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(54) **Title:** METHODS FOR LOCATING PASSIVE INTEGRATED TRANSPONDER TAGS, AND DEVICES AND SYSTEMS INCORPORATING SAME

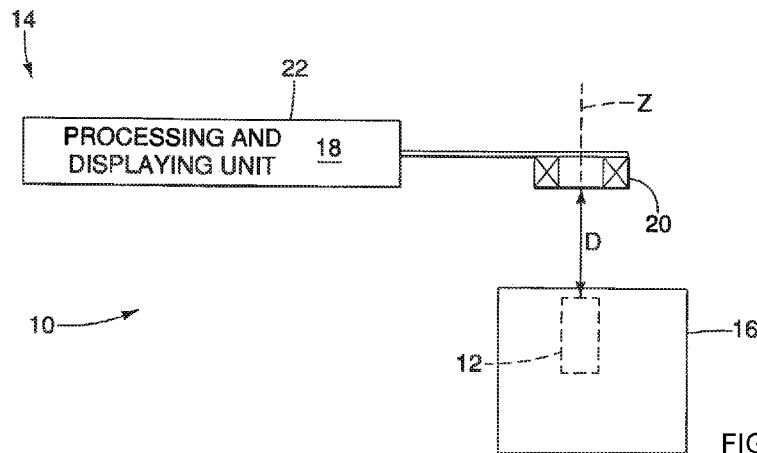


FIG. 1

(57) **Abstract:** A method for locating a passive integrated transponder (PIT) tag embedded in tissue includes moving a reading device relative to an area of interest in the tissue. The reading device includes a probe having a coil at a distal end thereof. The coil is configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue. The method also includes receiving one or more radio frequency (RF) signals with the reading device and determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the PIT tag embedded within the tissue. The method further includes generating an indication of a presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected.



METHODS FOR LOCATING PASSIVE INTEGRATED TRANSPONDER TAGS,
AND DEVICES AND SYSTEMS INCORPORATING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 63/586,795, filed September 29, 2023, the entire contents of which is incorporated by reference herein.

FIELD

[0002] The present disclosure generally relates to the field of location devices. More specifically, the disclosure relates to the field of localization devices and methods associated with locating passive integrated transponder tags (hereinafter "PIT tags"), and devices and systems incorporating same.

BACKGROUND

[0003] The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described in any way.

[0004] PIT tags have been used for many years to identify specimens, including livestock, domestic pets, birds, fish, and other marine animals for various management and/or research purposes. PIT tags have also been used for clinical purposes, such as, for example, to identify areas of interest within a patient's body and, for example, assist a surgeon in locating the area during a surgical procedure. In the field of women's health, for example, PIT tags have been used as localization devices to mark breast lesions for later investigation and/or surgical removal of the lesions. Each PIT tag generally includes a small ferrite-cored coil attached to a microchip. The microchip has a capacitor that causes the coil to resonate at a predetermined frequency when energized and circuitry to generate and transmit a coded identification number or message in response to a received interrogation signal which energizes the coil. PIT tags do not contain an internal energy source. Instead, energy needed to transmit the coded identification number is obtained through an electromagnetic coupling, which causes a transfer of energy from a powered device to the PIT tag. PIT tags, for example, are generally configured to respond to a signal emitted from a scanner. These scanners, also known as "readers," send out an electromagnetic

charge, and when a PIT tag is within range, the transponder it contains reacts to this charge and transmits the tag's unique identification code via a radio frequency (RF) signal. The code is then recorded by a device connected to the reader, providing a specific detection of an individual specimen. As used herein a "PIT tag reader," "reading device," or just "reader" is, therefore, a device that is capable of receiving a coded identification number transmitted by a PIT tag and displaying the number. In other words, a "PIT tag reading device" is a radio frequency identification (RFID) reader that uses electromagnetic fields (RF signals) to automatically identify a unique identification number associated with a respective PIT tag.

[0005] Typically, a PIT tag is a small, pill-shaped cylinder of glass that houses a radio transponder containing the PIT tag's unique code. In various embodiments, the glass covering, or envelope of a PIT tag is about 2 mm in diameter and about 11 mm in length, although other packaging is possible as would be understood by those of ordinary skill in the art. PIT tags are usually injected up to a few centimeters below the outer surface of an object or the specimen's skin using a hypodermic syringe and are typically read by a PIT tag reading device that is brought within close range of the PIT tag. Since PIT tag readers generally do not have the capability to distinguish between various incoming RF signals, they often experience large amounts of interference while attempting to read an individual PIT tag. For example, as a PIT tag reading device is brought within range of a given PIT tag, the reader can pick up the RF signals from other RF devices within its range, including, but not limited to other medical devices (which emit RF signals) within the vicinity of the PIT tag, and/or pick up friction interference from itself (e.g., from movement at its wire connections). This interference can make it difficult to discern the specific RF signal from the PIT tag, which the reader is looking for to identify the location of the PIT tag, from the other RF signals and noise. Furthermore, since PIT tag reading devices can also be configured to provide an audible indication when a signal is detected, such false detections can be annoying to a person using the reader to locate a PIT tag and to others nearby. These issues can be particularly problematic within an operating room suite in which the PIT tag reading device is being employed during a surgical procedure.

[0006] Thus, there is a need for improved methods of locating PIT tags, which enable a PIT tag reading device to distinguish between RF signals and other noise during PIT tag location. There is a further need to provide methods of locating PIT tags that prevent a PIT tag reading

device from providing false detections, and which trigger audible or other forms of detection notification only when a PIT tag is located.

SUMMARY

[0007] The present disclosure addresses one or more of the above-mentioned problems and/or achieves one or more of the above-mentioned desirable features. Other features and/or advantages may become apparent from the description which follows.

[0008] In one embodiment, a method for locating a passive integrated transponder (PIT) tag embedded in tissue includes moving a reading device relative to an area of interest in the tissue. The reading device includes a probe having a coil at a distal end thereof. The coil is configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue. The method also includes receiving one or more radio frequency (RF) signals with the reading device and determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the PIT tag embedded within the tissue. The method further includes generating an indication of a presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected.

[0009] In another embodiment, a method for locating a PIT tag embedded in tissue includes moving a reading device over an area of interest in the tissue to identify an approximate location of the PIT tag embedded within the tissue. The reading device includes a probe having a coil at a distal end thereof. The coil is configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue. The method also includes forming an incision in the tissue adjacent to the location of the PIT tag and inserting the probe into the incision. The method additionally includes receiving electromagnetic signals and determining whether each of the received electromagnetic signals includes a unique identifier. The method further includes generating an output for each of the received electromagnetic signals that includes a unique identifier.

[0010] In yet another embodiment, a system for locating one or more PIT tags in a body includes one or more PIT tags configured for implantation within a body. Each of the one or more PIT tags is configured to transmit an electromagnetic signal including a unique identifier of the respective PIT tag. The system also includes a handheld device including a probe having a coil at a distal end thereof. The coil is configured to transmit a signal resonating at a designated operating frequency of the one or more PIT tags. The probe is configured for insertion into an incision in the body in order to advance

the coil towards the one or more PIT tags located within the body. The handheld device is configured to receive electromagnetic signals and determine whether each of the received electromagnetic signals includes a unique identifier. The handheld device is also configured to generate an output only when one of the received electromagnetic signals includes a unique identifier.

[0011] It yet another embodiment, a method for locating a localization device embedded in breast tissue, includes moving a reading device relative to an area of interest in the breast tissue. The reading device includes a probe having a coil at a distal end thereof. The coil is configured to transmit a signal resonating at a frequency of the localization device embedded within the tissue. The method also includes receiving one or more radio frequency (RF) signals with the reading device and determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the localization device embedded within the breast tissue. The method further includes generating an indication of a presence and/or location of the localization device only when a RFID signal transmitted by the localization device embedded within the breast tissue is detected.

[0012] In a further embodiment, a method for locating a localization device embedded in breast tissue includes moving a reading device over an area of interest in the breast tissue to identify an approximate location of the localization device embedded within the breast tissue. The reading device includes a probe having a coil at a distal end thereof. The coil is configured to transmit a signal resonating at a frequency of the localization device embedded within the breast tissue. The method also includes forming an incision in the breast tissue adjacent to the location of the localization device and inserting the probe into the incision. The method additionally includes receiving electromagnetic signals and determining whether each of the received electromagnetic signals includes a unique identifier. The method further includes generating an output for each of the received electromagnetic signals that includes a unique identifier.

[0013] Additional objects and advantages will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the present teachings. At least some of the objects and advantages of the present disclosure may be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

[0014] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the present disclosure and claims, including equivalents. It should be understood that the present disclosure and claims, in their broadest sense, could be practiced without having one or more features of these exemplary aspects and embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate some exemplary embodiments of the present disclosure and together with the description, serve to explain certain principles. These drawings depict only typical embodiments of the disclosed inventions and are not therefore to be considered limiting of its scope. In the drawings:

[0016] FIG. 1 is a side view of an exemplary locating system in accordance with the present disclosure;

[0017] FIG. 2 is an overhead plan view of an exemplary PIT tag reading device of the locating system of FIG. 1;

[0018] FIG. 3 is a cross-sectional view of an exemplary pencil probe for use with the PIT tag reading device of FIG. 2;

[0019] FIG. 4 is a block diagram of an exemplary apparatus capable of locating a PIT tag and reading an associated tag identification number; and

[0020] FIG. 5 is a flowchart illustrating an exemplary method of using the PIT tag reading device of FIG. 2.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0021] Passive integrated transponder (PIT) tags are useful for providing identification (ID) information about a particular PIT tag that is embedded in a body or specimen. In the field of women's health, for example, PIT tags are used as localization devices to mark breast lesions for later investigation and/or surgical removal of the lesions. In various embodiments, for example, an actual physical location of a specific PIT tag within the object or specimen (e.g., embedded within the breast of a patient at the location of a lesion) can be determined by using an apparatus, or reading device, for locating and reading a coded identification number transmitted by the PIT tag, the coded identification number serving to identify the PIT tag. Recent

improvements to PIT tag locating apparatuses, or PIT tag reading devices, have allowed such apparatuses to become more robust. Contemplated readers can, for example, use electromagnetic couplings to change load conductance on an oscillator, which is measured and output to an accessory to provide an audio and/or visual indication to a user, thereby allowing the user to determine the position of the PIT tag embedded within the object or specimen, including the depth of the PIT tag relative to a coil of the reading device (e.g., relative the outer surface of the breast). Such improved reading devices can, for example, reduce the need for exploratory surgery or other locating methods to determine the location of the PIT tag within the object or embedded within the tissue of the specimen (e.g., within the breast of a patient). Various embodiments and examples of such locating apparatuses are disclosed, for example, in U.S. Application No. 12/371,048, which was filed on February 13, 2009, issued as U.S. Patent No. 8,973,584 on March 10, 2015; U.S. Application No. 14/642,217, which was filed on March 9, 2014, issued as U.S. Patent No. 9,867,550 on January 16, 2018; and U.S. Application No. 15/865,164, which was filed on January 8, 2018, issued as U.S. Patent No. 10,849,529 on December 1, 2020. The entire content of each of U.S. Patent No. 8,973,584, U.S. Patent No. 9,867,550, and U.S. Patent No. 10,849,529 is incorporated herein by reference.

[0022] During the locating process, as a PIT tag reading device is brought within range of a given PIT tag, the reader can be susceptible to interference from other sources. For example, the reader can pick up radio frequency (RF) signals from other devices within its range, including other mobile communication and/or medical devices within the vicinity of the PIT tag (e.g., iPhone, watch, cautery device, etc.), and/or pick up friction interference from its own components (e.g., from movement at its wire connections as the reader is advanced within an incision in the tissue). This interference, or noise, can make it difficult for the reader to discern the specific RF signal from the PIT tag, thereby resulting in the reader providing false audio and/or visual feedback (i.e., indications) to the user (e.g., surgeon).

[0023] In accordance with various embodiments, PIT tag reading devices can employ improved methods for locating PIT tags that function to isolate and act on signals that have identification numbers associated with them, while ignoring all other signals. For example, in various embodiments, a method for locating a PIT tag embedded in tissue, such as, for example, the breast of a patient, includes moving a reading device relative to an area of interest in the tissue

(e.g., breast) to receive one or more radio frequency (RF) signals with the reading device. The reading device can, for example, include a probe having a coil at a distal end, wherein the coil is configured to transmit a signal resonating at a frequency of the PIT tag, as will be described further below. To prevent unwanted feedback, for example, from the received RF signals that are not associated with the PIT tag, the method also contemplates isolating a radio frequency identification (RFID) signal associated with the PIT tag from other RF signals based on the identification number contained within the RFID signal and providing feedback (e.g., an audible or visual indication) only for the isolated RFID signal. The reader will therefore only provide feedback for an electromagnetic signal, audible or otherwise, when there is a number associated with the signal. In other words, during the locating process, upon receipt of one or more RF signals, exemplary methods of the present disclosure contemplate performing the steps of: 1) determining whether at least one of the one or more RF signals is an RFID signal transmitted by the PIT tag embedded within the tissue; and 2) generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected. In this manner, systems for locating PIT tags in accordance with the present disclosure, which include PIT tag reading devices, are configured to employ such methods to receive electromagnetic signals, determine whether each of the received electromagnetic signals includes a unique identifier, and generate an output only when a received electromagnetic signal includes a unique identifier.

[0024] Referring now to FIGS. 1 and 2, one exemplary embodiment of a locating system 10 is generally shown. The locating system 10 includes a transponder, such as a PIT tag 12, and a transceiver, such as a PIT tag reading device 14. The PIT tag 12 is configured to be implanted within tissue, such as, for example, under the skin of a specimen 16 (e.g., within a breast 16 of a patient). The PIT tag 12 is further capable of transmitting a response signal when energized by an interrogating signal or electromagnetically coupled to a driven coil such as a coil in the reading device 14.

[0025] In accordance with the example embodiment of the PIT tag reading device shown in FIGS. 1 and 2, the PIT tag reading device 14 includes a processing and display unit 18 for analyzing data such as a load conductance, strength of a signal emitted by the transponder, and, optionally, encoded content of a message incorporated in this signal, such as, for example

information relating to an identification number of the PIT tag 12. The reading device 14 also includes a search coil 20, which in some embodiments is annular or cylindrical in shape, attached to the processing and display unit 18. The search coil 20 can be driven at a pre-selected frequency substantially equal to the natural resonant frequency of the PIT tag 12. The processing and display unit 18 can be housed in a hand-held case 22 that includes a display window 24. The display window 24 can be used to provide visual indications to a user regarding a located PIT tag, such as, for example, distance and/or PIT tag identification number information. In some embodiments, for example, as disclosed in U.S. Patent Nos. 8,973,584, 9,867,550, and 10,849,529, the entire content of each which is incorporated by reference herein, the PIT tag reading device 14 can measure a distance D between the search coil 20 and the PIT tag 12 when the search coil 20 is energized due to electromagnetic coupling to the PIT tag 12.

[0026] In some embodiments, as shown in FIG. 2, which is a top view of the PIT tag reading device 14 of FIG. 1, the search coil 20 may be moved laterally (i.e., in any of the directions indicated by the arrows L) over the skin of the specimen 16 (i.e., within an area of interest of the specimen) at a small distance above the skin or at the surface thereof to determine an approximate lateral position of a PIT tag 12 implanted within the tissue of the specimen 16. Once the lateral position of the PIT tag 12 is known, the search coil 20 can be lowered to contact the skin of the specimen 16 to determine the depth at which the PIT tag 12 was implanted, which can be calculated by the processing and display unit 18 based upon (i) a change in load conductance when there is electromagnetic coupling between the reading device 14 and the PIT tag 12, or (ii) a strength of the transponder signal received from the PIT tag 12, and the depth can be viewed via the display window 24. In various embodiments, the display window can also show information corresponding to a strength of the signal in graphical form (e.g., via a bar graph), information relating to an orientation of the tag relative to the search coil 20 in graphical or textual form, an icon that is illustrative of the current mode of the device (e.g., loop mode vs. probe mode), an identification number of the PIT tag 12, and/or the battery life of the reading device 14.

[0027] It will be appreciated by those of ordinary skill in the art that the measured data displayed by the PIT tag reading device 14 will depend upon the size, shape, and orientation of the search coil 20 in relation to the PIT tag 12, as well as the distance D between the PIT tag and

the search coil 20. For example, considering the magnetic flux distribution surrounding the search coil 20, one skilled in the art can appreciate that the maximum generated response for a PIT tag 12 that is oriented parallel to a center axis Z of the search coil 20 (see, e.g., FIG. 1) will occur when the center of the search coil is directly over the center of the PIT tag. A PIT tag 12 that is oriented obliquely relative to the center axis Z of the search coil 20 will generate a maximum response when the PIT tag is slightly off-center relative to the center axis Z of the search coil, and a horizontal PIT tag (i.e., a PIT tag oriented perpendicular to the center axis of the search coil) will generate two maxima of positions a little to either side of center of the PIT tag, with lower values in between the two maxima. Thus, it should be noted that the effects of orientation, as well as other factors, including the presence of signal noise as discussed further below, can limit the ability of the reading device 14 to obtain an exact measurement of the depth and lateral position of a PIT tag 12 implanted in a specimen 16.

[0028] Sometimes a PIT tag 12 is implanted in an area where a specimen's skin is irregular or not generally flat, or the PIT tag 12 is implanted at a greater depth within the specimen's tissue (e.g., at a greater depth within the breast of a patient). In such circumstances, it may be difficult to accurately determine the position of the PIT tag 12 using the above search coil 20. Thus, in some embodiments, as illustrated in FIG. 3, the reading device 14 may include a pencil-shaped probe 130, having a coil 144 at a distal end thereof, to locate a PIT tag 12. The probe 130, for example, is configured for insertion into an incision in the tissue of the specimen (e.g., specimen 16) and is therefore generally formed from a relatively long and thin cylindrical tube 132 having a first, proximal end 134 and a second, distal end 136. The tube 132 may be made of any durable material that will not adversely react with the specimen, including, but not limited to, plastic and/or stainless steel, and preferably has an outer diameter of about 4 mm to about 8 mm and a length of about 150-200 mm. In some embodiments, as shown in FIG. 3, the first end 134 of the tube 132 is capped by a plastic cap 138, and the second end 136 of the tube 132 is fitted with a cable or connector 140 so that the probe 130 can be connected to the processing and display unit 18. A coil 144 is positioned within the second, distal end 136 of the of the tube 132. In some embodiments, the coil 144 is ferrite-cored and is disposed within the plastic cap 138. The coil 144 functions as a search coil similar to the search coil 20 of FIG. 1, and is configured to output a signal

to the processing and display unit 18 via lead wires 142 and the connector 140 located at the proximal end 134 of the tube 132.

[0029] In such embodiments, prior to using the probe 130, an approximate lateral location of the PIT tag 12 can first be determined using the search coil 20, as discussed above. For example, the reading device is in a “loop mode” or “search mode,” in which the search coil 20 scans laterally across a surface of the skin (e.g., a surface of the breast) until it detects a strong RF signal. Upon detection of a strong signal, the search coil 20 is moved perpendicularly into contact with the breast, and if necessary to isolate the signal, compress the soft tissue of the breast. The surgeon can then mark this location as a reference point, for example, with a marker or felt tip pen on the surface of the skin. The reading device 14 can then be switched into a “pencil mode” or “probe mode,” in which the reading device will now use the probe 130 to further locate the PIT tag 12. For example, an incision can then be made in an area that will reduce visible scarring for the patient (e.g., around the areola or on a fold under the breast during a breast surgery), and the probe 130 can be used to locate the PIT tag 12 while referencing the visible mark on the surface of the skin. For example, in various embodiments, the reading device 14 can be configured to switch from an initial, search or “loop mode” in which it utilizes the search coil 20 to determine an approximate lateral location of the PIT tag 12 into a secondary, probe or “pencil mode” in which the reading device 14 utilizes the probe 130 to determine a more precise location of the PIT tag 12. The processing and display unit 18 can be configured, for example, to switch the reading device 14 between the modes (i.e., activate the pencil mode) when the probe 130 is connected to the reading device 14 via the connector 140 (e.g., when the processing and display unit 18 receives a signal from the lead wires 142 of the probe). Those of ordinary skill would understand that the probe 130 can also be used to determine the approximate lateral location of the PIT tag 12 (i.e., such that the search coil 20 is not used), although the probe 130 may be less accurate than the search coil 20 due to its reduced size.

[0030] As discussed above, a small incision can then be made in the specimen 16 at either the determined lateral location or at another approximate location that will reduce visible scarring for the patient, and the probe 130 can be inserted in the incision. The probe 130 may then be manipulated within the incision to determine the shortest distance between the PIT tag 12 and the coil 144. It should be noted that because of the relative size difference between the coil 144

used within the probe 130 and the search coil 20, the range of the probe 130 is generally less than that of the search coil 20. Contemplated search coils 20 can, for example, have a range of about 6 cm. Exemplary embodiments of the present disclosure, however, contemplate probes 130 with extended ranges compared to previously available probes. Conventional probes, for example, can generally start to pick up RF signals at about 6 cm, but are not able to determine (i.e., read) an identification number within an RFID signal until the probe is within about 1-2 cm of the PIT tag. Contemplated probes 130 can have an increased range such that when using the probe 130 (i.e., when the reading device 14 is in pencil mode) the reading device 14 is able to read an identification number of the PIT tag 12 at an increased distance of about 3 cm from the PIT tag 12. Thus, the probe 130 has an increased sensitivity such that it can identify an RFID signal (i.e., read an identification number) earlier than was previously possible, thereby also helping to prevent unwanted feedback as the probe 130 is continuously moved toward the PIT tag 12.

[0031] The reading device 14 is therefore configured to not only locate an implanted PIT tag 12, but also read a tag identification number associated with the PIT tag 12. The signal (e.g., radio frequency identification (RFID) signal) has a message which contains a binary tag identification number sequence along with header information and error-detection bits, as defined by ISO 11784 and 11785 standards. The signal and message can be decoded using known techniques, as would be understood by those of ordinary skill in the art and are therefore not discussed in detail herein.

[0032] Referring now to FIG. 4, an exemplary circuit 160 that may be used with the reading device 14 is illustrated. With circuit 160, the reading device 14 is capable of PIT tag location, reading a decoded tag identification number, and automatic detection of a probe (i.e., to switch the reading device 14 into pencil mode from loop mode). A microcontroller 72 can use a crystal 74 to control a drive frequency that is selected to match a resonance frequency of a selected PIT tag 12. In some embodiments, the drive frequency can be derived from a timer output of the microcontroller 72. However, other methods of obtaining the drive frequency are contemplated, such as by using a frequency synthesizer. An output of the microcontroller 72 is then input into a drive circuit 76 that drives a resonator 162 (shown in dashed lines) that is formed from a capacitor C and a plug-in coil or probe 164 (e.g., either search coil 20 or probe 130) connected to the circuit 160 via a socket 166. The output of the drive circuit 76 is connected to one end of

the capacitor C. The other end of the capacitor C is connected to the socket 166 and a demodulator 86. The socket 166, for example, can provide a tight connection between the circuit and the search coil 20 or probe 130, thereby also helping to prevent friction interference from the reading device 14 itself.

[0033] The resonator 162 is driven at a particular frequency and with enough power to generate an interrogation signal that excites a response from the PIT tag 12 when electromagnetic coupling between the resonator 162 and the PIT tag 12 occurs. The response signal generated by the PIT tag 12 is superimposed onto the interrogating signal across the resonator 162 and is demodulated by the demodulator 86. A bandpass amplifier 90 receives the output of the demodulator 86 which includes the interrogating signal as an input, and separates the interrogating signal from the response signal. The response signal is provided as the output of the bandpass amplifier 90 and is input into both a comparator 168 that converts the response signal to logic levels suitable for the microcontroller interface and a peak detector 92. The output of the comparator 168 includes the tag identification number transmitted by the PIT tag 12 in its response signal. The output of the peak detector 92 is a voltage that is related to the distance D between the PIT tag 12 and the coil or probe 164.

[0034] A probe detector 170 detects whether the search coil 20 or the probe 130 is connected to the circuit 160 via the socket 166. In another embodiment (not shown) the search coil 20 may be fixed (i.e., constantly connected to circuit 160), as in FIGS. 1 and 2, such that it is only the probe 130 that is attached using a plug and socket. The output of the probe detector 170 is provided to the microcontroller 72 so that the microcontroller can switch the reading device 14 between modes (e.g., between the loop mode and the pencil mode) to properly interpret the received data. In other words, when the probe detector 170 detects that the probe 130 is connected to the reading device 14 (i.e., via the socket 166), the microcontroller 72 is configured to switch the reading device 14 into the pencil mode.

[0035] As also shown in FIG. 4, the microcontroller 72 is also connected to one or more switches (two switches S1, S2 being shown in the embodiment of FIG. 4). The switches S1, S2, for example, allow a user to adjust the settings of the reading device 14, such as audio tone amplitude and display backlight level. As would be understood by those of ordinary skill, the switches S1, S2 are also configured to allow the reading device 14 to read, store, and display the

information relating to an identification number of a detected PIT tag that is within range of the reading device 14. If no PIT tag 12 is within an operating range (i.e., capable of electromagnetically coupling with the search coil 20 or probe 130), the switches S1, S2 may have an alphanumeric display 126 show previously-stored tag identification numbers. Microcontroller flash memory or an external EEPROM, for example, may be used to store tag identification numbers and selected audio and/or backlight levels.

[0036] The microcontroller 72 also provides an output to a frequency synthesizer 118 to generate a tone that is related to the distance D between the PIT tag 12 and the search coil 20 or probe 130. The output of the frequency synthesizer 118 is input into an amplifier 120. Another output of the microcontroller 72 is fed into a digital-to-analog converter 172. The digital-to-analog converter 172 connects to the amplifier 120, and sets the gain of the amplifier. The output of the amplifier 120 is provided to a loudspeaker 106, which creates an audible tone as an indication of the distance D between the PIT tag 12 and the search coil 20 or probe 130 to a user. The microcontroller 72 also outputs another signal to the alphanumeric display 126 which can display a visual indication of the distance D , such as, for example, as a bar graph and scale.

[0037] As discussed above, to eliminate various other radio frequency (RF) signals that are within the range of the reading device 14, but which are not associated with the PIT tag 12, including, for example, signals associated with other medical devices being used in the same field as the reading device 14 and/or mobile communication devices within the range, the microcontroller 72 is further configured to ignore all signals that do not contain information relating to an identification number (e.g., ignore any signals that are not an RFID signal). In some embodiments, the microcontroller 72 is therefore configured to receive electromagnetic signals, determine whether each of the received electromagnetic signals includes a unique identifier for a PIT tag (e.g., PIT tag 12), and generate an output only when one of the received electromagnetic signals includes a unique identifier. In this manner, the microcontroller 72 is configured to provide an output to the frequency synthesizer 118 (i.e., to generate an audible tone) and/or an output to the alphanumeric display 126 (i.e., to display a visual indication) only when there is a unique identifier associated with the received electromagnetic signal. The microcontroller 72 is therefore able to ignore unwanted signal noise and prevent outputs that can lead to false indications.

[0038] In various embodiments, the microcontroller 72 may be configured to start monitoring the received signals to identify the signals with associated identification codes (e.g., determine which signals are RFID signals, while ignoring the other RF signals) upon entry into probe/pencil mode. For example, when the probe detector 170 detects that the probe 130 is connected to the circuit 160 via the socket 166, the microcontroller 72 may begin to isolate RFID signals from the other RF signals based on the information relating to the identification number embedded in the RFID signals, and then provide an output to the frequency synthesizer 118 and/or an output to the alphanumeric display 126 only for the isolated RFID signals (i.e., to provide an indication of only the isolated RFID signals). It will be understood, however, that microcontroller 72 can employ the disclosed signal noise reduction methods while in any mode of operation.

[0039] Those of ordinary skill in the art will understand that the reading device 14 described above with reference to FIGS. 1-4 is exemplary only and that various types and configurations of locating apparatuses may be used in accordance with the disclosed methods and systems to locate one or more PIT tags that are implanted within a specimen (e.g., embedded in tissue). For example, although reading device 14 includes two types of probes, search coil 20 and pencil probe 130, contemplated reading devices may include only one type of probe (search coil 20 or pencil probe 13) or have additional types and configurations of probes having coils that are configured to transmit a signal that resonates at a frequency of the one or more PIT tags.

[0040] Furthermore, those of ordinary skill in the art will understand that the location circuit 160 described above with reference to FIG. 4 is exemplary only and that various configurations of circuits, utilizing various components including various microcontrollers 72, may be used in the contemplated reading devices to execute the contemplated methods. In some embodiments, for example, location circuits may be utilized that include one or more relays, such that the location circuit can change its resonant frequency of oscillation to match a resonant frequency of a PIT tag, as disclosed in U.S. Patent Nos. 8,973,584, 9,867,550, and 10,849,529, the entire content of each which is incorporated by reference herein.

[0041] Referring now to FIG. 5, an exemplary method 200 of using the PIT tag reading device 14 to locate a PIT tag 12 is shown. The method 200 includes a step 210 of providing a search mechanism, such as, for example, the reading device 14 adjacent to an object surface. Although for

simplicity in the below example the PIT tag 12 is discussed as being embedded in tissue, such as, for example, under the skin of a specimen 16 as discussed above, it would be understood that the PIT tag 12 could be implanted in any object and is not in any manner limited to being embedded within tissue or under skin. In some embodiments, step 210 can include moving the reading device 14 relative to the tissue, for example, in an area of interest (e.g., in an area in which the PIT tag is known to have been implanted). The reading device 14 can include a handheld device that includes a probe having a coil at a distal end thereof. As discussed above, in some embodiments, the reading device 14 can be used in two different modes: 1) a first “loop” mode, in which a first probe, coil 20, of the reading device 14 is used to determine an approximate lateral location of a PIT tag 12, and 2) a second “pencil” mode in which a second probe, pencil probe 130 with a coil 144, is used to determine a more precise location of the PIT tag 12. In this manner, step 210 can include one or both of moving the coil 20 over the tissue, in an area of interest, to identify an approximate location of the PIT tag 12 embedded within the tissue and then inserting the probe 130 into an incision in the tissue. Accordingly, the contemplated methods may further include a step of forming an incision in the tissue, for example, adjacent to the approximate location of the PIT tag that is first located by the coil 20, and then inserting the probe 130 into the incision. Once again for simplicity, in the below discussion, the reading device 14 is in the second, pencil mode in which the probe 130 is inserted into and advanced within an incision.

[0042] Next, as the probe 130 is advanced within the incision, in the area of interest, in step 212 the search mechanism receives one or more radio frequency (RF) signals. The microcontroller 72, for example, can receive RF signals that are within a range of the probe 130 (i.e., that are capable of electromagnetically coupling with the probe 130), with one of the received RF signals being a radio frequency identification (RFID) signal from the PIT tag 12. As discussed above, the RFID signal can contain information relating to an identification number of the PIT tag 12 and information relating to a depth D of the PIT tag 12. As discussed above, in various embodiments, the microcontroller 72 can begin to identify an identification number in an RFID signal within a range of about 3 mm from the PIT tag 12.

[0043] In step 214, it is determined whether at least one of the one or more RF signals is a RFID signal transmitted by the PIT tag 12 (i.e., includes information relating to an identification number associated with the PIT tag 12). In other words, in step 216, the microcontroller 72 isolates the

RFID signal from other RF signals based on the identification number included in the signal. If the signal includes an identification number (i.e., if the signal is a RFID signal with a unique identifier associated with the signal), it is determined that a PIT tag has been located, and the process proceeds to step 216, otherwise the signal is ignored at step 218.

[0044] In step 216, an indication of the presence and/or location of the PIT tag is generated for the isolated RFID signal (i.e., for the located PIT tag 12). In some embodiments, for example, an audible and/or visual indication of a depth D of the PIT tag 12 is generated and, in other embodiments, a visual indication of the identification number of the PIT tag 12 is generated. An audible indication can include, for example, a beeping noise that can change in tone, pattern, and/or volume as the probe 130 gets closer to the PIT tag, while a visual indication can include display a graphical representation of the depth D, distance, and/or orientation between the probe 130 and the PIT tag 12. Thus, as discussed above, if the received electromagnetic signal includes an identification number, in step 216, the microcontroller 72 provides an output to the frequency synthesizer 118 (i.e., to generate an audible tone) and/or an output to the alphanumeric display 126 (i.e., to display a visual indication). However, if the received electromagnetic signal does not include an identification number, the microcontroller 72 ignores the signal and does not generate an audible and/or visual indication on the reader.

[0045] In this manner, PIT tag locating apparatuses, such as, for example, the reading device 14 may utilize method 200 to sift through the signal noise that is often encountered during a PIT tag locating procedure, allowing the reading device to ignore unwanted signals that can lead to false indications. For example, in additional instances in which two or more tags are used, for example to bracket a breast lesion, more than one PIT tag can also be detected via the identification numbers associated with the tags, such that each PIT tag generates an audible signal and a physician (e.g., surgeon) would be able to determine a specific tag based on the unique identification number that is displayed on the display window.

[0046] Examples

[0047] Illustrative examples of the methods and systems for locating passive integrated transponder (PIT) tags and localization devices embedded in breast tissue are provided below. Embodiments of the methods and systems described herein may include any one or more, and any combination of, the clauses described below:

[0048] Clause 1. A method for locating a passive integrated transponder (PIT) tag embedded in tissue, the method comprising:

moving a reading device relative to an area of interest in the tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue;

receiving one or more radio frequency (RF) signals with the reading device;

determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the PIT tag embedded within the tissue; and

generating an indication of a presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected.

[0049] Clause 2. The method of clause 1, wherein determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the PIT tag embedded within the tissue includes determining whether an identification number is associated with the RF signal.

[0050] Clause 3. The method of clause 1 or clause 2, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected includes isolating the RFID signal from any other RF signals received by the reading device based on the presence of the identification number associated with the RFID signal.

[0051] Clause 4. The method of any of clauses 1-3, wherein moving the reading device relative to an area of interest in the tissue comprises moving the reading device relative to an area of interest in a breast of a patient.

[0052] Clause 5. The method of any one of clauses 1-3, wherein moving the reading device relative to an area of interest in the tissue comprises moving a handheld reading device relative to the tissue.

[0053] Clause 6. The method of any one of clauses 1-5, wherein moving the reading device relative to the area of interest in the tissue comprises moving the probe over the tissue to identify an approximate location of the PIT tag embedded within the tissue.

[0054] Clause 7. The method of any one of clauses 1-6, wherein moving the reading device relative to the area of interest in the tissue comprises inserting the probe into an incision in the tissue.

[0055] Clause 8. The method of any one of clauses 1-7, wherein the at least one RFID signal includes information relating to a depth of the PIT tag relative to the coil.

[0056] Clause 9. The method of any one of clauses 1-8, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected comprises providing an audible indication of a depth of the PIT tag as the probe is advanced within the incision.

[0057] Clause 10. The method of any one of clauses 3-9, wherein isolating the RFID signal comprises ignoring any RF signal that does not have information relating to an identification number.

[0058] Clause 11. The method of any one of clauses 3-10, wherein isolating the RFID signal comprises determining whether each of the received one or more RF signals includes information relating to an identification number.

[0059] Clause 12. The method of any one of clauses 1-11, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected comprises generating an audible indication.

[0060] Clause 13. The method of any one of clauses 1-12, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected comprises generating a visual indication of the identification number of the PIT tag.

[0061] Clause 14. The method of clause 13, wherein generating the visual indication of the identification number comprises displaying the identification number of the PIT tag on a display device.

[0062] Clause 15. A method for locating an integrated transponder (PIT) tag embedded in tissue, the method comprising:

- moving a reading device over an area of interest in the tissue to identify an approximate location of the PIT tag embedded within the tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue;
- forming an incision in the tissue adjacent to the location of the PIT tag;
- inserting the probe into the incision;

receiving electromagnetic signals;
determining whether each of the received electromagnetic signals includes a unique identifier; and
generating an output for each of the received electromagnetic signals that includes a unique identifier.

[0063] Clause 16. The method of clause 15, wherein moving the reading device over the area of interest in the tissue comprises moving a handheld reading device over the tissue.

[0064] Clause 17. The method of clause 15, wherein generating the output comprises providing an audible indication of a depth of the PIT tag relative to the coil as the probe is advanced within the incision.

[0065] Clause 18. The method of clause 15, wherein generating the output comprises providing a visual indication of the unique identifier.

[0066] Clause 19. The method of clause 18, wherein providing the visual indication of the unique identifier comprises displaying an identification number of the PIT tag on a display device.

[0067] Clause 20. A system for locating one or more passive integrated transponder (PIT) tags in a body, the system comprising:

one or more PIT tags configured for implantation within a body, each of the one or more PIT tags being configured to transmit an electromagnetic signal including a unique identifier of the respective PIT tag; and

a handheld device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a designated operating frequency of the one or more PIT tags, the probe being configured for insertion into an incision in the body in order to advance the coil towards the one or more PIT tags located within the body, the handheld device being configured to:

receive electromagnetic signals;

determine whether each of the received electromagnetic signals includes a unique identifier; and

generate an output only when one of the received electromagnetic signals includes a unique identifier.

[0068] Clause 21. The system of clause 20, wherein the handheld device is configured to generate an audible indication when one of the received electromagnetic signals includes a unique identifier.

[0069] Clause 22. The system of clause 21, wherein the audible indication comprises an audible beeping and/or speaking.

[0070] Clause 23. The system of any one of clauses 20-22, wherein the handheld device is configured to generate a visual indication when one of the received electromagnetic signals includes a unique identifier.

[0071] Clause 24. The system of clause 23, further comprising a display device configured to show the visual indication of the unique identifier.

[0072] Clause 25. The system of clause 23, wherein the visual indication comprises a string of numbers and/or a graphic image.

[0073] Clause 26. The system of clause 20, wherein the one or more PIT tags are configured for implantation within a breast of a patient.

[0074] Clause 27. A method for locating a localization device embedded in breast tissue, the method comprising:

- moving a reading device relative to an area of interest in the breast tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the localization device embedded within the tissue;

- receiving one or more radio frequency (RF) signals with the reading device;

- determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the localization device embedded within the breast tissue; and

- generating an indication of a presence and/or location of the localization device only when a RFID signal transmitted by the localization device embedded within the breast tissue is detected.

[0075] Clause 28. The method of clause 27, wherein determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the localization device embedded within the breast tissue includes determining whether an identification number is associated with the RF signal.

[0076] Clause 29. The method of clause 27 or claim 28, wherein generating an indication of the presence and/or location of the localization device only when a RFID signal transmitted by the

localization device embedded within the breast tissue is detected includes isolating the RFID signal from any other RF signals received by the reading device based on the presence of the identification number associated with the RFID signal.

[0077] Clause 30. The method of any one of clauses 27-29, wherein moving the reading device relative to the area of interest in the breast tissue comprises moving the probe over the breast tissue to identify an approximate location of the localization device embedded within the breast tissue.

[0078] Clause 31. The method of any one of clauses 27-30, wherein moving the reading device relative to the area of interest in the breast tissue comprises inserting the probe into an incision in the breast tissue.

[0079] Clause 32. The method of any one of clauses 27-31, wherein the at least one RFID signal includes information relating to a depth of the localization device relative to the coil.

[0080] Clause 33. The method of any one of clauses 27-32, wherein generating an indication of the presence and/or location of the localization device only when a RFID signal transmitted by the localization device embedded within the breast tissue is detected comprises providing an audible indication of a depth of the localization device as the probe is advanced within the incision.

[0081] Clause 34. A method for locating a localization device embedded in breast tissue, the method comprising:

- moving a reading device over an area of interest in the breast tissue to identify an approximate location of the localization device embedded within the breast tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the localization device embedded within the breast tissue;

- forming an incision in the breast tissue adjacent to the location of the localization device;

- inserting the probe into the incision;

- receiving electromagnetic signals;

- determining whether each of the received electromagnetic signals includes a unique identifier; and

- generating an output for each of the received electromagnetic signals that includes a unique identifier.

[0082] Clause 35. The method of clause 34, wherein moving the reading device over the area of interest in the breast tissue comprises moving a handheld reading device over the breast tissue.

[0083] Clause 36. The method of clause 34, wherein generating the output comprises providing an audible indication of a depth of the localization device relative to the coil as the probe is advanced within the incision.

[0084] Clause 37. The method of clause 34, wherein generating the output comprises providing a visual indication of the unique identifier.

[0085] Clause 38. The method of clause 34, wherein generating the output comprises providing a visual indication of an orientation of the localization device relative to the probe.

[0086] Clause 39. The method of any one of clauses 34-38, wherein the localization device is an integrated transponder (PIT) tag.

[0087] All numeric values are herein assumed to be modified by the term “about,” whether or not explicitly indicated. The term “about” generally refers to a range of numbers that one of skill in the art would consider equivalent to the recited value (i.e., having the same function or result). In many instances, the terms “about” may include numbers that are rounded to the nearest significant figure.

[0088] The recitation of numerical ranges by endpoints includes all numbers within that range (e.g., 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5).

[0089] This description and the accompanying drawings that illustrate exemplary embodiments should not be taken as limiting. Various mechanical, compositional, structural, electrical, and operational changes may be made without departing from the scope of this description and the claims, including equivalents. In some instances, well-known structures and techniques have not been shown or described in detail so as not to obscure the disclosure. Furthermore, elements and their associated features that are described in detail with reference to one embodiment may, whenever practical, be included in other embodiments in which they are not specifically shown or described. For example, if an element is described in detail with reference to one embodiment and is not described with reference to a second embodiment, the element may nevertheless be included in the second embodiment.

[0090] It is noted that, as used herein, the singular forms “a,” “an,” and “the,” and any singular use of any word, include plural referents unless expressly and unequivocally limited to one referent.

As used herein, the term “include” and its grammatical variants are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that can be substituted or added to the listed items.

[0091] Further, this description’s terminology is not intended to limit the disclosure. For example, spatially relative terms—such as “beneath,” “below,” “lower,” “above,” “upper,” “forward,” “front,” “behind,” and the like—may be used to describe one element’s or feature’s relationship to another element or feature as illustrated in the orientation of the figures. These spatially relative terms are intended to encompass different positions and orientations of a device in use or operation in addition to the position and orientation shown in the figures. For example, if a device in the figures is inverted, elements described as “below” or “beneath” other elements or features would then be “above” or “over” the other elements or features. Thus, the exemplary term “below” can encompass both positions and orientations of above and below. A device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0092] Further modifications and alternative embodiments will be apparent to those of ordinary skill in the art in view of the disclosure herein. For example, the systems may include additional components that were omitted from the diagrams and description for clarity of operation. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the systems and methods of the present disclosure. It is to be understood that the various embodiments shown and described herein are to be taken as exemplary. Elements and materials, and arrangements of those elements and materials, may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the present teachings may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of the description herein. Changes may be made in the elements described herein without departing from the scope of the present disclosure.

[0093] It is to be understood that the particular examples and embodiments set forth herein are non-limiting, and modifications to structure, dimensions, materials, and methodologies may be made without departing from the scope of the present disclosure. Other embodiments in accordance with the present disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with being entitled to their full breadth of scope, including equivalents.

What is claimed is:

1. A method for locating a passive integrated transponder (PIT) tag embedded in tissue, the method comprising:
 - moving a reading device relative to an area of interest in the tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue;
 - receiving one or more radio frequency (RF) signals with the reading device;
 - determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the PIT tag embedded within the tissue; and
 - generating an indication of a presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected.
2. The method of claim 1, wherein determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the PIT tag embedded within the tissue includes determining whether an identification number is associated with the RF signal.
3. The method of claim 1 or claim 2, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected includes isolating the RFID signal from any other RF signals received by the reading device based on the presence of the identification number associated with the RFID signal.
4. The method of any of claims 1-3, wherein moving the reading device relative to an area of interest in the tissue comprises moving the reading device relative to an area of interest in a breast of a patient.
5. The method of any one of claims 1-3, wherein moving the reading device relative to an area of interest in the tissue comprises moving a handheld reading device relative to the tissue.

6. The method of any one of claims 1-5, wherein moving the reading device relative to the area of interest in the tissue comprises moving the probe over the tissue to identify an approximate location of the PIT tag embedded within the tissue.
7. The method of any one of claims 1-6, wherein moving the reading device relative to the area of interest in the tissue comprises inserting the probe into an incision in the tissue.
8. The method of any one of claims 1-7, wherein the at least one RFID signal includes information relating to a depth of the PIT tag relative to the coil.
9. The method of any one of claims 1-8, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected comprises providing an audible indication of a depth of the PIT tag as the probe is advanced within the incision.
10. The method of any one of claims 3-9, wherein isolating the RFID signal comprises ignoring any RF signal that does not have information relating to an identification number.
11. The method of any one of claims 3-10, wherein isolating the RFID signal comprises determining whether each of the received one or more RF signals includes information relating to an identification number.
12. The method of any one of claims 1-11, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected comprises generating an audible indication.
13. The method of any one of claims 1-12, wherein generating an indication of the presence and/or location of the PIT tag only when a RFID signal transmitted by the PIT tag embedded within the tissue is detected comprises generating a visual indication of the identification number of the PIT tag.

14. The method of claim 13, wherein generating the visual indication of the identification number comprises displaying the identification number of the PIT tag on a display device.
15. A method for locating an integrated transponder (PIT) tag embedded in tissue, the method comprising:
- moving a reading device over an area of interest in the tissue to identify an approximate location of the PIT tag embedded within the tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the PIT tag embedded within the tissue;
 - forming an incision in the tissue adjacent to the location of the PIT tag;
 - inserting the probe into the incision;
 - receiving electromagnetic signals;
 - determining whether each of the received electromagnetic signals includes a unique identifier; and
 - generating an output for each of the received electromagnetic signals that includes a unique identifier.
16. The method of claim 15, wherein moving the reading device over the area of interest in the tissue comprises moving a handheld reading device over the tissue.
17. The method of claim 15, wherein generating the output comprises providing an audible indication of a depth of the PIT tag relative to the coil as the probe is advanced within the incision.
18. The method of claim 15, wherein generating the output comprises providing a visual indication of the unique identifier.
19. The method of claim 18, wherein providing the visual indication of the unique identifier comprises displaying an identification number of the PIT tag on a display device.

20. A system for locating one or more passive integrated transponder (PIT) tags in a body, the system comprising:
- one or more PIT tags configured for implantation within a body, each of the one or more PIT tags being configured to transmit an electromagnetic signal including a unique identifier of the respective PIT tag; and
 - a handheld device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a designated operating frequency of the one or more PIT tags, the probe being configured for insertion into an incision in the body in order to advance the coil towards the one or more PIT tags located within the body, the handheld device being configured to:
 - receive electromagnetic signals;
 - determine whether each of the received electromagnetic signals includes a unique identifier; and
 - generate an output only when one of the received electromagnetic signals includes a unique identifier.
21. The system of claim 20, wherein the handheld device is configured to generate an audible indication when one of the received electromagnetic signals includes a unique identifier.
22. The system of claim 21, wherein the audible indication comprises an audible beeping and/or speaking.
23. The system of any one of claims 20-22, wherein the handheld device is configured to generate a visual indication when one of the received electromagnetic signals includes a unique identifier.
24. The system of claim 23, further comprising a display device configured to show the visual indication of the unique identifier.
25. The system of claim 23, wherein the visual indication comprises a string of numbers and/or a graphic image.

26. The system of claim 20, wherein the one or more PIT tags are configured for implantation within a breast of a patient.
27. A method for locating a localization device embedded in breast tissue, the method comprising:
- moving a reading device relative to an area of interest in the breast tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the localization device embedded within the tissue;
 - receiving one or more radio frequency (RF) signals with the reading device;
 - determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the localization device embedded within the breast tissue; and
 - generating an indication of a presence and/or location of the localization device only when a RFID signal transmitted by the localization device embedded within the breast tissue is detected.
28. The method of claim 27, wherein determining whether at least one of the one or more RF signals is a radio frequency identification (RFID) signal transmitted by the localization device embedded within the breast tissue includes determining whether an identification number is associated with the RF signal.
29. The method of claim 27 or claim 28, wherein generating an indication of the presence and/or location of the localization device only when a RFID signal transmitted by the localization device embedded within the breast tissue is detected includes isolating the RFID signal from any other RF signals received by the reading device based on the presence of the identification number associated with the RFID signal.
30. The method of any one of claims 27-29, wherein moving the reading device relative to the area of interest in the breast tissue comprises moving the probe over the breast tissue to identify an approximate location of the localization device embedded within the breast tissue.

31. The method of any one of claims 27-30, wherein moving the reading device relative to the area of interest in the breast tissue comprises inserting the probe into an incision in the breast tissue.
32. The method of any one of claims 27-31, wherein the at least one RFID signal includes information relating to a depth of the localization device relative to the coil.
33. The method of any one of claims 27-32, wherein generating an indication of the presence and/or location of the localization device only when a RFID signal transmitted by the localization device embedded within the breast tissue is detected comprises providing an audible indication of a depth of the localization device as the probe is advanced within the incision.
34. A method for locating a localization device embedded in breast tissue, the method comprising:
- moving a reading device over an area of interest in the breast tissue to identify an approximate location of the localization device embedded within the breast tissue, the reading device including a probe having a coil at a distal end thereof, the coil being configured to transmit a signal resonating at a frequency of the localization device embedded within the breast tissue;
 - forming an incision in the breast tissue adjacent to the location of the localization device;
 - inserting the probe into the incision;
 - receiving electromagnetic signals;
 - determining whether each of the received electromagnetic signals includes a unique identifier; and
 - generating an output for each of the received electromagnetic signals that includes a unique identifier.
35. The method of claim 34, wherein moving the reading device over the area of interest in the breast tissue comprises moving a handheld reading device over the breast tissue.

36. The method of claim 34, wherein generating the output comprises providing an audible indication of a depth of the localization device relative to the coil as the probe is advanced within the incision.
37. The method of claim 34, wherein generating the output comprises providing a visual indication of the unique identifier.
38. The method of claim 34, wherein generating the output comprises providing a visual indication of an orientation of the localization device relative to the probe.
39. The method of any one of claims 34-38, wherein the localization device is an integrated transponder (PIT) tag.

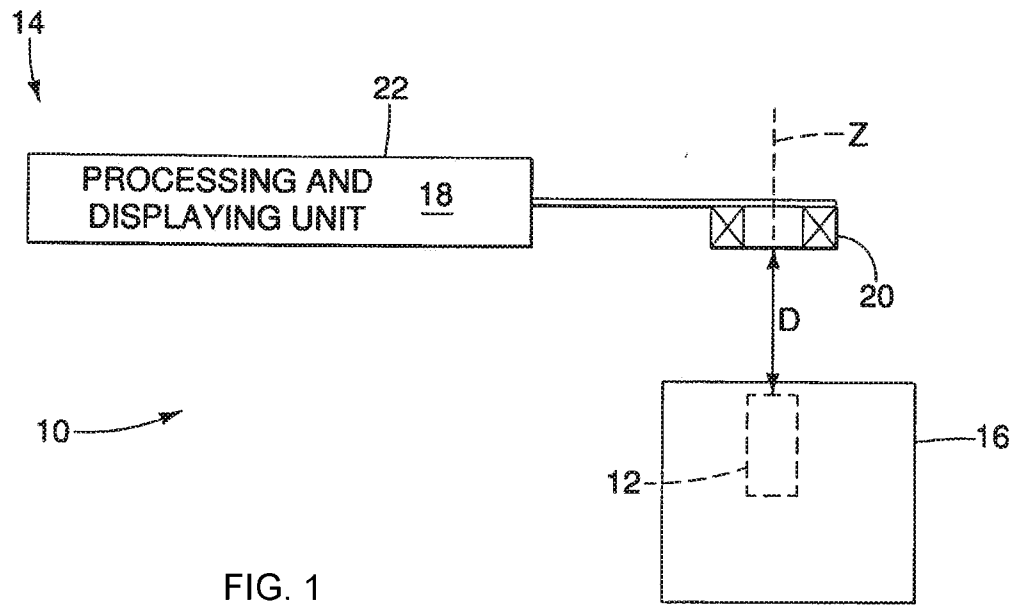


FIG. 1

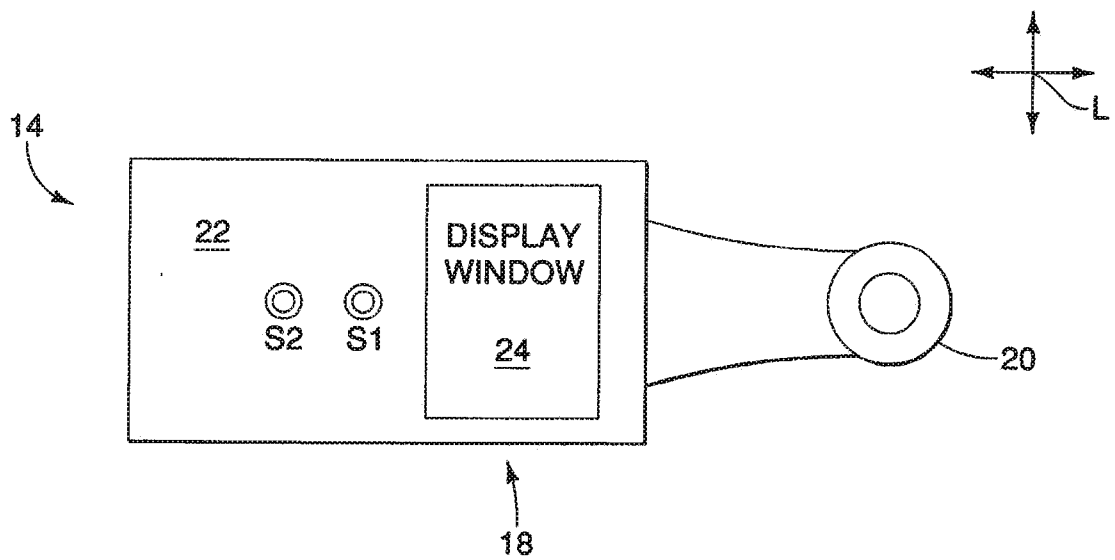


FIG. 2

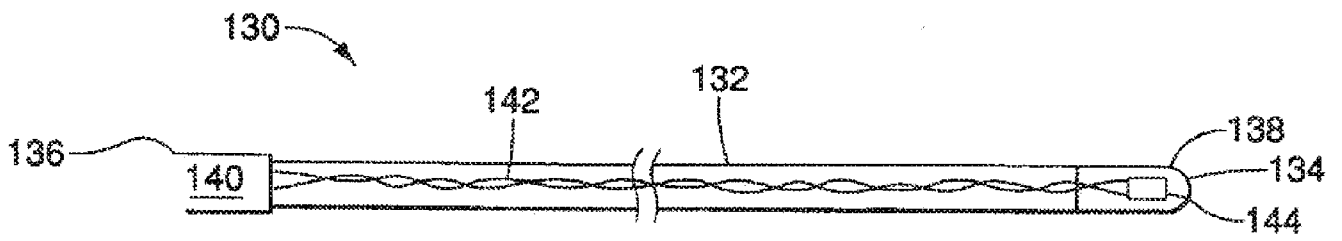


FIG. 3

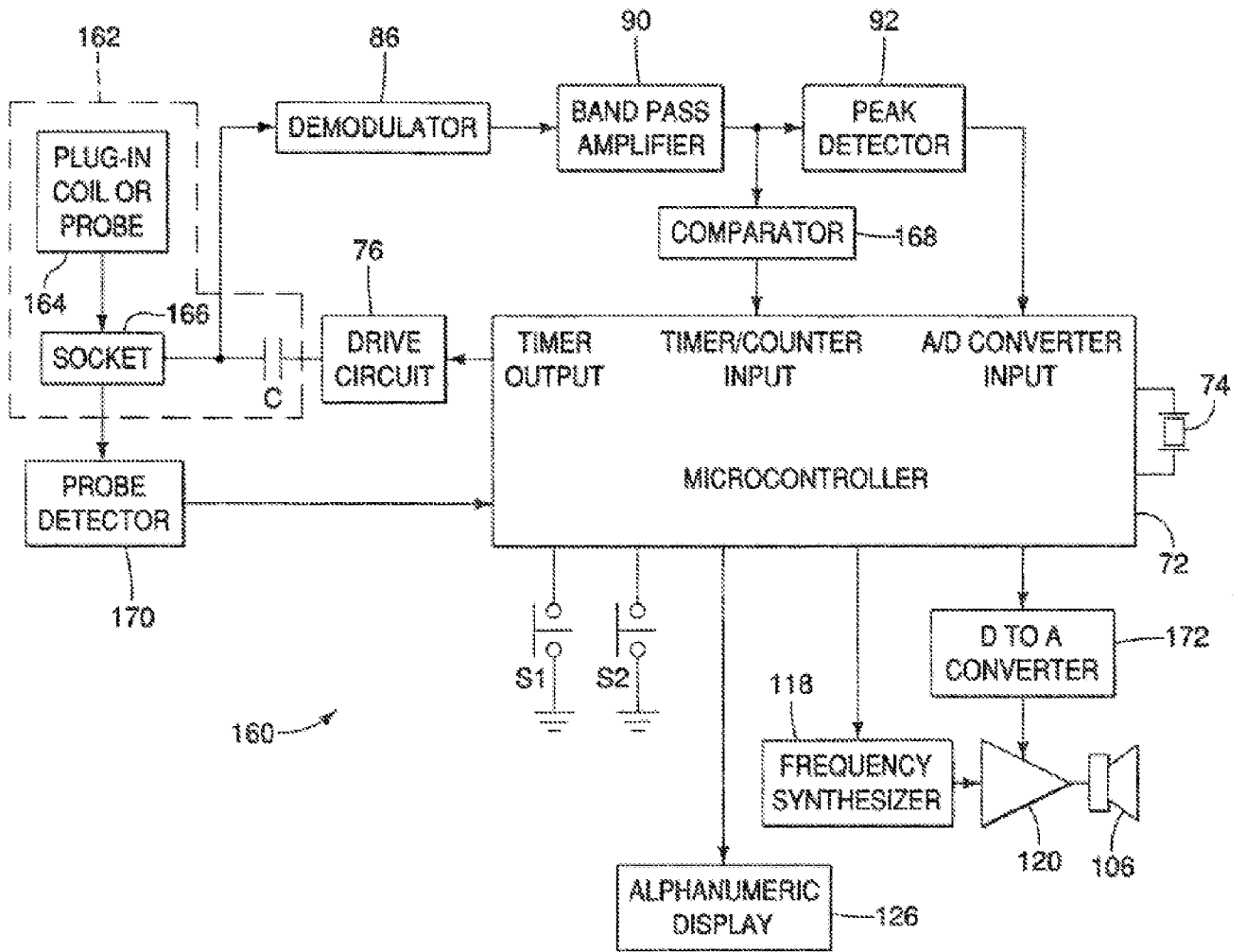


FIG. 4

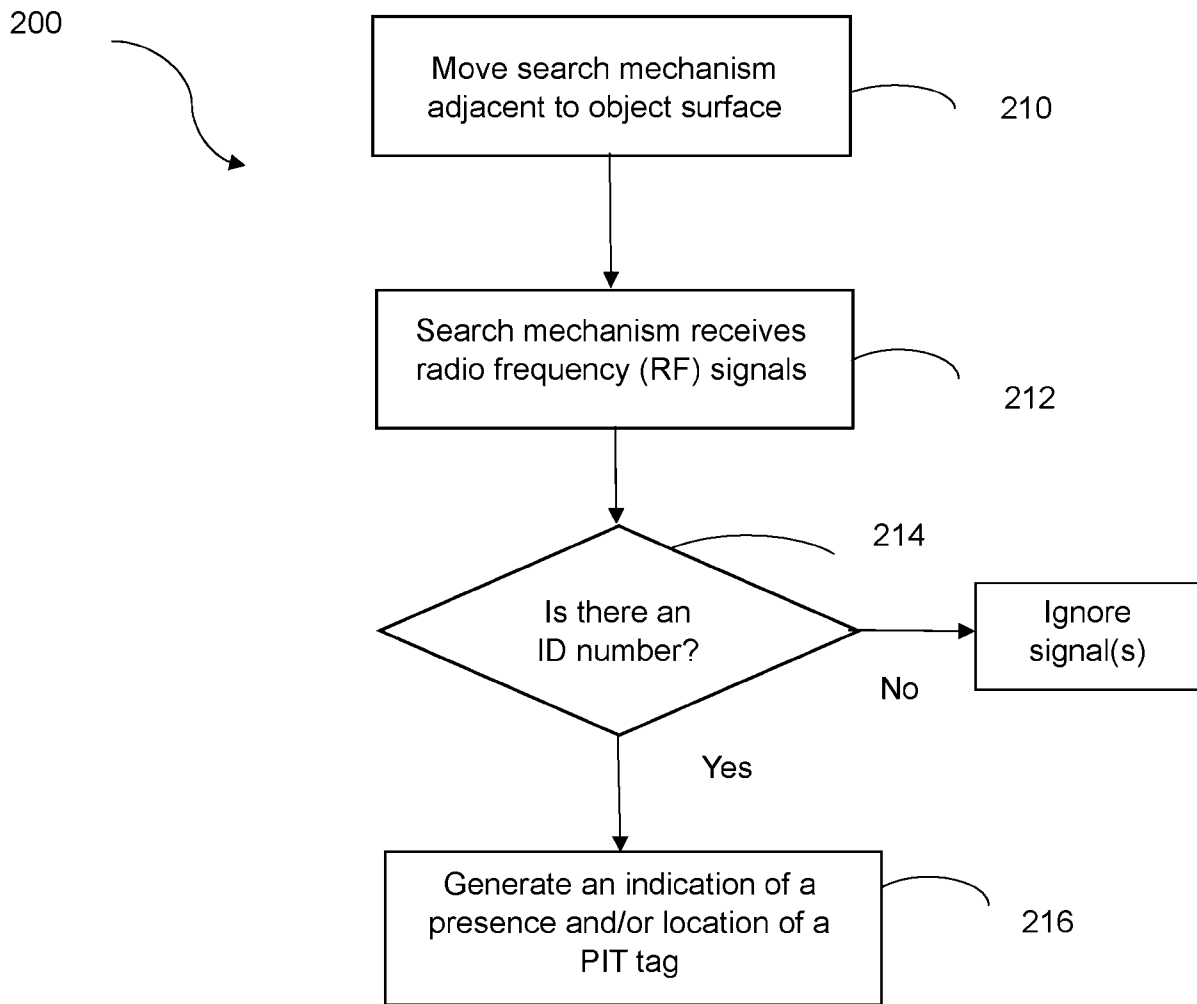


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No PCT/US2024/047247

A. CLASSIFICATION OF SUBJECT MATTER INV. A61B5/06 A61B90/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) A61B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, INSPEC, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/264891 A1 (BRANDER CHRISTOPHER [AU] ET AL) 24 September 2015 (2015-09-24) the whole document -----	1-6,8, 10-14, 20-30,32
X	WO 2007/117478 A2 (HEALTH BEACONS INC [US]; PETCAVICH ROBERT J [US]; REICHER MURRAY [US]) 18 October 2007 (2007-10-18) the whole document -----	1-6,8, 10-14, 20-30,32
A	US 2017/007352 A1 (KING LAURA G [US] ET AL) 12 January 2017 (2017-01-12) the whole document -----	1-6,8, 10-14, 20-30,32
- / - -		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search	Date of mailing of the international search report	
6 November 2024	22/11/2024	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Abraham, Volkhard	

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/047247

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2022/183585 A1 (VAN DER WEIDE DANIEL W [US] ET AL) 16 June 2022 (2022-06-16) paragraph [0010] - paragraph [0038] paragraph [0100] - paragraph [0126] figures 1-15 -----	1-6,8, 10-14, 20-30,32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/047247

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: 7, 9, 15-19, 31, 33-39
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/US2024/047247

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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			US 2019090779 A1 28-03-2019
			US 2022183585 A1 16-06-2022
			WO 2018031826 A1 15-02-2018
