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(54) **Bidirectional communication between a sensor unit and a monitor unit in patient monitoring**

Bidirektionelle Verbindung zwischen einer Sensoreinheit und einer Überwachungseinheit in einem Patientenüberwachungssystem

Communication bidirectionnelle entre une unité de capteur et une unité de surveillance pour la surveillance de patient

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EP 2 355 065 B1

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Description

[0001] This invention relates to patient monitoring systems and, more particularly, to the use of bidirectional communication between a sensor unit and a monitor unit.

BACKGROUND OF THE INVENTION

[0002] Advances in sensor technology, electronics, and communications have made it possible for physiological characteristics of patients to be monitored even when the patients are ambulatory and not in continuous, direct contact with a hospital monitoring system. For example, US Patent 5,959,529 describes a monitoring system having a remote monitoring unit in which a monitor unit receives the sensor output of a sensor unit that is associated with the patient. The sensor unit and the monitor unit are preferably linked by a wireless communication path. The remote monitoring unit monitors one or more physiological characteristics of the patient according to the medical problem of the patient, such as the heartbeat and its waveform. Under selected conditions, the remote monitoring unit communicates with a central unit to provide data to the central unit and to receive programming, instructions, and medical instructions from the central unit.

[0003] The monitoring system of the '529 patent and other monitoring systems, while operable, offer the opportunity for improvement and optimisation of the performance of the systems. The present invention provides such an improvement and optimisation for remote patient monitoring systems.

[0004] US-A-5,461,365 describes a multi-hazard alarm system in which one or more remote sensing units are in two-way radio communication with a monitoring base station. Hazard sensors may sense hazard conditions and send data to the remote units.

[0005] EP0811959 (A1) describes a radio controlled alarm system, for example for a fire alarm. Remote signal generators communicate bidirectionally with a central station via substations which are in bi-directional contact with each other.

[0006] FR-A-2787905 describes an alarm or surveillance system in which slave processor modules communicate asynchronously with a master unit. The master unit can send out interrogation messages to the same units on a number of channels and transmits further messages on a different communication channel if no response is received within a predetermined period.

[0007] EP-A-0,834,846 describes a system for signalling detected hazards from remote locations to a central station. The central station evaluates an alarm condition from the remote signals received. The signals are transmitted at radio frequency at two different frequencies. A test signal may be sent at one of these frequencies to check the transmission channel.

[0008] EP0484880 (A2) describes a radio alarm system where a central unit receives with its receivers at

least two radio signals from each signalling unit and checks the affiliation of the signalling units transmitting the radio signals by checking the validity of the coding.

[0009] US Patent 5,950,110 describes a wireless security system having a plurality of RF sensor/transmitters and a system controller, jamming signals are detected by comparing a near-term noise value with the expected signal strength of transmissions from the RF sensor/transmitters minus a detection threshold, and with the sum of a long-term noise value and a jamming threshold.

SUMMARY OF THE INVENTION

[0010] The present invention provides a monitoring system and a method for its use according respectively to claims 1 and 9. The monitoring system retains the basic architecture of a remote monitoring unit having a sensor unit and a monitor unit, which in turn may communicate with a central unit. The performance of the system achieves improved communications performance between the sensor unit and the monitor unit.

[0011] In accordance with the invention, a monitoring system comprises a remote monitoring unit having a sensor unit, which in turn comprises a sensor having a sensor output, a sensor bidirectional local transceiver that receives the sensor output, and a sensor unit processor in communication with the sensor unit bidirectional local transceiver. The remote monitoring unit further comprises a monitor unit having a monitor unit bidirectional local transceiver that supports bidirectional wireless communications with the sensor bidirectional local transceiver, a monitor unit processor in communication with the monitor unit bidirectional local transceiver, and a monitor unit bidirectional remote transceiver in communication with the monitor unit processor. The monitoring system may further include a central unit comprising a central unit bidirectional remote transceiver supporting bidirectional communications with the monitor unit bidirectional remote transceiver, and a central unit processor in communication with the central unit bidirectional remote transceiver.

[0012] A key feature of the monitoring system is that it transmits information bidirectionally between the sensor unit and the monitor unit. The sensor unit is conventionally viewed as having only a transmitter to transmit information to the monitor unit. However, substantial improvements in system performance as well as user convenience result from bidirectional communication between the sensor unit and the monitor unit.

[0013] For example, it is possible that information transmitted from the sensor unit to the monitor unit is corrupted in some fashion. Corruption detection techniques may be employed by the monitor unit. The monitor unit transmits a retransmit signal to the sensor unit in the event that the information is corrupted, and the sensor unit may retransmit the information to the monitor unit until uncorrupted information is received at the monitor

unit.

[0014] In another case, the monitor unit determines a signal strength of the information transmitted from the sensor unit to the monitor unit. The monitor unit may then transmit a distance warning signal to the sensor unit that the patient is straying too far from the monitor unit. The monitor unit may also send a signal-strength signal to the sensor unit so that the power output of the sensor unit may be adjusted as required under the circumstances so that no more battery power is consumed than is necessary.

[0015] In yet another situation, the sensor unit may transmit information to the monitor unit at a first frequency, and the monitor unit determines whether the signal is adversely affected by frequency-dependent interference. The monitor unit transmits a frequency-change signal to the sensor unit in the event that the information is adversely affected by frequency-dependent interference, so that the sensor unit may transmit further information to the monitor unit at a second frequency.

[0016] The monitor unit may also transmit a warning signal to the sensor unit to signal the patient to take action such as replacing a battery, viewing a message, visiting the monitor unit, and so on.

[0017] Thus, in the present approach the sensor unit is not viewed simply as a transmit-only device, which senses a physiological or other condition, converts the sensed value to an electrical signal, and then transmits the electrical signal to the monitor unit. Instead, the quality of the information received at the monitor unit and the performance of the local transceiver system may be controlled with communications back to the sensor system, and other information may be communicated to the patient through the sensor unit.

[0018] Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention. The scope of the invention is not, however, limited to this preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Figure 1 is a block diagram of a monitoring system; and

Figures 2-6 are block flow diagrams of methods for using the bi-directional communications capability between the sensor unit and the monitor unit of the monitoring system.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Figure 1 is a block diagram of a monitoring system 20. The monitoring system 20 comprises a remote monitoring unit 22 and a central unit 24. The remote mon-

itoring unit 22 includes sensor unit 26 and a monitor unit 28. The sensor unit 26 is normally carried on the body of the patient and monitors some condition of the patient or associated with the patient. The monitor unit 28 is located in moderate proximity to the patient. For example, the monitor unit 28 may be carried on the body of the patient, such as on a belt clip in the manner of a pager, or it may be placed in one room of the patient's home while the patient moves about the home. The sensor unit 26 and the monitor unit 28 are in continuous wireless communication with each other. The central unit 24 typically includes a dedicated computer, a file server, or a network connection. The central unit 24 usually serves multiple remote monitoring units 22 assigned to different patients and is in selective periodic communication with each of the remote monitoring units 22 by a wireless or land-line communication link, or through the internet.

[0021] The sensor unit 26 includes a sensor 30, and in some cases multiple sensors 30. The sensor 30 performs only a sensing function and not a control function for some other piece of apparatus. Examples of operable sensors 30 include a heart monitor sensor, a blood pressure monitor sensor, a temperature monitor sensor, a respiration sensor, a brain wave sensor, a blood chemistry sensor such as a blood glucose sensor or a blood oxygen sensor, a patient position sensor, and a patient activity sensor. Sensors of various types are known in the art, and the details of their construction and operation do not form a part of the present invention.

[0022] A sensor output 32 of each sensor 30 is provided to a sensor unit processor 34, which typically includes a microprocessor and may include necessary electronics associated with the sensor 30 such as a signal conditioner, an analog-to-digital converter, and the like. The sensor unit processor 34 may also include a patient warning device, an audio communications device such as an audio transceiver, and other features. The sensor unit 26 further includes one terminal of a sensor bidirectional local transceiver 36 that is in communication with the sensor unit processor 34 and that also receives the sensor output 32, either directly or through the sensor unit processor 34. The sensor unit processor 34 may also include a unidirectional or bidirectional audio capability with a microphone and/or a speaker, and in that case the sensor bidirectional local transceiver 36 supports voice communication as well as data communication.

[0023] The monitor unit 28 includes a monitor unit bidirectional local transceiver 38 that supports bidirectional wireless communication with the sensor bidirectional local transceiver 36, as indicated by the wireless communications link 40. The two bidirectional local transceivers 36 and 38 are preferably radio frequency transceivers of relatively low power. In a preferred case using currently available technology, the two bidirectional local transceivers 36 and 38 are Texas Instruments TRF 6900A transceivers operating in the ISM frequency band of from about 902 MHz to about 928 MHz and at a controllable power level of up to about 4 milliwatts. Such transceivers

typically have a range of up to about 10 to 100 meters, and are therefore termed "local transceivers". Their range is limited by their available maximum power consumption, and their power is typically supplied by respective batteries (not shown) in the sensor unit 26 and the monitor unit 28.

[0024] In one conventional practice, the communication between the sensor unit 26 and the monitor unit 28 would be unidirectional in the direction from the sensor unit 26 to the monitor unit 28, keeping in mind that the sensor 30 performs only its sensing function and not a control function for some other piece of apparatus. In this conventional practice, there would be no reason to have communications from the monitor unit 28 back to the sensor unit 26. The present invention uses bidirectional communications with the sensor and provides important features and practices deriving from the bidirectional communications that optimize the operation of the monitoring system 20, and yield surprising and unexpected advantages relative to the conventional unidirectional communications approach. These approaches available through bidirectional communications will be discussed subsequently.

[0025] The monitor unit 28 further includes a monitor unit processor 42 in communication with the monitor unit bidirectional local transceiver 38. The monitor unit processor 42 typically includes a microprocessor. A monitor unit bidirectional remote transceiver 44 is in communication with the monitor unit processor 42.

[0026] The central unit 24 includes a central unit bidirectional remote transceiver 46 supporting bidirectional communications with the monitor unit bidirectional remote transceiver 44. The remote transceivers 44 and 46 may be of any operable type. In a preferred embodiment, the remote transceivers 44 and 46 are selectively linked by two (or more) different communications links. The remote transceivers 44 and 46 may be linked through the available cellular telephone system 48 to implement wireless communications on an urgent basis or in some cases for routine communications. In this communications arrangement, the monitor unit bidirectional remote transceiver 44 is typically linked to the cellular telephone system 48 via a dial-up wireless communications link 50, and the central unit bidirectional remote transceiver 46 is typically linked to the cellular telephone system 48 via a landline 52. (The link between the central unit bidirectional remote transceiver 46 and the cellular telephone system 48 may instead also be via a dial-up wireless communications link. An internet-based may also be used where available, with access to the internet being through a land line or with a wireless connection. The internet link may utilize any of the high-speed communications capabilities available in that medium.)

[0027] The second communications link between the remote transceivers 44 and 46 is a land-line 54 through the conventional hard-wired telephone system to implement routine communications. The monitor unit 28 is preferably structured to be connected with a base station

58 for communication through a connector 60. The base station 58 desirably includes a cradle in which the monitor unit 28 is received. The connector 60 is mated and electrically connected to the monitor unit 28 when the monitor unit 28 is placed into the cradle. The base station 58 includes a modem 62 that provides for bidirectional communication through the connector 60 with the monitor unit 28, and for land-line communication 54 to the central unit bidirectional remote transceiver 46. The base station 58 also includes a charging unit 64 and an appropriate connector that charges the rechargeable batteries of the monitor unit 28 when the monitor unit 28 is connected to the base station 58. The base station 58 may optionally be provided with an interface/communications link 65, such as an RS232 connector or a universal serial bus, to a separate optional computer 66 for local communications with the monitor unit 28. The computer 66, where present, may be linked by a separate communication path 67, such as a land line telephone line, to the central unit bidirectional remote transceiver 46.

[0028] In this architecture, the communications link through the base station 58 and land-line 54 is preferred for use when available. When there is no access to the conventional telephone system, however, the monitor unit 28 uses the communications link through the cellular telephone system 48. This cellular telephone capability allows the monitor unit 28 to be portable so that the patient has freedom of movement within the service area of the cellular telephone system. The present system is compatible with the use of other types of remote communications links, such as marine communications links, satellite communications links, and other communications technologies now available or that will be developed.

[0029] The central unit 24 further includes a central unit processor 56 in communication with the central unit bidirectional remote transceiver 46. The central unit processor 56 typically includes a microprocessor and interfaces with medical personnel and databases.

[0030] Further details of portions of the monitoring system 20 may be found in US Patent 5,959,529, whose entire disclosure is incorporated by reference.

[0031] Figures 2-6 are block diagrams illustrating examples of practices utilizing the bidirectional communication capability of the bidirectional local transceivers 36 and 38. Other practices may be employed as well in utilizing the bidirectional communication capability, and the use of the present invention is not limited to those discussed in relation to Figures 2-6.

[0032] Referring to Figure 2, the sensor unit 26 transmits information to the monitor unit 28, numeral 70, via the bidirectional local transceivers 36 and 38 over the communications link 40. This information is typically patient data from the sensor output 32, but it may be other information as well. Such information is normally transmitted in data packets. It is possible that the transmitted information is corrupted in some fashion, as by the loss of data bits. The monitor unit 28 determines whether the information is corrupted, numeral 72, using any suitable

technique such as, for example, checksums, cyclic redundancy checks, or forward error correction and checking. The monitor unit 28 transmits a retransmit signal to the sensor unit 26, numeral 74, in the event that the information is corrupted as determined in step 72. In that event, the sensor unit 26 retransmits the same information to the monitor unit 28, numeral 76.

[0033] Referring to Figure 3 showing another practice, the sensor unit 26 transmits information to the monitor unit 28, numeral 80. The monitor unit 28 determines a signal strength of the information, numeral 82. This determination is preferably made by evaluating the amplitude of a standard portion of the information that is provided for this purpose, either with an analog instrument or digitally. In the event that the signal strength is too low, suggesting that the physical distance between the sensor unit 26 and the monitor unit 28 is too far under the current transmission conditions, the monitor unit 28 transmits a distance warning signal to the sensor unit 26, numeral 84. The sensor unit 26 notifies the patient that the patient should not stray so far from the monitor unit 28 or should check the battery. Optionally, the monitor unit 28 may also inform the central unit 24 that the patient is exceeding the permissible distance between the sensor unit 26 and the monitor unit 28, so that the central unit 24 may separately contact the patient.

[0034] The approach of Figure 3 may also be applied to determining whether the battery of the sensor unit 26 is discharging to such a low level that it may not support later transmissions. In this variation, the sensor unit transmits a battery voltage or other indication of the state of the battery charge in step 80. The transmitted information is evaluated, numeral 82. If the battery is discharged to an unsuitably low level, the patient is warned, numeral 84, so that the patient can change or recharge the battery.

[0035] Even when the battery is not nearing discharge, it is desirable to adjust the operation of the sensor bidirectional local transceiver 36 so that it does not transmit at a higher power level than is necessary, in order to conserve the battery charge. Referring to Figure 4 showing this practice, the sensor unit 26 transmits information to the monitor unit 28 at a first power output of the sensor bidirectional local transceiver 36, numeral 90. The monitor unit 28 determines a signal strength of the transmitted information, numeral 92, using the same approaches as discussed above in relation to step 82. The monitor unit 28 transmits a signal-strength signal to the sensor unit 26, numeral 94. The sensor unit 28 may thereafter adjust the power output of the sensor bidirectional local transceiver 36 to a second power output, numeral 96. (This practice may be performed in the opposite direction as well, wherein the monitor unit 28 transmits information to the sensor unit 26 at a first power output, the sensor unit 26 determines a signal strength of the information, the sensor unit 26 transmits a signal-strength signal to the monitor unit 28, and the monitor unit 28 adjusts the power output of the monitor unit bidirectional local trans-

ceiver 38.) The adjustment of the power output is important to conserving the battery power of the sensor unit 26 and the monitor unit 28. These units typically are small in size with relatively small battery capacity, and the adjustment of the power output helps to prolong the battery life. The adjustment of the power output may increase the power output when needed, or decrease the power output to the level where there is just sufficient signal strength to meet the requirements of the receiving unit.

[0036] Referring to Figure 5 showing another practice, the sensor unit 26 transmits information to the monitor unit 28 at a first frequency, numeral 100. The monitor unit 28 determines whether the transmitted signal is adversely affected by frequency-dependent interference, numeral 102. That is, most types of radio frequency interference are frequency-dependent, so that they affect transmissions at some frequencies and do not affect transmissions at other frequencies. The nature of the frequency-dependent interference may be determined in the monitor unit 28 by existing techniques such as noting corruption in data transmitted at different frequencies and by receiving data at unanticipated times. After the nature of the frequency-dependent interference and a potential clear frequency are determined, the monitor unit 28 transmits a frequency-change signal to the sensor unit 28, numeral 104. The sensor unit 26 then changes the frequency of transmission of the sensor bidirectional local transceiver 36, and the sensor unit 26 transmits further information to the monitor unit 28 at a second frequency, numeral 106. The further information can be a retransmission of the information which was interfered with at the first frequency, or subsequent information, or both. This process may be repeated if interference is observed and becomes troubling at the second frequency.

[0037] Referring to Figure 6 showing another practice, the sensor unit 26 transmits information to the monitor unit 28, numeral 110. The monitor unit 28 transmits a warning signal to the sensor unit 26, numeral 112. The warning signal may be generated responsive to the information transmitted in step 110, or may be responsive to other sources. The warning signal may request the patient to come to the monitor unit, may request the patient to contact the central unit 24, or may request the patient to take one of many other possible actions such as replacing batteries in the sensor unit.

[0038] The various practices in Figures 2-6 are possible only because of the bidirectional communication capability between the local transceivers 36 and 38. These practices may be used individually, or in combination with each other or with other bidirectional capabilities.

[0039] Although a particular embodiment of the invention has been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the invention which is defined by the appended claims.

[0040] Further examples can be described with reference to the following numbered clauses, with preferred features laid out in the dependent clauses:

Clause 1: A method for monitoring a patient, comprising the steps of: providing a monitoring system comprising: a remote monitoring unit comprising a sensor unit comprising a sensor having a sensor output, a sensor bidirectional local transceiver that receives the sensor output, and a sensor unit processor in communication with the sensor unit bidirectional local transceiver, and a monitor unit comprising a monitor unit bidirectional local transceiver that supports bidirectional wireless communications with the sensor bidirectional local transceiver, a monitor unit processor in communication with the monitor unit bidirectional local transceiver, and a monitor unit bidirectional remote transceiver in communication with the monitor unit processor; and transmitting information bidirectionally between the sensor unit and the monitor unit.

Clause 2: The method of clause 1, wherein the step of transmitting includes the steps of the sensor unit transmitting information to the monitor unit, the monitor unit determining whether the information is corrupted, and the monitor unit transmitting a retransmit signal, to the sensor unit in the event that the information is corrupted.

Clause 3: The method of clause 2, including an additional step, after the step of the monitor unit transmitting, of the sensor unit retransmitting the information to the monitor unit.

Clause 4: The method of clause 1, wherein the step of transmitting includes the steps of the sensor unit transmitting information to the monitor unit, the monitor unit determining a signal strength of the information, and the monitor unit transmitting a distance warning signal to the sensor unit.

Clause 5: The method of clause 1, wherein the step of transmitting includes the steps of the sensor unit transmitting information to the monitor unit at a first power output, the monitor unit determining a signal strength of the information, and the monitor unit transmitting a signal-strength signal to the sensor unit.

Clause 6: The method of clause 5, including an additional step, after the step of the monitor unit transmitting, of the sensor unit adjusting the power output to a second power output.

Clause 7: The method of clause 1, wherein the step of transmitting includes the steps of the sensor unit transmitting information to the monitor unit at a first frequency, the monitor unit determining whether the signal is adversely affected by frequency-dependent interference, the monitor unit transmitting a frequency-change, signal to the sensor unit in the event that the information is adversely affected by frequency-dependent interference.

Clause 8: The method of clause 7, including an additional step, after the step of the monitor unit transmitting, of the sensor unit transmitting further information to the monitor unit at a second frequency.

Clause 9: The method of clause 1, wherein the step of transmitting includes the steps of the sensor unit transmitting information to the monitor unit, and the monitor unit transmitting a warning signal to the sensor unit.

Clause 10: The method of clause 1, wherein the step of providing a monitoring system further includes providing a central unit comprising a central unit bidirectional remote transceiver supporting bidirectional communications with the monitor unit bidirectional remote transceiver, and a central unit processor in communication with the central unit bidirectional remote transceiver.

Clause 11: The method of clause 10, wherein the method for monitoring a patient further includes transmitting information bidirectionally between the monitor unit and the central unit.

Clause 12: A monitoring system comprising a remote monitoring unit comprising a sensor unit comprising a sensor having a sensor output, a sensor bidirectional local transceiver that receives the sensor output, and a sensor unit processor in communication with the sensor unit bidirectional local transceiver; and a monitor unit comprising a monitor unit bidirectional local transceiver that supports bidirectional wireless communications with the sensor bidirectional local transceiver, a monitor unit processor in communication with the monitor unit bidirectional local transceiver, and a monitor unit bidirectional remote transceiver in communication with the monitor unit processor.

Clause 13: The monitoring system of clause 12, wherein the monitoring system further includes a central unit comprising a central unit bidirectional remote transceiver supporting bidirectional communications with the monitor unit bidirectional remote transceiver, and a central unit processor in communication with the central unit bidirectional remote transceiver.

Claims

1. A remote patient monitoring system (20) comprising:
 - a remote monitoring unit (22) comprising
 - a sensor unit (26) that is carried on a body of the patient and monitors a condition of the patient, the sensor unit comprising
 - a sensor (30) having a sensor output (32),
 - a sensor bidirectional local transceiver (36) that receives the sensor output (32), and
 - a sensor unit processor (34) in communication with the sensor bidirectional lo-

cal transceiver (36); and

a monitor unit (28) comprising

a monitor unit bidirectional local transceiver (38) that supports bidirectional wireless communications with the sensor bidirectional local transceiver (36), a monitor unit processor (42) in communication with the monitor unit bidirectional local transceiver (38), and a monitor unit bidirectional remote transceiver (44) in communication with the monitor unit processor (42), wherein the remote transceiver (44) is operable to communicate with a central unit (24), and

wherein information is transmitted bidirectionally between the sensor unit (26) and the monitor unit (28), the sensor unit being configured to transmit information including at least patient data from the sensor output (32) to the monitor unit at a first frequency, the monitor unit (28) being configured to perform at least one of the following operations:

- (a) determining whether the transmitted information is corrupt and transmitting a retransmit signal to the sensor unit (26) to cause the sensor unit (26) to retransmit previously transmitted information,
- (b) determining a signal strength of the information and based on the determined signal strength, transmitting a distance warning signal to the sensor unit (26), and
- (c) determining whether the signal is adversely affected by frequency-dependent interference and transmitting a frequency-change signal to the sensor unit (26) in the event that the information is adversely affected by the frequency-dependent interference, and the sensor unit (26) being configured to transmit further information to the monitor unit (28) at a second frequency, wherein the transmitting of the further information including at least a retransmission of the information which was interfered with at the first frequency.

2. The remote patient monitoring system (20) of claim 1, wherein the monitor unit employs a corruption detection technique and transmits a retransmit signal to the sensor unit (26) in the event that the information is corrupted, and the sensor unit retransmits the information to the monitor unit (28) until uncorrupted information is received at the monitor unit.

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3. The remote patient monitoring system (20) of claim 2, wherein the corruption detection technique is a checksum technique, a cyclic redundancy check technique, or a forward error correction and checking technique.

4. The remote patient monitoring system (20) of any of claims 1 to 3, wherein the frequency-dependent interference is determined in the monitor unit (28) by noting corruption in the transmitted data and by receiving data at unanticipated times.

5. The remote patient monitoring system (20) of any of claims 1 to 4, wherein the sensor (30) is a heart monitor sensor, a blood pressure monitor sensor, a brain wave sensor or a blood chemistry sensor.

6. The remote patient monitoring system (20) of claim 1 or 2, wherein the monitor unit (28) can be carried on the body of the patient.

7. The remote patient monitoring system (20) of claim 1 or 2, wherein the information transmitted by the sensor unit is transmitted in data packets.

8. The remote patient monitoring system (20) of any preceding claim, wherein the remote patient monitoring system (20) further includes the central unit (24), comprising

a central unit bidirectional remote transceiver (46) supporting bidirectional communications with the monitor unit bidirectional remote transceiver (44) via a cellular telephone system (48), and a central unit processor (56) in communication with the central unit bidirectional remote transceiver.

9. A method for monitoring a patient, comprising the steps of providing a remote patient monitoring system (20) comprising

a remote monitoring unit (22) comprising a sensor unit (26) that is carried on a body of the patient and monitors a condition of the patient, the sensor unit comprising

a sensor (30) having a sensor output (32), a sensor bidirectional local transceiver (36) that receives the sensor output (32), and a sensor unit processor (34) in communication with the sensor bidirectional lo-

cal transceiver (36); and
a monitor unit (28) comprising

a monitor unit bidirectional local transceiver (38) that supports bidirectional wireless communications with the sensor bidirectional local transceiver (36), a monitor unit processor (42) in communication with the monitor unit bidirectional local transceiver (38), and a monitor unit bidirectional remote transceiver (44) in communication with the monitor unit processor (42), wherein the remote transceiver (44) is operable to communicate with a central unit (24), and

transmitting information bidirectionally between the sensor unit (26) and the monitor unit (28), wherein the step of transmitting includes the steps of
the sensor unit transmitting information including at least patient data from the sensor output (32) to the monitor unit at a first frequency, the monitor unit (28) being configured to perform at least one of the following operations:

- (a) determining whether the transmitted information is corrupt and transmitting a retransmit signal to the sensor unit (26) to cause the sensor unit (26) to retransmit previously transmitted information,
- (b) determining a signal strength of the information and based on the determined signal strength, transmitting a distance warning signal to the sensor unit (26), and
- (c) determining whether the signal is adversely affected by frequency-dependent interference and transmitting a frequency-change signal to the sensor unit (26) in the event that the information is adversely affected by frequency-dependent interference, and the sensor unit (26) being configured to transmit further information to the monitor unit (28) at a second frequency, wherein the transmitting of the further information including at least a retransmission of the information which was interfered with at the first frequency.

10. The method of claim 9, wherein the monitor unit employs a corruption detection technique and determines whether the information is corrupted, further comprising:

the monitor unit (28) transmitting a retransmit signal to the sensor unit (26) in the event that

the information is corrupted, and the sensor unit retransmitting the information to the monitor unit (28) until uncorrupted information is received at the monitor unit.

11. The method of claim 10, wherein the corruption detection technique is a checksum technique, a cyclic redundancy check technique, or a forward error correction and checking technique.

12. The method of any of claims 9 to 11, wherein the frequency-dependent interference is determined in the monitor unit (28) by noting corruption in the transmitted data and by receiving data at unanticipated times.

13. The method of any of claims 9 to 12, wherein the sensor (30) is a heart monitor sensor, a blood pressure monitor sensor, a brain wave sensor or a blood chemistry sensor.

14. The method of any one of claims 9 to 13, wherein the step of providing a remote patient monitoring system further includes providing the central unit (24), said central unit comprising

a central unit bidirectional remote transceiver (46) supporting bidirectional communications with the monitor unit bidirectional remote transceiver (44) via a cellular telephone system (48), and
a central unit processor (56) in communication with the central unit bidirectional remote transceiver.

15. The method of claim 14, wherein the method for monitoring a patient further includes transmitting information bidirectionally between the monitor unit (28) and the central unit (24) via the cellular telephone system.

Patentansprüche

1. Patientenfernüberwachungssystem (20), umfassend:

eine Fernüberwachungseinheit (22), umfassend

eine Sensoreinheit (26), die an einem Körper des Patienten getragen wird und einen Zustand des Patienten überwacht, wobei die Sensoreinheit Folgendes umfasst

einen Sensor (30) mit einem Sensorausgang (32), einen bidirektionellen lo-

kalen Sendeempfänger des Sensors (36), der den Sensorausgang (32) empfängt, und einen Prozessor der Sensoreinheit (34) in Kommunikation mit dem bidirektionalen lokalen Sendeempfänger des Sensors (36); und

eine Überwachungseinheit (28), umfassend

einen bidirektionalen lokalen Sendeempfänger der Überwachungseinheit (38), der bidirektionelle Funkkommunikation mit dem bidirektionalen lokalen Sendeempfänger des Sensors (36) unterstützt,

einen Prozessor der Überwachungseinheit (42) in Kommunikation mit dem bidirektionalen lokalen Sendeempfänger der Überwachungseinheit (38); und einen bidirektionalen Remote-Sendeempfänger der Überwachungseinheit (44) in Kommunikation mit dem Prozessor der Überwachungseinheit (42), wobei der Remote-Sendeempfänger (44) betriebsfähig ist, um mit

einer Zentraleinheit (24) zu kommunizieren, und wobei Informationen bidirektionell zwischen der Sensoreinheit (26) und der Überwachungseinheit (28) übertragen werden, wobei die Sensoreinheit dazu konfiguriert ist, Informationen, die wenigstens Patientendaten beinhalten, bei einer ersten Frequenz von dem Sensorausgang (32) an die Überwachungseinheit zu übertragen, wobei die Überwachungseinheit (28) dazu konfiguriert ist, wenigstens einen der folgenden Vorgänge auszuführen:

(a) Bestimmen, ob die übertragenen Informationen korrupt sind, und Übertragen eines Neuübertragungssignals an die Sensoreinheit (26), um die Sensoreinheit (26) zu veranlassen, zuvor übertragene Informationen erneut zu übertragen,

(b) Bestimmen einer Signalstärke der Informationen und, auf Grundlage der bestimmten Signalstärke, Übertragen eines Entfernungswarnsignals an die Sensoreinheit (26), und

(c) Bestimmen, ob das Signal durch frequenzabhängige Interferenz beeinträchtigt wird, und Übertragen eines Frequenzwechselsignals an die Sensoreinheit (26) für den Fall, dass die In-

formationen durch die frequenzabhängige Interferenz beeinträchtigt werden, und wobei die Sensoreinheit (26) dazu konfiguriert ist, bei einer zweiten Frequenz weitere Informationen an die Überwachungseinheit (28) zu übertragen, wobei das Übertragen der weiteren Informationen wenigstens eine Neuübertragung der Informationen beinhaltet, die bei der ersten Frequenz gestört wurden.

2. Patientenfernüberwachungssystem (20) nach Anspruch 1, wobei die Überwachungseinheit eine Korruptionserkennungstechnik benutzt und ein Neuübertragungssignal an die Sensoreinheit (26) überträgt, falls die Informationen korrupt sind, und die Sensoreinheit die Informationen erneut an die Überwachungseinheit (28) überträgt, bis nicht korrupte Informationen an der Überwachungseinheit empfangen werden.
3. Patientenfernüberwachungssystem (20) nach Anspruch 2, wobei die Korruptionserkennungstechnik eine Prüfsummentchnik, eine zyklische Redundanzprüfungstechnik oder eine vorwärtsgerichtete Fehlerkorrektur- und Prüftechnik ist.
4. Patientenfernüberwachungssystem (20) nach einem der Ansprüche 1 bis 3, wobei die frequenzabhängige Interferenz in der Überwachungseinheit (28) durch Feststellen von Korruption in den übertragenen Daten und durch Empfangen von Daten zu unerwarteten Zeiten bestimmt wird.
5. Patientenfernüberwachungssystem (20) nach einem der Ansprüche 1 bis 4, wobei der Sensor (30) ein Herzüberwachungssensor, ein Blutdrucküberwachungssensor, ein Gehirnwellensensor oder ein Sensor für die chemische Zusammensetzung des Blutes ist.
6. Patientenfernüberwachungssystem (20) nach Anspruch 1 oder 2, wobei die Überwachungseinheit (28) am Körper des Patienten getragen werden kann.
7. Patientenfernüberwachungssystem (20) nach Anspruch 1 oder 2, wobei die von der Sensoreinheit übertragenen Informationen in Datenpaketen übertragen werden.
8. Patientenfernüberwachungssystem (20) nach einem der vorangehenden Ansprüche, wobei das Patientenfernüberwachungssystem (20) ferner Folgendes beinhaltet die Zentraleinheit (24), umfassend

- einen bidirektionellen Remote-Sendeempfänger der Zentraleinheit (46), der bidirektionelle Kommunikation mit dem bidirektionellen Remote-Sendeempfänger der Überwachungseinheit (44) über ein zellulares Telefonsystem (48) unterstützt, und
5
einen Prozessor der Zentraleinheit (56) in Kommunikation mit dem bidirektionellen Remote-Sendeempfänger der Zentraleinheit.
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- 9.** Verfahren zum Überwachen eines Patienten, folgende Schritte umfassend
Bereitstellen eines Patientenfernüberwachungssystems (20), umfassend:
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- eine Fernüberwachungseinheit (22), umfassend
eine Sensoreinheit (26), die an einem Körper des Patienten getragen wird und einen Zustand des Patienten überwacht, wobei die Sensoreinheit Folgendes umfasst
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- einen Sensor (30) mit einem Sensorausgang (32),
25
einen bidirektionellen lokalen Sendempfhänger des Sensors (36), der den Sensorausgang (32) empfängt, und
einen Prozessor der Sensoreinheit (34) in Kommunikation mit dem bidirektionellen lokalen Sendempfhänger des Sensors (36); und
30
- eine Überwachungseinheit (28), umfassend
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einen bidirektionellen lokalen Sendempfhänger der Überwachungseinheit (38), der bidirektionelle Funkkommunikation mit dem bidirektionellen lokalen Sendempfhänger des Sensors (36) unterstützt,
40
einen Prozessor der Überwachungseinheit (42) in Kommunikation mit dem bidirektionalen lokalen Sendempfhänger der Überwachungseinheit (38), und
einen bidirektionellen Remote-Sendeempfänger der Überwachungseinheit (44) in Kommunikation mit dem Prozessor der Überwachungseinheit (42), wobei der Remote-Sendeempfänger (44) betriebsfähig ist, um mit einer Zentraleinheit (24) zu kommunizieren, und
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50
- bidirektionelles Übertragen von Informationen zwischen der Sensoreinheit (26) und der Überwachungseinheit (28), wobei der Schritt des Übertragens folgende Schritte beinhaltet
55
- Übertragen von Informationen durch die Sensoreinheit, die wenigstens Patientendaten beinhalten, von dem Sensorausgang (32) an die Überwachungseinheit bei einer ersten Frequenz, wobei die Überwachungseinheit (28) dazu konfiguriert ist, wenigstens einen der folgenden Vorgänge auszuführen:
60
- (a) Bestimmen, ob die übertragenen Informationen korrupt sind, und Übertragen eines Neuübertragungssignals an die Sensoreinheit (26), um die Sensoreinheit (26) zu veranlassen, zuvor übertragene Informationen erneut zu übertragen,
65
(b) Bestimmen einer Signalstärke der Informationen und, auf Grundlage der bestimmten Signalstärke, Übertragen eines Entfernungswarnsignals an die Sensoreinheit (26), und
(c) Bestimmen, ob das Signal durch frequenzabhängige Interferenz beeinträchtigt wird, und Übertragen eines Frequenzwechselsignals an die Sensoreinheit (26) für den Fall, dass die Informationen durch frequenzabhängige Interferenz beeinträchtigt werden, und wobei die Sensoreinheit (26) dazu konfiguriert ist, bei einer zweiten Frequenz weitere Informationen an die Überwachungseinheit (28) zu übertragen, wobei das Übertragen der weiteren Informationen wenigstens eine Neuübertragung der Informationen beinhaltet, die bei der ersten Frequenz gestört wurden.
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- 10.** Verfahren nach Anspruch 9, wobei die Überwachungseinheit eine Korruptionserkennungstechnik benutzt und bestimmt, ob die Informationen korrupt sind, ferner umfassend:
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- Übertragen eines Neuübertragungssignals durch die Überwachungseinheit (28) an die Sensoreinheit (26), falls die Information korrupt sind, und
erneutes Übertragen der Informationen durch die Sensoreinheit an die Überwachungseinheit (28), bis nicht korrupte Informationen an der Überwachungseinheit empfangen werden.
80
- 11.** Verfahren nach Anspruch 10, wobei die Korruptionserkennungstechnik eine Prüfsummentchnik, eine zyklische Redundanzprüfungstechnik oder eine vorwärtsgerichtete Fehlerkorrektur- und Prüftechnik ist.
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- 12.** Verfahren nach einem der Ansprüche 9 bis 11, wobei

die frequenzabhängige Interferenz in der Überwachungseinheit (28) durch Feststellen von Korruption in den übertragenen Daten und durch Empfangen von Daten zu unerwarteten Zeiten bestimmt wird.

- 5
13. Verfahren nach einem der Ansprüche 9 bis 12, wobei der Sensor (30) ein Herzüberwachungssensor, ein Blutdrucküberwachungssensor, ein Gehirnwellensensor oder ein Sensor für die chemische Zusammensetzung des Blutes ist.
- 10
14. Verfahren nach einem der Ansprüche 9 bis 13, wobei der Schritt des Bereitstellens eines Patientenfernüberwachungssystems ferner Folgendes beinhaltet Bereitstellen der Zentraleinheit (24), wobei die Zentraleinheit Folgendes umfasst
- 15
- einen bidirektionellen Remote-Sendeempfänger der Zentraleinheit (46), der bidirektionelle Kommunikation mit dem bidirektionellen Remote-Sendeempfänger der Überwachungseinheit (44) über ein zelluläres Telefonsystem (48) unterstützt, und
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- einen Prozessor der Zentraleinheit (56) in Kommunikation mit dem bidirektionellen Remote-Sendeempfänger der Zentraleinheit.
- 25
15. Verfahren nach Anspruch 14, wobei das Verfahren zum Überwachen eines Patienten ferner Folgendes beinhaltet bidirektionelles Übertragen von Informationen zwischen der Überwachungseinheit (28) und der Zentraleinheit (24) über das zellulare Telefonsystem.
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Revendications

- 35
1. Système de surveillance à distance de patient (20), comprenant :
- 40
- une unité de surveillance à distance (22) comprenant
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- une unité de capteur (26) qui est portée sur un corps du patient et qui surveille un état du patient, l'unité de capteur comprenant
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- un capteur (30) ayant une sortie de capteur (32),
- un émetteur-récepteur local bidirectionnel de capteur (36) qui reçoit la sortie de capteur (32), et
- un processeur d'unité de capteur (34) en communication avec l'émetteur-récepteur local bidirectionnel de capteur (36) ; et
- 55
- une unité de surveillance (28) comprenant

un émetteur-récepteur local bidirectionnel d'unité de surveillance (38) qui supporte des communications sans fil bidirectionnelles avec l'émetteur-récepteur local bidirectionnel de capteur (36),

un processeur d'unité de surveillance (42) en communication avec l'émetteur-récepteur local bidirectionnel d'unité de surveillance (38), et

un émetteur-récepteur distant bidirectionnel d'unité de surveillance (44) en communication avec le processeur d'unité de surveillance (42), dans lequel l'émetteur-récepteur distant (44) peut fonctionner pour communiquer avec une unité centrale (24), et

dans lequel de l'information est transmise bidirectionnellement entre l'unité de capteur (26) et l'unité de surveillance (28), l'unité de capteur étant configurée pour transmettre de l'information incluant au moins des données de patient issues de la sortie de capteur (32) à l'unité de surveillance à une première fréquence, l'unité de surveillance (28) étant configurée pour effectuer au moins l'une des opérations suivantes :

- (a) la détermination pour savoir si l'information transmise est altérée et la transmission d'un signal de retransmission à l'unité de capteur (26) pour faire en sorte que l'unité de capteur (26) retransmette de l'information précédemment transmise,
- (b) la détermination d'une intensité de signal de l'information, et sur la base de l'intensité de signal déterminée, la transmission d'un signal d'alerte de distance à l'unité de capteur (26), et
- (c) la détermination pour savoir si le signal est affecté négativement par une interférence dépendant de la fréquence et la transmission d'un signal de changement de fréquence à l'unité de capteur (26) dans le cas où l'information est affectée négativement par l'interférence dépendant de la fréquence, et l'unité de capteur (26) étant configurée pour transmettre de l'information complémentaire à l'unité de surveillance (28) à une deuxième fréquence, dans lequel la transmission de l'information complémentaire inclue au moins une retransmission de l'information ayant fait l'objet d'une interférence à la première fréquence.

2. Système de surveillance à distance de patient (20) selon la revendication 1, dans lequel l'unité de surveillance utilise une technique de détection d'altéra-

- tion et transmet un signal de retransmission à l'unité de capteur (26) dans le cas où l'information est altérée, et l'unité de capteur retransmettant l'information à l'unité de surveillance (28) jusqu'à ce que de l'information non altérée soit reçue à l'unité de surveillance.
- 5
3. Système de surveillance à distance de patient (20) selon la revendication 2, dans lequel la technique de détection d'altération est une technique de somme de contrôle, une technique de contrôle de redondance cyclique, ou une correction d'erreur sans voie de retour et une technique de contrôle.
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4. Système de surveillance à distance de patient (20) selon l'une quelconque des revendications 1 à 3, dans lequel l'interférence dépendant de la fréquence est déterminée dans l'unité de surveillance (28) en notant une altération dans les données transmises et en recevant des données à des moments non anticipés.
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5. Système de surveillance à distance de patient (20) selon l'une quelconque des revendications 1 à 4, dans lequel le capteur (30) est un capteur de surveillance du coeur, un capteur de surveillance de la pression sanguine, un capteur d'ondes cérébrales ou un capteur de la chimie du sang.
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6. Système de surveillance à distance de patient (20) selon la revendication 1 ou 2, dans lequel l'unité de surveillance (28) peut être portée sur le corps du patient.
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7. Système de surveillance à distance de patient (20) selon la revendication 1 ou 2, dans lequel l'information transmise par l'unité de capteur est transmise par paquets de données.
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8. Système de surveillance à distance de patient (20) selon une quelconque revendication précédente, dans lequel le système de surveillance à distance de patient (20) comprend en outre l'unité centrale (24) comprenant
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- 45
- un émetteur-récepteur distant bidirectionnel d'unité centrale (46) supportant des communications bidirectionnelles avec l'émetteur-récepteur distant bidirectionnel d'unité de surveillance (44) via un système de téléphone cellulaire (48), et
- 50
- un processeur d'unité centrale (56) en communication avec l'émetteur-récepteur distant bidirectionnel d'unité centrale.
- 55
9. Procédé pour surveiller un patient, comprenant les étapes de
- fourniture d'un système de surveillance à distance
- de patient (20) comprenant
- une unité de surveillance à distance (22) comprenant
- une unité de capteur (26) qui est portée sur un corps du patient et qui surveille un état du patient, l'unité de capteur comprenant
- un capteur (30) ayant une sortie de capteur (32),
- un émetteur-récepteur local bidirectionnel de capteur (36) qui reçoit la sortie de capteur (32), et
- un processeur d'unité de capteur (34) en communication avec l'émetteur-récepteur local bidirectionnel de capteur (36) ; et
- une unité de surveillance (28) comprenant
- un émetteur-récepteur local bidirectionnel d'unité de surveillance (38) qui supporte des communications sans fil bidirectionnelles avec l'émetteur-récepteur local bidirectionnel de capteur (36),
- un processeur d'unité de surveillance (42) en communication avec l'émetteur-récepteur local bidirectionnel d'unité de surveillance (38), et
- un émetteur-récepteur distant bidirectionnel d'unité de surveillance (44) en communication avec le processeur d'unité de surveillance (42), dans lequel l'émetteur-récepteur distant (44) peut fonctionner pour communiquer avec une unité centrale (24), et
- de transmission d'information bidirectionnelle entre l'unité de capteur (26) et l'unité de surveillance (28), dans lequel l'étape de transmission comprend les étapes de
- transmission, par l'unité de capteur, d'une information comprenant au moins des données de patient issues de la sortie de capteur (32) à l'unité de surveillance à une première fréquence, l'unité de surveillance (28) étant configurée pour effectuer au moins l'une des opérations suivantes :
- (a) la détermination pour savoir si l'information transmise est altérée et la transmission d'un signal de retransmission à l'unité de capteur (26) pour faire en sorte que l'unité de capteur (26) retransmette de l'information précédem-

ment transmise,

(b) la détermination d'une intensité de signal de l'information, et sur la base de l'intensité de signal déterminée, la transmission d'un signal d'alerte de distance à l'unité de capteur (26), et

(c) la détermination pour savoir si le signal est affecté négativement par une interférence dépendant de la fréquence et la transmission d'un signal de changement de fréquence à l'unité de capteur (26) dans le cas où l'information est affectée négativement par l'interférence dépendant de la fréquence, et l'unité de capteur (26) étant configurée pour transmettre de l'information complémentaire à l'unité de surveillance (28) à une deuxième fréquence, dans lequel la transmission de l'information complémentaire inclue au moins une retransmission de l'information ayant fait l'objet d'une interférence à la première fréquence.

10. Procédé selon la revendication 9, dans lequel l'unité de surveillance utilise une technique de détection d'altération et détermine si l'information est altérée, comprenant en outre :

la transmission, par l'unité de surveillance (28), d'un signal de retransmission à l'unité de capteur (26) dans le cas où l'information est altérée, et

l'unité de capteur retransmettant l'information à l'unité de surveillance (28) jusqu'à ce que de l'information non altérée soit reçue à l'unité de surveillance.

11. Procédé selon la revendication 10, dans lequel la technique de détection d'altération est une technique de somme de contrôle, une technique de contrôle de redondance cyclique, ou une correction d'erreur sans voie de retour et une technique de contrôle.

12. Procédé selon l'une quelconque des revendications 9 à 11, dans lequel l'interférence dépendant de la fréquence est déterminée dans l'unité de surveillance (28) en notant une altération dans les données transmises et en recevant des données à des moments non anticipés.

13. Procédé selon l'une quelconque des revendications 9 à 12, dans lequel le capteur (30) est un capteur de surveillance du coeur, un capteur de surveillance de la pression sanguine, un capteur d'ondes cérébrales ou un capteur de la chimie du sang.

14. Procédé selon l'une quelconque des revendications

9 à 13, dans lequel l'étape de fourniture d'un système de surveillance à distance de patient comprend en outre

la fourniture de l'unité centrale (24), ladite unité centrale comprenant

un émetteur-récepteur distant bidirectionnel d'unité centrale (46) supportant des communications bidirectionnelles avec l'émetteur-récepteur distant bidirectionnel d'unité de surveillance (44) via un système de téléphone cellulaire (48), et un processeur d'unité centrale (56) en communication avec l'émetteur-récepteur distant bidirectionnel d'unité centrale.

15. Procédé selon la revendication 14, dans lequel le procédé pour la surveillance d'un patient comprend en outre :

la transmission d'informations bidirectionnelles entre l'unité de surveillance (28) et l'unité centrale (24) via le système de téléphone cellulaire.

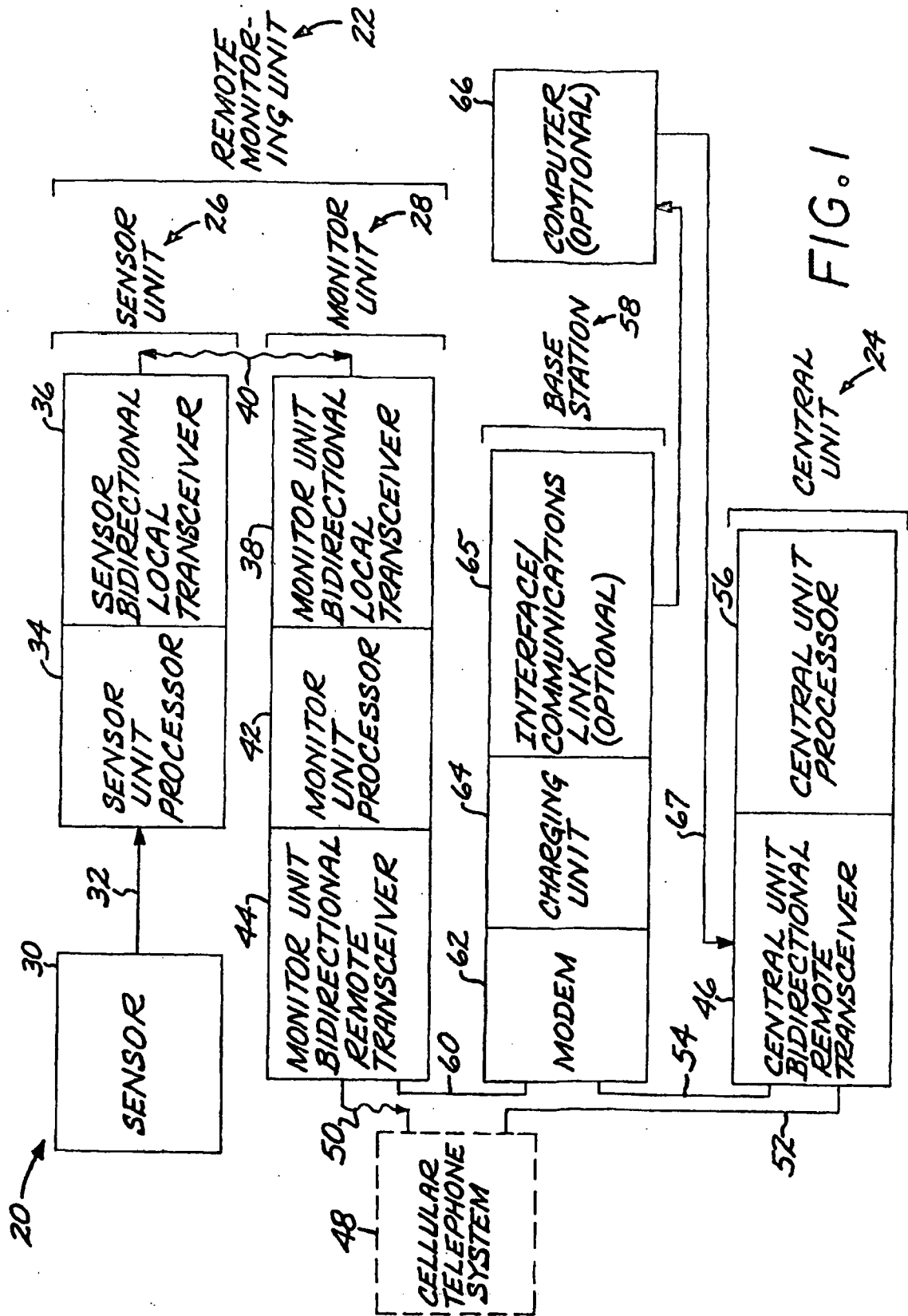


FIG. 1

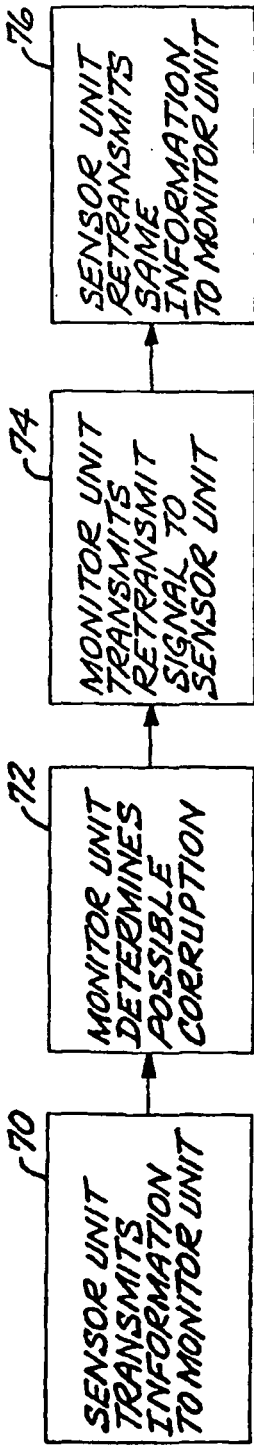


FIG. 2

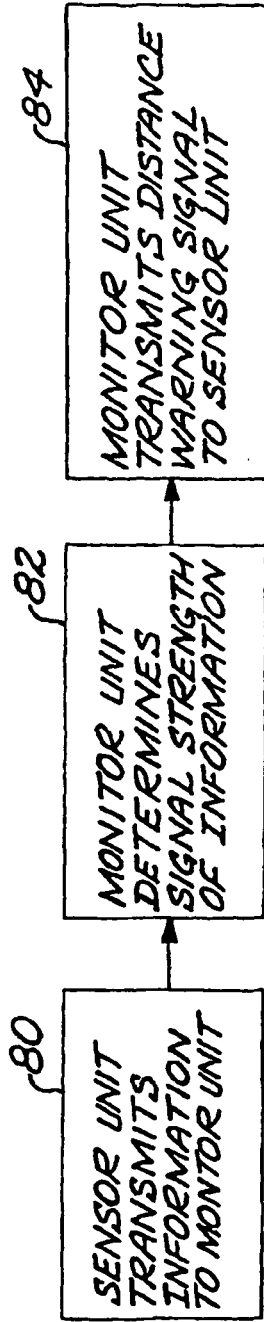


FIG. 3

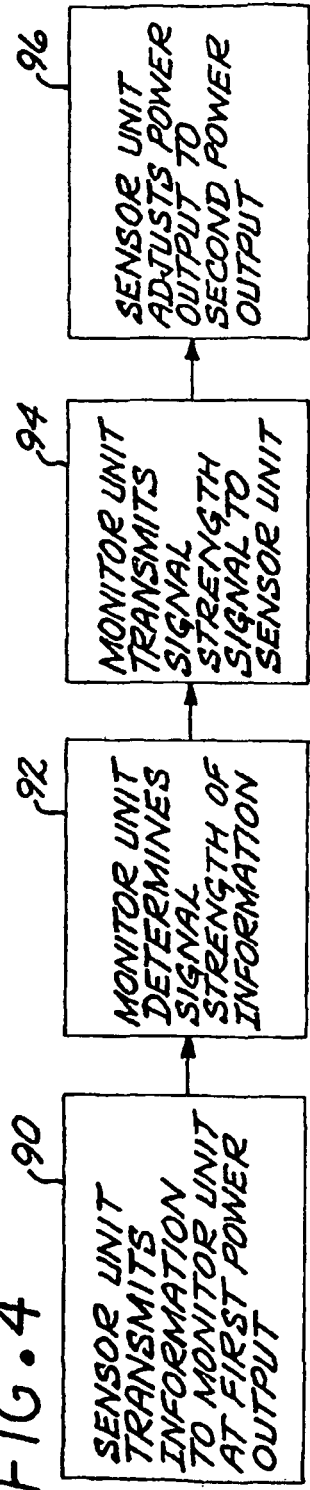


FIG. 4

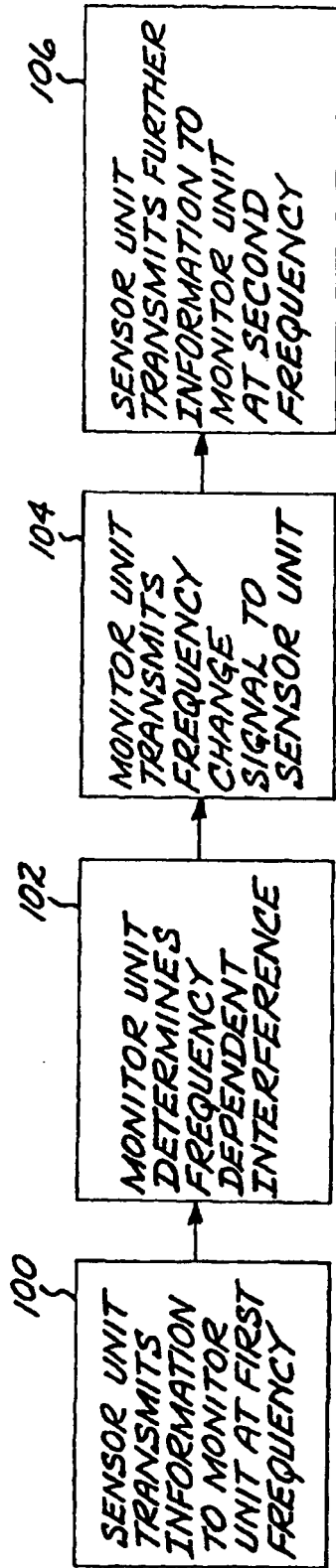


FIG. 5

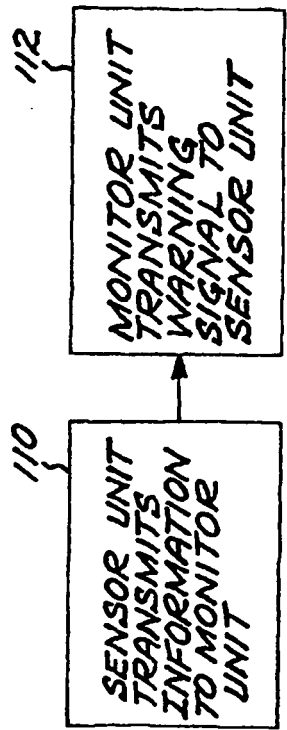


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	在患者监测中传感器单元和监视器单元之间的双向通信		
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外部链接	Espacenet		

摘要(译)

监视系统包括远程监视单元，该远程监视单元具有与监视器单元双向无线通信的传感器单元。信息在传感器单元和监视器单元之间双向传输。监视器单元可以通知传感器单元已发送的数据已被破坏，单元之间的距离变得太大，传输信号强度可能被改变，干扰需要改变发送频率，或者需要注意病人到监护仪单元。

