNS: 0 ^ 0 v 0 ^ 0
- PRIMARY WINS: 0 v 0 ^ 0 v 0
- SECONDARY WINS: 0 ^ 0 v 0 ^ 0
- Use IP header compression:
- Use default gateway on remote network:
- Buttons: OK, CANCEL

FIG. 5

TIME	PLACE	CONNECTIVITY DATA											COM- PRESSOR	HEATER	% LHe LEVEL	LHe PRESSURE (PSIA)	COLDHEAD TEMP (K)	SLEEVE RECON TEMP (K)	SHIELD TEMP (F)	SLEEVE TEMP (K)	RECON TEMP (K)
		ATTEMPTS	RT Tx/Rx RATE (BYTES / SEC)	AVG (ms)	% LOSS	H ₂ O FLOW (GPM)	H ₂ O TEMP (F)														
8:42	PRE-TRIP@MR PAD13	1	15.88	2519	0	2.886	51.36	38.79	5.324	4.271	4.249	4.026	98.78	ON	ON						
11:53	PAD13 ON GENERATOR	1	15.85	2524	0	2.885	51.36	38.79	5.324	4.271	4.305	3.996	98.78	OFF	ON						
12:23	I-94 EAST BETWEEN GEMS AND MILWAUKEE-LIGHT RAIN CLOUDY	3	15.85	2524	0	2.954	51.4	38.79	5.324	4.282	4.26	3.93	98.78	OFF	ON						
12:49	I-894 EAST	3	15.92	2513	0	2.955	51.55	38.79	5.324	4.271	4.317	3.907	98.78	OFF	ON						
1:28	I-94 SOUTH BETWEEN MILWAUKEE AND CHICAGO	2	15.82	2528	0	2.955	51.23	38.35	5.324	4.271	4.249	3.939	98.78	ON	ON						
1:53	I-294 SOUTH CHICAGO BYPASS	2	15.10	2649	20	2.955	51.4	38.35	5.324	4.271	4.26	3.998	98.78	ON	ON						
2:31	I-94 NORTH DOWNTOWN CHICAGO	1	15.16	2638	0	2.966	51.5	38.35	5.324	4.282	4.282	4.053	98.78	ON	ON						
2:57	I-94 NORTH DOWNTOWN CHICAGO	2	15.23	2627	10	2.966	51.6	38.35	5.337	4.282	4.26	4.113	98.78	OFF	ON						
3:20	I-94 NORTH BETWEEN CHICAGO AND MILWAUKEE	1	15.79	2533	0	2.965	51.62	38.79	5.337	4.282	4.26	4.09	98.78	OFF	ON						
4:25	I-94 NORTH DOWNTOWN MILWAUKEE	1	15.79	2533.88	20	2.966	51.67	38.35	5.324	4.282	4.249	4.09	98.78	OFF	ON						
5:00	I-94 WEST BETWEEN MILWAUKEE AND GEMS	1	15.13	2642.9	10	2.966	51.55	38.97	5.337	4.282	4.154	4.154	98.78	OFF	ON						

ROUTE: 250
MILES
THROUGH
CHICAGO
W / AM45

FIG. 7

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WIRELESS MONITORING OF A MOBILE MAGNET

CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

FIELD OF THE INVENTION

The present invention relates generally to mobile magnet systems used in medical diagnostics. More specifically, the present invention relates to systems and methods of monitoring such mobile magnet systems.

BACKGROUND OF THE INVENTION

A mobile magnetic resonance imaging (mobile MRI) system provides medical imaging that is transportable for sale or lease to medical facilities in a variety of locations. The mobile MRI is mounted to a movable trailer and towed by a tractor or truck. The mobile MRI offers great convenience and flexibility for various medical diagnostic applications.

One challenge of the mobile MRI is cooling the magnet. The mobile MRI includes a cooling system filled with a coolant, such as, liquid helium. Several characteristics of the coolant must be monitored, including the coolant level, coolant temperature, and coolant pressure. In the conventional system, a data monitor stores this information and provides an alert when one of the coolant characteristics exceeds a predetermined threshold. An operator at the mobile MRI must then make a service call to a technician to have the mobile MRI serviced.

One drawback of this method of monitoring the mobile MRI is that a human operator must be present at all times to watch the data monitor. The mobile MRI sometimes experiences periods during which no human operator is actively watching the data monitor. For example, during travel to a medical facility or during temporary storage at a yard facility, no human operator is present to monitor the mobile MRI. Consequently, the coolant level is not always timely replaced and additional magnet repair and service is required due to unobserved coolant depletion.

Accordingly, there is a need for an improved system and method for monitoring mobile magnet systems. Further, there is a need for a system and method for monitoring a mobile magnet without the need for constant human supervision of the mobile magnet. Further still, there is a need for a centralized monitoring system of a plurality of mobile magnets to improve the timeliness and cost-effectiveness of mobile magnet service.

SUMMARY OF THE INVENTION

According to one exemplary embodiment, a method of servicing a mobile magnet is provided. The mobile magnet has a sensor configured to sense a characteristic of the mobile magnet and a computer coupled to the sensor configured to receive sensor data representative of the sensed characteristic. The method includes receiving the sensor data at a remote monitoring station via a wireless communication link with the computer; determining whether the

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mobile magnet needs service based on the sensor data; and dispatching a service technician to the mobile magnet when the mobile magnet needs service.

According to another exemplary embodiment, a wireless monitoring system for a mobile magnet installed on a mobile vehicle is provided. The mobile magnet has a sensor configured to sense a characteristic of the mobile magnet and a computer coupled to the sensor configured to store mobile magnet data representative of the sensed characteristic. The system includes a wireless transmitter, a wireless receiver, and a central computer. The wireless transmitter is coupleable to the computer and configured to receive the mobile magnet data from the computer, to convert the mobile magnet data to a format suitable for wireless transmission, and to transmit the converted mobile magnet data wirelessly. The wireless receiver is located remotely from the mobile magnet and is configured to receive the transmitted mobile magnet data. The central computer is coupled to the wireless receiver and is configured to store the mobile magnet data and to provide an indication whether the mobile magnet needs service.

According to yet another exemplary embodiment, a mobile magnet system includes a mobile magnet adapted for use in a medical diagnostic application, a coolant system configured to provide a coolant to the mobile magnet, and a plurality of sensors coupled to the coolant system configured to sense characteristics of the coolant system. The mobile magnet system further includes a data recorder coupled to the sensors and configured to store sensor data based on the sensed characteristics and a wireless transmitter coupled to the data recorder and configured to receive the sensor data, to convert the sensor data to a format suitable for wireless transmission, and to transmit the sensor data wirelessly to a remote central computer.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more fully understood from the following detailed description, taken in conjunction with the accompanying drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a simplified block diagram of a mobile magnet monitoring and service system according to an exemplary embodiment;

FIG. 2 is a flow chart of a method of servicing a mobile magnet according to an exemplary embodiment;

FIG. 3 is a block diagram of a transceiver unit for the system of FIG. 1;

FIG. 4 is a diagram of a mounting for a transceiver antenna for the system of FIG. 1;

FIG. 5 is a diagram illustrating three display screens generated by the central computer of the system of FIG. 1;

FIG. 6 is a diagram illustrating a display screen generated by the central computer of the system of FIG. 1; and

FIG. 7 is a table having data from exemplary mobile magnet monitoring applications.

DETAILED DESCRIPTION OF THE INVENTION

Referring first to FIG. 1, a mobile magnet monitoring and service system 10 is shown in block diagram form. System 10 includes a mobile magnet system 12, a central monitoring facility 14, and a service technician center 16. Mobile magnet system 12 includes a mobile magnet 18, such as the type used in a magnetic resonance imaging system, which is housed in a mobile apparatus, such as a wheeled trailer.

Mobile magnet system **12** is adapted to perform a medical procedure on a patient, such as an MRI or other diagnostic procedure. In this exemplary embodiment, mobile magnet system **12** is a GE True Mobile MR System, manufactured by General Electric Medical Systems, Milwaukee, Wis.

Mobile magnet system **12** further includes a cooling system **20** coupled to mobile magnet **18** configured to cool mobile magnet **18**. In this exemplary embodiment, a liquid coolant, such as liquid helium, consumable coolant, water, or other coolant, is held in a reservoir within cooling system **20** and is pumped throughout mobile magnet **18** to cool the magnet core.

Mobile magnet system **12** further includes a plurality of sensors **22** positioned at various locations on or near magnet core **18** and/or cooling system **20** configured to sense various characteristics of mobile magnet **18**. For example, sensors **22** may sense coolant level, coolant temperature, coolant pressure, cooling system status (e.g., compressor status, etc.), magnet system status, etc. Exemplary sensors include a system cabinet power monitor sensor, a compressor run state/temperature sensor (e.g., GE part number 2262271 manufactured by Sumitomo), a magnet heater state sensor (e.g., Sumitomo part number 668956 manufactured by Sumitomo Cryogenics/America), a magnet pressure sensor (e.g., American Magnetics part number 034603 manufactured by American Magnetics, Inc.), a magnet temperature sensor (e.g., Sumitomo part number 668956 manufactured by Sumitomo Cryogenics/America), and a magnet quench detector (e.g., GE Pacific PTE part number 878102 manufactured by GE Pacific PTE Ltd.). Sensors **22** may further sense other characteristics of mobile magnet **18** and other characteristics of mobile magnet system **12**.

Sensors **22** are coupled to a computer **24**. Computer **24** is a magnet monitor/data recorder in this exemplary embodiment, but may be any type of computing apparatus having digital and/or analog components, input/output ports, displays, etc. Computer **24** is configured to receive sensed signals from sensors **22** and to store sensor data or mobile magnet data based on the signals in an associated memory (e.g., a hard drive, magnetic tape, solid state memory, etc.).

Mobile magnet system **12** further includes a network (e.g., a local area network) or data bus **26** coupling computer **24** to a location signal generation circuit **28** and to a wireless transceiver **30**. Network **26** further couples computer **24**, circuit **28**, and transceiver **30** to other co-located computer systems. Network **26** allows computer **24** to collect operational data not provided by sensors **22**. This additional operational data can also be transferred to remote, central facility **14** to assist in prediction of service needs.

In this exemplary embodiment, location signal generation circuit **28** includes a global positioning receiver configured to receive satellite signals from a plurality of global positioning system satellites and to generate location data in latitude/longitude/elevation coordinates and to provide the location data to network **26**. In alternative embodiments, location signal generation circuit **28** may utilize other navigational tools, such as, a wheel speed sensor, a gyroscope, a compass, other radio frequency signals (e.g., differential GPS signals, position triangulating signals, etc.), cellular phone signals, pager signals, wireless E-911 signals, etc. Location signal generation circuit **28** may be integral with wireless transceiver **30**, or may include a separate receiver unit.

Mobile magnet system **12** further includes a wireless transceiver **30**, an exemplary embodiment of which will be described in greater detail with reference hereinbelow to

FIG. **3**. Central monitoring facility **14** includes a similar wireless transceiver **32**. Wireless transceiver **30** and wireless transceiver **32** are configured for uni- or bi-directional communication via communication link **34**. Communication link **34** may include any wireless communication technology, including radio frequency, circuit-switched links provided by terrestrial cellular systems (e.g., AMPS, CDMA, TDMA, iDEN or GSM) as well as geostationary satellite networks (American Mobile Satellite Corporation, TMI Communications, Inmarsat, Globalstar), packet-switched links provided by terrestrial networks (Mobitex, DataTac, CDPD), and satellite networks (Norcom, AMSC, TMI, Inmarsat, Orbcomm, Qualcomm), etc. In this exemplary embodiment, a circuit-switched data link provided by American Mobile Satellite Corporation, Skycell, is utilized with a mobile satellite terminal, specifically, a Westinghouse Series 1000 Mobile Satellite Terminal, manufactured by Westinghouse Wireless Solutions Company. This satellite terminal provides nation-wide or even global coverage for data and voice services, which is particularly advantageous since mobile magnet system **12** may travel great distances.

Central monitoring facility **14** is at a location remote from mobile magnet system **12** and configured to communicate with a plurality of mobile magnet systems, such as, system **12**. Facility **14** includes wireless transceiver **32** and a central computer **36**. Central computer **36** includes suitable storage memory, input/output devices, and displays necessary to perform the functions described hereinbelow. Central computer **36** is further configured to communicate with a service call receiver **38** (e.g., a telephone, a wireless transceiver, a pager, etc.) at a service technician center **16** to dispatch a service technician in the vicinity of mobile magnet system **12** for service of mobile magnet **18**. Alternatively, a human operator may operate central computer **36** and place a service request to service technician center **16** using any suitable communication medium, such as, a telephone, pager, etc.

According to one alternative, wireless transceiver **32** need not be located at facility **14**. Rather, a terrestrial wired network connection may serve to couple central computer **36** with wireless transceiver **32** located at the wireless service provider facility (not shown). For this exemplary embodiment, wireless transceiver **32** resides at the AMSC ground station in Reston, Va. and the Public Switched Telephone Network (PSTN) is used to couple computer **36** to wireless transceiver **32**.

In operation, computer **24** is configured to monitor one or more characteristics (e.g., coolant level, coolant temperature, coolant pressure, etc.) of mobile magnet **18** and/or coolant system **20** using sensors **22**. Computer **24** is configured to receive sensor data (e.g., mobile magnet data) representative of the sensed characteristics and to store the sensor data in a volatile or non-volatile memory. Periodically (e.g., hourly, every few hours, daily, weekly, etc.), computer **24** provides the mobile magnet data to network **26**. Alternatively, computer **24** may provide the mobile magnet data directly to wireless transceiver **30** via a separate bus. Transceiver **30** converts the mobile magnet data to a format suitable for wireless transmission, utilizing one of the wireless technologies set forth hereinabove, and transmits the converted mobile magnet data wirelessly via communication link **34** to wireless transceiver **32**.

Referring now to FIG. **2**, a method **50** of servicing mobile magnet system **12** using one or more components of system **10** will now be described. At step **52**, central computer **36** receives the sensor data via the wireless communication link and stores the sensor data in a memory. At step **54**, location data may also be received, as will be described hereinbelow.

At step 56, central computer 36 may perform various analysis and monitoring functions on sensor data when it is received. For example, central computer 36 can determine the condition of coolant circulating through mobile magnet 18 based on the sensor data. Central computer 36 can further predict, based on historical data, the next time mobile magnet system 12 will need service. Central computer 36 can further diagnose and categorize (e.g., by severity) various problems with mobile magnet system 12. For example, if coolant pressure suddenly drops significantly, central computer 36 can identify this drop as a serious problem. Based on step 56, a local service technician may be dispatched to mobile magnet system 12, as shown by step 58. For example, if a serious problem is identified, central computer 36 will make an immediate service call to service technician center 16 and indicate the level of urgency.

According to one alternative embodiment of step 56, computer 24 continuously monitors one or more characteristics of mobile magnet system 12 and, upon detecting a problem indicating a need for service, transmits mobile magnet data via wireless transceiver 30 to central computer 36. Computer 36 then may further diagnose the problem and, if necessary, make the necessary service call or calls to service technician center 16. Alternatively, computer 36 may directly make the necessary service call without further diagnosis, since computer 24 has already detected a problem indicating a need for service.

Computers 24 and 36 may operate autonomously or with the assistance of a human operator. According to one example, at step 56, computer 36 displays the raw sensor data received from wireless transceiver 32, and a human operator makes a determination whether mobile magnet 18 needs service. The human operator then contacts a service technician at a nearby service technician center 16 and orders a service call to mobile magnet system 12. Regardless of whether a human operator is used, the determination of whether service is required may be made in any number of ways, such as by comparing the mobile magnet data to a predetermined parameter or threshold. For example, if the level of a consumable coolant drops below a minimum consumable coolant level, service is needed to re-fill the consumable coolant. In this example, one human operator can monitor multiple mobile magnet systems from a single, central facility.

According to a further advantageous feature, location generation circuit 28 generates location data representative of the location of mobile magnet system 12 and provides the location data on network 26. Computer 24 receives the location data and provides the location data in a format suitable for transmission via wireless transceiver 30. Wireless transceiver 30 is configured to transmit the data either alone or in combination (i.e., juxtaposed) with each transmission of mobile magnet data to central monitoring facility 14 to provide spatial reference to the imaging system. Location data could be included in a log file and/or an alarm log of computer 24. Further, a position history file could be added into the log file structure of computer 24 to record the history of movement of system 12. This feature enables numerous advantageous functionalities. For example, an operator at central monitoring facility 14 could receive location data from computer 24 via wireless link 34 to determine where system 12 is and where it has been. Computer 24 could be configured for "location call-out" to allow system 12 to report a change in location periodically or at incremental distances, both of which would be configurable by remote programming or by a human operator resident in system 12. A remote operator at facility 14 could

poll system 12 for position information and position history. Further, a human operator at system 12 could use position information to determine route optimization. Mobile magnet system 12 frequently moves from location to location and may move from the range of one service technician to another. Thus, the location data assists in identifying the nearest service technician center and further assists in instructing the service technician where mobile magnet system 12 is located. Thus, the spatial reference is leveraged to support location of the mobile system for timely and economical replenishment of coolant or other service events.

According to yet another advantageous feature, central computer 36 may provide data to mobile magnet system 12, utilizing wireless link 34 in a bi-directional embodiment. For example, computer 36 may provide sensor configuration data, computer software updates, transceiver configuration data, such as which frequency to use or which phone number to call, a system reboot command to perform a system reboot, a temporary power down command, reset alerts, etc.

Referring to FIGS. 3-7, a working example will now be described in detail. It is understood that the specific components and configuration recited herein are merely exemplary. Referring to FIG. 3, a wireless transceiver unit (TU) 60 which may be utilized for wireless transceiver 30 (and/or wireless transceiver 32) will now be described. In this exemplary embodiment, transceiver unit 60 is a Westinghouse Series 1000 transceiver using a mobile satellite, circuit-switched data channel, such as that provided by American Mobile Satellite Corporation. Computer 24 is configured to use an external modem and is coupled to transceiver unit 60 at data connector 62 using, for example, RS-232 cable 64. The Westinghouse Series 1000 transceiver provides standard modem interface and functionality including the Hayes AT Command Set. An antenna electronics unit (AEU) 66 is mounted in close proximity to transceiver unit 60 and within 15 feet of a high gain contoured dome antenna 68 (see also FIG. 4). Transceiver unit 60 further includes a GPS/CTRL connector 70 which may receive GPS data from location signal generation circuit 28 and display this GPS data on a handset 169. GPS/CTRL connector 70 further includes a jump between pins 6 and 1 on the CTRL port for un-commanded power-up initialization.

Referring now to FIG. 4, antenna 68 is mounted on the front of the wheeled vehicle (e.g., a van in this embodiment) forward of (at least one inch) and below air conditioning units associated with the van. Antenna 68 is mounted to an aluminum bracket 72 which is, in turn, mounted to the air conditioning units. The air conditioning units are shock mounted to the trailer (not shown) to minimize the vibration from the air conditioning units. A ¼-inch thick LEXAN resin shield 74 having a bend 76 of approximately 80 degrees protects antenna 68 from damage due to branches, birds, or other small objects that may strike the front of the van while moving at highway speeds. LEXAN is a trademark of and is manufactured by General Electric Plastics. Antenna 68 is mounted to provide adequate antenna look angle for satellite access in any direction of van travel anywhere in the continental United States.

Referring now to FIG. 5, remote monitoring of system 12 in this working example was performed using a laptop PC running Microsoft Windows 95 as central computer 36. FIG. 5 illustrates three display screens utilized for establishing the dial-up, circuit-switched satellite connection. In the first screen 80, a telephone number associated with transceiver 30 is input in a telephone number field 82. A PCMCIA modem local to computer 36 is selected in field 84 configured for 4,800 bits per second, 8-N-1 format, hardware flow

control, no error correction, terminal Windows post dial. In a second screen **86**, TCP/IP protocol is selected at field **88**. At a third screen **90**, "server assigned IP address" is selected at field **92**. The AMSC circuit switched data service allows connections to mobile wireless transceiver **32** via telephone or over the PSTN. Thus, the screens of FIG. **5** serve to configure the Windows 95 operating system of central computer **36** for the activation of such a telephone call. Following the initiation of such a PSTN call, the PCMCIA modem synchronizes with a modem at transceiver **32**, then computers **24** and **36** establish a Point-to-Point (PPP) protocol link upon which TCP/IP protocol traffic may be exchanged.

Referring now to FIG. **6**, after dial-up network configuration is complete, the laptop PC contacts wireless transceiver **30** via satellite. Transceiver **30** provides access to network **26**. An operator then inputs a TCP/IP address to connect to computer **24**. After the PPP network connection is established, data can now be accessed using TCP/IP-based applications (e.g., telnet, FTP, HTTP web browsing, etc.). Display screen **94** illustrates an example of HTTP web browser access.

Computer **24** is configured to provide sensor data in HTML file format in this exemplary embodiment, as shown in FIG. **6**. A chart **96** has columns for item name **98**, value **100**, units **102**, alarm on/off **104**, and status **106**. For example, water flow has a value of 2.918 GPM (gallons per minute) and the alarm is "Y" indicating "Off" and the status is OK. As another example, the nitrogen level is at 0% and the alarm is "N" indicating "On" or "Neutral" and the status is "Off". Additional data (e.g., MR system fault logs) is reported in a second table **108**.

Referring now to FIG. **7**, a table of several successful communication sessions utilizing the working example of FIGS. **3-6** is shown. The fourth column, labeled "RT Tx/Rx rate" indicates the time required for a data package to travel from computer **24** to central computer **36** and back again to computer **24**. Several observations were made: 1. robust login scripting is required to establish automatic connections, 2. error detection and correction functionality is required as the mobile wireless environment was observed to induce data corruption, and 3. the data rate achieved (approximately 450 Bytes per second (BPS) to send data) was sufficient to support magnet monitoring.

While the exemplary embodiments illustrated in the FIGS. and described above are presently preferred, it should be understood that these embodiments are offered by way of example only. For example, the particular values, settings and speeds of the communication link will vary based on the hardware and software being used. Furthermore, a variety of wireless technologies are commercially available for such an implementation. Accordingly, the present invention is not limited to a particular embodiment, but extends to various modifications that nevertheless fall within the scope of the appended claims.

What is claimed is:

1. A method of servicing a mobile magnetic resonance imaging magnet, the mobile magnetic resonance imaging magnet having a sensor configured to sense a characteristic of the mobile magnetic resonance imaging magnet and a computer coupled to the sensor configured to receive sensor data representative of the sensed characteristic, comprising:

receiving the sensor data at a remote monitoring station via a wireless communication link with the computer that is coupled to the sensor of the mobile magnetic resonance imaging magnet;

determining whether the mobile magnetic resonance imaging magnet needs service based on the sensor data; and

dispatching a service technician to the mobile magnetic resonance imaging magnet when the mobile magnetic resonance imaging magnet needs service.

2. The method of claim **1**, further comprising receiving location data at the remote monitoring station via the wireless communication link, wherein the location data is representative of the location of the mobile magnet.

3. The method of claim **1**, wherein the sensor data is received periodically.

4. The method of claim **1**, wherein the sensor data is received only when the computer detects a need for service of the mobile magnetic resonance imaging magnet.

5. The method of claim **1**, wherein the wireless communication link includes a satellite network.

6. The method of claim **1**, wherein the sensor data is representative of at least one of coolant level, coolant temperature, and coolant pressure.

7. The method of claim **1**, wherein the step of determining includes comparing the received sensor data to a predetermined parameter.

8. The method of claim **7**, wherein the received sensor data is representative of a level of consumable coolant of the mobile magnetic resonance imaging magnet and the predetermined parameter includes a minimum consumable coolant level.

9. The method of claim **1**, further comprising transmitting data via the wireless communication link from the remote monitoring station to the computer.

10. The method of claim **1**, wherein the sensor data is generated by at least one of a compressor run state/temperature sensor, a magnet heater state sensor, a magnet pressure sensor, a magnet temperature sensor, and a magnet quench detector.

11. A wireless monitoring system for a mobile magnetic resonance imaging magnet installed on a mobile vehicle, comprising:

a mobile magnetic resonance imaging magnet;

a sensor configured to sense a characteristic of the mobile magnetic resonance imaging magnet;

a computer coupled to the sensor configured to store mobile magnetic resonance imaging magnet data representative of the sensed characteristic;

a wireless transmitter coupled to the computer configured to receive the mobile magnetic resonance imaging magnet data from the computer, to convert the mobile magnetic resonance imaging magnet data to a format suitable for wireless transmission, and to transmit the converted mobile magnetic resonance imaging magnet data wirelessly;

a wireless receiver located remotely from the mobile magnetic resonance imaging magnet configured to receive the transmitted mobile magnetic resonance imaging magnet data; and

a central computer coupled to the wireless receiver configured to store the mobile magnetic resonance imaging magnet data and to provide an indication whether the mobile magnetic resonance imaging magnet needs service.

12. The wireless monitoring system of claim **11**, wherein the sensor is at least one of a compressor run state/temperature sensor, a magnet heater state sensor, a magnet pressure sensor, a magnet temperature sensor, and a magnet quench detector.

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13. The wireless monitoring system of claim 11, further comprising a location signal generation circuit configured to generate location data representative of an approximate location of the mobile magnetic resonance imaging magnet, wherein the wireless transmitter is configured to transmit the location data wirelessly. 5

14. The wireless monitoring system of claim 13, wherein the location signal generation circuit includes a global positioning system receiver.

15. The wireless monitoring system of claim 11, wherein the wireless transmitter includes a circuit switched satellite data terminal. 10

16. The wireless monitoring system of claim 11, wherein the stored mobile magnetic resonance imaging magnet data is representative of at least one of coolant level, coolant temperature, and coolant pressure. 15

17. The wireless monitoring system of claim 11, wherein the wireless transmitter is configured to transmit the mobile magnetic resonance imaging magnet data when service of the mobile magnetic resonance imaging magnet is needed. 20

18. The wireless monitoring system of claim 17, wherein the wireless transmitter is configured to transmit the mobile magnetic resonance imaging magnet data periodically.

19. The wireless monitoring system of claim 11, wherein the central computer is configured to provide data to the wireless receiver, wherein the wireless receiver includes an associated wireless transmitter configured to receive the data and to transmit the data wirelessly, wherein the wireless transmitter includes an associated wireless receiver configured to receive the data and to provide the data to the computer. 25

20. A mobile magnetic resonance imaging magnet system, comprising:

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a mobile magnetic resonance imaging magnet adapted for use in a medical diagnostic application;

a coolant system configured to provide a coolant to the mobile magnetic resonance imaging magnet;

a plurality of sensors coupled to the coolant system configured to sense characteristics of the coolant system;

a data recorder coupled to the sensors configured to store sensor data based on the sensed characteristics; and

a wireless transmitter coupled to the data recorder configured to receive the sensor data, to convert the sensor data to a format suitable for wireless transmission, and to transmit the sensor data wirelessly to a remote central computer.

21. The mobile magnetic resonance imaging magnet system of claim 20, further comprising a location signal generation circuit configured to generate location data representative of the approximate location of the mobile magnetic resonance imaging magnet system, wherein the wireless transmitter is configured to receive the location data, to convert the location data to a format suitable for wireless transmission, and to transmit the location data wirelessly to the remote central computer.

22. The mobile magnetic resonance imaging magnet system of claim 20, wherein the wireless transmitter is configured to transmit the sensor data both periodically and when the data recorder determines that service of the mobile magnetic resonance imaging magnet system is needed.

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专利名称(译)	移动磁铁的无线监控		
公开(公告)号	US6621413	公开(公告)日	2003-09-16
申请号	US09/639698	申请日	2000-08-16
申请(专利权)人(译)	通用电气医疗系统全球性技术公司，有限责任公司		
当前申请(专利权)人(译)	通用电气医疗系统全球性技术公司，有限责任公司		
[标]发明人	ROMAN JAMES P JOSEPHSON SEAN S DAVENPORT DAVID M		
发明人	ROMAN, JAMES P. JOSEPHSON, SEAN S. DAVENPORT, DAVID M.		
IPC分类号	G01R33/28 G01R33/3815 A61B5/055 G01R33/389 H04B7/15 G08B1/08 A61B5/00		
CPC分类号	G01R33/28 Y10S128/903		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种通过无线监控服务移动磁体的系统和方法。移动磁体具有被配置为感测移动磁体的特性的传感器和被耦合到传感器的计算机，该计算机被配置为接收表示所感测的特性的传感器数据。该方法包括通过与计算机的无线通信链路在远程监控站接收传感器数据；根据传感器数据确定移动磁体是否需要服务；当移动磁铁需要维修时，将服务技术人员派遣到移动磁铁上。

