US 20070035383A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2007/0035383 A1
(43) Pub. Date: Feb. 15, 2007

Roemerman et al.

(54) **RADIO FREQUENCY IDENTIFICATION INTERROGATION SYSTEMS AND METHODS OF OPERATING THE SAME**

(76) Inventors: **Steven D. Roemerman**, Highland Village, TX (US); **John P. Volpi**, Garland, TX (US)

Correspondence Address:
SLATER & MATSIL, L.L.P.
17950 PRESTON RD, SUITE 1000
DALLAS, TX 75252-5793 (US)

(21) Appl. No.: **11/501,348**

(22) Filed: **Aug. 9, 2006**

Related U.S. Application Data

(60) Provisional application No. 60/706,822, filed on Aug. 9, 2005.

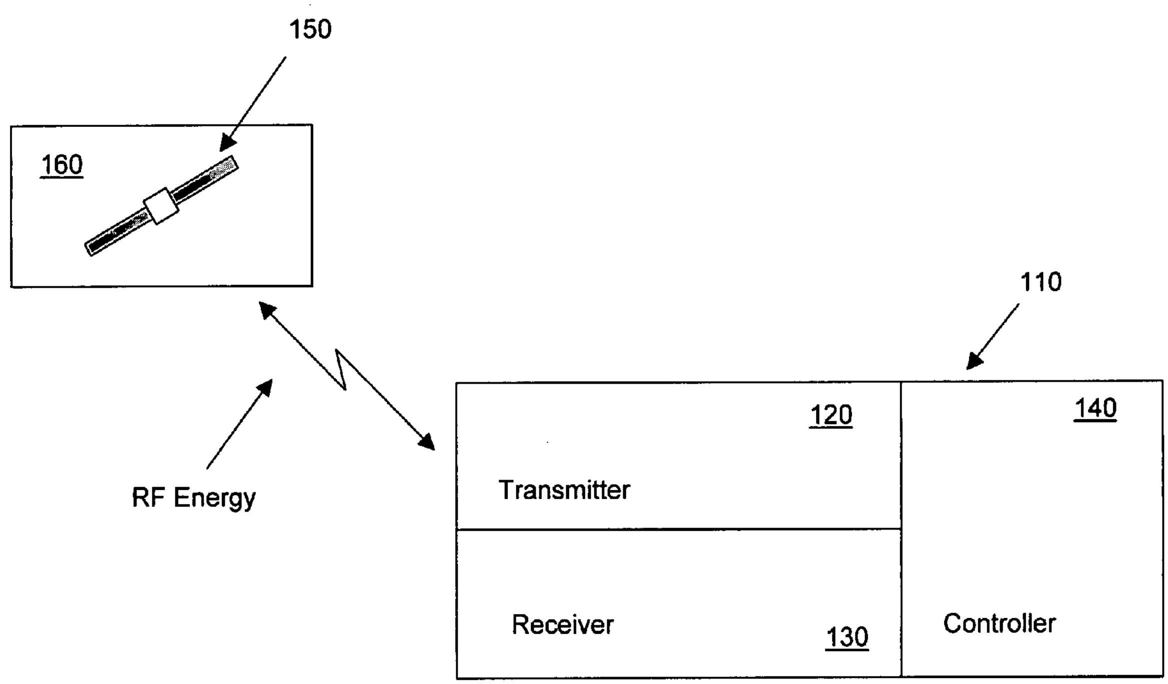
Publication Classification

(51) **Int. Cl.**
H04Q 5/22 (2006.01)

(52) **U.S. Cl.** **340/10.1**; 340/505; 340/572.1; 340/572.8; 340/539.1

(57) **ABSTRACT**

An interrogation system and method of operating the same. In one embodiment, the interrogation system includes a structure having a plurality of modules and a washer located within one of the plurality of modules including a radio frequency identification (RFID) tag with a code. The interrogation system also includes an interrogator configured to read the RFID tag and discern a type of structure based on information about the plurality of modules from the code.



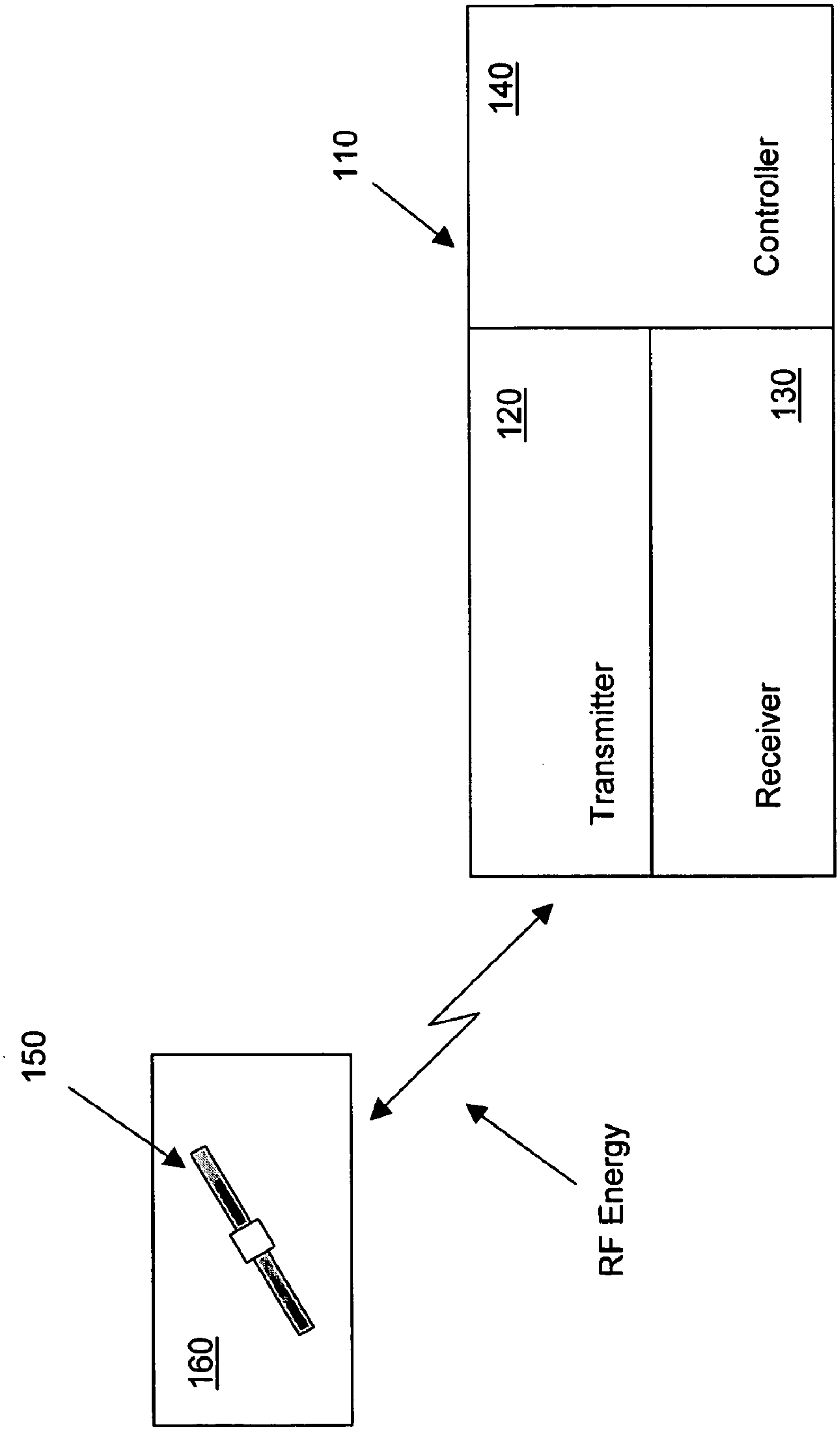

110
140
Controller
120
Transmitter
130
Receiver
150
160
RF Energy

FIGURE 1

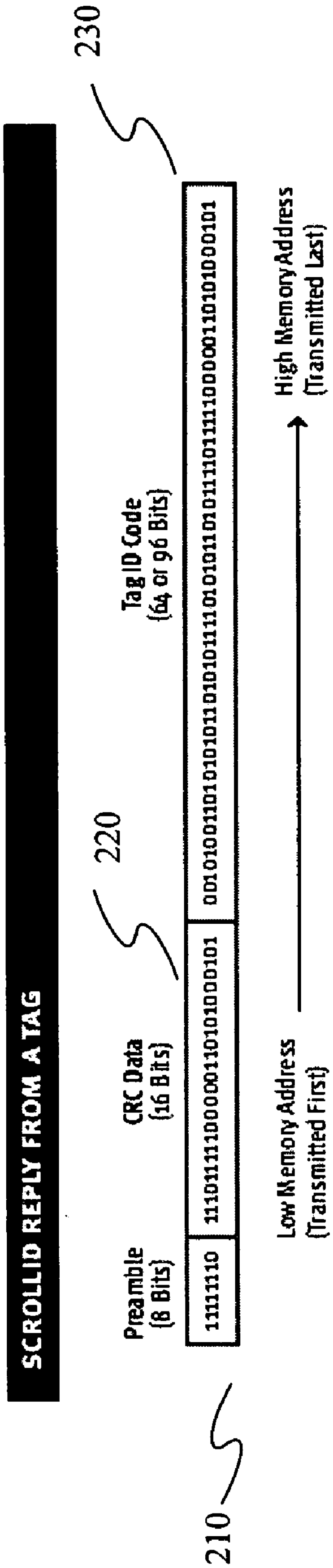

SCROLLID REPLY FROM A TAG
Preamble (8 Bits)
CRC Data (16 Bits)
Tag ID Code (64 or 96 Bits)
11111110
Low Memory Address (Transmitted First)
High Memory Address (Transmitted Last)
210
220
230

FIGURE 2

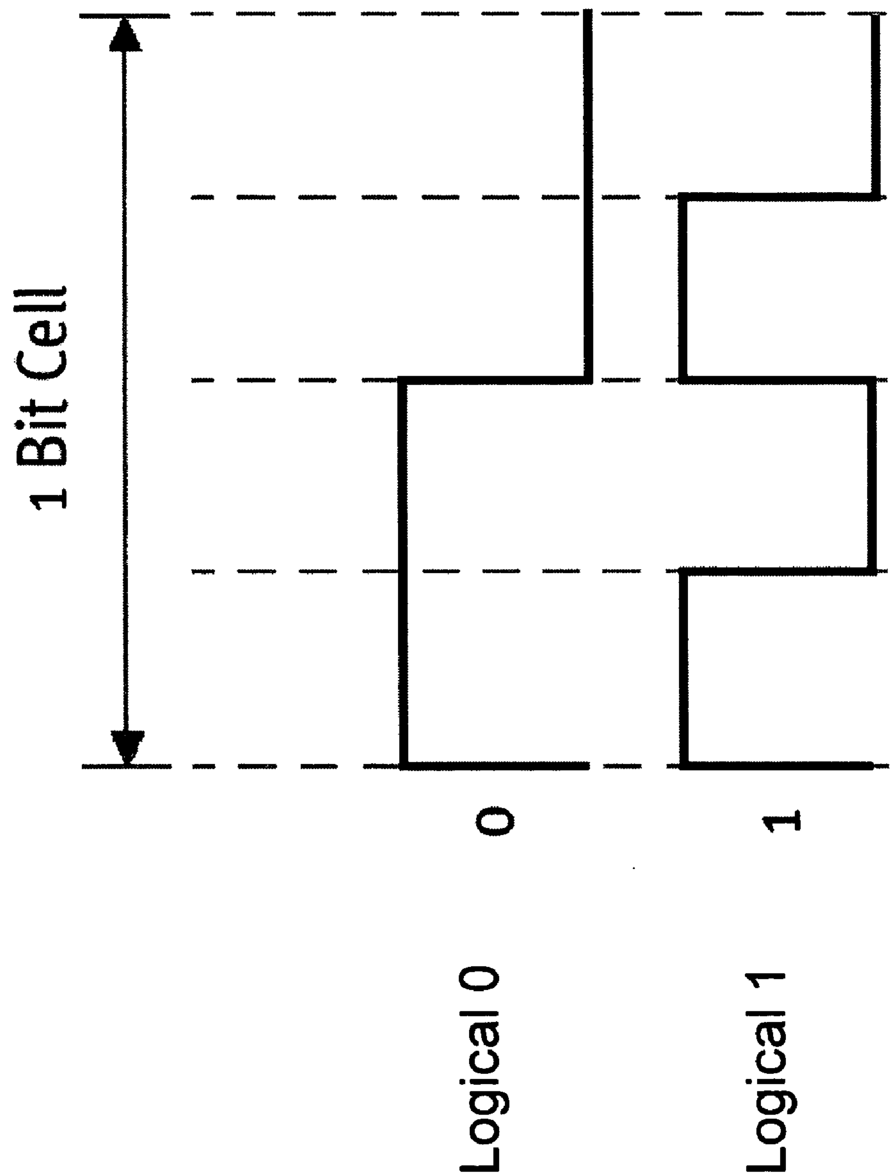


FIGURE 3

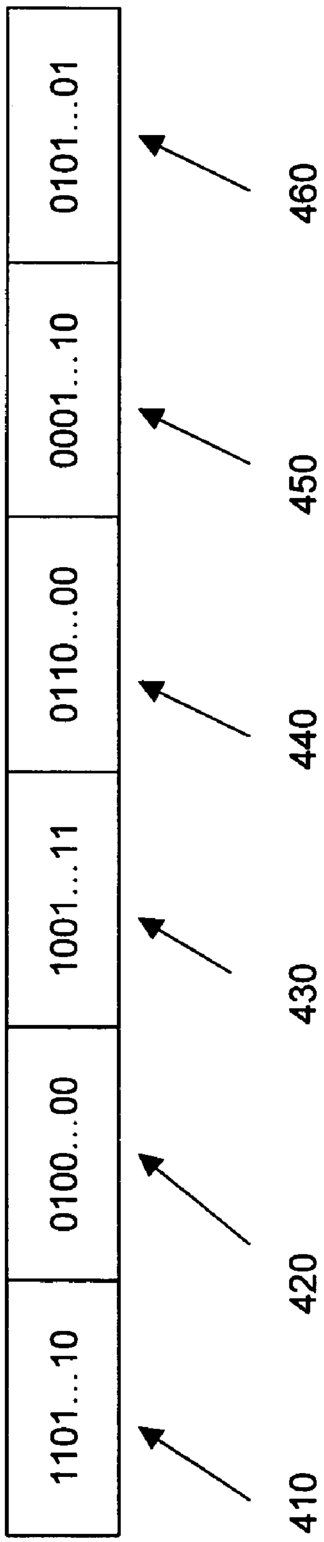

1101…10
0100…00
1001…11
0110…00
0001…10
0101…01
410
420
430
440
450
460

FIGURE 4

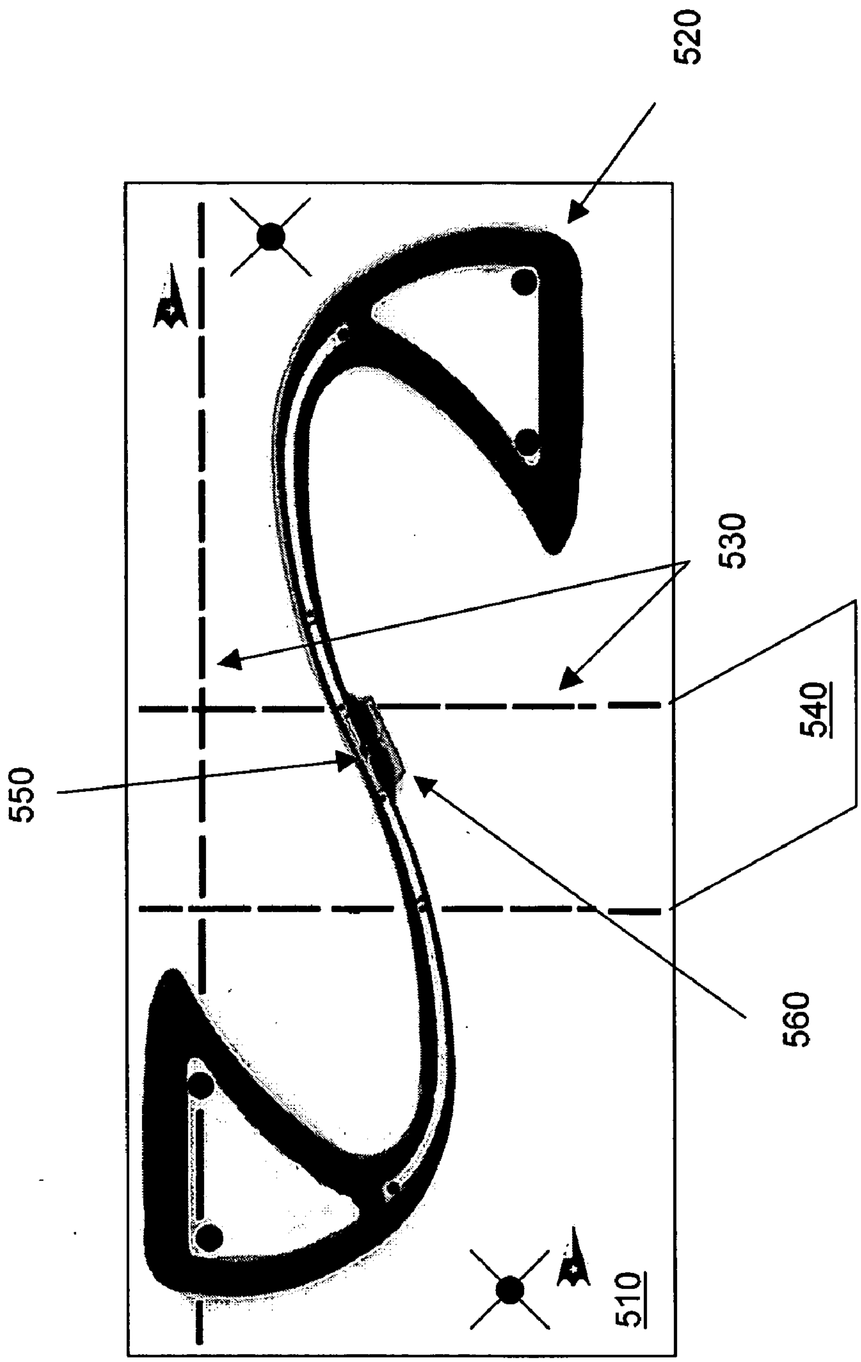


FIGURE 5

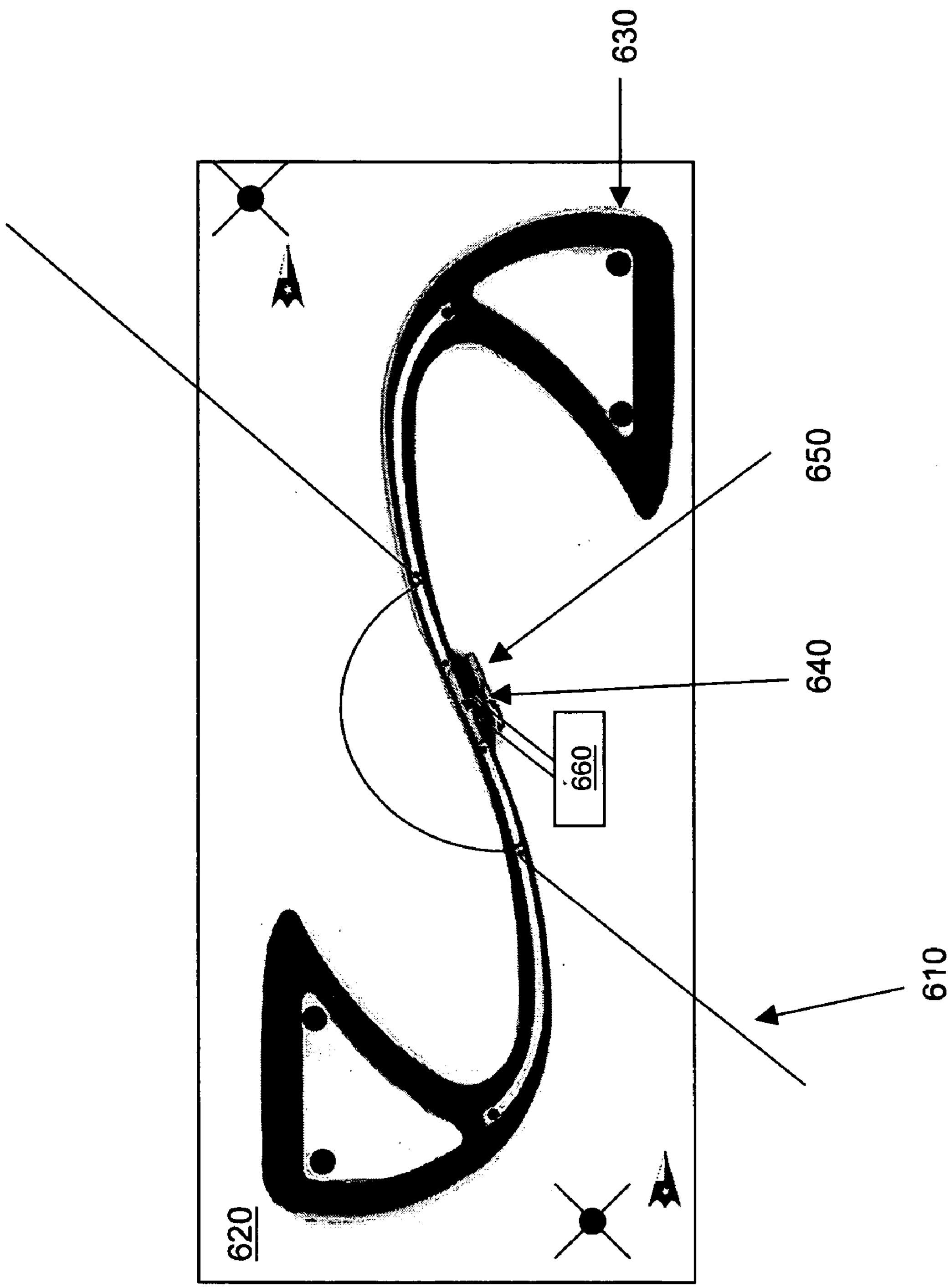


FIGURE 6

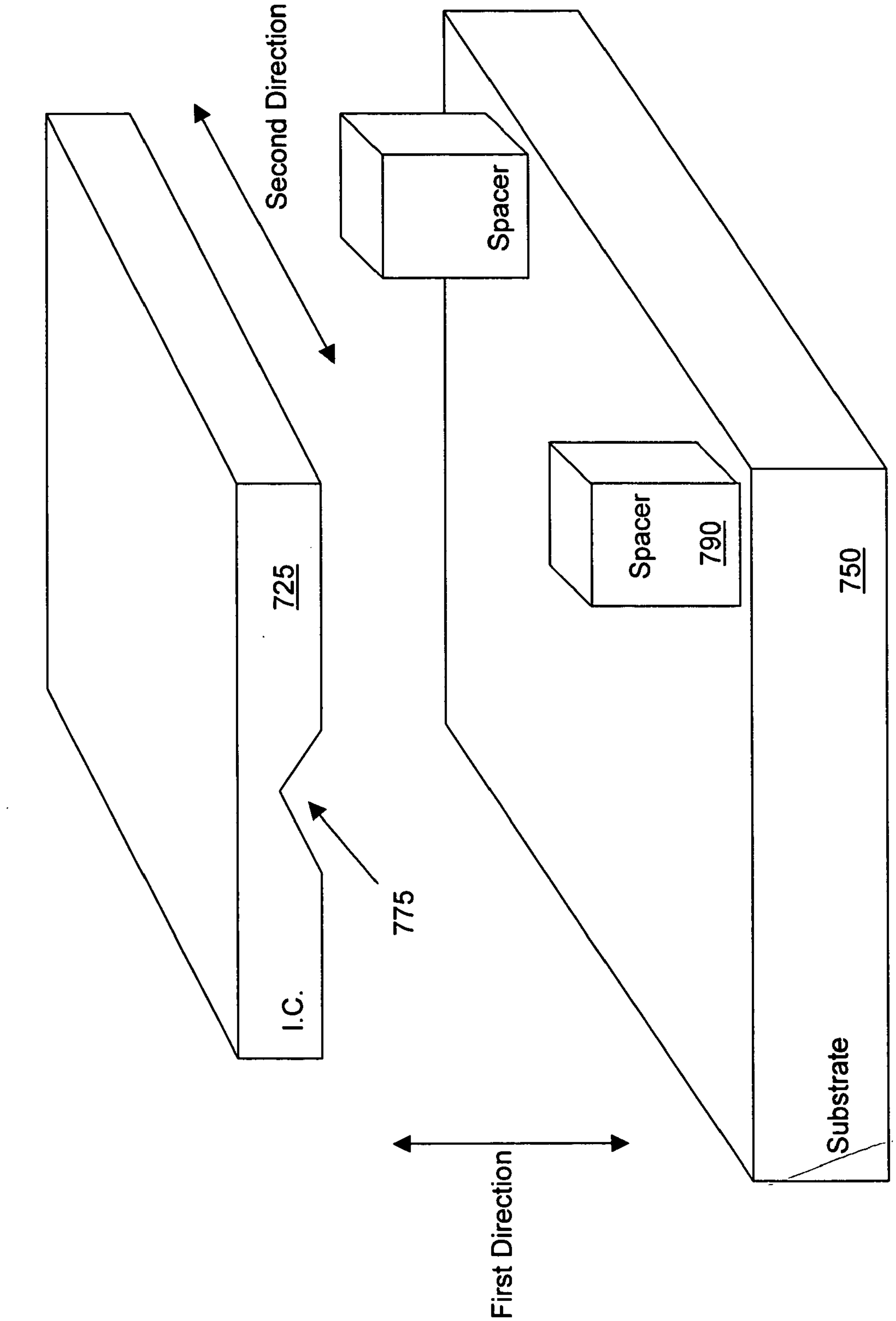

Second Direction
Spacer
Spacer
790
725
750
I.C.
775
Substrate
First Direction

FIGURE 7

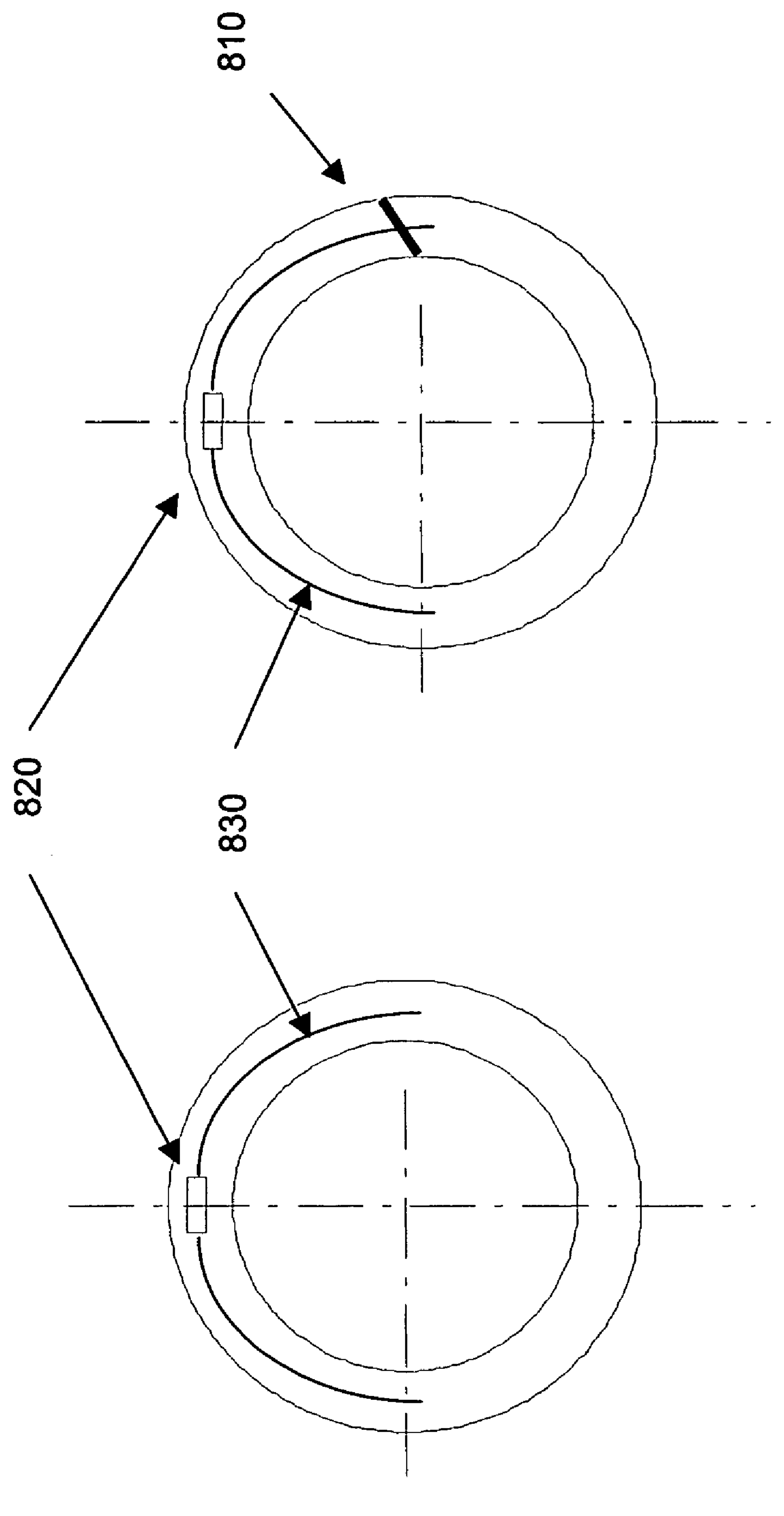


FIGURE 8B

FIGURE 8A

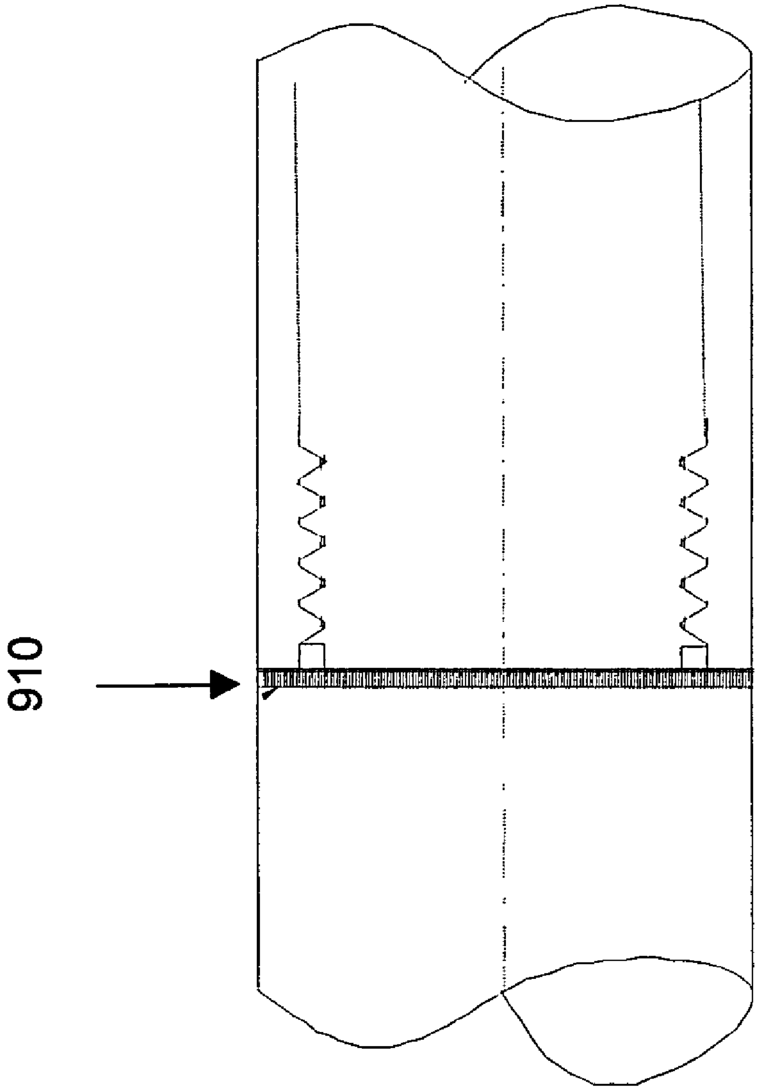


FIGURE 9

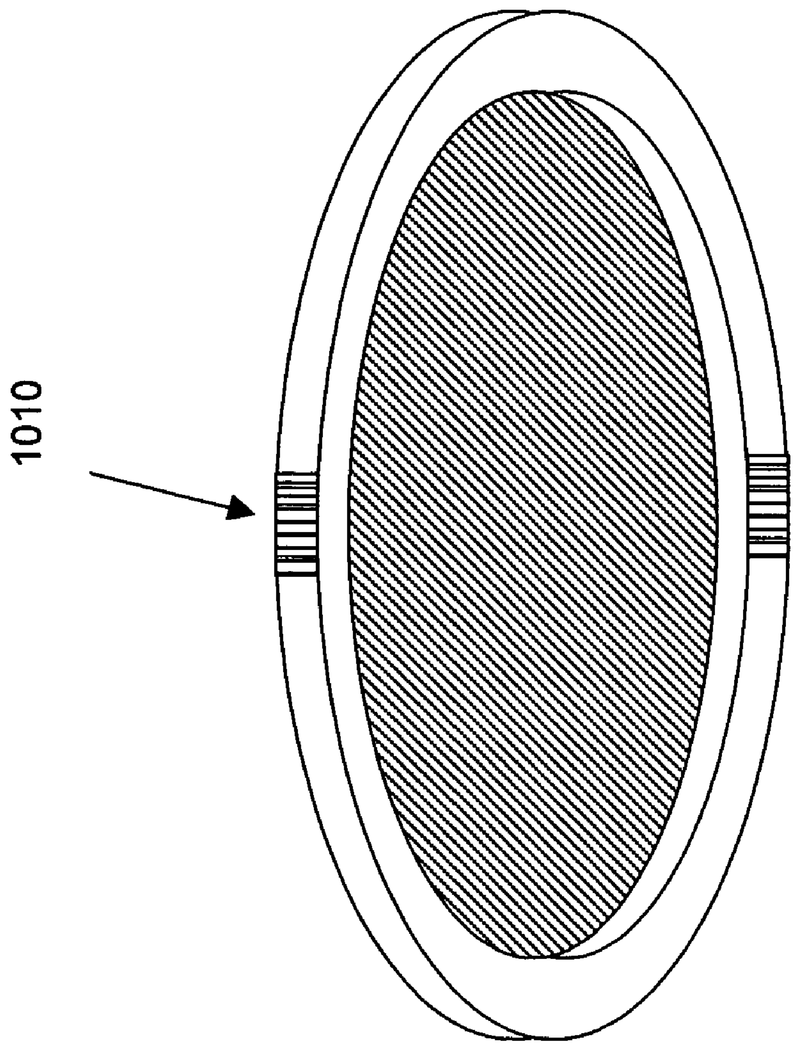


FIGURE 10

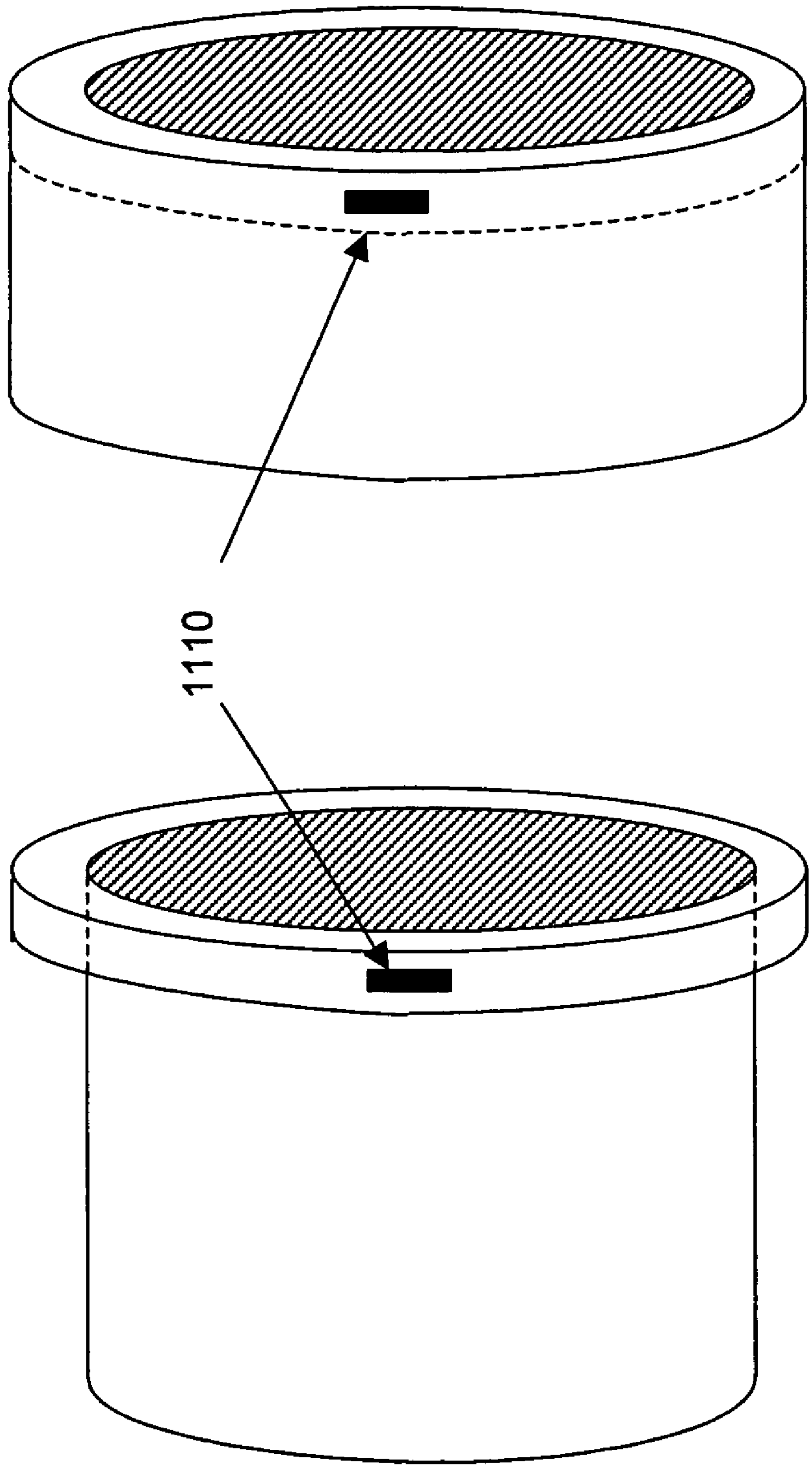


FIGURE 11B

FIGURE 11A

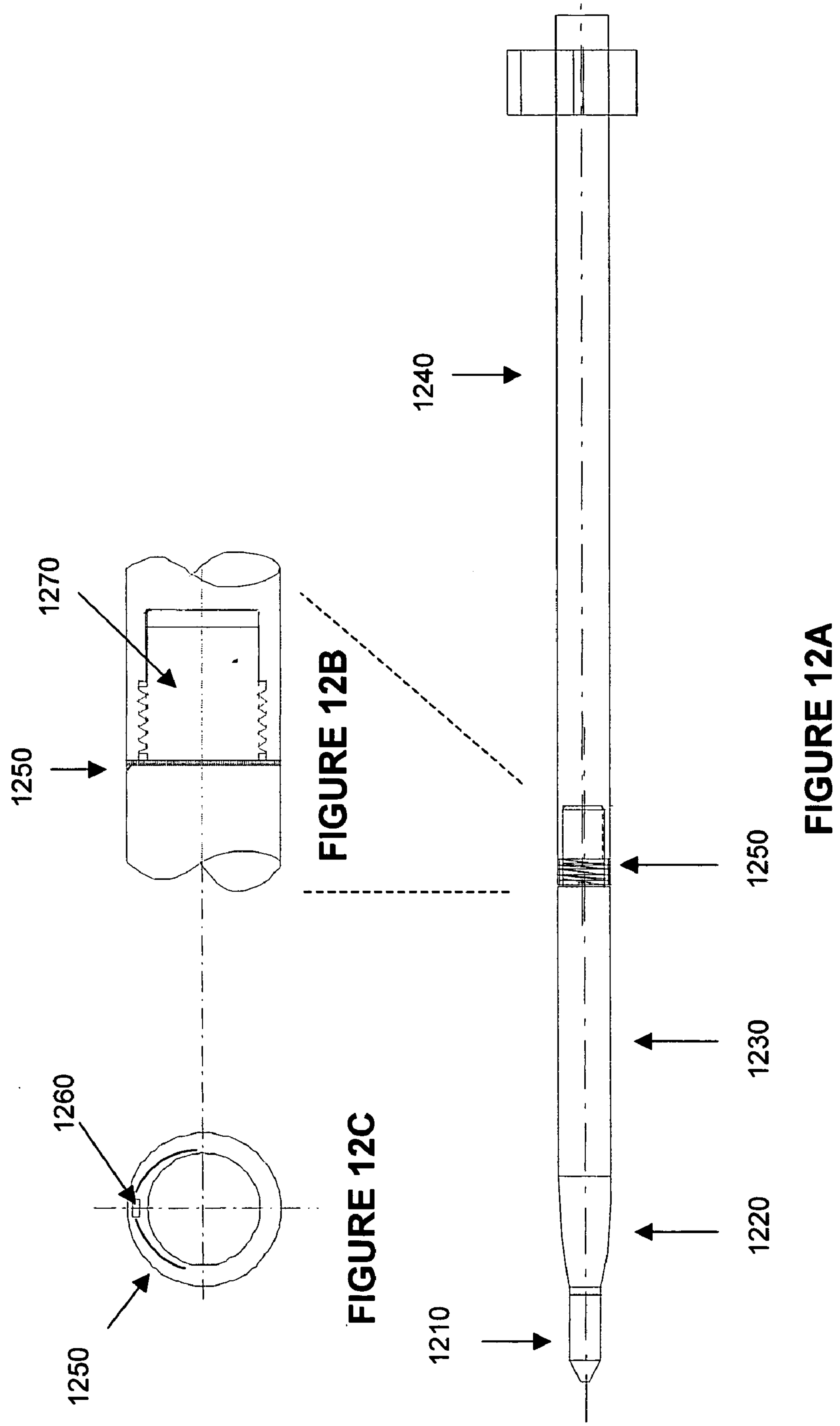


FIGURE 12A

FIGURE 12B

FIGURE 12C

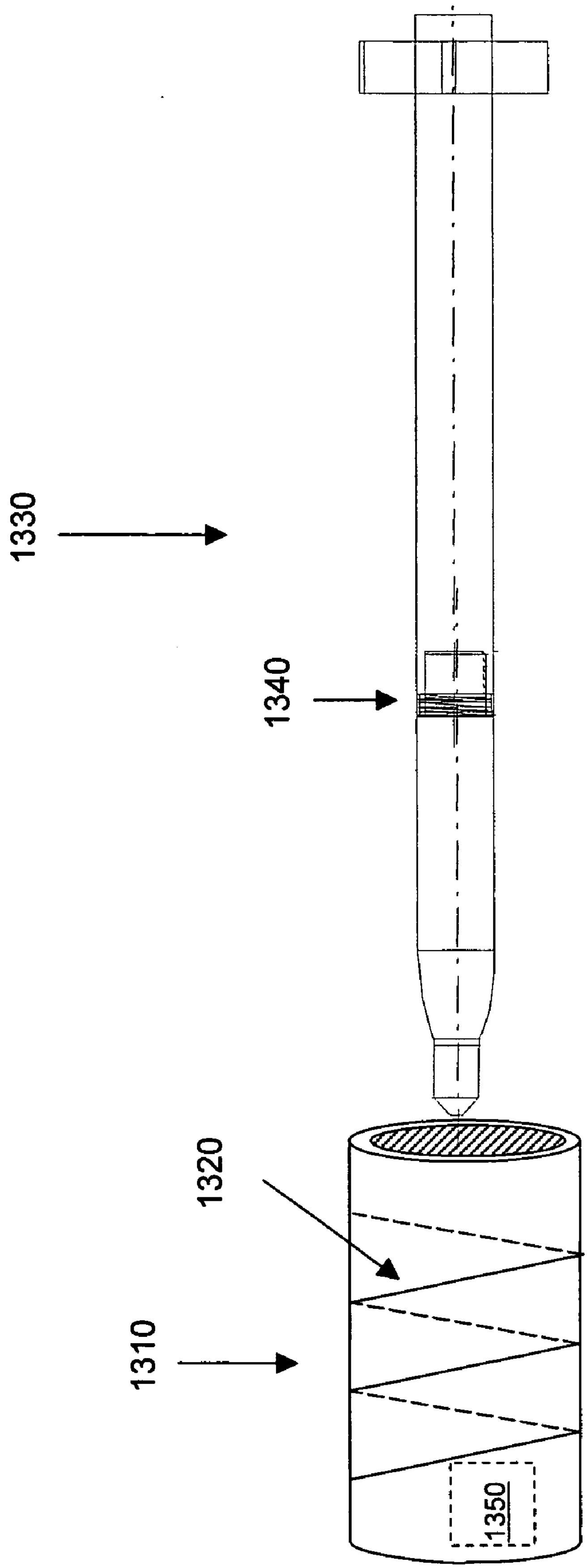


FIGURE 13

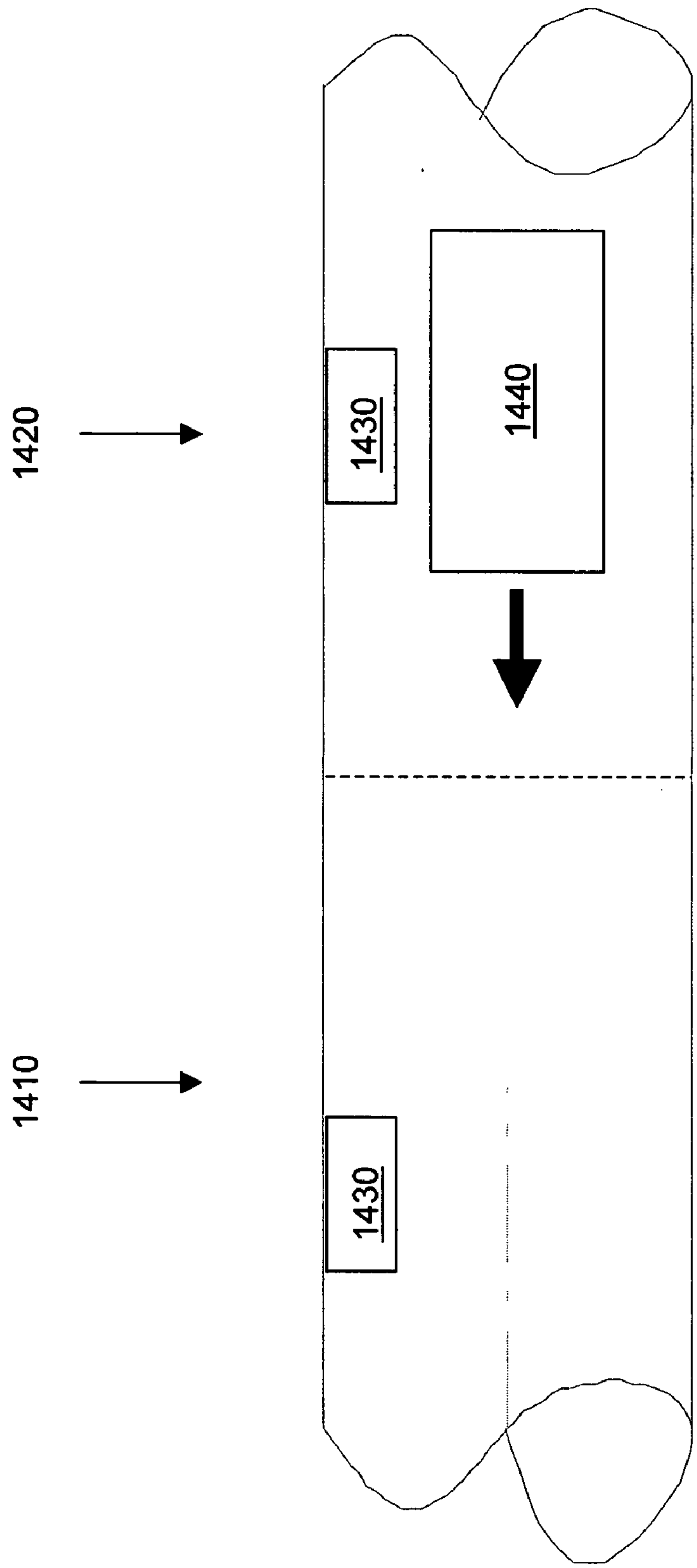


FIGURE 14

RADIO FREQUENCY IDENTIFICATION INTERROGATION SYSTEMS AND METHODS OF OPERATING THE SAME

[0001] This application claims the benefit of U.S. Provisional Application No. 60/706,822, entitled "System and Method for AutoID Related to Tubular Structures," filed on Aug. 9, 2005, which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention is directed, in general, to communication systems and, more specifically, to radio frequency identification (RFID) interrogation systems and methods of operating the same.

BACKGROUND

[0003] Asset tracking for the purposes of inventory control or the like is employed in a multitude of industry sectors such as in the food industry, apparel markets and any number of manufacturing sectors, to name a few. In many instances, a bar coded tag or radio frequency identification (RFID) tag is affixed to the asset and a reader interrogates the item to read the tag and ultimately to account for the asset being tracked. Although not readily adopted, RFID systems may be employed on a more granular level to track RFID objects (items with an RFID tag) at the unit level as opposed at the pallet level. Additionally, RFID systems may be employed in security and military applications to track RFID objects including people with RFID tags affixed thereto.

[0004] As mentioned above, there is a widespread practice in other fields for counting, tracking and accounting for items, and two of the more prevalent and lowest cost approaches involve various types of bar coding and RFID techniques. As with bar coding, the RFID techniques are primarily used for automatic data capture and, to date, the technologies are generally not compatible with the counting of RFID objects at the unit level. A reason for the incompatibility in the supply chain field for the bar coding and RFID techniques is a prerequisite to identify items in noisy environments.

[0005] Even in view of the foregoing limitations for the application of RFID techniques in less than ideal conditions, RFID tags have been compatible with a number of arduous environments. In the pharmaceutical industry, for instance, RFID tags have survived manufacturing processes that require products to be sterilized for a period of time at over 120 degrees Celsius. Products are autoclaved while mounted on steel racks tagged with an RFID tag such that a rack identification (ID) number and time/date stamp can be automatically collected at the beginning and end of the process as the rack travels through the autoclave on a conveyor. The RFID tags can be specified to withstand more than 1000 hours at temperatures above 120 degrees Celsius.

[0006] While identification tags or labels may be able to survive the difficult conditions associated with medical applications, there is yet another challenge directed to attaching an identification element to any small device. The RFID tags are frequently attached to devices by employing mechanical techniques or may be affixed with sewing techniques. A more common form of attachment of an RFID tag to a device is by bonding techniques including encapsulation or adhesion.

[0007] While manufacturers have multiple options for bonding, critical disparities between materials may exist in areas such as biocompatibility, bond strength, curing characteristics, flexibility and gap-filling capabilities. A number of bonding materials are used in the assembly and fabrication of both disposable and reusable medical devices, many of which are certified to United States Pharmacopoeia Class VI requirements. These products include epoxies, silicones, ultraviolet curables, cyanoacrylates, and special acrylic polymer formulations.

[0008] As previously mentioned, familiar applications for RFID techniques include "smart labels" in airline baggage tracking and in many stores for inventory control and for theft deterrence. In some cases, the smart labels may combine both RFID and bar coding techniques. The tags may include batteries and typically only function as read only devices or as read/write devices. Less familiar applications for RFID techniques include the inclusion of RFID tags in automobile key fobs as anti-theft devices, identification badges for employees, and RFID tags incorporated into a wrist band as an accurate and secure method of identifying and tracking prison inmates and patrons at entertainment and recreation facilities. Within the medical field, RFID tags have been proposed for tracking patients and patient files, employee identification badges, identification of blood bags, and process management within the factories of manufacturers making products for medical practice.

[0009] Typically, RFID tags without batteries (i.e., passive devices) are smaller, lighter and less expensive than those that are active devices. The passive RFID tags are typically maintenance free and can last for long periods of time. The passive RFID tags are relatively inexpensive, often as small as an inch in length, and about an eighth of an inch in diameter when encapsulated in hermetic glass cylinders. Recent developments indicate that they will soon be even smaller. Considering only a single RFID standard as an example, the EPC UHF RFID tags can be encoded with 64 or more bits of data that represent a large number of unique ID numbers (e.g., about 18,446,744,073,709,551,616 unique ID numbers). Obviously, this number of encoded data provides more than enough unique codes to identify every item used in a surgical procedure or in other environments that may benefit from asset tracking.

[0010] An important attribute of RFID interrogation systems is that a number of RFID tags should be interrogated simultaneously stemming from the signal processing associated with the techniques of impressing the identification information on the carrier signal. A related and desirable attribute is that there is not typically a minimum separation required between the RFID tags. Using an anti-collision algorithm, multiple RFID tags may be readily identifiable and, even at an extreme reading range, only minimal separation (e.g., five centimeters or less) to prevent mutual de-tuning is generally necessary. Most other identification systems, such as systems employing bar codes, usually impose that each device be interrogated separately. The ability to interrogate a plurality of closely spaced RFID tags simultaneously is desirable for applications requiring rapid interrogation of a large number of items.

[0011] In general, the sector of radio frequency identification is one of the fastest growing areas within the field of automatic identification and data collection. A reason for the proliferation of RFID systems is that RFID tags may be affixed to a variety of diverse objects (also referred to as "RFID objects") and a presence of the RFID tags may be detected without actually physically viewing or contacting the RFID tag. As a result, multiple applications have been developed for the RFID systems and more are being developed every day.

[0012] The parameters for the applications of the RFID systems vary widely, but can generally be divided into three significant categories. First, an ability to read the RFID tags rapidly. Another category revolves around an ability to read a significant number of the RFID tags simultaneously (or nearly simultaneously). A third category stems from an ability to read the RFID tags reliably at increased ranges or under conditions wherein the radio frequency signals have been substantially attenuated. While significant progress has been made in the area of reading multiple RFID tags almost simultaneously (see, for instance, U.S. Pat. No. 6,265,962 entitled "Method for Resolving Signal Collisions Between Multiple RFID Transponders in a Field," to Black, et al., issued Jul. 24, 2001, which is incorporated herein by reference), there is still room for significant improvement in the area of reading the RFID tags reliably at increased ranges or under conditions when the radio frequency signals have been substantially attenuated.

[0013] Accordingly, what is needed in the art is radio frequency identification interrogation systems and related methods to identify and account for all types of items regardless of the environment or application that overcomes the deficiencies of the prior art. Additionally, what is needed in the art is a radio frequency identification interrogation system that provides a location of a radio frequency identification object. Also, what is needed in the art is radio frequency identification tags that facilitate higher sensitivity reading and exhibit characteristics that protect the integrity of the information associated therewith.

SUMMARY OF THE INVENTION

[0014] These and other problems are generally solved or circumvented, and technical advantages are generally achieved, by advantageous embodiments of the present invention which includes an interrogation system and method of operating the same. In one embodiment, the interrogation system includes a structure having a plurality of modules and a washer located within one of the plurality of modules including a radio frequency identification (RFID) tag with a code. The interrogation system also includes an interrogator configured to read the RFID tag and discern a type of structure based on information about the plurality of modules from the code.

[0015] In another aspect, the present invention provides an interrogation system including a structure including a plurality of sections, wherein each of the sections includes an RFID tag. The interrogation system also includes an interrogator within the structure configured to read the RFID tags and discern a location of the interrogator within the structure.

[0016] The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures or processes for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0018] FIG. **1** illustrates a diagram of an embodiment of an RFID interrogation system constructed in accordance with the principles of the present invention,

[0019] FIG. **2** illustrates a block diagram of an embodiment of a reply code from an RFID tag in response to a query by an interrogator constructed in accordance with the principles of the present invention,

[0020] FIG. **3** illustrates a waveform diagram of an exemplary one-bit cell of a response from an RFID tag to an interrogator in accordance with the principles of the present invention,

[0021] FIG. **4** illustrates a block diagram of an embodiment of a reply code from an RFID tag in response to a query by an interrogator constructed in accordance with the principles of the present invention,

[0022] FIGS. **5** to **7** illustrate block diagrams of alternative embodiments of RFID tags constructed in accordance with the principles of the present invention,

[0023] FIGS. **8**A and **8**B illustrate diagrams of embodiments of a washer employable with a structure in accordance with the principles of the present invention,

[0024] FIG. **9** illustrates a side view of an embodiment of a section of a module of a structure in accordance with the principles of the present invention,

[0025] FIG. **10** illustrates a diagram of an embodiment of a washer employable with a structure in accordance with the principles of the present invention,

[0026] FIGS. **11**A and **11**B illustrate side views of embodiments of washers employable with a structure in accordance with the principles of the present invention,

[0027] FIGS. **12**A to **12**C illustrate diagrams of an embodiment of a structure in accordance with the principles of the present invention,

[0028] FIG. **13** illustrates a diagram of an embodiment of an interrogation system in accordance with the principles of the present invention, and

[0029] FIG. **14** illustrates a diagram of an embodiment of an interrogation system in accordance with the principles of the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0030] The making and using of the presently preferred embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention. The present invention will be described with respect to exemplary embodiments in a specific context, namely, interrogation systems and methods of operating the same.

[0031] Referring initially to FIG. **1**, illustrated is a diagram of an embodiment of an RFID interrogation system constructed in accordance with the principles of the present invention. The RFID interrogation system includes an interrogator **110** with a transmitter **120**, a receiver **130**, and a controller **140**. The interrogator **110** energizes an RFID tag **150** located on an RFID object **160** and then receives the encoded radio frequency (RF) energy (reflected or transmitted) from the RFID tag **150**, which is detected and decoded by the receiver **130**. The controller **140** provides overall control of the interrogator as well as providing reporting functions. Additionally, the interrogator typically includes a data input/output port, keyboard, display, power conditioner, power source, battery, antennas, and a housing. An example of an interrogator is provided in U.S. Pat. No. 7,019,650, entitled "Interrogator and Interrogation System Employing the Same," to Volpi, et al., issued Mar. 28, 2006, and U.S. Publication No. 2005/0201450, entitled "Interrogator and Interrogation System Employing the Same," to Volpi, et al., filed Mar. 3, 2005, which are incorporated herein by reference. For examples of related RFID systems, see U.S. Patent Publication No. 2006/0017545, entitled "Radio Frequency Identification Interrogation Systems and Methods of Operating The Same," to Volpi, et al., filed Mar. 25, 2005, and U.S. Patent Publication No. 2006/0077036, entitled "Interrogation System Employing Prior Knowledge About an Object to Discern an Identity Thereof," to Roemerman, et al., filed Sep. 29, 2005, which are incorporated herein by reference.

[0032] Additionally, the RFID interrogation system may be employed with multiple RFID objects and with different types of RFID tags. For example, the RFID tags may be passive, passive with active response, and fully active. For a passive RFID tag, the transmitted energy provides a source to charge an energy storage device within the RFID tag. The stored energy is used to power a response from the RFID tag wherein a matching impedance and thereby a reflectivity of the RFID tag is altered in a coded fashion of ones ("1") and zeros ("0"). At times, the RFID tag will also contain a battery to facilitate a response therefrom. The battery can simply be used to provide power for the impedance matching/mismatching operation described above, or the RFID tag may even possess an active transmitting function and may even respond at a frequency different from a frequency of the interrogator. Any type of tag (e.g., RFID tag) whether presently available or developed in the future may be employed in conjunction with the RFID interrogation system. Additionally, the RFID objects (i.e., an object with an RFID tag) may include more than one RFID tag, each carrying different information (e.g., object specific or sensors reporting on the status of the object) about the RFID object. The RFID tags may also include more than one integrated circuit, each circuit including different coded information for a benefit of the interrogation system. For an example of a passive RFID tag, see U.S. Pat. No. 6,859,190 entitled "RFID Tag with a Quadrupler or N-Tupler Circuit for Efficient RF to DC Conversion," to Pillai, et al., issued on Feb. 22, 2005, and U.S. Pat. No. 6,618,024 entitled "Holographic Label with a Radio Frequency Transponder," by Adair, et al., issued Sep. 9, 2003, which are incorporated herein by reference. Of course, other types of RFID tags including surface acoustic wave identification tags such as disclosed in U.S. Patent Application Publication No. 2003/0111540 entitled "Surface Acoustic Wave Identification Tag having Enhanced Data Content and Methods of Operation and Manufacture Thereof," to Hartmann, filed Dec. 18, 2001, which is incorporated herein by reference, may be employed in conjunction with the principles of the present invention.

[0033] Turning now to FIG. **2**, illustrated is a block diagram of an embodiment of a reply code from an RFID tag in response to a query by an interrogator constructed according to the principles of the present invention. In the present embodiment, the reply code (also referred to as "code") includes three sections, namely, a preamble **210**, a cyclic redundancy check (CRC) field **220** to check for bit errors, and a tag identification (ID) code **230** that uniquely specifies an RFID tag. In this example, the preamble **210** is a fixed length having eight bits, the CRC field **220** is 16 bits and the tag ID code **230** is either 64 or 96 bits. Of course, the length of the respective sections of the reply code and the sections that form the reply code may be modified including the addition of additional or different sections and still fall within the broad scope of the present invention. The bits of the reply code are generated sequentially or serially at a rate determined by an oscillator acting like a clock within the RFID tag. The frequency of the oscillator is synchronized to a clock of an interrogator during the initial interrogation by the interrogator.

[0034] The interrogator may employ the tag ID code **230** to more definitively detect and identify a specific RFID tag and a digital signature associated with the RFID tag. More specifically, it is possible to detect an RFID tag employing portions of or the entirety of the reply code. As an example, the interrogator may employ the tag ID code **230** only to detect a presence of an RFID tag or employ the additional bits available from the CRC field **220** as well as the preamble **210** or other sections of the reply code to create a longer and more sensitive data stream for processing and identifying an RFID tag. Also, in a conventional reader mode, the RFID tags may be detected via incoming RF energy and without apriori knowledge of any information about the RFID tag. In this instance, a relatively strong signal incident on the interrogator is preferable to generate a sufficiently positive signal to noise ratio (SNR) to reliably detect the incoming signal and, ultimately, the presence of the RFID tag.

[0035] Turning now to FIG. **3**, illustrated is a waveform diagram of an exemplary one-bit cell of a response from an RFID tag to an interrogator in accordance with the principles of the present invention. With a logical "1" response, zero encoding is in a frequency shift keying (FSK) modulation format to distinguish logical "1" from logical "0," but an on/off nature of the backscatter return signal of the RFID tag is also actually an amplitude shift keying (ASK) signal. The shift in amplitude is detected by the interrogator and the frequency of operation determines whether the detection represents a logical "1" or logical "0." For a better understanding of RFID tags, see "Technical Report 860 MHz-930 MHz Class I Radio Frequency Identification Tag Radio Frequency & Logical Communication Interface Specification Candidate Recommendation," Version 1.0.1, November 2002, promulgated by the Auto-ID Center, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Bldg 3-449, Cambridge Mass. 02139-4307, and "EPC Radio-Frequency Identity Protocols Class-1 Generation2-2 UHF RFID Protocol for Communications at 860-960 MHz," Version 1.09, January 2005, promulgated by EPCglobal Inc., Princeton Pike Corporate Center, 1009 Lenox Drive, Suite 202, Lawrenceville N.J. 08648," which are incorporated herein by reference.

[0036] The backscatter return signal is embodied in the response from an RFID tag. A low backscatter return signal is generated when the RFID tag provides a matched load so that any energy incident on the antenna of the RFID tag is dissipated within the RFID tag and therefore not returned to the interrogator. Alternatively, a high backscatter return signal is generated when the RFID tag provides a mismatched load so that any energy incident on the antenna of the RFID tag is reflected from the RFID tag and therefore returned to the interrogator. For more information, see "RFID Handbook," by Klaus Finkenzeller, published by John Wiley & Sons, Ltd., 2nd edition (2003), which is incorporated herein by reference.

[0037] Turning now to FIG. **4**, illustrated is a block diagram of an embodiment of a reply code from an RFID tag in response to a query by an interrogator constructed according to the principles of the present invention. The reply code (also referred to as a "code") includes a preamble **410** located at a fore end of the reply code, a CRC field **420**, a first tag ID code section **430**, an aftamble (e.g., a midamble) **440**, a second tag ID code section **450** and another aftamble (e.g., a postamble) **460**. For the purposes herein, the term "aftamble" refers to being located later in the bit stream after the preamble. The additional sections of the reply code such as the midamble **440** and the postamble **460** assist in establishing signal synchronization as well as signal identification or identification type. The tag ID code is divided into at least two sections with the midamble **440** located in a middle section of the reply code inserted therebetween. The tag ID code includes information that more definitively allows for the detection and identification of a specific RFID tag and a digital signature associated with the RFID tag. Finally, the postamble **460** is aft of the midamble **440** and forms the tail end of the reply code.

[0038] With their location within the reply code, as opposed to only a preamble at the beginning, the midamble **440** and the postamble **460** are able to resynchronize the reply code or provide additional information as to the health or stability of the communication channel (e.g., fading) accommodating the reply code. The midamble **440** and postamble **460** also allow for longer codes to be reliably read and detected or tolerate poorer oscillator performance with respect to, for instance, synchronization and drift. The preamble **410**, midamble **440** and postamble **460** can be used to derive information about a quality of a clock associated with the RFID tag. The midamble **440** and postamble **460** cooperating with the preamble **410** provides information to derive clock bias and drift rate more accurately than a preamble **410** by itself, especially with longer reply codes. The midamble **440** and postamble **460** cooperate with the preamble **410** to allow the interrogator to correct for clock bias and drift to improve the bit error rate of the reply code and the sensitivity of the interrogator.

[0039] An interrogator may employ a correlating receiver to initially correlate on portions of the reply code such as the midamble **440**, thereby using that information to gain additional timing integrity with regard to the incoming bit stream including the reply code over a communication channel. The additional timing integrity may then be used to practically allow longer integration times for the correlating receiver. As a result, effective longer integration times will directly contribute to better signal to noise ratios without increasing false alarm rates and augment the detection properties of the interrogator. The aforementioned reply code will be advantageous as longer tag ID codes and, generally, reply codes are adopted, reading ranges are extended, and reading rates under less than ideal conditions are increased.

[0040] The role of the midamble **440** and postamble **460** may be extended beyond providing single fixed codes for the RFID tags. For instance, the midamble **440** and postamble **460** may also convey information as to identifying classes or subclasses of RFID tags and therefore the objects to which they are attached. In this manner, the RFID tags may then be commanded to a quiet mode wherein such RFID tags will not contribute to responses or the response from the RFID tags may be included or rejected outright in the integration function of the correlating receiver of the interrogator.

[0041] As mentioned above, the midamble **440** or postamble **460** provide enhanced timing information associated with reply code to better enable coherent integration in addition to or instead of non-coherent integration. Coherent integration is performed prior to correlation and has the advantage of increasing the received signal to noise ratio directly as 'N' where N is the number of samples integrated. This is in contrast to non-coherent integration which increases the received signal to noise ratio as the square root of N. Coherent integration, when possible, is preferable but is often difficult to implement due to a lack of timing information to be effectively implemented. The use of the midamble **440** or the postamble **460** facilitates coherent integration due to the better timing information provided with the reply code.

[0042] It is also possible to look for specific code segments or fragments at known locations within the tag ID code(s). For example, if it is known that the first K bits of a tag ID code are dedicated to a specific manufacturer, then out of a group of RFID tags, only those RFID tags corresponding to that specific manufacturer could be quickly identified. Alternatively, there are many other specific code segments or fragments corresponding to, but not limited to, elements such as product type, date of manufacture, country of origin or any other useful information. The correlating receiver can correlate on specific segments of the reply code and quickly provide useful information to any query so directed.

[0043] Alternatively, the interrogator may specifically look for segments or fragments as discussed above, but then use that information to reject such RFID tags. An example might be to look for items of a specific product that were NOT made by a particular manufacturer. Other similar examples include, but are not limited to, elements such as: product type, date of manufacture, country of origin or any other useful item of information. Those skilled in the art will readily see from these examples that a number of population sorting methods can be achieved to achieve a wide range of desired outcomes. A number of problems related to poor signal to noise ratios, large populations of RFID tags to be read, sorting of the RFID tags, and other similar problems can be addressed by these methods.

[0044] The correlation of reply codes in the context of RFID interrogation systems as disclosed in U.S. Publication No. 2005/0201450, entitled "Interrogator and Interrogation System Employing the Same," to Volpi, et al., filed Mar. 3, 2005, which is incorporated herein by reference, teaches about substantially improving receiver sensitivity when employing correlation techniques and spread spectrum techniques to detect RFID tags. Those techniques are principally directed to increasing the sensitivity of the interrogator and do not specifically address improving the sensitivity of the RFID tag's ability to detect a command therefrom.

[0045] For instance, consider an RFID tag that includes a system for receiving a command enhanced by correlation and spread spectrum techniques. In one embodiment, the RFID tag includes a correlation subsystem dedicated to each relevant command from an interrogator. Whenever the interrogator sent that command, that RFID tag's ability to detect and thereby respond would be significantly enhanced. The number of commands detected in this manner varies with the application and type of RFID tag. This feature does not change any of the standard commands used for querying an RFID tag and comprehends using and detecting commands as defined by the specifications for that class of RFID tag.

[0046] Alternatively, a series of new commands may serve as queries from the interrogator. The commands or queries may have the unique properties of being from a set of orthogonal codes such as, without limitation, families or sequences of codes from Walsh-Hadamard, Gold, ML and Kasami codes. Each code has specific properties, but all share the same property of orthogonality so that the cross correlation function between any two codes within a family is very low. This greatly reduces the likelihood that a specific command detected by the correlating RFID tag will be erroneously interpreted as being a different command. Another embodiment is to consider a specific interrogator command as a key. This is useful for high value or security applications. As an example, responses to subsequent queries are only responded to by the interrogator and the RFID tag once an initial key is used and acknowledged.

[0047] Additionally, enhanced security can be achieved by configuring the RFID tags to respond when at least two different interrogators each present a unique query within a specified time or order with respect to each other. In another embodiment, the interrogators may both provide a simultaneous query. The aforementioned RFID interrogation systems are valid for standard RFID tag decoding as well as for correlating RFID tag decoding. They may also be used with active RFID tags wherein the RFID tag's responses can be at different bands and of more complex response types. These embodiments are particularly useful for high value objects or for security applications such as, without limitation, shipping high value cargo and for unique identification in counter-terrorism applications.

[0048] As mentioned above, for a correlating receiver, the RFID reply code can be generated using sequences from orthogonal codes such as, without limitation, Walsh-Hadamard, ML, Gold, and Kasami codes. The tag ID codes generated using these sequences will in general have good cross correlation characteristics.

[0049] Of course, "off-the-shelf" codes from standard RFID tags may be employed to advantage as well. The "standard RFID tags" might include the data represented in a standard bit pattern of an electronic product code (EPC) RFID tag, or any other data load which complies with a pre-determined set of rules. In conjunction therewith, all of the data bits loaded in an RFID tag, or only a portion, such as the manufacturer's code, may be employed to advantage. The cross correlation characteristics may not be as good, but the correlating receiver will still provide better results than a conventional receiver when employed to detect standard, non-orthogonal codes.

[0050] The use of standard tags allows significant improvements in many useful processes such as for the so called "x-ray reading" processes in which RFID objects (e.g., pallets loaded with several tagged cartons) are to be interrogated to detect the RFID tags thereon including the RFID tags embedded deep inside the stack of cartons. This process is also useful in medical and veterinarian applications, where RFID tags may be so deeply embedded in tissue, organic fluids, or other materials, that the link margin between the RFID tag and the interrogator is degraded. Those skilled in the art will readily see that the use of a correlating receiver with data content based on some apriori standard, but not necessarily a pseudo noise (PN) code chosen for optimal signal processing considerations, has a very large number of useful applications, and represents a technique to improve a large number of processes in a number of fields such as, without limitation, logistics, material handling, process control, medical, veterinary, and military applications.

[0051] Turning now to FIGS. **5** to **7**, illustrated are block diagrams of alternative embodiments of RFID tags constructed in accordance with the principles of the present invention. RFID tags can, in some circumstances, become unwanted, or even a hazard. In these situations, it is desirable to have a technique to ensure that the RFID tag cannot function. For instance, the electronic product code (EPC) standards provide a "kill" function in which an RFID tag can be instructed to never respond again to any inquiries. To invoke this "kill" function, an interrogator may instruct the RFID tag to not respond.

[0052] There are many cases, however, when the kill function is not adequate, or is impractical. For example, in the case of the RFID tagging of ordnance, with one purpose being to find unexploded ordnance (UXO), there is no way to know apriori which RFID objects will operate properly, and which will be "duds" and thereby become UXO. It is desirable in this sort of circumstance to know that most or all of the RFID tags which are no longer of interest (such as those which had been attached to munitions that did function), do not function or respond to interrogation. Inasmuch as the RFID tags are very small, and are mechanically very strong, there is a possibility that the RFID tags will continue to function, even after the explosion of a bomb. So, it is of interest to devise a technique to disable the RFID tags that is simple, reliable, inexpensive, and which does not rely on a interrogator or the like to instruct the RFID tag to invoke a "kill" mode. Thus, the system of the present invention includes a structure for disabling the RFID tags by, for instance, destroying an integrity of an antenna thereof. The antenna is an important feature of the RFID tag and, therefore, provides a viable aspect to attack the validity thereof.

[0053] Referring now to FIG. **5**, the RFID tag includes a substrate **510** on which an antenna **520** is located with perforations **530** (akin to consumer product packages) in the substrate **510**. The conductive ink, deposited metal, or other conductor which composes the antenna **520** is arranged on the substrate **510** in such a way that the perforations **530** do not interfere with the antenna **520**. When mechanical stress is imposed on the RFID tag, it will tear along the perforations **530** (facilitating a tearing) and, as a result, the antenna **520** is compromised, thereby disabling the RFID tag.

[0054] A class of applications for the principles of the present invention is to provide consumers with system that assures privacy by the destruction of RFID tags. This is one of many applications wherein user controlled destruction might be desirable. Another example of an application of assured destruction, or assured privacy, is the use of RFID tags in military applications, wherein there may be a concern that an enemy using an interrogator might find the RFID tag. In such cases, a "pull tab"**540** attached to the substrate **510** may be employed to disable or destroy the RFID tag by pulling the pull tab **540** away from the substrate **510**. The RFID tag also includes an electronic circuit (e.g., an integrated circuit) **550** including a clock and a carrier **560** with an electrical connection therebetween. The carrier **560** is coupled to the substrate **510** by mechanical and electrical connectivity. As mentioned above, those skilled in the art understand that other types of RFID tags including RFID tags based on piezo-electric transducers are well within the broad scope of the present invention. Thus, the RFID tag includes a non-electrical destruction mechanism (e.g., at least the perforations **530** or the pull tab **540**) coupled to the substrate and configured to render the RFID tag inoperative upon an occurrence of an event.

[0055] Referring now to FIG. **6**, illustrated is an alternative embodiment of an RFID tag constructed according to the principles of the present invention. A small lanyard **610** made of a material that is of higher tensile strength than a substrate **620** is attached to the substrate **620** bearing the antenna **630**. When mechanical stress is applied differentially to the RFID tag and the lanyard **610**, the lanyard **610** will tear the substrate **620**, in much the same way that a wire cheese slicer cuts through cheese or tears it apart. In the general case, the RFID tag is arranged so that when predetermined mechanical force is applied, the substrate **620** bearing the antenna **630** is subjected to mechanical failure and, as a result, the RFID tag's antenna **630** is destroyed. The substrate **620** may be formed from acetate, Mylar or other suitable dielectric substrate. The RFID tag also includes an electronic circuit (e.g., an integrated circuit) **640** including a clock and a carrier **650** with an electrical connection therebetween. The RFID tag also includes a sensor (e.g., a strain gauge) **660** as described below. Again, the RFID tag includes a non-electrical destruction mechanism (e.g., at least the lanyard **610**) coupled to the substrate and configured to render the RFID tag inoperative upon an occurrence of an event.

[0056] Often it is desirable not only to know about the existence of an RFID object by querying the RFID tag attached thereto, but also to know some additional information about the object itself. This information can be derived by sensors (e.g., sensor **660**) embedded as part of the RFID tag or as external inputs to the RFID tag. Examples of such sensors include, but are not limited to, temperature sensors and strain gauges and information such as maximum or minimum temperature achieved at some time in the past, a failure mode, or a state change may be obtained therefrom.

[0057] The use of embedded RFID tags has been put forth for applications such as strain gauges in composite materials, and for recording environmental history data, in particular for monitoring the storage environment for sensitive items such as warheads. By embedding the RFID tags with other sensors and employing correlating receivers, a number of desirable attributes may be achieved. Among these desirable attributes are the ability to operate the interrogator at lower power levels, which is a consideration for some processes in which the total energy input should be managed, such as explosives applications wherein power limitations may be much more severe than FCC Part 15 or similar limits, and processes such as biomedical research applications where interrogator power might influence a biological process.

[0058] In the case of a tagged submunition such as the BLU-97, an RFID tag might be applied to the ballute, which is the drogue intended to slow and stabilize the munition. These drogues are typically made of nylon or a similar woven material, and provide a good RF location for an RFID tag. However, the drogues often survive a BLU-97 explosion. Exemplary embodiments of such weapons are described in U.S. patent application Ser. No. 10/841,192 entitled "Weapon and Weapon System Employing the Same," to Roemerman, et al., filed May 7, 2004, and U.S. patent application Ser. No. 10/997,617 entitled "Weapon and Weapon System Employing the Same," to Tepera, et al., filed Nov. 24, 2004, which are incorporated herein by reference.

[0059] A method for destroying the electric continuity of the antenna **630** is to cause the substrate **620**, the antenna **630** or a combination thereof to tear, separate or rip. A tearing, separation or ripping action can be achieved by integrating a high tensile strength lanyard or twisted thread constructed of a high tensile strength lanyard such as Kevlar or thread twisted from Kevlar filaments, into the antenna **630**. The high tensile strength thread could be attached to slots, which already exist in the BLU-97 body. A Kevlar lanyard has a tensile strength in the range of 500,000 pounds-force per square inch. If a munition operates properly, the main body of the munition will be fragmented, and will be distributed by the blast of the explosion as shrapnel. The Kevlar lanyards have a higher tensile strength than most substrates made of materials such as Mylar. Mylar film has a tensile strength in the range of 30,000 pounds-force per square inch. When a lanyard is put in tension because of the movement of a fragment to which it is attached, the high tensile strength lanyard will pull on the substrate **620** introducing areas of high stress and stress concentrations causing the substrate **620** to tear, or antenna **630** to fracture and separate.

[0060] Inasmuch as the RFID tag is attached to the drogue, and because other lanyards will be pulling in other directions, the RFID tag is unable to accelerate in response to the force from the lanyard. As a result, the substrate **620** fails and the lanyard tears or cuts a path through it. If the lanyard has been properly placed, the path will cut through the antenna **630**. The illustrated embodiment provides an arrangement that accommodates the aforementioned application and can take advantage of the lanyards to destroy the RFID tag. Of course, a wide range of applications can benefit from the design criteria as described with respect to the illustrate embodiment and other features, such as labels, are applicable herewith.

[0061] Another application associated with the RFID tags as described herein is to attach the RFID tag to items under warranty. If an article is returned for warranty work, and the RFID tag has been disabled because of unauthorized disassembly, then the warranty is void. A perforated RFID tag or an RFID tag with a lanyard may be configured in such a way that upon opening an item, the RFID tag will be mechanically compromised, and thereby electrically disabled. The RFID tag may accommodate both perforations and lanyard holes. Of course, one of the aforementioned features may be removed or replaced with yet other features to attain an analogous result. Additionally, the lanyard holes may be aligned with the perforations, and thereby serve both roles.

[0062] Yet another way to disable the tags is to alter the response characteristic of the circuit by incorporating an environmentally sensitive component or element on the substrate. The environmentally sensitive component, such as a thermocouple, thermister, acoustic sensor, pressure sensor, light sensor, acceleration sensor or selected combinations thereof, when exposed to predetermined environments, introduces into the circuit a signal in such a manner as to alter the circuit's response characteristics. One example is to incorporate a pressure sensitive or acceleration sensitive component, such as a piezo-electric crystal, into the circuit. When the pressure sensitive or acceleration sensitive component is exposed to the appropriate environmental conditions, a signal is introduced into the circuit in such a manner as to alter the circuit's response characteristic either by acting to disable, destroy, change the circuit's coding or combinations thereof. The interrogator will interpret the revised signal as that of an explosive unit that has been detonated.

[0063] Another embodiment employs a chemical destruction mechanism that may be seen in the example of a photoresistive element on the substrate, which changes the impedance match between the circuit and the antenna. At a sufficient illumination level, the interrogator signal no longer provides enough power to activate the circuit, and the RFID tag is rendered inoperative. Those skilled in the art will see that the addition of such environmental sensors can be arranged to either temporarily or permanently disable the RFID tag. As an example, elements of the RFID tag may be soluble in a liquid so that when exposed to liquid the RFID tag is disabled.

[0064] Referring now to FIG. **7**, another embodiment of the RFID tag includes an integrated circuit **725** mounted above a substrate **750**. The RFID tag is supported in one or more locations such that only a portion of the integrated circuit **725** is directly supported, and the remainder of the RFID tag is cantilevered. Under sufficient acceleration, this mechanical arrangement will fail. Under sufficient acceleration in a first direction, the integrated circuit material (e.g., silicon) will fail. In some cases, it may be necessary to create a back side etch **775** in a back side of the integrated circuit to provide a lower acceleration at which material failure occurs. So, by means of example, the forces and accelerations of an explosion create a shock wave, which moves in a predictable direction. By attaching the RFID tag to the bomb casing in such a way that the blast wave will compromise the integrated circuit material, the RFID tag will be rendered inoperative, even if the bomb fragment is large enough to contain the entire RFID tag, and even if the RFID tag is otherwise intact.

[0065] In some cases, it may be desirable to add an additional direction of failure, and FIG. **7** illustrates that if the supporting spacers (one of which is designated **790**) between the integrated circuit **725** and the carrier are appropriately configured, the spacers **790** will fail, given sufficient acceleration in a second direction. Inasmuch as commonly used ceramic materials have much greater compression strength than shearing strength, and because ceramics are often used for integrated circuit carriers and other integrated circuit assemblies, ceramics are an illustrative embodiment of a material for a supporting spacer **790** with the characteristics shown. However, it is important to note that wide ranges of supporting spacer configurations are also within the broad scope of the present invention. For example, by techniques including backside thinning of the substrate **750**, the supporting spacers **790** may be mechanically integral to the integrated circuit **725**. Again, the RFID tag includes a non-electrical destruction mechanism (e.g., at least the integrated circuit **725** and the supporting spacer **790**) coupled to the substrate and configured to render the RFID tag inoperative upon an occurrence of an event.

[0066] There are a wide number of applications that may benefit from the principles described herein, including applications involving sensitive products, or applications wherein items or articles are exposed to excessive or undesirable environmental conditions such as pressure or excessive acceleration. Also, other methods to destroy the functional integrity of the RFID tag, and hence destroy or change the ability of the RFID tag to respond to the interrogator, are well within the broad scope of the present invention. Likewise, it is well within the broad scope of the present invention to incorporate methods and sensors to detect undesirable environments and apply the response of sensors in a manner to alter the circuit's response to an interrogator.

[0067] Additionally, there are a number of applications that may benefit from the attachment of an RFID tag or other auto ID technologies to structures such as cylindrical or tubular structures. Examples of such applications include identification of a plumbing or tubular joint type, identification of a structural location, and identification of an RFID object having a cylindrical structure. In the embodiments that follow, a system of affixing and locating auto ID devices to these structures at useful locations, as well as an interrogation system for reading or detecting the auto ID devices when installed is hereinafter provided.

[0068] Turning now to FIGS. **8**A and **8**B, illustrated are diagrams of embodiments of a washer employable with a structure in accordance with the principles of the present invention. More specifically, FIG. **8**A illustrates a flat washer and FIG. **8**B illustrates a split washer including a split **810**

therein. The washers include an RFID tag **820** with an embedded antenna **830**. It is recognized that the antenna **830** can be configured to be in specific locations of the washers to effect greater read sensitivities including complete annular ring and placement of the antenna **830** near a surface of the washer or, alternatively, deeply embedded therein. Additionally, the RFID tag **820** may include an integrated antenna or use the metal characteristics of the washer to serve as the antenna or supplement an integrated antenna. Additionally, while the washer is illustrated as a substantially circular configuration, those skilled in the art understand that the washer can be configured in any shape and configuration depending on the application.

[**0069**] Turning now to FIG. **9**, illustrated is a side view of an embodiment of a section of a module of a structure in accordance with the principles of the present invention. In the illustrated embodiment, the module (or section thereof) is a pipe and within the module is a washer **910** with an RFID tag. The washer **910** is affixed to the pipe via a glued or epoxy joint and the washer may be internal to a blind mate coupler. When employed with an interrogator, the RFID tag may be located for reading from within or outside the pipe.

[**0070**] Turning now to FIG. **10**, illustrated is a diagram of an embodiment of a washer employable with a structure in accordance with the principles of the present invention. The washer includes an auto ID tag (e.g., barcode) **1010**, which may be placed on the face or edge of the washer. Additionally, the washer may be color coded to provide an indication of the type of information encoded on the auto ID tag **1010**. In addition to the auto ID tag **1010**, therefore, the washer may include another identifier such as the color coded identifier. Thus, other methods of identification other than an RFID tag may also be used, either in conjunction with an RFID tag, or in place thereof.

[**0071**] Turning now to FIGS. **11**A and **11**B, illustrated are side views of embodiments of washers employable with a structure in accordance with the principles of the present invention. The washers in the present embodiments are flanges and include an RFID tag **1110**. Thus, other types of washers such as flanges, spacers, blind mate couplers are well within the broad scope of the present invention.

[**0072**] Turning now to FIGS. **12**A to **12**C, illustrated are diagrams of an embodiment of a structure in accordance with the principles of the present invention. More specifically, FIG. **12**A illustrates a side view of the structure and, FIGS. **12**B and **12**C illustrate a section of a module and a washer, respectively, thereof. In the illustrated embodiment, the structure is a weapon (e.g., a 70 mm rocket) having a plurality of modules including a fuse **1210**, a seeker (e.g., an M423HEPD) **1220**, a warhead (e.g., an M29) **1230**, and a guidance and control module (e.g., including a M66 rocket motor) **1240**. The structure also includes a washer **1250** with an RFID tag **1260** including a reply code (or code) with information about the plurality of modules. While the washer **1250** is located in the warhead **1230** proximate an internal joint **1270** thereof (see FIG. **12**B), those skilled in the art should understand that the washer may be located in any one of the plurality of modules or a washer may be located in several (and potentially all) of the plurality of modules. In the case that a washer (i.e., a washer and another washer(s)) is located in more than one module, each washer includes an RFID tag (i.e., an RFID tag and another RFID tag(s)) with a code (i.e., a code and another code(s)) with information about the plurality of modules. Thus, an interrogator can read the RFID tag **1260** and discern a type of the structure based on information about the plurality of modules encoded in the code(s).

[**0073**] Turning now to FIG. **13**, illustrated is a diagram of an embodiment of an interrogation system in accordance with the principles of the present invention. The interrogation system includes an interrogator **1310** including a receiver, transmitter and controller as described above with respect to FIG. **1**. The interrogator (e.g., an electromagnetically transparent, cylindrical configuration, transparent in the electromagnetic band used by the RFID tag and interrogator) **1310** also includes an antenna **1320** about the cylindrical configuration thereof. The antenna **1320** may be affixed to the cylindrical configuration by an adhesive or other mechanical methods. The antenna **1320** generally refers to both RF and induction type RFID, and depending on diameter and wave length, may refer to far field or near field. In addition, a number of locations are desirable for coil, loop, or other suitable antennas. These can be on the internal diameter, the external diameter, and can be affixed by various mechanisms of the interrogator **1310**. For instance, the antenna **1320** can be embedded within and affixed to the structure of the interrogator **1310**.

[**0074**] The interrogation system also includes a structure (e.g., a weapon) **1330** having a plurality of modules (see, e.g., the description with respect to FIGS. **12**A to **12**C) and a washer **1340** with an RFID tag thereon. Thus, the interrogation system comprehends a cylindrical or tube like configuration for the interrogator **1310** through which the structure **1330** shall pass. The interrogator **1310** includes an antenna **1320** for the purpose of detecting the RFID tag on the washer **1340** located within a module of the structure **1330**. At least the area of the interrogator **1310** containing the antenna **1320** shall be amenable to passing electromagnetic energy of at least the frequencies required for energizing (if necessary) the RFID tag and receiving data therefrom. It is also possible that the specific location and range of the antenna **1320** may be intentionally quite small. In another embodiment, a multiplicity of antennas can be placed at various locations along the interrogator **1310** and measure characteristics such as velocity and/or progress of the structure **1330** along the interrogator can also be derived. The interrogator **1310** may also include a sensor **1350** configured to measure the characteristics as described above.

[**0075**] Turning now to FIG. **14**, illustrated is a diagram of an embodiment of an interrogation system in accordance with the principles of the present invention. The interrogation system includes a structure having first and second sections **1410**, **1420** with an RFID tag **1430** having a reply code(s) (or code(s)) located therein. The interrogation system also includes an interrogator **1440** within the structure configured to read the RFID tags **1430** and discern a location of the interrogator **1440** within the structure. By installing RFID tags **1430** or other auto ID devices at various locations, an interrogator **1440** moving down the structure can accurately locate its position, and its associated time. Thus, the antenna for the interrogator can be affixed to a fixed location on a structure (see FIG. **13**) or on an interrogator moving within a structure as described herein.

[0076] An example of an application for the interrogation system includes a pipeline wherein a well casing may be several thousand feet in length, and may be shaped to approach oil, gas, water or other resource. The interrogation system can also test a property of the structure by, for instance, testing an integrity of the structure by sensing a temperature thereof. Of course, a pipeline is but one example of an application for the interrogation system as described herein.

[0077] Exemplary embodiments of the present invention have been illustrated with reference to specific electronic components. Those skilled in the art are aware, however, that components may be substituted (not necessarily with components of the same type) to create desired conditions or accomplish desired results. For instance, multiple components may be substituted for a single component and vice-versa. The principles of the present invention may be applied to a wide variety of applications to identify and detect RFID objects.

[0078] For a better understanding of communication theory and radio frequency identification communication systems, see the following references "RFID Handbook," by Klaus Finkenzeller, published by John Wiley & Sons, Ltd., 2nd edition (2003), "Technical Report 860 MHz-930 MHz Class I Radio Frequency Identification Tag Radio Frequency & Logical Communication Interface Specification Candidate Recommendation," Version 1.0.1, November 2002, promulgated by the Auto-ID Center, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Bldg 3-449, Cambridge Mass. 02139-4307, "Introduction to Spread Spectrum Communications," by Roger L. Peterson, et al., Prentice Hall Inc. (1995), "Modern Communications and Spread Spectrum," by George R. Cooper, et al., McGraw-Hill Book Inc. (1986), "An Introduction to Statistical Communication Theory," by John B. Thomas, published by John Wiley & Sons, Ltd. (1995), "Wireless Communications, Principles and Practice," by Theodore S. Rappaport, published by Prentice Hall Inc. (1996), "The Comprehensive Guide to Wireless Technologies," by Lawrence Harte, et al, published by APDG Publishing (1998), "Introduction to Wireless Local Loop," by William Webb, published by Artech Home Publishers (1998) and "The Mobile Communications Handbook," by Jerry D. Gibson, published by CRC Press in cooperation with IEEE Press (1996). For a better understanding of conventional readers, see the following readers, namely, a "MP9320 UHF Long-Range Reader" provided by SAMSys Technologies, Inc. of Ontario, Canada, a "MR-1824 Sentinel-Prox Medium Range Reader" by Applied Wireless ID of Monsey, N.Y. (see also U.S. Pat. No. 5,594,384 entitled "Enhanced Peak Detector," U.S. Pat. No. 6,377,176 entitled "Metal Compensated Radio Frequency Identification Reader," and U.S. Pat. No. 6,307,517 entitled "Metal Compensated Radio Frequency Identification Reader"), "2100 UAP Reader," provided by Intermec Technologies Corporation of Everett, Wash. and "ALR-9780 Reader," provided by Alien Technology Corporation of Morgan Hill, Calif. The aforementioned references, and all references herein, are incorporated herein by reference in their entirety.

[0079] Also, although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. For example, many of the processes discussed above can be implemented in different methodologies and replaced by other processes, or a combination thereof.

[0080] Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. An interrogation system, comprising:

a structure, including:

a plurality of modules, and

a washer located within one of said plurality of modules including a radio frequency identification (RFID) tag with a code; and

an interrogator configured to read said RFID tag and discern a type of said structure based on information about said plurality of modules from said code.

2. The interrogation system as recited in claim 1 wherein said structure includes another washer located within another one of said plurality of modules including another RFID tag with another code, said interrogator configured to read said another RFID tag and discern a type of said structure based on information about said plurality of modules from said code and said another code.

3. The interrogation system as recited in claim 1 wherein said structure is a weapon.

4. The interrogation system as recited in claim 1 wherein said plurality of modules include a fuse, seeker, warhead, and guidance and control module.

5. The interrogation system as recited in claim 1 wherein said washer is cylindrical.

6. The interrogation system as recited in claim 1 wherein said washer is selected from the group consisting of:

a flat washer,

a split washer,

a blind mate coupler, and

a flange.

7. The interrogation system as recited in claim 1 wherein said washer includes an antenna for said RFID tag.

8. The interrogation system as recited in claim 1 wherein said washer includes another identifier.

9. The interrogation system as recited in claim 1 wherein said interrogator includes a sensor configured to measure a characteristic of said structure.

10. The interrogation system as recited in claim 1 wherein said interrogator includes a transmitter, a receiver and a controller.

11. An interrogation system, comprising:

a structure including a plurality of sections, each of said plurality of sections including a radio frequency identification (RFID) tag; and

an interrogator within said structure configured to read said RFID tags and discern a location of said interrogator within said structure.

12. The interrogation system as recited in claim 11 wherein said interrogator is configured to read said RFID tags and discern a time associated therewith.

13. The interrogation system as recited in claim 11 wherein said interrogator tests a property of said structure.

14. The interrogation system as recited in claim 11 wherein said interrogator tests an integrity of said structure by sensing a temperature of said structure.

15. The interrogation system as recited in claim 11 wherein said structure is a pipeline.

16. A method of operating an interrogation system, comprising:

providing a structure including a plurality of modules and a washer located within one of said plurality of modules including a radio frequency identification (RFID) tag with a code;

reading said RFID tag; and

discerning a type of said structure based on information about said plurality of modules from said code.

17. The method as recited in claim 16 wherein said structure includes another washer located within another one of said plurality of modules including another RFID tag with another code, said method further comprising reading said another RFID tag and discerning a type of said structure based on information about said plurality of modules from said code and said another code.

18. The method as recited in claim 16 wherein said structure is a weapon.

19. The method as recited in claim 16 wherein said plurality of modules include a fuse, seeker, warhead, and guidance and control module.

20. The method as recited in claim 16 wherein said washer is cylindrical.

21. The method as recited in claim 16 wherein said washer is selected from the group consisting of:

a flat washer,

a split washer,

a blind mate coupler, and

a flange.

22. The method as recited in claim 16 wherein said washer includes an antenna for said RFID tag.

23. The method as recited in claim 16 wherein said washer includes another identifier.

24. The method as recited in claim 16 further comprising measuring a characteristic of said structure.

25. The method as recited in claim 16 wherein said interrogator includes a transmitter, a receiver and a controller.

* * * * *