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(54) **Apparatus, method and software for tracking an object**

Vorrichtung, Verfahren und Software zur Verfolgung von Gegenständen

Dispositif, procédé et logiciel pour suivre des objets

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- **FEISTE, K. L., FETTER MARQUES, P. , REICHERT, CH., REIMCHE, W., STEGEMANN,D.: "Characterization of Nodular Cast Iron Properties by Harmonic Analysis of Eddy Current Signals" NDT.NET, [Online] vol. 3, no. 10, October 1998 (1998-10), XP002295053 Retrieved from the Internet: URL:http://www.ndt.net/article/ecndt98/nuc lear/245/245.htm> [retrieved on 2004-09-03]**

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Description

CROSS-REFERENCES TO RELATED APPLICATION

[0001] This application is related to European Patent Application No. 04253208.5 filed on even date, entitled, "Dynamic Metal Immunity by Hysteresis," in the name of Biosense Webster, Inc., and claiming priority from US Patent Application No. 10/448291 filed on 29th May, 2003 (Attorney's ref: P037724EP).

FIELD OF THE INVENTION

[0002] The present invention relates generally to non-contact tracking of objects using a magnetic field, and specifically to counteracting the effect of a moving, magnetic field-responsive article in a magnetic field.

BACKGROUND OF THE INVENTION

[0003] Non-contact electromagnetic locating and tracking systems are well known in the art, with an exceptionally broad spectrum of applications, including such diverse topics as military target sighting, computer animation, and precise medical procedures. For example, electromagnetic locating technology is widely used in the medical field during surgical, diagnostic, therapeutic and prophylactic procedures that entail insertion and movement of objects such as surgical devices, probes, and catheters within the body of the patient. The need exists for providing real-time information for accurately determining the location and orientation of objects within the patient's body, preferably without using X-ray imaging.

[0004] US-A-5,391,199 and US-A-5,443,489 describe systems wherein the coordinates of an intrabody probe are determined using one or more field sensors, such as Hall effect devices, coils, or other antennae carried on the probe. Such systems are used for generating three-dimensional location information regarding a medical probe or catheter. A sensor coil is placed in the catheter and generates signals in response to externally-applied magnetic fields. The magnetic fields are generated by a plurality of radiator coils, fixed to an external reference frame in known, mutually-spaced locations. The amplitudes of the signals generated in response to each of the radiator coil fields are detected and used to compute the location of the sensor coil. Each radiator coil is preferably driven by driver circuitry to generate a field at a known frequency, distinct from that of other radiator coils, so that the signals generated by the sensor coil may be separated by frequency into components corresponding to the different radiator coils.

[0005] WO-A-96/05768 describes a system that generates six-dimensional position and orientation information regarding the tip of a catheter. This system uses a plurality of sensor coils adjacent to a locatable site in the catheter, for example near its distal end, and a plurality of radiator coils fixed in an external reference frame. These coils generate signals in response to magnetic fields generated by the radiator coils, which signals allow for the computation of six location and orientation coordinates, so that the position and orientation of the catheter are known without the need for imaging the catheter.

[0006] US-A-6,239,724 describes a telemetry system for providing spatial positioning information from within a patient's body. The system includes an implantable telemetry unit having (a) a first transducer, for converting a power signal received from outside the body into electrical power for powering the telemetry unit; (b) a second transducer, for receiving a positioning field signal that is received from outside the body; and (c) a third transducer, for transmitting a locating signal to a site outside the body, in response to the positioning field signal.

[0007] US-A-5,425,382 describes apparatus and methods for locating a catheter in the body of a patient by sensing the static magnetic field strength gradient generated by a magnet fixed to the catheter.

[0008] US-A-5,558,091 describes a magnetic position and orientation determining system which uses uniform fields from Helmholtz coils positioned on opposite sides of a sensing volume and gradient fields generated by the same coils. By monitoring field components detected at a probe during application of these fields, the position and orientation of the probe is deduced. A representation of the probe is superposed on a separately-acquired image of the subject to show the position and orientation of the probe with respect to the subject.

[0009] Other locating devices using a position sensor attached to a catheter are described in US-A-4,173,228, US-A-5,099,845, US-A-5,325,873, US-A-5,913,820, US-A-4,905,698 and US-A-5,425,367.

[0010] Commercial electrophysiological and physical mapping systems based on detecting the position of a probe inside the body are presently available. Among them, CARTO™, developed and marketed by Biosense Webster, Inc. (Diamond Bar, California), is a system for automatic association and mapping of local electrical activity with catheter location.

[0011] Electromagnetic locating and tracking systems are susceptible to inaccuracies when a metal or other magnetically-responsive article is introduced into the vicinity of the object being tracked. Such inaccuracies occur because the magnetic fields generated in this vicinity by the location system's radiator coils are distorted. For example, the radiator coils' magnetic fields may generate eddy currents in such an article, and the eddy currents then cause parasitic magnetic fields that react with the field that gave rise to them. In a surgical environment, for example, there is a substantial amount of conductive and permeable material including basic and ancillary equipment (operating tables, carts, movable lamps, etc.) as well as invasive surgery apparatus (scalpels, catheters, scissors, etc.). The eddy currents generated in these articles and the resultant electromagnetic field distortions can lead to errors in determining the position of the object being tracked.

[0012] It is known to address the problem of the interference of static metal objects by performing an initial calibration, in which the response of the system to a probe placed at a relatively large number of points of interest is measured. This may be acceptable for addressing stationary sources of electromagnetic interference, but it is not satisfactory for solving the interference problems induced by moving magnetically-responsive objects.

[0013] US-A-6,373,240 describes an object tracking system comprising one or more sensor coils adjacent to a locatable point on an object being tracked, and one or more radiator coils, which generate alternating magnetic fields in a vicinity of the object when driven by respective alternating electrical currents. For each radiator coil, a frequency of its alternating electrical current is scanned through a plurality of values so that, at any specific time, each of the radiator coils radiates at a frequency which is different from the frequencies at which the other radiator coils are radiating.

[0014] The sensor coils generate electrical signals responsive to the magnetic fields, which signals are received by signal processing circuitry and analyzed by a computer or other processor. When a metal or other field-responsive article is in the vicinity of the object, the signals typically include position signal components responsive to the magnetic fields generated by the radiator coils at their respective instantaneous driving frequencies, and parasitic signal components responsive to parasitic magnetic fields generated because of the article. The parasitic components are typically equal in frequency to the instantaneous frequency of the driving frequency, but are shifted in phase, so that the effect at each sensor coil is to produce a combined signal having a phase and an amplitude which are shifted relative to the signal when no field-responsive article is present. The phase-shift is a function of the driving frequency, and so will vary as each driving frequency is scanned. The computer processes the combined signal to find which frequency produces a minimum phase-shift, and thus a minimum effect of the parasitic components, and this frequency is used to calculate the position of the object. Varying the driving frequency until the phase shift is a minimum is described as an effective method for reducing the effect of field-responsive articles on the signal.

[0015] US-A-6,172,499 describes a device for measuring the location and orientation in the six degrees of freedom of a receiving antenna with respect to a transmitting antenna utilizing multiple-frequency AC magnetic signals. The transmitting component consists of two or more transmitting antennae of known location and orientation relative to one another. The transmitting antennae are driven simultaneously by AC excitation, with each antenna occupying one or more unique positions in the frequency spectrum. The receiving antennae measure the transmitted AC magnetic field plus distortions caused by conductive metals. As described, a computer then extracts the distortion component and removes it from the received signals, providing the correct position and orientation output.

[0016] US-A-6,246,231 describes a method of flux containment in which the magnetic fields from transmitting elements are confined and redirected from the areas where conducting objects are commonly found.

[0017] US-A-5,767,669 describes a method for subtracting eddy current distortions produced in a magnetic tracking system. The system utilizes pulsed magnetic fields from a plurality of generators, and the presence of eddy currents is detected by measuring rates of change of currents generated in sensor coils used for tracking. The eddy currents are compensated for by adjusting the duration of the magnetic pulses.

[0018] US-A-4,945,305 and US-A-4,849,692 describe tracking systems that circumvent the problems of eddy currents by using pulsed DC magnetic fields. Sensors which are able to detect DC fields are used in the systems, and eddy currents are detected and adjusted for by utilizing the decay characteristics and the amplitudes of the eddy currents.

[0019] US-A-5,600,330 describes a non-dipole loop transmitter-based magnetic tracking system. This system is described as showing reduced sensitivity to small metallic objects in the operating volume.

[0020] EP-A-0,964,261 describes systems for compensating for eddy currents in a tracking system using alternating magnetic field generators. In a first system the eddy currents are compensated for by first calibrating the system when it is free from eddy currents, and then modifying the fields generated when the eddy currents are detected. In a second system the eddy currents are nullified by using one or more shielding coils placed near the generators.

[0021] US-A-5,831,260 describes a combined electromagnetic and optical hybrid locating system that is intended to reduce the disadvantages of each individual system operating alone.

[0022] US-A-6,122,538 describes hybrid position and orientation systems using different types of sensors including ultrasound, magnetic, tilt, gyroscopic, and accelerometer subsystems for tracking medical imaging devices.

[0023] Article surveillance systems using soft magnetic materials and low frequency detection systems have been known since the Picard patent (Ser. No. 763,861) was issued in France in 1934. Surveillance systems based on this approach generally use a marker consisting of ferromagnetic material having a high magnetic permeability. When the marker is interrogated by a magnetic field generated by the surveillance system, the marker generates harmonics of the interrogating frequency because of the non-linear hysteresis loop of the material of the marker. The surveillance system detects, filters, and analyzes these harmonics in order to determine the presence of the marker. Numerous patents describe systems based on this approach and improvements thereto, including, for example, US-A-4,622,542, US-A-4,309,697, US-A-5,008,649 and US-A-6,373,387.

[0024] US-A-4,791,412 describes an article surveillance system based upon generation and detection of phase shifted harmonic signals from encoded magnetic markers. The system is described as incorporating a signal processing technique for reducing the effects of large metal objects in the surveillance zone.

[0025] US-A-6,150,810, US-A-6,127,821, US-A-5,519,317 and US-A-5,506,506 describe apparatus for detecting the presence of ferrous objects by generating a magnetic field and detecting the response to the field from the object. A typical application of such an apparatus is detection and discrimination of objects buried in the ground. US-A-4,868,504 describes a metal detector for locating and distinguishing between different classes of metal objects. This apparatus performs its analysis by using harmonic frequency components of the response from the object.

[0026] US-A-5,028,869 describes apparatus for the nondestructive measurement of magnetic properties of a test body by detecting a tangential magnetic field and deriving harmonic components thereof. By analyzing the harmonic components, the apparatus calculates the maximum pitch of the hysteresis curve of the test body.

[0027] An article by Feiste KL et al. entitled, "Characterization of Nodular Cast Iron Properties by Harmonic Analysis of Eddy Current Signals," NDT.net, Vol. 3, No. 10 (1998), available as of May 2002 at http://www.ndt.net/article/ecndt98/nuclear/245/245.htm describes applying harmonic analysis to nodular cast iron samples to evaluate the technique's performance in predicting metallurgical and mechanical properties of the samples.

[0028] There is a need for a straightforward, accurate, real-time method that addresses the problem of interference induced in electromagnetic locating and tracking systems caused by the introduction of non-stationary metallic or other magnetically-responsive articles into the measurement environment.

SUMMARY OF THE INVENTION

[0029] It is an object of some aspects of the present invention to provide apparatus and methods for improving the accuracy of electromagnetic locating and-tracking systems.

[0030] It is also an object of some aspects of the present invention to provide apparatus and methods for increasing accuracy of electromagnetic location and tracking systems without concern for the presence of moving electrically- and/or magnetically-responsive materials in the space wherein measurements are being taken.

[0031] It is a further object of some aspects of the present invention to provide apparatus and methods for enabling electromagnetic location and tracking systems to function accurately in the presence of moving electrically- and/or magnetically-responsive materials in the space wherein the measurements are being taken, substantially without regard to the quantity of such materials, their conductive characteristics, velocities, orientation, direction and the length of time that such materials are within the space.

[0032] It is yet a further object of some aspects of the present invention to provide apparatus and methods for operating electromagnetic location and tracking systems without the necessity of employing means for reducing or circumventing the effects caused by eddy currents induced in moving electrically- and/or magnetically-responsive objects in the space wherein measurements arc being taken.

[0033] According to a first aspect of the invention, there is provided an assessment apparatus of the type defined in the accompanying claim 1.

[0034] According to a second aspect of the invention, there is provided a method of assessing of the type defined in the accompanying claim 7.

[0035] According to a third aspect of the invention, there is provided a computer software product for assessing of the type defined in the accompanying claim 12.

[0036] Further preferred aspects are set out in the accompanying dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The present invention will be more fully understood from the following detailed description of preferred embodiments thereof, taken together with the drawings, in which:

Fig. 1 is a schematic, pictorial illustration of an electromagnetic locating and tracking system used during a medical procedure, in accordance with a preferred embodiment of the present invention;
Fig. 2 is a schematic, pictorial illustration of an assessment system, in accordance with a preferred embodiment of the present invention; and
Figs. 3A, 3B, and 3C are simplified frequency response graphs illustrating an example assessment of an interfering element, in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0038] Fig. 1 is a schematic, pictorial illustration of an electromagnetic locating and tracking system 18 utilized to track an object, such as a probe 20, in the body of a patient 24 while providing immunity to the introduction, movement (dx), or removal of an interfering element 40, such as a ferromagnetic element, in or near a space 60 around the patient, in accordance with a preferred embodiment of the present invention. System 18 comprises a set of radiators 34, which are driven by a control unit 50 to track probe 20, preferably but not necessarily using methods and apparatus which are described in the above-cited US Patents and PCT Patent Publication to Ben-Haim and Ben-Haim et al. Thus, probe 20 comprises a position sensor (not shown), which preferably comprises field sensors, such as Hall effect devices, coils, or other antennae, for use in position determination. Alternatively or additionally, methods and apparatus known in the art are used to facilitate the tracking of probe 20. Control unit 50 comprises circuitry for processing signals received from probe 20, for detecting element 40, and for calculating the absolute position of probe 20 using a harmonic correction algorithm, as described hereinbelow.

[0039] Element 40 typically comprises an article made completely or partially of magnetically permeable material, such as ferromagnetic material. Examples of such articles include surgical tools, movable lamps, and carts. Element 40 generates parasitic fields, the phases and amplitudes of which generally depend on properties of element 40, including its dielectric constant, magnetic permeability, geometrical shape and orientation relative to probe 20. It will be appreciated that although element 40 is shown in Fig. 1 as a single element, element 40 could comprise a number of separate elements, which are often brought in and out of the area of a medical procedure.

[0040] Fig. 2 is a schematic, pictorial illustration of an assessment system 16, in accordance with a preferred embodiment of the present invention. In this preferred embodiment, prior to system 18 being used on a patient, each element 40 which may interfere with measurements of the position of probe 20 is preferably assessed by assessment system 16. To assess each element 40, the element is initially not present in space 60. One or more radiators 34 radiate a fundamental frequency for which assessment is desired. Alternatively, radiators 34 radiate a plurality of fundamental frequencies for which assessment is desired, one frequency at a time. Suitable frequencies are typically between about 200 Hz and about 12 kHz. The one or more fundamental frequencies radiated are preferably those used by radiators 34 for position sensing of probe 20 during a procedure. A receiving coil 22, fixed at any point in space 60, receives the radiated signals and conveys them to control unit 50. In a preferred embodiment of the present invention, receiving coil 22 comprises a sensor, such as a coil, Hall effect device or other antenna, dedicated to this function. In this case, the sensor in receiving coil 22 preferably is substantially identical to the sensor in probe 20. Alternatively, probe 20, temporarily fixed at any point in space 60, functions as receiving coil 22. Further alternatively, one of radiators 34, which is not being used for radiating during assessment, functions as receiving coil 22. For some applications, receiving coil 22 is oriented so that at least one of its sensors (such as a coil) is oriented to increase or maximize the strength of the signal received.

[0041] In the next step of the assessment process, element 40 is introduced into space 60, preferably near receiving coil 22. Each of the one or more fundamental frequencies radiated before the introduction of element 40 is again radiated by the same radiators 34. Receiving coil 22 receives the radiated signals and conveys them to control unit 50. In the case of a ferromagnetic element, the signal received is distorted by interference caused in part by phase shifting caused by the non-linearity of the element's hysteresis loop. This non-linearity of the hysteresis loop also induces higher harmonics of the radiated fundamental frequency. Each type of material generally has a unique hysteresis curve and therefore generates different interference and a corresponding different pattern of higher harmonics.

[0042] Reference is now made to Figs. 3A, 3B, and 3C, which show, for a single radiated fundamental frequency, a simplified example of received signals and a calculated "fingerprint," in accordance with a preferred embodiment of the present invention. Fig. 3A shows the signal received by receiving coil 22 prior to the introduction of element 40 in space 60 (the "clean received signal"), the amplitudes of which at F_0, $3F_0$, and $5F_0$ are 4.0, 0.0, and 0.0, respectively. Fig. 3B shows the signal received by receiving coil 22 after the introduction of element 40 in space 60 (the "distorted received signal"), the amplitudes of which at F_0, $3F_0$, and $5F_0$ are 4.3, 2.0, and 1.0, respectively. For each radiated fundamental frequency, control unit 40 analyzes the received signals, preferably by removing the clean received signal from the distorted received signal, such as by subtraction. The resulting signal, shown in Fig. 3C, represents the effect of electromagnetic interference of element 40 on the clean received signal. In this example, this "fingerprint" signal has amplitudes at F_0, $3F_0$, and $5F_0$ of 0.3, 2.0, and 1.0, respectively. Each type of material generally causes a unique resulting subtracted signal, which allows these signals to serve as fingerprint signals. It will be understood that the harmonic frequencies shown in Figs. 3B and 3C are illustrative only; in practice, among other differences, higher harmonics generally are present. As described hereinbelow, the ratios of the amplitudes at the different frequencies, rather than the absolute values of the amplitudes, are typically stored and used for correction during position determination.

[0043] Alternatively, in a preferred embodiments of the present invention, to assess each element, radiators 34 generate fundamental frequencies which are measured by a receiving coil 22 twice: first, with element 40 at a first location in space 60, and second, with element 40 at a second location in space 60. The distortion of a first signal received when the element is at the first location differs from the distortion of a second signal received when the element is at the second location. For each radiated fundamental frequency, control unit 50 preferably calculates the difference between the first and second signals, such as by subtraction. The resulting signal (or ratios of its amplitudes at different frequencies, as described hereinbelow), representing the effect of the interference of element 40 on a signal that would have been received in the absence of element 40, is generally unique for each element 40 and therefore serves as a fingerprint of the element. To reduce the effect of noise and other random variations in measurement, measurements may be made when the element is in more than two locations, and the results of the calculation averaged in order to generate the fingerprint.

[0044] For example, assume that the signal shown in Fig. 3B represents the first signal generated when element 40 is at the first location (as mentioned above, the amplitudes of this signal at F_0, $3F_0$, and $5F_0$ are 4.3, 2.0, and 1.0, respectively). Further assume that the amplitudes of the second signal (not shown) at F_0, $3F_0$, and $5F_0$, generated when element 40 is at the second location, are 4.6, 4.0, and 2.0, respectively. Subtracting the first signal from the second signal results in a fingerprint signal with amplitudes at F_0, $3F_0$, and $5F_0$ of 0.3, 2.0, and 1.0, respectively. Ratios of these values are stored and used for correction during a procedure, as described hereinbelow. Substantially the same ratios typically result even when measurements are made at multiple first and second locations.

[0045] The table below illustrates examples of three fingerprint signals (with arbitrary example values), in accordance with a preferred embodiment of the present invention. Element #1 represents the example element reflected in Figs. 3A, 3B, and 3C, and elements #2 and #3 represent two other example elements. Reference is made to the left portion of the table, labeled "Frequency." f_o represents the transmitted fundamental frequency, the multiples of f_o represent harmonic frequencies thereof, and the values represent relative amplitudes.

	Frequency					Ratio	
	f_o	$2f_o$	$3f_o$	$4f_o$	$5f_o$	$5f_o/3f_o$	$3f_o/f_o$
Element #1	0.2	--	2.0	--	1.0	0.5	10.0
Element #2	0.3	--	1.5	--	1.2	0.8	5.0
Element #3	0.1	--	1.0	--	0.6	0.6	10.0

[0046] Reference is now made to the right portion of the table, labeled "Ratio." In a preferred embodiment of the present invention, for each element for which assessment is performed, ratios between two or more harmonic frequencies, and between one or more harmonic frequencies and the transmitted fundamental frequency (f_o) are calculated, preferably by control unit 50 or, alternatively, by an external computer system (not shown). Each individual element assessed is uniquely characterized by its calculated ratio and/or ratios. Other possible algorithms, e.g., using combinations of two or more harmonic frequencies with the transmitted fundamental frequency and/or with each other, will be apparent to those skilled in the art having read the disclosure of the present patent application. Such other algorithms may be performed in order to produce alternative or additional values that uniquely identify different types of elements. Alternatively or additionally, assessment ratios and/or other calculated results are obtained for specific types of materials rather than specific types of elements. (Identifying the specific interfering material, without necessarily identifying the object comprising the material, is generally sufficient to perform the correction techniques described herein) These ratios and/or results of other calculations are preferably stored in a database to which control unit 50 has access, and are used during a procedure for position compensation calculations, as described hereinbelow. ("Database," as used in the specification and in the claims, is to be understood as including substantially any suitable repository, memory device or data structure that may be used for storing this information.)

[0047] In a preferred embodiment, the assessment procedure is performed in a location other than an operating room environment. For example, the assessment procedure is performed in a different location in the medical facility in which the procedure is to be performed. In this embodiment, preferably one or more radiators substantially identical to radiators 34 are provided. After assessment, the resulting assessment data and calculations are transferred to control unit 50 using methods obvious to those skilled in the art.

[0048] Alternatively or additionally, assessment is performed offsite, preferably by a third party. In this case, preferably a large number of elements and/or materials commonly used in performing medical procedures are assessed. These assessments are stored as a library in a repository, such as a database. (It is to be understood that substantially any suitable memory device and data structure may be used for storing the library.) This library is transferred to control unit 50, either before or after control unit 50 is delivered to its user, using methods known in the art. Alternatively, the library is transferred to a computer system or network to which control unit 50 has access during a procedure. It will be appreciated that onsite and offsite assessment can easily be combined, giving the user of system 18 the ability to add elements 40 not included in the available library or libraries. Other details of implementing such a library system will be evident to those skilled in the art, having read the disclosure of the present patent application.

[0049] Reference is again made to Fig. 1. During a procedure being performed on a patient, when element 40 is introduced into the vicinity of space 60, the measured position of probe 20 differs from its actual position because of the interference generated by element 40. In a preferred embodiment of the present invention, to compensate for this interference, the harmonics induced in the signal received by probe 20 are analyzed by control unit 50. Calculations are performed on the amplitudes of the harmonics, such as the determination of ratios between the amplitudes of two or more harmonics. The results of these calculations are compared with those stored in the memory of control unit 50 in order to identify the type of previously-assessed element and/or material that element 40 is or includes, respectively. Once the element and/or material is known, the distorting effect of element 40 on the amplitude of the fundamental signal of interest received by probe 20 is calculated, for example by using the ratio of the amplitude of one or more of the harmonics to the amplitude of the fundamental signal, as calculated during the assessment and stored in a database to which control unit 50 has real-time access. The amplitude of this distorting effect is subtracted from the measured amplitude of the received fundamental signal of interest. The remaining signal, no longer distorted by the presence of element 40, is used as an input by control unit 50 for calculating the absolute position of probe 20.

[0050] Reference is again made to the right portion of the table above, labeled "Ratio," in order to provide an example of the calculation of an interference correction, using simple ratios of two harmonics, in accordance with a preferred embodiment of the present invention. For example, assume that, in the signal received by probe 20, the relative amplitude of f_o is 4.1, the relative amplitude of $3f_o$ is 1.0, and the relative amplitude of $5f_o$ is 0.5. The ratio of $5f_o$ to $3f_o$ is therefore 0.5. By comparing this ratio to the stored values reflected in the table, control unit 50 determines that, in this case, element 40 is the same type as element #1. To determine the distorting effect of element 40 on the received signal, the value of $3f_o$ (1.0) is divided by the stored ratio of $3f_o/f_o$ (10.0), resulting in 0.1. This result is subtracted from the measured amplitude of f_o (4.1), resulting in a corrected amplitude of 4.0, which is no longer distorted by the presence of element #1. This amplitude is used as an input for calculating the accurate position of probe 20.

[0051] In a preferred embodiment of the present invention, only one harmonic frequency is used to determine the identity of element 40. This is possible, for example, when one or more elements 40 being used during a procedure produce very different relative amplitudes at a certain harmonic frequency.

[0052] In a preferred embodiment of the present invention, during procedures in which multiple elements 40 are introduced into space 60 during a procedure, control unit 50 identifies each element 40 individually by performing suitable calculations. In some cases, these calculations use a number of higher harmonics, which provide additional distinguishing characteristics for elements 40, in order to aid in distinguishing multiple elements 40.

[0053] In a preferred embodiment of the present invention, when two or more elements 40 are made of the same ferromagnetic material or combination of ferromagnetic materials, there is generally no need to distinguish between these elements during a procedure. The interfering effect of such elements is combined and uniquely identifiable by the fingerprint of their material. Detection of and corrections for such elements is therefore preferably performed as a group by system 18, substantially without modification to the procedures described hereinabove.

[0054] Preferred embodiments of the present invention have been described with respect to a location system 18 wherein radiators 34 transmit electromagnetic signals and probe 20 receives these signals. It is to be understood that the scope of the present invention includes application of the techniques described herein to location systems wherein the probe transmits electromagnetic signals and radiators receive these signals.

[0055] It is to be understood that preferred embodiments of the present invention are described herein with respect to invasive medical techniques by way of example only. The scope of the present invention includes application of the techniques described herein to electromagnetic locating and tracking systems used for any purpose whatsoever.

[0056] It is to be further understood that the techniques described herein are applicable to assessment, identification and compensation for particular elements, e.g., a particular tool of known composition, as well as to assessment, identification and compensation for particular materials, e.g., a common ferromagnetic material. An "interfering article," as used in the specification and the claims, is thus to be understood as including both a particular discrete element (such as a tool) or a particular material (such as steel). Techniques described specifically with respect to element 40, element 41, or any other interfering article may be interchanged, as appropriate.

[0057] It is still further to be understood that control unit 50 may comprise a general-purpose computer, which is programmed in software to carry out the functions described herein. The software may be downloaded to the computer in electronic form, over a network, for example, or it may alternatively be supplied to the computer on tangible media, such as a CD-ROM. Further alternatively, control unit 50 may be implemented in dedicated hardware logic, or using a combination of hardware and software elements.

[0058] It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes is limited by the appended claims.

Claims

1. Assessment apparatus (16), comprising:

   a set of one or more radiators (34), which is adapted to generate an energy field at at least one fundamental frequency;
   a receiving sensor (22), which is adapted to generate a first signal responsive to the energy field when a field reactive article (40) is at a first location relative to the receiving sensor, and which is adapted to generate a second signal responsive to the energy field when the field reactive article is at a second location relative to the receiving sensor; and
   a control unit (50), **characterised in that** it is adapted to:

      receive an amplitude of the first signal and an amplitude of the second signal and to analyze them by calculating the difference between the first and second signal amplitudes in order to compute a fingerprint signal characteristic of the field reactive article (40), and
      store, in a database, data indicative of the fingerprint signal, in association with an identity of the field reactive article,
      wherein the data indicative of the fingerprint signal includes a harmonic frequency pattern of the fundamental frequency present in the fingerprint signal, and wherein the control unit (50) is adapted to detect the harmonic frequency pattern by calculating a ratio of an amplitude of a first harmonic of the fundamental frequency in the fingerprint signal to an amplitude of a second harmonic of the fundamental frequency in the fingerprint signal and a ratio of an amplitude of at least one harmonic frequency of the fundamental frequency present in the fingerprint signal to an amplitude of the fundamental frequency present in the fingerprint signal, and to store the ratios in the database, in association with the identity of the field reactive article (40).

2. Apparatus according to claim 1, wherein the field reactive article (40) is ferromagnetic, and wherein the receiving sensor (22) is adapted to generate the first and second signals when the ferromagnetic field reactive article is at the first and second locations, respectively.

3. Apparatus according to any preceding claim, wherein the control unit (50) is adapted to calculate the difference by subtracting an aspect in a frequency domain of the second signal from an aspect in the frequency domain of the first signal.

4. Apparatus according to any one of claims 1 to 3, wherein the receiving sensor (22) comprises at least one of: a Hall effect device, a coil and an antenna.

5. Apparatus according to any one of claims 1 to 4, wherein the fundamental frequency is between 200 Hz and 12 kHz, and wherein the radiators (34) are adapted to generate the energy field at the fundamental frequency.

6. Apparatus according to any one of claims 1 to 5,
   wherein the at least one fundamental frequency comprises a plurality of fundamental frequencies,
   wherein the set of radiators (34) is adapted to generate a plurality of energy fields at the plurality of fundamental frequencies,
   wherein the receiving sensor (22) is adapted to generate first and second signals responsive to each of the plurality of energy fields, and
   wherein the control unit (50) is adapted to compute fingerprint signals for the first and second signals at each of the fundamental frequencies, and to store in the database respective data indicative of the fingerprint signals, in association with the identity of the field reactive article (40) and in association with the respective fundamental frequency.

7. A method for assessing, comprising:

   generating an energy field at at least one fundamental frequency;
   generating a first signal responsive to the energy field when a field reactive article (40) is at a first location relative to a site of generation of the first signal;
   generating a second signal responsive to the energy field when the field reactive article is at a second location relative to a site of generation of the second signal;
   characterised by
   receiving an amplitude of the first signal and an amplitude of the second signal and analyzing them calculating

the difference between the first and second signal amplitudes so as to compute a fingerprint signal characteristic of the article; and
storing, in a database, data indicative of the fingerprint signal, in association with an identity of the field reactive article (40), and
wherein storing the data comprises detecting a harmonic frequency pattern of the fundamental frequency present in the fingerprint signal by calculating a ratio of an amplitude of a first harmonic of the fundamental frequency to an amplitude of a second harmonic of the fundamental frequency and a ratio of an amplitude of at least one harmonic frequency of the fundamental frequency present in the fingerprint signal to an amplitude of the fundamental frequency present in the fingerprint signal, and storing the ratios, in the database, in association with an identity of the field reactive article.

8. A method according to claim 7,
wherein the field reactive article (40) is ferromagnetic,
wherein generating the first signal comprises generating the first signal when the ferromagnetic field reactive article is at the first location, and
wherein generating the second signal comprises generating the second signal when the ferromagnetic field reactive is at the second location.

9. A method according to either of claims 7 or 8, wherein calculating the difference comprises subtracting an aspect in a frequency domain of the second signal from an aspect in the frequency domain of the first signal.

10. A method according to any one of claims 7 to 9, wherein the fundamental frequency is between 200 Hz and 12 kHz, and wherein generating the energy field comprises generating the energy field at the fundamental frequency.

11. A method according to any one of claims 7 to 10,
wherein the at least one fundamental frequency comprises a plurality of fundamental frequencies,
wherein generating the energy field comprises generating a plurality of energy fields at the respective plurality of fundamental frequencies,
wherein generating the first and second signals comprises generating respective first and second signals responsive to each of the plurality of energy fields,
wherein analyzing the first and second signals comprises computing fingerprint signals for the first and second signals at each of the fundamental frequencies, and
wherein storing the data comprises storing in the database respective data indicative of the fingerprint signals, in association with the identity of the interfering article and in association with the respective fundamental frequency.

12. A computer software product for assessing, the product comprising a computer-readable medium, in which program instructions are stored, which instructions, when read by a computer, cause the computer to:

receive a first signal generated by a sensor (22) when exposed to an energy field at at least one fundamental frequency when a field reactive article (40) is at a first location relative to a site of generation of the first signal;
receive a second signal generated by the sensor when exposed to the energy field when the field reactive article is at a second location relative to a site of generation of the second signal;
and **characterised by** causing the computer to analyze an amplitude of the first signal and an amplitude of the second signal by calculating the difference between the first and second amplitudes so as to compute a fingerprint signal characteristic of the article (40); and
store, in a database, data indicative of the fingerprint signal, in association with an identity of the field reactive article, and
wherein the instructions cause the computer to detect a harmonic frequency pattern of the fundamental frequency present in the fingerprint signal by calculating a ratio of an amplitude of a first harmonic of the fundamental frequency to an amplitude of a second harmonic of the fundamental frequency and a ratio of an amplitude of at least one of the harmonic frequencies of the fundamental frequency present in the fingerprint signal to an amplitude of the fundamental frequency present in the fingerprint signal, and to store the ratios in the database in association with the identity of the field reactive article (40).

13. A product according to claim 12,
wherein the field reactive article is ferromagnetic, and
wherein the instructions cause the computer to receive the first signal generated when the ferromagnetic field reactive

article is at the first location, and to receive the second signal generated when the ferromagnetic field reactive article is at the second location.

14. A product according to claim 12 or claim 13, wherein the instructions cause the computer to calculate the difference by subtracting an aspect in a frequency domain of the second signal from an aspect in the frequency domain of the first signal.

15. A product according to any one of claims 12 to 14, wherein the fundamental frequency is between 200 Hz and 12 kHz, and wherein the instructions cause the computer to receive the first and second signals generated by the sensor when exposed to the energy field.

16. A product according to any one of claims 12 to 15,
wherein the at least one fundamental frequency includes a plurality of fundamental frequencies, and
wherein the instructions cause the computer to:

receive respective first and second signals generated by the sensor (22) when exposed to a plurality of energy fields at the plurality of fundamental frequencies, and
analyze the first and second signals, so as to compute fingerprint signals for the first and
second signals at each of the fundamental frequencies, and to store in the database respective data indicative of the fingerprint signals, in association with the identity of the interfering article (40) and in association with the respective fundamental frequency.

Patentansprüche

1. Bewertungsvorrichtung (16), die aufweist:

einen Satz aus einem oder mehreren Strahlern (34), der dazu ausgelegt ist, ein Energiefeld mit wenigstens einer Grundfrequenz zu erzeugen;
einen empfangenden Sensor (22), der dazu ausgelegt ist, ein erstes Signal ansprechend auf das Energiefeld zu erzeugen, wenn ein auf ein Feld reagierender Gegenstand (40) sich an einem ersten Ort relativ zu dem empfangenden Sensor befindet, und der dazu ausgelegt ist, ein zweites Signal ansprechend auf das Energiefeld zu erzeugen, wenn der auf ein Feld reagierende Gegenstand sich an einem zweiten Ort relativ zu dem empfangenden Sensor befindet; und
eine Steuereinheit (50),

dadurch gekennzeichnet, dass sie dazu ausgelegt ist:

eine Amplitude des ersten Signals und eine Amplitude des zweiten Signals zu empfangen und sie zu analysieren, indem die Differenz zwischen der ersten und der zweiten Signalamplitude berechnet wird, um ein Fingerabdrucksignal zu berechnen, das für den auf ein Feld reagierenden Gegenstand (40) kennzeichnend ist, und in einer Datenbank Daten zu speichern, die für das Fingerabdrucksignal bezeichnend sind, in Verknüpfung mit einer Identität des auf ein Feld reagierenden Gegenstandes,

wobei die Daten, die für das Fingerabdrucksignal bezeichnend sind, ein Muster harmonischer Frequenzen der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, umfassen, und
wobei die Steuereinheit (50) dazu ausgelegt ist, das Muster der harmonischen Frequenzen zu erfassen, indem ein Verhältnis einer Amplitude einer ersten Harmonischen der Grundfrequenz in dem Fingerabdrucksignal zu einer Amplitude einer zweiten Harmonischen in der Grundfrequenz in dem Fingerabdrucksignal und ein Verhältnis einer Amplitude wenigstens einer harmonischen Frequenz der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, zu einer Amplitude der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, berechnet wird, und die Verhältnisse in der Datenbank in Verknüpfung mit der Identität des auf ein Feld reagierenden Gegenstandes (40) zu speichern.

2. Vorrichtung nach Anspruch 1, bei der der auf ein Feld reagierende Gegenstand (40) ferromagnetisch ist und bei der der empfangende Sensor (22) dazu ausgelegt ist, das erste und das zweite Signal zu erzeugen, wenn der ferromagnetische, auf ein Feld reagierende Gegenstand sich an dem ersten beziehungsweise dem zweiten Ort befindet.

3. Vorrichtung nach einem der vorangehenden Ansprüche, bei der die Steuereinheit (50) dazu ausgelegt ist, die Differenz zu berechnen, indem ein Aspekt in einer Frequenzdomäne des zweiten Signals von einem Aspekt in der Frequenzdomäne des ersten Signals subtrahiert wird.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, bei der der empfangende Sensor (22) wenigstens eine aus: einer Hall-Effekt-Einheit, einer Spule und einer Antenne aufweist.

5. Vorrichtung nach einem der Ansprüche 1 bis 4, bei der die Grundfrequenz zwischen 200 Hz und 12 kHz liegt und bei der die Strahler (34) dazu ausgelegt sind, das Energiefeld mit der Grundfrequenz zu erzeugen.

6. Vorrichtung nach einem der Ansprüche 1 bis 5,
bei der wenigstens eine Grundfrequenz eine Vielzahl von Grundfrequenzen aufweist,
wobei der Satz der Strahler (34) dazu ausgelegt ist, eine Vielzahl von Energiefeldern mit der Vielzahl der Grundfrequenzen zu erzeugen,
wobei der empfangende Sensor (22) dazu ausgelegt ist, erste und zweite Signale zu erzeugen, ansprechend auf jedes aus der Vielzahl von Energiefeldern, und
wobei die Steuereinheit (50) dazu ausgelegt ist, Fingerabdrucksignale für das erste und das zweite Signal bei jeder der Grundfrequenzen zu berechnen und in der Datenbank jeweilige Daten zu speichern, die für die Fingerabdrucksignale bezeichnend sind, in Verknüpfung mit der Identität des auf ein Feld reagierenden Gegenstandes (40) und in Verknüpfung mit der jeweiligen Grundfrequenz.

7. Bewertungsverfahren, das aufweist:

Erzeugen eines Energiefeldes mit wenigstens einer Grundfrequenz;
Erzeugen eines ersten Signals, das auf das Energiefeld anspricht, wenn ein auf ein Feld reagierender Gegenstand (40) sich an einem ersten Ort relativ zu einer Erzeugungsstelle des ersten Signals befindet;
Erzeugen eines zweiten Signals ansprechend auf das Energiefeld, wenn der auf ein Feld reagierende Gegenstand sich an einem zweiten Ort relativ zu einer Erzeugungsstelle des zweiten Signals befindet;
gekennzeichnet durch:

Empfangen einer Amplitude des ersten Signals und einer Amplitude des zweiten Signals und Analysieren derselben **durch** Berechnen der Differenz zwischen der ersten und der zweiten Signalamplitude, um so ein Fingerabdrucksignal zu berechnen, das für den Gegenstand kennzeichnend ist; und
Speichern, in einer Datenbank, von Daten, die für das Fingerabdrucksignal bezeichnend sind, in Verknüpfung mit einer Identität des auf ein Feld reagierenden Gegenstandes (40), und

wobei das Speichern der Daten das Erfassen eines Musters harmonischen Frequenzen der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, umfasst, indem ein Verhältnis einer Amplitude einer ersten Harmonischen der Grundfrequenz zu einer Amplitude einer zweiten Harmonischen der Grundfrequenz und ein Verhältnis einer Amplitude wenigstens einer harmonischen Frequenz der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, zu einer Amplitude der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, berechnet werden, und Speichern der Verhältnisse in der Datenbank in Verknüpfung mit einer Identität des auf ein Feld reagierenden Gegenstands.

8. Verfahren nach Anspruch 7, bei dem der auf ein Feld reagierende Gegenstand (40) ferromagnetisch ist,
bei dem das Erzeugen des ersten Signals das Erzeugen des ersten Signals, wenn sich der ferromagnetische, auf ein Feld reagierende Gegenstand an dem ersten Ort befindet, aufweist und
bei dem das Erzeugen des zweiten Signals das Erzeugen des zweiten Signals, wenn sich der ferromagnetische, auf ein Feld reagierende Gegenstand an dem zweiten Ort befindet, aufweist.

9. Verfahren nach Anspruch 7 oder 8, bei dem das Berechnen der Differenz das Subtrahieren eines Aspektes in einer Frequenzdomäne des zweiten Signals von einem Aspekt in der Frequenzdomäne des ersten Signals aufweist.

10. Verfahren nach einem der Ansprüche 7 bis 9, bei dem die Grundfrequenz zwischen 200 Hz und 12 kHz liegt und bei dem das Erzeugen des Energiefeldes das Erzeugen des Energiefeldes mit der Grundfrequenz aufweist.

11. Verfahren nach einem der Ansprüche 7 bis 10,
bei dem die wenigstens eine Grundfrequenz eine Vielzahl von Grundfrequenzen aufweist,

bei dem das Erzeugen des Energiefeldes das Erzeugen einer Vielzahl von Energiefeldern mit der jeweiligen Vielzahl von Grundfrequenzen aufweist,
bei dem das Erzeugen der ersten und der zweiten Signale das Erzeugen jeweiliger erster und zweiter Signale ansprechend auf jedes aus der Vielzahl der Energiefelder aufweist,
bei dem das Analysieren der ersten und der zweiten Signale das Berechnen von Fingerabdrucksignalen für die ersten und die zweiten Signale bei jeder der Grundfrequenzen aufweist und
bei dem das Speichern der Daten das Speichern jeweiliger Daten, die für die Fingerabdrucksignale bezeichnend sind, in der Datenbank aufweist, in Verknüpfung mit der Identität des störenden Gegenstandes und in Verknüpfung mit der jeweiligen Grundfrequenz.

12. Computer-Softwareprodukt zum Bewerten, wobei das Produkt ein computerlesbares Medium aufweist, in dem Programmbefehle gespeichert sind, wobei die Befehle, wenn sie von einem Computer gelesen werden, bewirken, dass der Computer:

ein erstes Signal empfängt, das von einem Sensor (22) erzeugt wird, wenn er einem Energiefeld mit wenigstens einer Grundfrequenz ausgesetzt wird, wenn ein auf ein Feld reagierender Gegenstand (40) sich an einem ersten Ort relativ zu einer Erzeugungsstelle des ersten Signals befindet;
ein zweites Signal empfängt, das von dem Sensor erzeugt wird, wenn er dem Energiefeld ausgesetzt wird, wenn sich der auf ein Feld reagierende Gegenstand an einem zweiten Ort relativ zu einer Erzeugungsstelle des zweiten Signals befindet;
und **gekennzeichnet dadurch, dass** beim Computer bewirkt wird, dass er eine Amplitude des ersten Signals und eine Amplitude des zweiten Signals analysiert, indem die Differenz zwischen der ersten und der zweiten Amplitude berechnet wird, um so ein Fingerabdrucksignal zu berechnen, das für den Gegenstand (40) kennzeichnend ist; und
er in einer Datenbank Daten, die für das Fingerabdrucksignal bezeichnend sind, in Verknüpfung mit einer Identität des auf ein Feld reagierenden Gegenstandes speichert, und

wobei die Befehle bewirken, dass der Computer ein Muster harmonischer Frequenzen der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, erfasst, indem ein Verhältnis einer Amplitude einer ersten Harmonischen der Grundfrequenz zu einer Amplitude einer zweiten Harmonischen der Grundfrequenz und ein Verhältnis einer Amplitude wenigstens einer der harmonischen Frequenzen der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, zu einer Amplitude der Grundfrequenz, die in dem Fingerabdrucksignal vorhanden ist, berechnet wird, und er die Verhältnisse in der Datenbank in Verknüpfung mit der Identität des auf ein Feld reagierenden Gegenstandes (40) speichert.

13. Produkt nach Anspruch 12,
wobei der auf ein Feld reagierende Gegenstand ferromagnetisch ist und
wobei die Befehle bewirken, dass der Computer das erste Signal empfängt, das erzeugt wird, wenn sich der ferromagnetische, auf ein Feld reagierende Gegenstand an dem ersten Ort befindet, und das zweite Signal empfängt, das erzeugt wird, wenn sich der ferromagnetische, auf ein Feld reagierende Gegenstand an dem zweiten Ort befindet.

14. Produkt nach Anspruch 12 oder Anspruch 13, wobei die Befehle bewirken, dass der Computer die Differenz berechnet, indem ein Aspekt in einer Frequenzdomäne des zweiten Signals von einem Aspekt in der Frequenzdomäne des ersten Signals subtrahiert wird.

15. Produkt nach einem der Ansprüche 12 bis 14, wobei die Grundfrequenz zwischen 200 Hz und 12 kHz liegt und wobei die Befehle bewirken, dass der Computer das erste und das zweite Signal empfängt, die von dem Sensor erzeugt werden, wenn er dem Energiefeld ausgesetzt ist.

16. Produkt nach einem der Ansprüche 12 bis 15,
wobei die wenigstens eine Grundfrequenz eine Vielzahl von Grundfrequenzen umfasst und
wobei die Befehle bewirken, dass der Computer:

ein jeweiliges erstes und zweites Signal empfängt, die von dem Sensor (22) erzeugt werden, wenn er einer Vielzahl von Energiefeldern mit der Vielzahl von Grundfrequenzen ausgesetzt wird, und
die ersten und die zweiten Signale analysiert, um so Fingerabdrucksignale für die ersten und zweiten Signale bei jeder der Grundfrequenzen zu berechnen und in der Datenbank die jeweiligen Daten, die für die Fingerabdrucksignale bezeichnend sind, in Verknüpfung mit der Identität des störenden Gegenstandes (40) und in

Verknüpfung mit der jeweiligen Grundfrequenz speichert.

Revendications

1. Appareil d'évaluation (16), comprenant :

■ un ensemble d'un ou de plusieurs éléments rayonnants (34), qui est adapté pour générer un champ d'énergie à au moins une fréquence fondamentale ;
■ un capteur de réception (22), qui est adapté pour générer un premier signal en réponse au champ d'énergie quand un article réactif au champ (40) se situe à un premier emplacement par rapport au capteur de réception, et qui est adapté pour générer un second signal en réponse au champ d'énergie lorsque l'article réactif au champ se situe à un second emplacement par rapport au capteur de réception ; et
■ une unité de commande (50),

caractérisé en ce qu'il est adapté pour :

■ recevoir une amplitude du premier signal et une amplitude du second signal et à les analyser en calculant la différence entre les amplitudes des premier et second signaux de manière à calculer une caractéristique de signal d'empreinte de l'article réactif au champ (40), et
■ stocker, dans une base de données, les données indicatives du signal d'empreinte, en association avec une identité de l'article réactif au champ,

dans lequel les données indicatives du signal d'empreinte incluent un motif de fréquence harmonique de la fréquence fondamentale présente dans le signal d'empreinte, et dans lequel l'unité de commande (50) est adaptée pour détecter le motif de fréquence harmonique en calculant un rapport de l'amplitude d'un premier harmonique de la fréquence fondamentale dans le signal d'empreinte, sur l'amplitude d'un second harmonique de la fréquence fondamentale dans le signal d'empreinte, et un rapport de l'amplitude d'au moins une fréquence harmonique de la fréquence fondamentale présente dans le signal d'empreinte, sur l'amplitude de la fréquence fondamentale présente dans le signal d'empreinte, et à stocker les rapports dans la base de données, en association avec l'identité de l'article réactif au champ (40).

2. Appareil selon la revendication 1, dans lequel l'article réactif au champ (40) est ferromagnétique, et dans lequel le capteur de réception (22) est adapté pour générer les premier et second signaux lorsque l'article ferromagnétique réactif au champ se trouve aux premier et second emplacements, respectivement.

3. Appareil selon l'une quelconque des revendications précédentes,
dans lequel l'unité de commande (50) est adaptée pour calculer la différence en soustrayant un aspect dans un domaine fréquentiel du second signal d'un aspect dans le domaine fréquentiel du premier signal.

4. Appareil selon l'une quelconque des revendications 1 à 3, dans lequel le capteur de réception (22) comprend au moins un parmi un dispositif à effet Hall, une bobine et une antenne.

5. Appareil selon l'une quelconque des revendications 1 à 4, dans lequel la fréquence fondamentale est comprise entre 200 Hz et 12 kHz, et dans lequel les éléments rayonnants (34) sont adaptés pour générer le champ d'énergie à la fréquence fondamentale.

6. Appareil selon l'une quelconque des revendications 1 à 5,

■ dans lequel l'au moins une fréquence fondamentale comprend une pluralité de fréquences fondamentales,
■ dans lequel l'ensemble d'éléments rayonnants (34) est adapté pour générer une pluralité de champs d'énergie à la pluralité de fréquences fondamentales,
■ dans lequel le capteur de réception (22) est adapté pour générer des premier et second signaux en réponse à chacun de la pluralité des champs d'énergie, et
■ dans lequel l'unité de commande (50) est adaptée pour calculer les signaux d'empreinte des premier et second signaux à chacune des fréquences fondamentales, et à stocker dans la base de données, les données respectives indicatives des signaux d'empreinte, en association avec l'identité de l'article réactif au champ (40) et en association avec la fréquence fondamentale respective.

7. Procédé d'évaluation, comprenant les étapes consistant à :

■ générer un champ d'énergie à au moins une fréquence fondamentale ;
■ générer un premier signal en réponse au champ d'énergie quand un article réactif au champ (40) se situe à un premier emplacement par rapport à un site de génération du premier signal ;
■ générer un second signal sensible au champ d'énergie lorsque l'article réactif au champ se situe à un second emplacement par rapport à un site de génération du second signal ;

caractérisé par les étapes consistant à :

■ recevoir une amplitude du premier signal et une amplitude du second signal et à les analyser en calculant la différence entre les amplitudes du premier signal et du second signal de manière à calculer une caractéristique de signal d'empreinte de l'article ; et
■ stocker, dans une base de données, les données indicatives du signal d'empreinte, en association avec une identité de l'article réactif au champ (40), et

dans lequel l'étape consistant à stocker les données comprend l'étape consistant à détecter un motif de fréquence harmonique de la fréquence fondamentale présente dans le signal d'empreinte, en calculant un rapport de l'amplitude d'un premier harmonique de la fréquence fondamentale, sur l'amplitude d'un second harmonique de la fréquence fondamentale,
et un rapport de l'amplitude d'au moins une fréquence harmonique de la fréquence fondamentale présente dans le signal d'empreinte, sur l'amplitude de la fréquence fondamentale présente dans le signal d'empreinte, et à stocker les rapports dans la base de données, en association avec une identité de l'article réactif au champ.

8. Procédé selon la revendication 7,

■ dans lequel l'article réactif au champ (40) est ferromagnétique,
■ dans lequel la génération du premier signal comprend la génération du premier signal lorsque l'article ferromagnétique réactif au champ, se trouve au premier emplacement, et
■ dans lequel la génération du second signal comprend la génération du second signal lorsque l'article ferromagnétique réactif au champ, se trouve au second emplacement.

9. Procédé selon l'une quelconque des revendications 7 ou 8, dans lequel l'étape consistant à calculer la différence comprend la soustraction d'un aspect dans un domaine fréquentiel du second signal, d'un aspect dans le domaine fréquentiel du premier signal.

10. Procédé selon l'une quelconque des revendications 7 à 9, dans lequel la fréquence fondamentale est comprise entre 200 Hz et 12 kHz, et dans lequel la génération du champ d'énergie comprend la génération du champ d'énergie à la fréquence fondamentale.

11. Procédé selon l'une quelconque des revendications 7 à 10,

■ dans lequel l'au moins une fréquence fondamentale comprend une pluralité de fréquences fondamentales,
■ dans lequel la génération du champ d'énergie comprend la génération d'une pluralité de champs d'énergie aux fréquences fondamentales respective,
■ dans lequel la génération des premier et second signaux comprend la génération des premier et second signaux respectifs en réponse à chacun de la pluralité de champs d'énergie,
■ dans lequel l'analyse des premier et second signaux comprend le calcul des signaux d'empreinte des premier et second signaux à chacune des fréquences fondamentales, et
■ dans lequel le stockage des données comprend le stockage dans la base de données des données respectives indicatives des signaux d'empreinte, en association avec l'identité de l'article réactif au champ et en association avec la fréquence fondamentale respective.

12. Produit de logiciel informatique destiné à évaluer, le produit comprenant un support pouvant être lu par un ordinateur, dans lequel des instructions de programme sont stockées, lesquelles instructions, quand elles sont lues par un ordinateur, font que l'ordinateur :

■ reçoit un premier signal généré par un capteur (22) quand il est exposé à un champ d'énergie à au moins une fréquence fondamentale quand un article réactif au champ (40) se situe à un premier emplacement par rapport à un site de génération du premier signal ;

■ reçoit un second signal généré par le capteur quand il est exposé au champ d'énergie lorsque l'article réactif au champ se situe à un second emplacement par rapport à un site de génération du second signal ;

■ et **caractérisé par le fait que** l'ordinateur analyse une amplitude du premier signal et une amplitude du second signal en calculant la différence entre les amplitudes des premier et second signaux, de manière à calculer une caractéristique de signal d'empreinte de l'article (40) ; et

■ stocke, dans une base de données, les données indicatives du signal d'empreinte, en association avec une identité de l'article réactif au champ, et

■ dans lequel les instructions font que l'ordinateur détecte un motif de fréquence harmonique de la fréquence fondamentale présente dans le signal d'empreinte, en calculant un rapport de l'amplitude d'un premier harmonique de la fréquence fondamentale, sur l'amplitude d'un second harmonique de la fréquence fondamentale,

■ et un rapport de l'amplitude d'au moins l'une des fréquences harmoniques de la fréquence fondamentale présente dans le signal d'empreinte, sur l'amplitude de la fréquence fondamentale présente dans le signal d'empreinte, et stocke les rapports dans la base de données, en association avec l'identité de l'article réactif au champ.

13. Produit selon la revendication 12,

■ dans lequel l'article réactif au champ est ferromagnétique, et

■ dans lequel les instructions font que l'ordinateur reçoit le premier signal généré lorsque l'article ferromagnétique réactif au champ se situe au premier emplacement, et reçoit le second signal généré lorsque l'article ferromagnétique réactif au champ se situe au second emplacement.

14. Produit selon la revendication 12 ou la revendication 13, dans lequel les instructions font que l'ordinateur calcule la différence en soustrayant un aspect dans un domaine fréquentiel du second signal d'un aspect dans le domaine fréquentiel du premier signal.

15. Produit selon l'une quelconque des revendications 12 à 14, dans lequel la fréquence fondamentale est comprise entre 200 Hz et 12 kHz, et dans lequel les instructions font que l'ordinateur reçoit les premier et second signaux générés par le capteur quand il est exposé au champ d'énergie.

16. Produit selon l'une quelconque des revendications 12 à 15,

■ dans lequel l'au moins une fréquence fondamentale inclut une pluralité de fréquences fondamentales, et

■ dans lequel les instructions font que l'ordinateur :

■ reçoit les premier et second signaux respectifs générés par le capteur (22) quand il est exposé à une pluralité de champs d'énergie à la pluralité de fréquences fondamentales, et

■ analyse les premier et second signaux, de manière à calculer les signaux d'empreinte des premier et second signaux à chacune des fréquences fondamentales, et à stocker dans la base de données, les données respectives indicatives des signaux d'empreinte, en association avec l'identité de l'article réactif au champ (40) et en association avec la fréquence fondamentale respective.

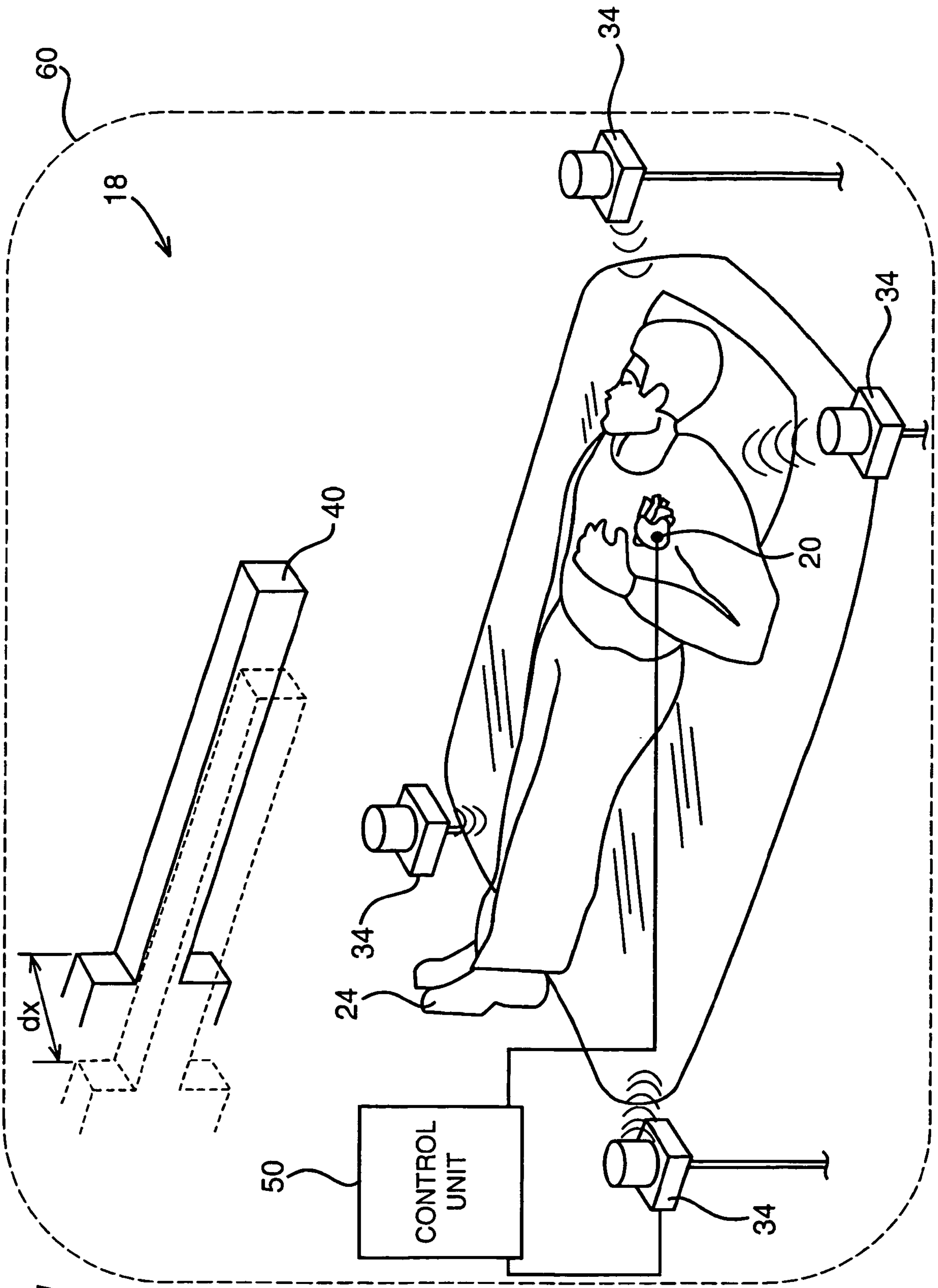

FIG. 1

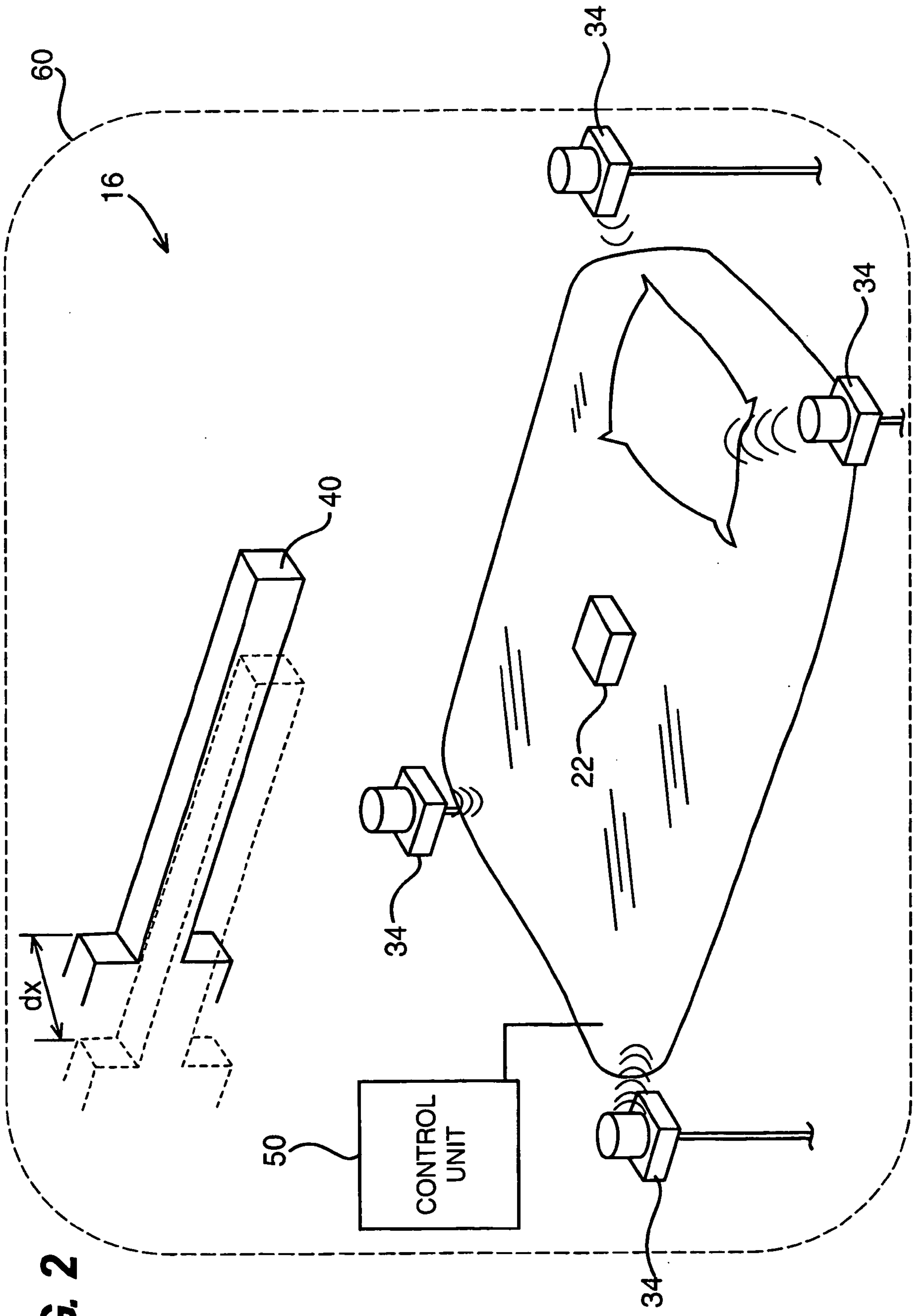

FIG. 2

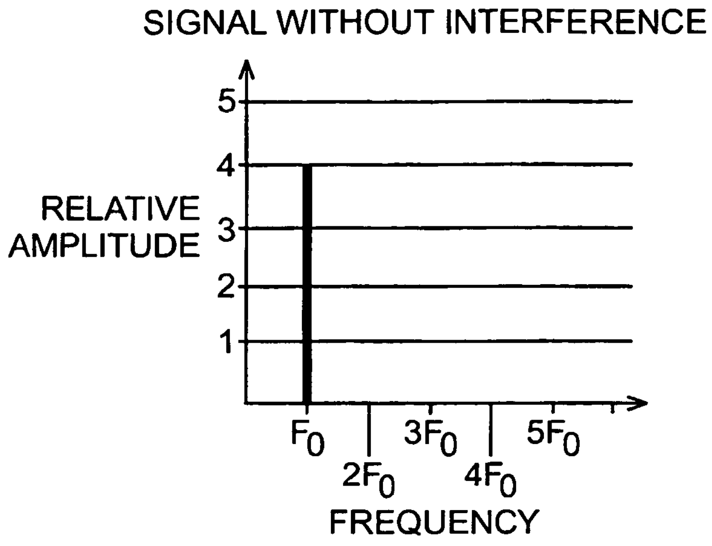

FIG. 3A

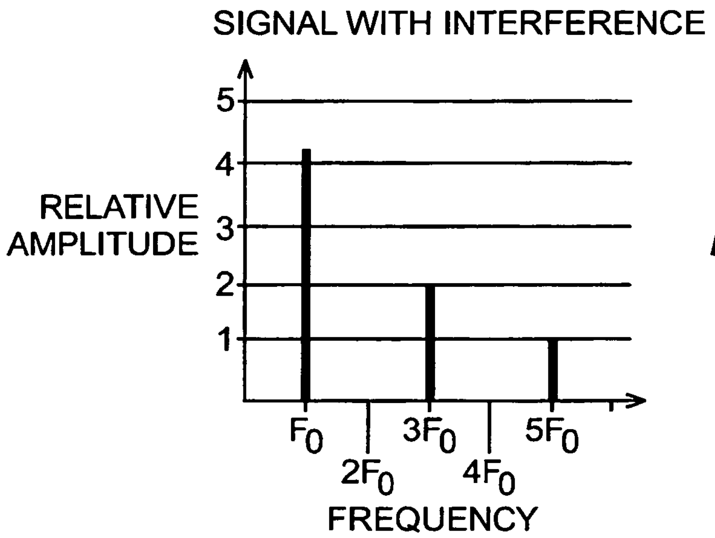

FIG. 3B

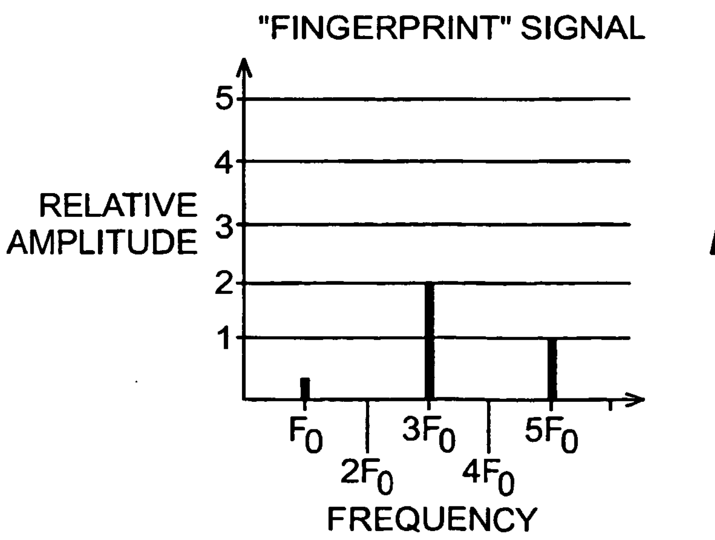

FIG. 3C

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	用于跟踪对象的装置，方法和软件		
公开(公告)号	EP1510174B1	公开(公告)日	2009-07-15
申请号	EP2004253229	申请日	2004-05-28
[标]申请(专利权)人(译)	韦伯斯特生物官能公司		
申请(专利权)人(译)	生物传感韦伯斯特，INC.		
当前申请(专利权)人(译)	生物传感韦伯斯特，INC.		
[标]发明人	GOVARI ASSAF		
发明人	GOVARI, ASSAF		
IPC分类号	A61B5/06 G01B7/004 G01N27/72 A61B19/00 A61B5/00		
CPC分类号	A61B5/06 A61B5/062		
代理机构(译)	MERCER，CHRISTOPHER PAUL		
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其他公开文献	EP1510174A1		
外部链接	Espacenet		

摘要(译)

提供评估装置，包括一组一个或多个辐射器（34），其适于在至少一个基频产生能量场。接收传感器适于在干扰物品（40）相对于接收传感器处于第一位置时响应于能量场而产生第一信号，并且适于在干扰物品时响应于能量场产生第二信号。位于相对于接收传感器的第二位置。控制单元（50）适于（a）接收和分析第一和第二信号，以便计算干扰物品的指纹信号特征，以及（b）在数据库中存储指示指纹信号的数据。 ，与干扰物品的身份相关联。

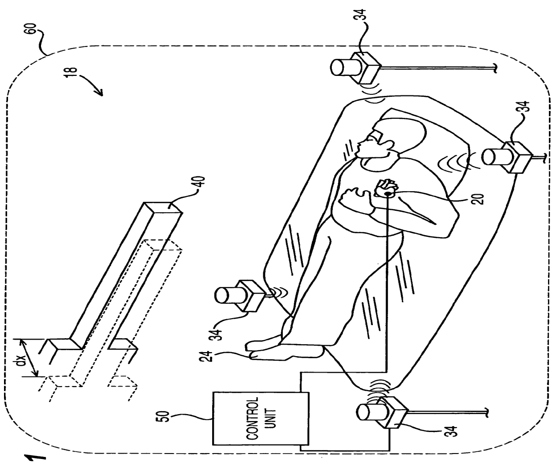

FIG. 1