

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
29 April 2004 (29.04.2004)

PCT

(10) International Publication Number
WO 2004/036803 A2

(51) International Patent Classification⁷: **H04L**
(21) International Application Number:
PCT/IL2003/000834
(22) International Filing Date: 15 October 2003 (15.10.2003)
(25) Filing Language: English
(26) Publication Language: English
(30) Priority Data:
60/418,162 15 October 2002 (15.10.2002) US
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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

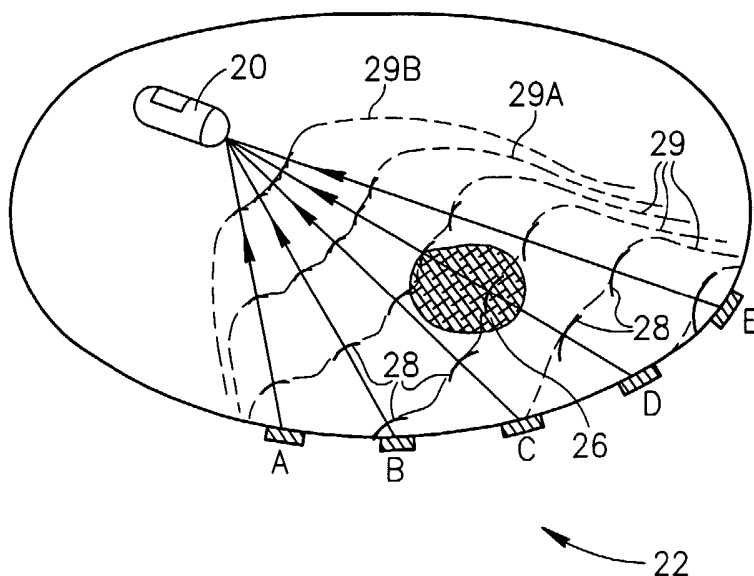
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Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DEVICE, SYSTEM AND METHOD FOR TRANSFER OF SIGNALS TO A MOVING DEVICE



(57) Abstract: A system for transfer of a signal, such as an energizing signal, to a transmitting in vivo sensing device. The in vivo device includes at least one signal transmitter and at least one signal receiving unit. The system includes an external phased array antenna. The phased array antenna receives a signal from the sensing device and then transmits a signal to the device phased in the reverse order to that of receipt of the signal from the sensing device.

DEVICE, SYSTEM AND METHOD FOR TRANSFER OF SIGNALS TO A MOVING DEVICE

FIELD OF THE INVENTION

5 The present invention relates to the transfer of signals, such as for example an energizing signal, to a moving device generally and to such transfer to an in vivo sensing device in particular.

BACKGROUND OF THE INVENTION

10 Ingestible devices such as capsules known in the art may have an in vivo sensing system, such as an in vivo camera system or other sensing systems such as temperature sensors or pH sensors. An encapsulated in-vivo video camera system may capture and transmit images of the gastrointestinal (GI) tract while it passes through the GI lumen. The system may include a capsule that can pass through the entire digestive tract and operate as
15 an autonomous video endoscope.

 Fig. 1 shows an exemplary prior art ingestible device 10 within a human body 12. Device 10 has an imaging device 14, which transmits in vivo images to a set of antennas 16 within an antenna belt 17 surrounding a portion of body 12. Device 10 may, for example, take the form of a capsule, but may take other suitable shapes or forms.

20 Device 10 has power sources such as batteries 18 which provide power to the various elements of device 10. However, batteries may add weight to the device and may have a limited capacity.

 Some endoscopic devices have no batteries. Energy may be provided to these devices by for example transmitting an electromagnetic field at a patient's body in which

such a device is inserted. The device may include an element that can receive and convert the transmitted waves to electric power.

Typically, a device is an autonomously moving unit where the medium present between the electromagnetic waves receiving unit in the device and the external
5 electromagnetic field may be non-homogenous due to the presence of obstructions or different materials, for example bone, muscle, fat, and tumors. Other material may be present between the receiving unit and the external field. A patient may be placed in an electromagnetic field generating cage and the relevant section of the patient's body may be irradiated by an electromagnetic field in order to ensure that electromagnetic waves reach a
10 device within the patient's body even if obstructions, such as described above, are present. Thus, there exists a need for a more efficient method of providing energy to an in vivo device.

SUMMARY OF THE INVENTION

According to some embodiments of the invention antennas, such as antennas for
15 receiving a signal from an in vivo device, may be operated as a phased array antenna to transfer a signal, for example, an energizing signal, to a moving energy receiving unit containing device, such as an in vivo device. According to embodiments of the invention, an indication used to convey information (typically referred to as a "signal") may be transferred to an autonomous in vivo device. This indication may include, according to one
20 embodiment, an energizing signal, which may typically be used to provide energy to such an in vivo device. Suitable units other than antennas may be used to transfer a signal such as an energy signal.

According to one embodiment there is provided a system for transfer of a signal to an in vivo device, typically an autonomous in vivo transmitting sensing device. According to one embodiment the device includes at least one signal receiving unit. According to an embodiment of the invention the system includes an external phased array antenna.

5 According to one embodiment the phased array antenna includes at least two antennas. Typically the phased array antenna may receive and transmit. According to one embodiment the external phased array antenna can receive a signal from the sensing device and can then transmit to the device phased or arranged in the reverse order to that of receipt of the signal from the sensing device.

10 According to an embodiment of the invention there is provided a method for transfer of a signal, such as energy, to an autonomous in vivo sensing device. The method may include the steps of for example receiving a signal transmitted from an in vivo device, recording an array or order of receipt, and transmitting a signal to the device using for example the reverse order of receipt of the transmitted signal from the device.

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BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features, and

20 advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

Figure 1 is a prior art schematic illustration of a system of an ingestible device;

Figures 2A₁ and 2A₂ are schematic illustrations of a device, constructed and operative in accordance with one embodiment of the present invention; in Fig. 2A₂, a device is shown transmitting to an antenna, for example an antenna belt;

Figure 2B is a timing diagram illustration of the receipt of signals to antennas, e.g., the various antennas of Fig. 2A₂, according to an embodiment of the invention;

Figure 3A is a timing diagram illustration of the transmission of signals from various antennas, e.g., the antennas of Fig. 2A₂, in accordance with an embodiment of the present invention;

Figure 3B is a schematic illustration of the antennas of Fig. 2A₂ transmitting according to the timing diagram of Fig. 3A, according to an embodiment of the invention;

Figures 4A and 4B are graphical illustrations of two alternative signals transmitted to the device, in accordance with an embodiment of the present invention;

Figure 5 is a block diagram illustration of an energy receiving unit, useful in receiving signals according to embodiments of the invention, e.g., receiving signals of Figs. 4A and 4B; and

Figure 6 is a flow chart depicting a method for signal transfer to an in vivo device, according to an embodiment of the invention.

It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE INVENTION

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as "processing", "computing", "calculating", "determining", or the like, refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulate and/or transform data represented as physical, such as electronic, quantities within the computing system's registers and/or memories into other data similarly represented as physical quantities within the computing system's memories, registers or other such information storage, transmission or display devices.

According to some embodiments of the invention antennas in for example a garment or holder such as an antenna belt (for example, antenna belt 17 of Fig. 1) may in one embodiment be operated as a phased array antenna. Example of phased array antennas are discussed, for example, in the book, Electromagnetics with Applications, 5th Edition, by Kraus and Fleisch, McGraw-Hill, 1999, pp. 264 – 273. Antennas may be arranged in other fashions, using other holders or garments, and a holder need not be used.

As is known in the art, phased array antennas may generate focused beams which may be moved (e.g., by changing the relative phasing of the antennas), for example as the object receiving the beam moves. According to an embodiment of the invention such a beam may be used to transfer energy or any other suitable signal to a moving receiving unit (e.g., an energy receiving unit), such as a unit in an in vivo device.

In one embodiment, in contrast to some prior art phased array antennas, which require knowing the location of an object to which a signal is being transmitted and require a homogenous medium through which to transmit, a signal from an in vivo device may for example provide enough information for a phased array to focus a beam back to the device
5 without requiring knowledge of the location of the device or of the intervening medium. In other embodiments location information may be known or calculated.

Reference is now made to Figs. 2A₁, 2A₂, 2B, 3A and 3B which illustrate an embodiment of the present invention. Figs. 2A₁, 2A₂ and 3B show an in vivo sensing device, such as an ingestible imaging device 20 (which may, for example, take the form
10 of a capsule, but may take other suitable shapes or forms) with a receiving unit 27, such as an energy receiving unit and an antenna array 22, while Figs. 2B and 3A are timing diagrams of the operations of the device and the antenna array, respectively, according to embodiments of the invention. Other suitable antenna arrangements and timing schemes may be used. Receiving unit 27 may receive signals other than, for example, energy.

15 In Fig. 2A₁, according to one embodiment of the invention, device 20 includes a sensing system 211, a signal receiving unit, such as receiving unit 27, a transmitter 24, one or more antennas 23, and a processing unit 212. In alternate embodiments, the sensing device need not be a capsule or a self contained or autonomous device. For example, the sensing device may be or may be located at the tip of a medical device, such as, an
20 endoscope, needle, catheter, stent etc.

The sensing system may include a suitable in vivo sensor, such as a pH meter, a temperature sensor, a pressure sensor, a biological or chemical sensor, an image sensor, etc. More than one sensor may be included in a device according to some embodiments. The in vivo sensor may be exposed to the in vivo environment by, for example, being properly

positioned in the device 20. For example, a pH sensor may include an electrode which protrudes from the shell or covering of the device, such as the capsule shell, as is known in the art. In another embodiment an image sensor may be exposed to the in vivo environment through an optical window in the device 20, as known in the art. Typically, the in vivo
5 sensor relays data to a transmitter 24 for transmitting the data to an external receiving system, such as to antenna array 22. An in vivo imaging device which transmits image data to an external receiving system is described, for example, in embodiments described in US Patent 5,604,531 to Iddan, et al. and/or WO 01/65995 to Glukhovsky, both assigned to the assignee of the present application and both incorporated by reference. An external
10 receiving, processing and display system which may be used with embodiments of the present invention may be similar to embodiments described in US Patent 5,604,531 to Iddan, et al. and/or WO 01/65995 to Glukhovsky. Of course, other suitable in-vivo sensing systems and external receiving, processing and display systems may be used.

According to some embodiments, an imaging device such as a capsule shaped
15 device is inserted into a body lumen such as, for example, the gastro-intestinal tract. For example, the device may be ingested. According to one embodiment the device 20 typically includes an imaging sensor (e.g., sensing unit 211), an illumination source (not shown) and an optical head (not shown) which may include one or more optical elements, such as one or more lenses and a lens holder. One or more suitable optical elements may be used for
20 focusing images onto the imaging sensor. The optical head may be placed behind an optical window or dome to, for example, isolate its electric components from liquids found in a body, which may interfere with the operation of such components. The imaging sensor may be, for example, a solid state imaging sensor, such as charged coupled devices (CCDs) and complementary metal oxide semiconductors (CMOS). The imaging sensor may generate

electronic signals such as image signals, which may be transmitted by way of, for example, a circuit board to a processor chip, which may, inter alia, carry out processing or conditioning of the signal. An example of a processor chip that may be used in embodiments of the present invention is an ASIC (application specific integrated circuit).

5 According to one embodiment the ASIC may have transmitting capabilities, for example, operating on a minimum shift keying (MSK) modulation system to effect transmitting of digital signals through an antenna on radio frequencies to a receiving system. Thus, in certain embodiments components such as transmitter 24 may be combined with other components, e.g., with processing unit 212. Other components and other arrangements of
10 components may be used.

According to some embodiments transmitter 24 may be capable of working in a receiving and in a transmitting mode for transmitting signals to, for example, an external phased array antenna 22 and for receiving signals from antenna 22. For example, transmitter 24 may be a transceiver. According to some embodiments transmitter 24 may
15 include or be attached to an omni-directional antenna; for example antenna 23 may be an omni-directional antenna. According to some embodiments antenna 23 may include more than one antenna. According to some embodiments transmitter 24 is capable of transmitting to an external phased array antenna 22 while receiving unit 27 is capable of receiving signals transmitted from the antenna 22. Other components may be used for transmitting and
20 receiving.

According to some embodiments a power supply, such as one or more batteries, is included in the device 20 for providing energy to elements of the device. According to some embodiments an energy storage unit 180 may be included in the device 20. The storage unit 180 may include, for example, a rechargeable battery, a capacitor or other suitable

chargeable units. Typically a storage unit 180 is connected to receiving unit 27, possibly via intermediate components. According to some embodiments these two units may be contained in the same component. According to some embodiments receiving unit 27 may provide energy to at least some of the device elements (e.g., to an illumination source, to an image sensor, etc.)

In Fig. 2A₂ device 20 transmits a signal to antenna array 22 using, for example, an omni-directional antenna, for example antenna 23. Antenna array 22 typically includes two or more antennas. In Fig. 2A₂ antenna array 22 includes antennas A, B, C, D and E, however any other suitable number of antennas may be used. Each of the antennas A, B, C, D and E may be omni-directional, but other types of antennas may be used. According to embodiments of the invention, the antennas may operate in receiving and/or in transmitting modes. For example, antenna array 22 may include transceivers. According to some embodiments antenna array 22 may be designed to surround a body portion. The array may be included in a garment that can be worn or placed on a relevant body portion, e.g., around a patient's stomach.

Typically, located outside the patient's body in one or more locations, are a receiver 52, connected to antennas A-E, for receiving image and possibly other data from device 20, a receiver storage unit 56, for storing image and other data, and a processor or controller 53. The receiver 52 may be connected (permanently or temporarily) to, for example, a data processor 54, a data processor storage unit 59, and an data or image monitor 58, for displaying, for example, image data transmitted by the device 20 and received and/or recorded by the receiver 52. Typically, the receiver 52 and receiver storage unit 56 are small and portable, and are worn on the patient's body during recording of the images. Preferably, data processor 54, data processor storage unit 59 and monitor 58 are part of a personal

computer or workstation, which includes standard components such as a controller or processor 63, a memory (e.g., storage unit 59, or other memory), a disk drive, and input-output devices, although alternate configurations are possible. In alternate embodiments, the data reception and storage components may be of another configuration.

5 The receiving and recording components may be, for example, similar to embodiments described in the above-mentioned U.S. Patent No. 5,604,531 and/or WO 01/65995. However, the receiving and recording components may be of other configurations.

 The signal transmitted from device 20 may be any type of signal, such as a signal
10 including data (e.g., image data, pH data, etc.), an image signal, an audio signal, a synchronization signal, a localization signal, a signal from one or more sensors in the device that send signals (such a PH, temperature, pressure) and/or chemical and/or biological signals from an appropriate sensor that may be included in the device, etc. According to one embodiment an external receiving system (e.g., receiving system 52), which may include
15 antenna array 22, may further include or be attached to a control and/or processing unit (e.g., data processor 54, controller or processor 63, controller or processor 53) for executing processing operations, for example, as described herein. Other components, such as a memory, may be included in the external receiving system.

 Fig. 2A₂ shows an exemplary signal, propagating as a wave through a patient's body
20 to antenna array 22. The wave is shown with constant phase surfaces 25 that are shown roughly circular and which bend, for example, as they go through an obstruction 26 (such as a body part). It should be appreciated that this is a simplification for illustrative purposes; typically, the shape of the wave is a function of the media through which the wave passes, its homogeneity, as well as the size and shape of the obstruction(s).

In the example of Fig. 2A₂, the medium 200 may be relatively homogeneous but device 20 may not be centered relatively to antenna array 22. It is fairly distant from antennas A, B, C, D and E and on the opposite side therefrom of obstruction 26. Accordingly, antennas A, B, C, D and E may receive the signal at different times. Antenna
5 A is the closest antenna to device 20 and antenna E is the furthest antenna. Antenna D has an obstructed “line-of-sight” to device 20 due to the presence of obstruction 26.

The signal in this example may arrive at the antennas in the following order: antenna A, antenna B, antenna C, antenna E and antenna D, wherein, for each neighboring antenna pair, there is a time difference array of arrival, for example, as shown in Fig. 2B.
10 Thus, between antennas A and B, the time difference is $\Delta 1$, that between antennas B and C is $\Delta 2$, that between antennas C and E is $\Delta 3$ and that between antennas E and D is $\Delta 4$. This arrangement and operation is by way of example only; in use, other operational situations may arise.

As part of the processing operation, the strength array, typically defined as the
15 strength of the signal at each antenna as well as the time array, typically defined as the timing of receipt of the signal at each antenna, may be stored. With this information, for example, the signal may be typically processed, using the signal from the antenna with the strongest signal and ignoring the output of the remaining signals. Other suitable systems and methods for storing signal receipt data may be used or stored. For example, separate
20 data constructs or structures for timing and strength need not be used, and other suitable data, other than timing and strength, may be used.

According to an embodiment of the invention a “time array” may describe how a signal traveled from device 20 to antenna array 22 and further, that transmitting a signal to device 20 using the antennas of array 22 phased with the reverse timing to that of the receipt

of the signal from device 20 may generate a focused beam back to device 20. This is shown for example in Figs. 3A and 3B.

Thus, the phasing for the example of Figs. 2A₂ and 2B, which is shown in Fig. 3A, is to activate the antennas in the following order, reverse to that of receipt: antenna D, antenna E, antenna C, antenna B and antenna A and to define their phasing as the reverse
5 phasing of receipt, as follows: $\Delta 4$, $\Delta 3$, $\Delta 2$, and $\Delta 1$.

Fig. 3B shows, as an example, the signals from the five antennas A, B, C, D and E. Each antenna may produce its own omni-directional wave 28, timed according to, for example, the phasing discussed above. The interference of these waves may produce a wave
10 front pattern, for example waves 29 that may converge into a focused beam according to for example the Huygens principle known in the art

In this example, antenna D may transmit first. Its wave may be shown ahead of the others but may be slowed down as it passes through obstruction 26. Those of its waves which have passed through obstruction 26, for example, have almost converged at wave
15 29A, with those of the other antennas and are closer to converging, for example at wave 29B, and generally may converge upon arrival at device 20. Control of transmission may be performed by a suitable control unit, for example, e.g., data processor 54, controller or processor 63, and/or controller or processor 53.

Similarly, the waves produced by the other antennas begin as separate waves but,
20 due to the phasing of production of the waves, converge generally upon arrival at device 20.

With a focused beam according to an embodiment of the invention, the amount of energy transmitted from antenna array 22 may be approximately one order of magnitude lower than the amount transmitted from an omni-directional or prior art antenna for device 20 to capture the same amount of energy. In other words, the phased array, according to an

embodiment of the invention, reduces the amount of power needed for transmission by a factor of at least 10, for example, depending on the number of antennas used. Typically, a larger amount of antennas facilitates focusing of a transmitted beam. In other embodiments, other reductions in the amount of power needed may be achieved.

5 The focused beam may transmit sufficient energy to energize an energy receiving unit in device 20. An exemplary energy receiving unit 30 is shown in Fig. 5. According to one embodiment of the invention, device 20 may have no batteries or possibly, much smaller ones or fewer batteries than devices of the prior art. According to embodiments of the invention a device may have a storage unit, e.g., a capacitor or one or more rechargeable
10 batteries, e.g., for storing energy transmitted from an antenna array 22. For example, storage unit 180 may store energy.

 Figs. 4A and 4B, to which reference is now made, illustrate two alternative energizing signals, according to embodiments of the invention. Suitable energizing signals other than those shown in Figs 4A and 4B may be used. Fig. 4A shows a simple harmonic
15 train having active portions T1 and silent intervals T2 between pairs of active portions T1. Fig. 4B shows an amplitude modulated version of the energizing signal of Fig. 4A. Any suitable type of modulation known in the art (two well-known examples of which are amplitude modulation (AM) or frequency modulation (FM)) may be utilized and the modulation may be used to encode uplink data and/or commands to device 20.

20 During silent intervals T2, antenna array 22 may be in "receive mode", ready to receive any signal which device 20 may transmit. Such signals typically include data that device 20 has acquired, such as images, biological data, chemical data, etc. Other signals may be transmitted, such as beacon signals or other signals. In one embodiment silent

intervals T2 are of the order of for example 1 msec or of any length sufficient to receive a typical transmission from device 20. Other intervals may be used.

Silent intervals T2 may be of a fixed length or may be variable, ending once a transmission from device 20 has ended. Fixed length intervals may indicate a synchronous
5 operation while variable length transmissions may indicate an asynchronous operation. Active portions T1 may start only after a first transmission may be received from device 20. Device 20 may switch its antenna 23 from transmit mode to receive mode once it has finished its transmission and may switch back to transmit mode once active portion T1 has been received. Similarly, antenna array 22 may switch back to receive mode once it has
10 finished transmitting active portion T1. Other suitable configurations and signaling schemes may be used.

Active portions T1 may be, for example, radio frequency (RF) bursts of about 1 millijoule of energy with a frequency of up to, for example, 1.0 GigaHertz. Since the energizing signals of Figs. 4A and 4B are transmitted as focused beams, the energy may be
15 efficiently transferred to device 20, to be captured by energy receiving unit 27. Other suitable energy levels and frequencies may be used; the values discussed herein are only by way of example.

Reference is now made to Fig. 5. In one embodiment, energy receiving unit 30 may include components such as a duplexer switch 31, a tuned tank circuit 32, a rectifier 34
20 and an energy storage unit 36. If present, switch 31 may connect energy receiving unit 30 to antenna 23 during receive mode. Other ways of determining between transmission and reception may be used. For example, two separate frequencies may be used, in which case, there may be no need for switch 31. Other suitable configurations for an energy receiving unit may be used.

Tuned tank circuit 32 may be any suitable circuit that may tune to the carrier frequency of active portions T1. Tank circuits are known in the art and are described, for example, in The Art of Electronics, 2nd Edition, by Horowitz and Hill, Cambridge University Press, 1989, p. 883. Accordingly, they will not be described further herein except to indicate
5 that they are minimally an “LC” block formed of a capacitor and an inductor.

Rectifier 34 may be, for example, a diode bridge and may, for example, rectify the sinusoidal energizing signal produced by tank circuit 32, thereby producing a non-negative energizing signal having a large portion of the power of the signal transmitted from antenna array 20. According to one embodiment energy storage unit 36 may be a capacitor
10 or a rechargeable battery pack and may be operative to receive the non-negative energizing signal of rectifier 34. Other components and methods may be used.

It will be appreciated that, with regular transmissions of active portion T1, energy storage unit 36 may be fairly small.

It will be appreciated that the present invention may be utilized in many systems
15 that have a multitude of receiving antennas and a mobile device (e.g., a mobile phone) moving through the area covered by the receiving antennas.

For example, if an in vivo device (e.g., implantable lab on chip, in vivo sensing device, such as an imaging device, stimulating device, RF ID tag etc.), includes a transmitter, then the transmitter and the antennas receiving its energizing signal may
20 perform the energy transfer method according to an embodiment of the invention. Accordingly, such devices within the body may require no or relatively small energy storage units. Furthermore, a patient may be subject to a smaller electromagnetic field, rendering the method device and system according to embodiments of the invention more efficient than known methods and devices.

It will further be appreciated that, according to an embodiment of the present invention, sufficient energy may be transferred to, for example, cauterize or destroy a tumor or otherwise provide in vivo treatment. According to one embodiment, an in vivo device may identify the presence of a pathology, such as a tumor, and transmit a signal indicating
5 such. With this signal, in accordance with an embodiment of the invention, a strong, focused beam may be provided back to the location of the device, or slightly moved there from, resulting in energy focused (e.g., to burn, cauterize etc.) at the location of the tumor.

It will still further be appreciated that embodiments of the present invention may be used in typically non-biomedical applications and, in particular, in any powered device
10 that is difficult to access. Embodiments of the present invention may be used for example to power mobile telephones. The battery of the device need not be replaced; instead, the powered device may have a transmitter thereon transmitting a sufficient signal that may allow the antenna array to then transmit back an energizing signal in the from, for example, a focused beam with sufficient energy to store until the next transmission from the powered
15 device.

A system and method according to another embodiment may be applied to an RF identification (ID) tag. RF ID tags may provide identification or other information, for example when queried, and may be passive, providing a signal only when queried, or active, periodically or otherwise providing a signal. RF ID systems may utilize various methods to
20 identify the location of each tag. One standard localization method that may be used, for example, is through triangulation.

RF ID tags may be utilized in numerous in vivo applications; for example, an RF ID tag may be included in an ingestible device such as a capsule. The presence of the RF ID tag in a patient's body at different periods after ingesting it may give a picture of the

patient's gastrointestinal motility. Thus, a patient's body may be scanned by a system, according to an embodiment of the invention, for the presence of a tag and for providing energy to such a tag.

The present invention, according to one embodiment, may be utilized with active tags, providing the tags with periodic bursts of an energizing signal after receiving one of the periodic signals from the tags. Additionally, the present invention may be utilized with RF ID tags operating at low power. Such a tag may be one whose battery life is almost finished. Since a low power signal is noisy, the system may require multiple transmissions before being able to generate the focused beam. Alternatively, the system may provide a single, omni-directional pulse to provide sufficient energy to the tag for it to provide a relatively non-noisy signal. The antenna array may then determine the phasing from this relatively non-noisy signal and may generate a focused beam back to the tag, thereby to increase its stored energy.

Reference is now made to Fig. 6 in which a schematic flowchart of a method for transfer of a signal to an in vivo sensing device, is depicted. In a first step a signal is received from an in vivo sensing device (602). Typically, the signal is received by an external phased array antenna. An array or order of receipt is recorded (604) (and may be stored, for example in storage unit 59 and/or storage unit 56) and a signal is transmitted to the in vivo device using the reverse order of receipt of the transmitted signal from the device (606). Recording of received signals, calculation of a response signal, and control of transmission may be performed by a suitable control unit, for example, e.g., data processor 54, controller or processor 63, and/or controller or processor 53. The array or order of receipt may be for example, a time array or a

strength array of receipt, or other suitable array. According to one embodiment the method includes the step of energizing at least one component of the device.

While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents will now occur to
5 those of ordinary skill in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

What is claimed is:

1. A system for transfer of a signal to an in vivo device, said system
comprising:
an in vivo sensing device, the device comprising at least one signal
receiving unit, and
an external phased array antenna.
2. The system according to claim 1 wherein the phased array antenna includes
at least two antennas.
3. The system according to claim 1 wherein the phased array antenna is
configured for surrounding a portion of a body.
4. The system according to claim 1 wherein the phased array antenna is
configured for transmission and reception.
5. The system according to claim 1 comprising at least an image sensor.
6. The system according to claim 1 wherein the sensing device includes an
image sensor.
7. The system according to claim 1 wherein the sensing device is selected from
a group consisting of: pH sensor, temperature sensor, pressure sensor,
chemical sensor, biological sensor.
8. The system according to claim 1 wherein the sensing device comprises
at least one storage unit.
9. The system according to claim 8 wherein the storage unit is a capacitor or a
rechargeable battery.
10. The system according claim 1 wherein the sensing device comprises
at least one antenna.

11. The system according to claim 10 wherein the antenna is an omni-directional antenna.
12. The system according to claim 1 wherein the signal receiving unit is an energy receiving unit configured to receive power to at least partially power the sensing device.
13. The system according to claim 1 wherein the phased array antenna is configured to transmit a signal having an active portion and a silent interval.
14. The system according to claim 13 wherein the silent interval lasts for a period in the order of magnitude of 1 msec.
15. The system according to claim 13 wherein the active portion includes RF bursts.
16. The system according to claim 13 wherein the active portion includes bursts of about 1 milijoule.
17. The system according to claim 13 wherein the active portion includes bursts at a frequency of about 1 GigaHertz.
18. The system according to claim 1 wherein the phased array antenna is configured to transmit a modulated signal.
19. The system according to claim 18 wherein the modulated signal is an amplitude modulated signal or frequency modulated signal.
20. The system according to claim 1 wherein the phased array antenna is configured to receive a signal from the sensing device and to be phased with the reverse order to that of receipt of the signal from the sensing device.

21. The system according to claim 1 wherein the phased array antenna is configured to receive a signal from the sensing device and to be phased with the reverse timing to that of a receipt of the signal from the sensing device.
- 5 22. A system for transfer of a signal to an in vivo device, said system comprising:
an in vivo transmitting RF ID tag, the tag comprising at least one signal receiving unit, and
an external phased array antenna.
- 10 23. A method for transfer of a signal to an in vivo sensing device, the method comprising the steps of:
receiving a signal transmitted from said in vivo sensing device;
recording an order of receipt said signal; and
transmitting a signal to said in vivo sensing device using the reverse
15 order of receipt of the transmitted signal from the said in vivo sensing device.
24. The method according to claim 23 wherein the order of receipt is a time array.
25. The method according to claim 23 comprising the steps of energizing at
20 least one component of said in vivo sensing device.
26. The method according to claim 23 comprising the steps of:
transmitting a signal from the in vivo sensing device;
switching from transmit to receive mode;

receiving a signal which includes at least one active portion and at least one silent interval; and

switching from receive mode to transfer mode at an end of the active portion of the signal.

5 27. A method for measuring gastrointestinal motility comprising the steps of:

ingesting an RF ID tag;

receiving a transmitted signal from the RF ID tag;

recording a time array of receipt;

recording a strength array of receipt; and

10 performing triangulation thereby obtaining position of the RF ID tag.

28. A system for transfer of a signal to an in vivo device, the system

comprising:

a receiver to receive a signal transmitted from said in vivo device; and

a controller to:

15 record an order of receipt; and to

transmit a signal to said in vivo sensing device using a reverse order

of receipt of the transmitted signal from the said in vivo device.

29. The system according to claim 28 wherein the order of receipt is a time array.

20 30. The system according to claim 28 wherein the controller is to cause the energizing of at least one component of said in vivo sensing device.

31. An in vivo device comprising:

an imager;

an energy receiving unit; and

an omni-directional antenna.

32. The in vivo device of claim 31 comprising an energy storage unit to store energy received from the energy receiving unit.

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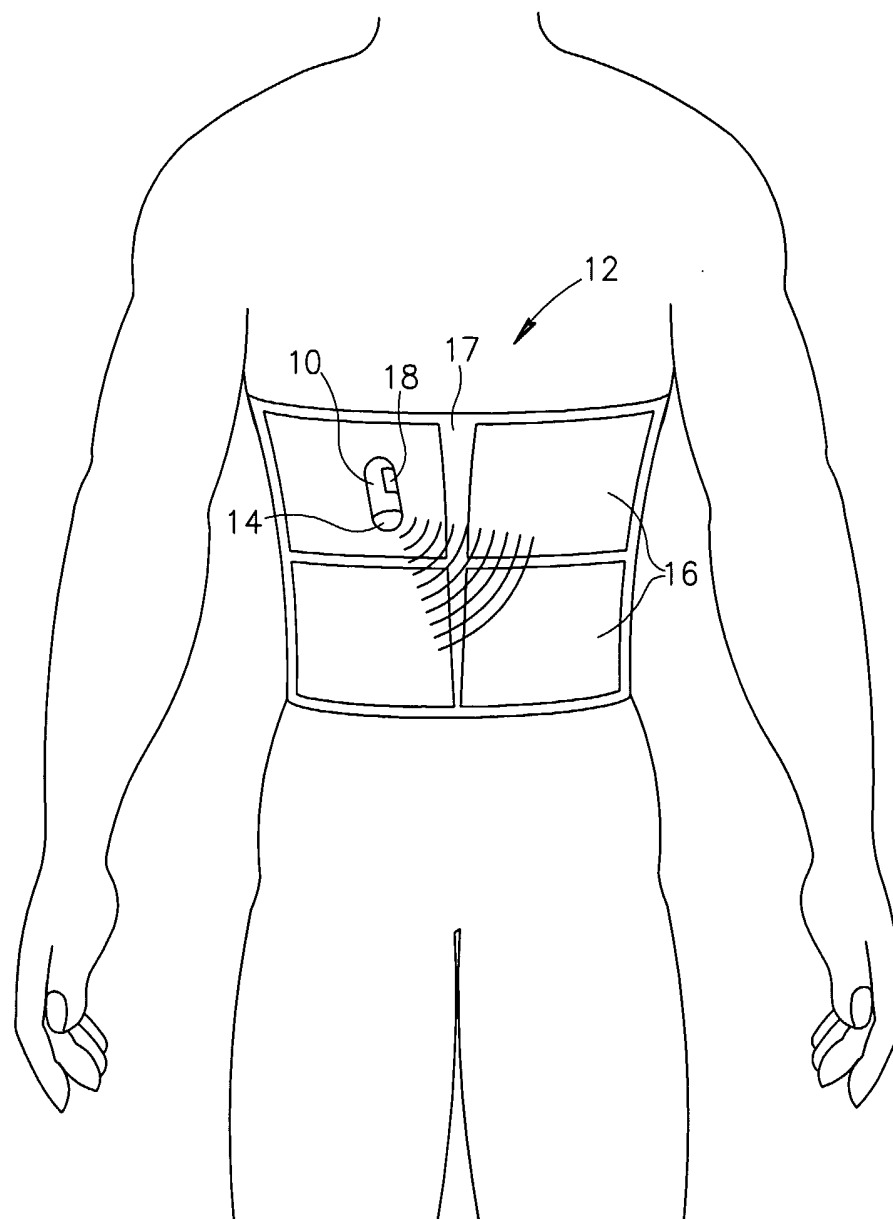


FIG.1

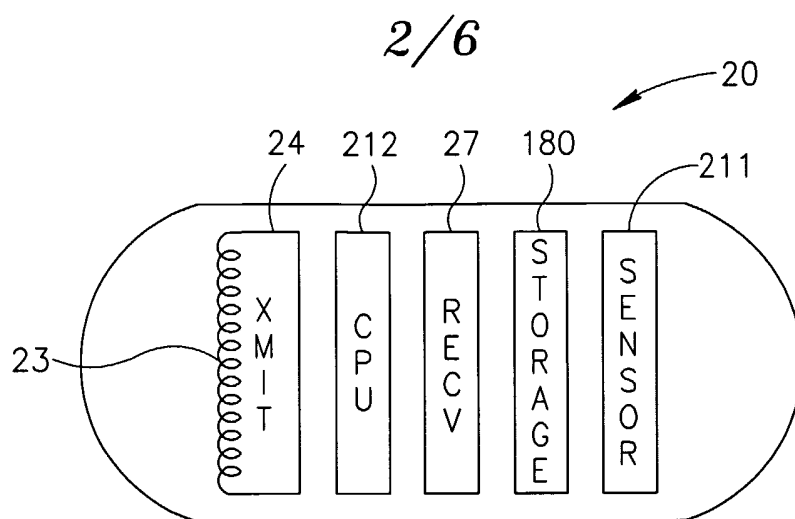


FIG.2A₁

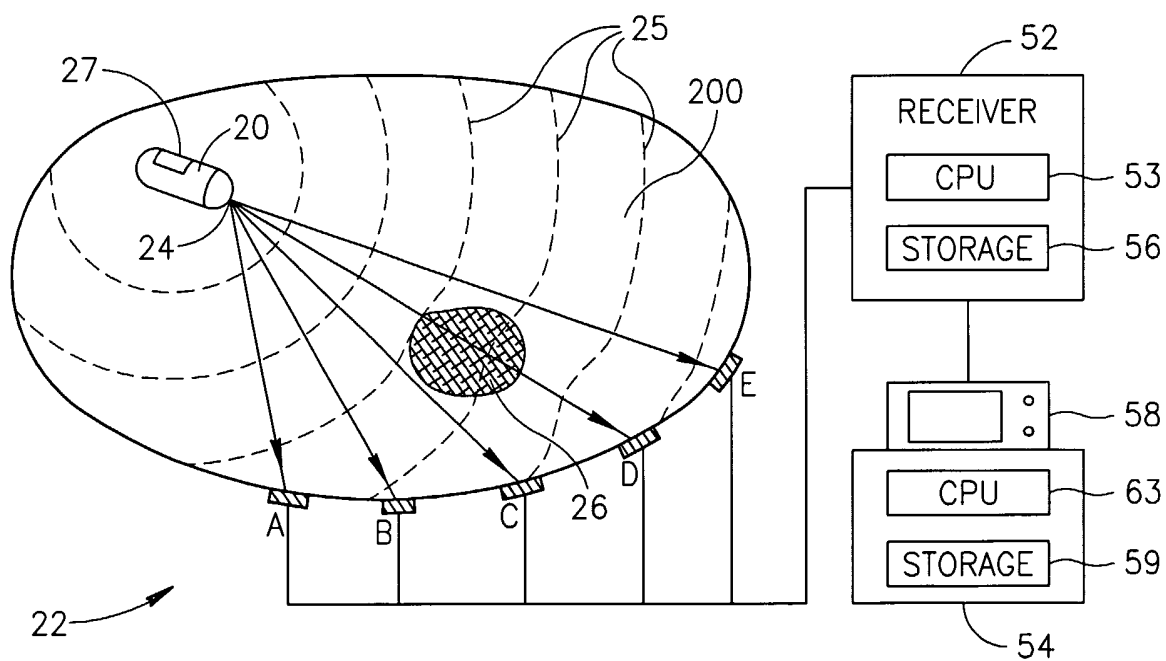


FIG.2A₂

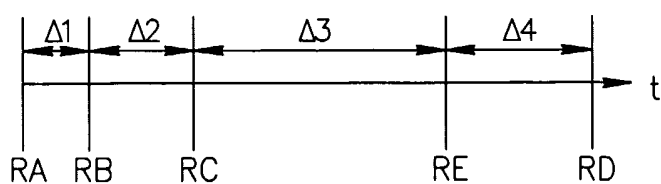


FIG.2B

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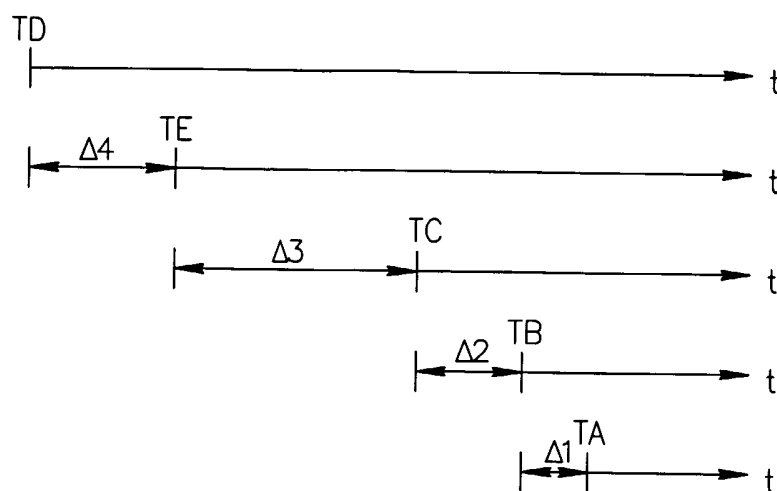


FIG.3A

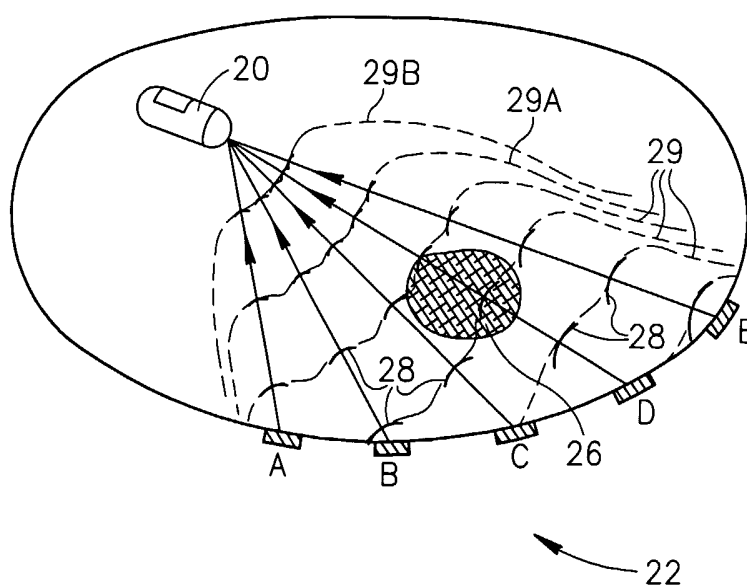


FIG.3B

FIG. 4A

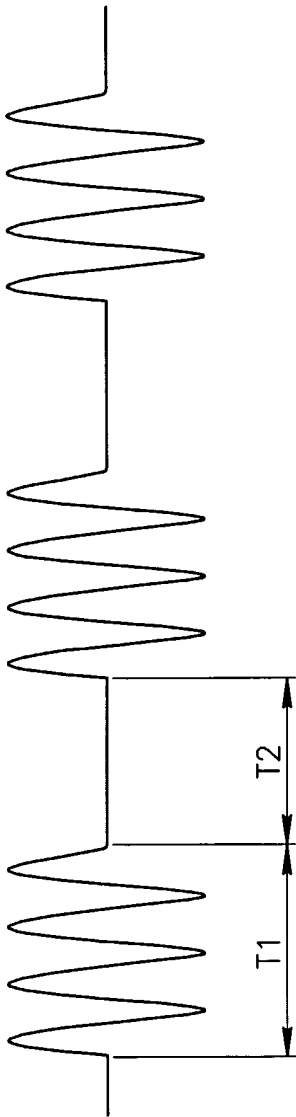
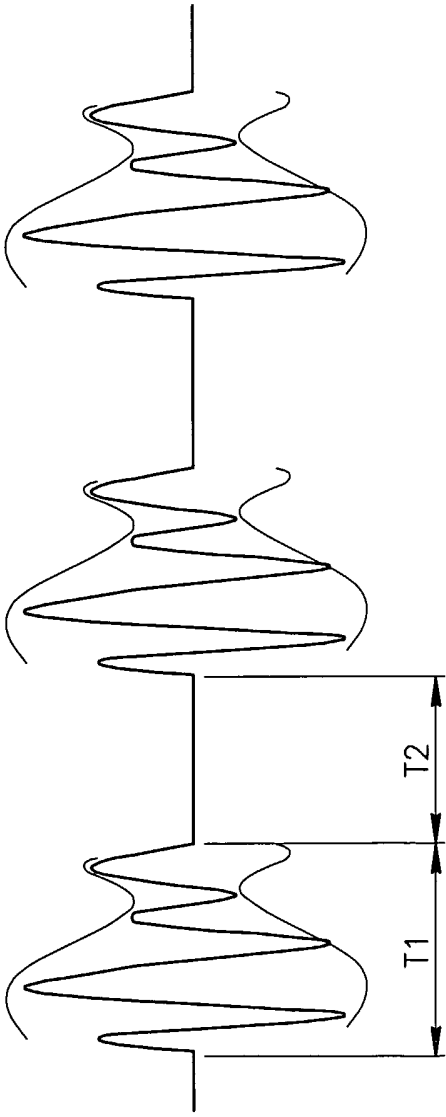


FIG. 4B



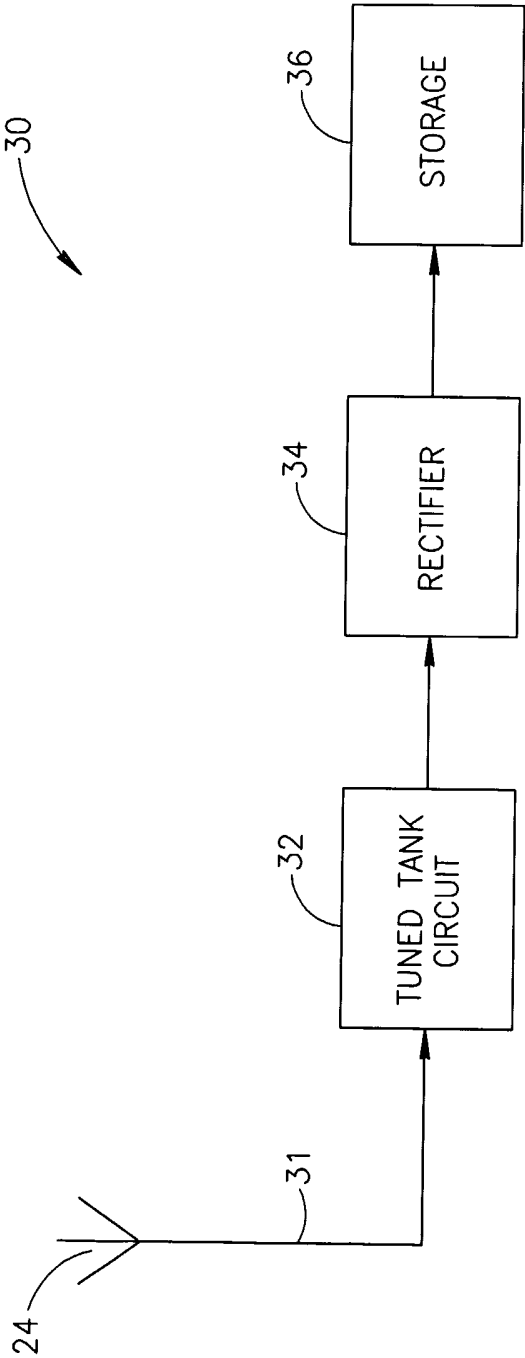


FIG.5

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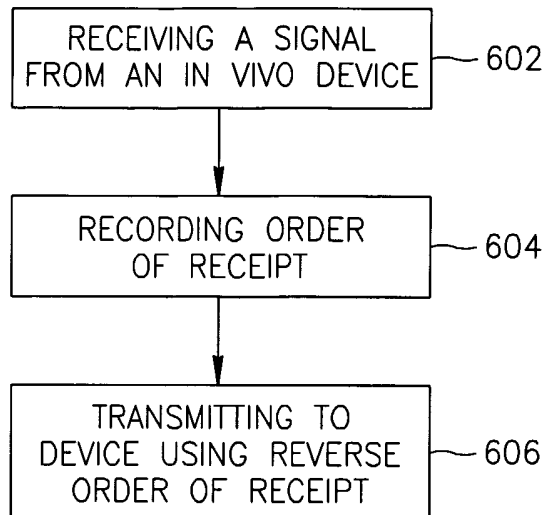


FIG. 6