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(54) **WIRELESS COMMUNICATION SYSTEMS AND METHODS**

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Related U.S. Patent Documents

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Filed: **May 14, 1998**

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(63) Continuation of application No. 10/893,101, filed on Jul. 16, 2004, now Pat. No. Re. 41,916.

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H04Q 5/22 (2006.01)

(52) **U.S. Cl.** **340/10.1; 235/384; 141/94; 141/98; 141/230; 700/302**

(58) **Field of Classification Search** **340/10.1; 235/384, 361; 141/94, 98, 231; 700/302**
See application file for complete search history.

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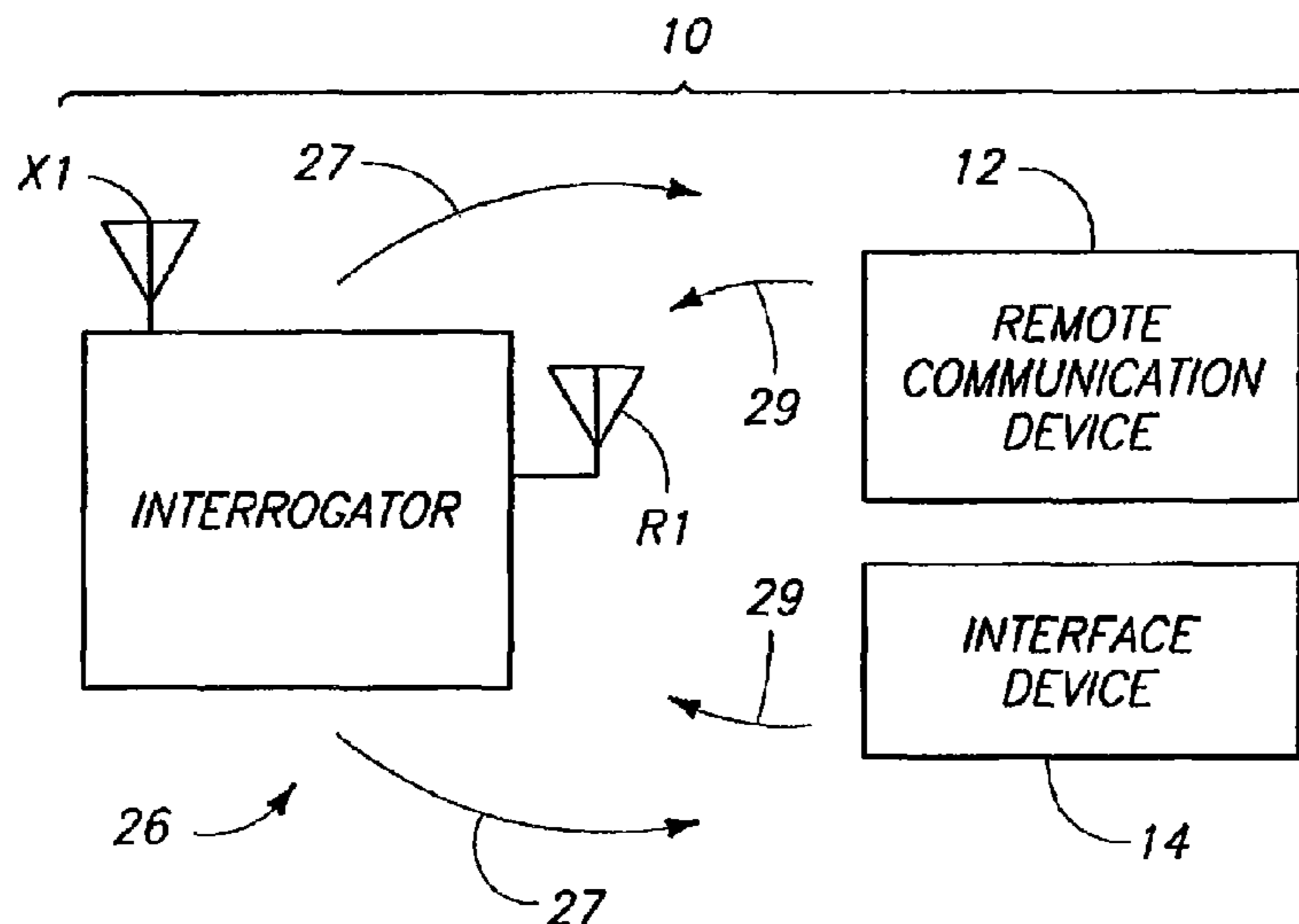
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(57) **ABSTRACT**

The present invention includes wireless communication systems, interfacing devices, communication methods, methods of interfacing with an interrogator, and methods of operating an interrogator. According to one embodiment, a wireless communication system includes a remote communication device; an interrogator configured to output a forward link wireless communication and receive a reply link wireless communication from the remote communication device responsive to the forward link wireless communication; and an interface device configured to interface with the interrogator using a wireless medium[, the interrogator being configured to be controlled by the interface device].

30 Claims, 7 Drawing Sheets



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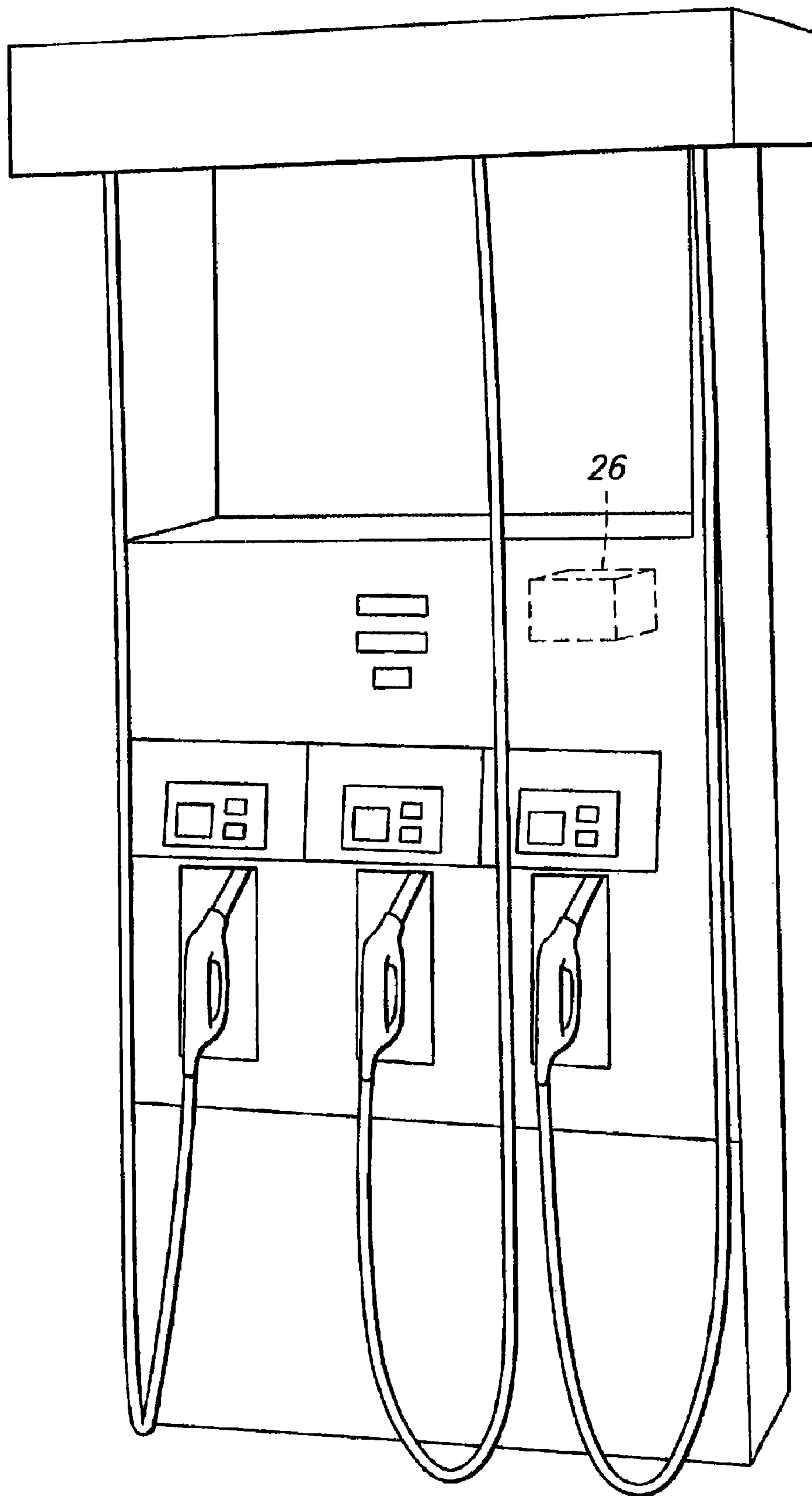
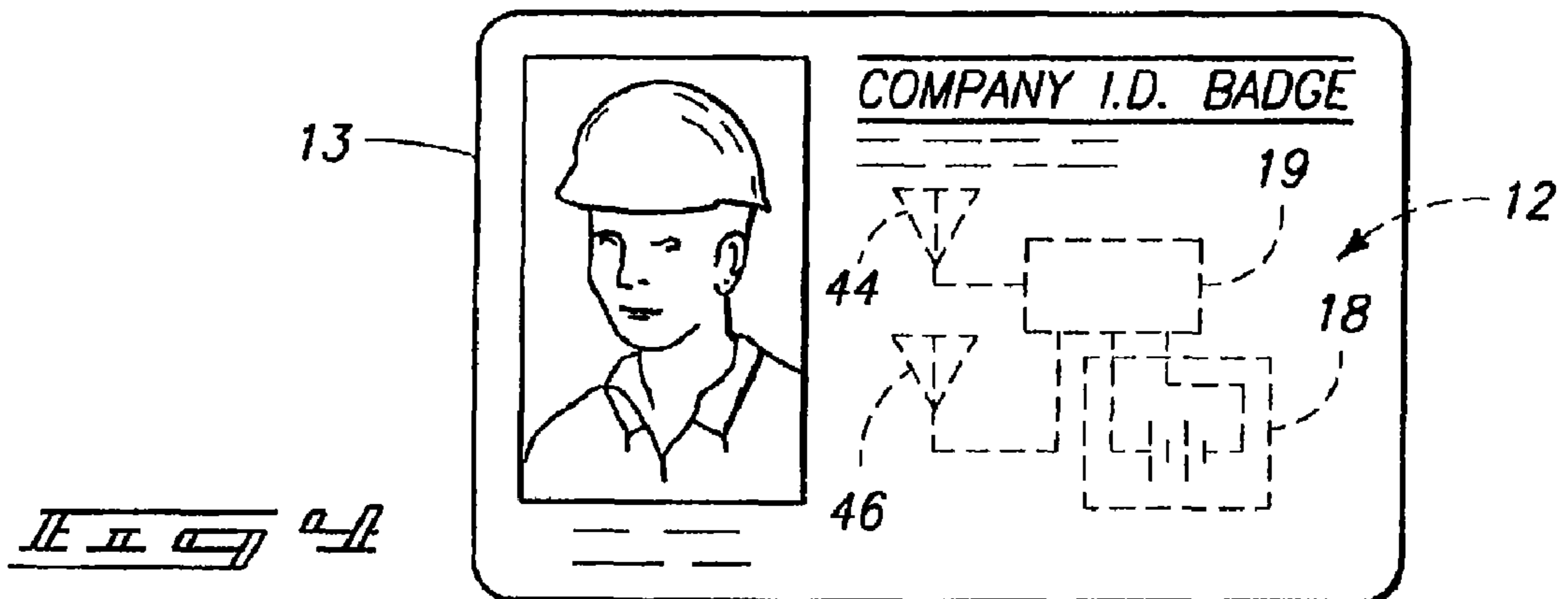
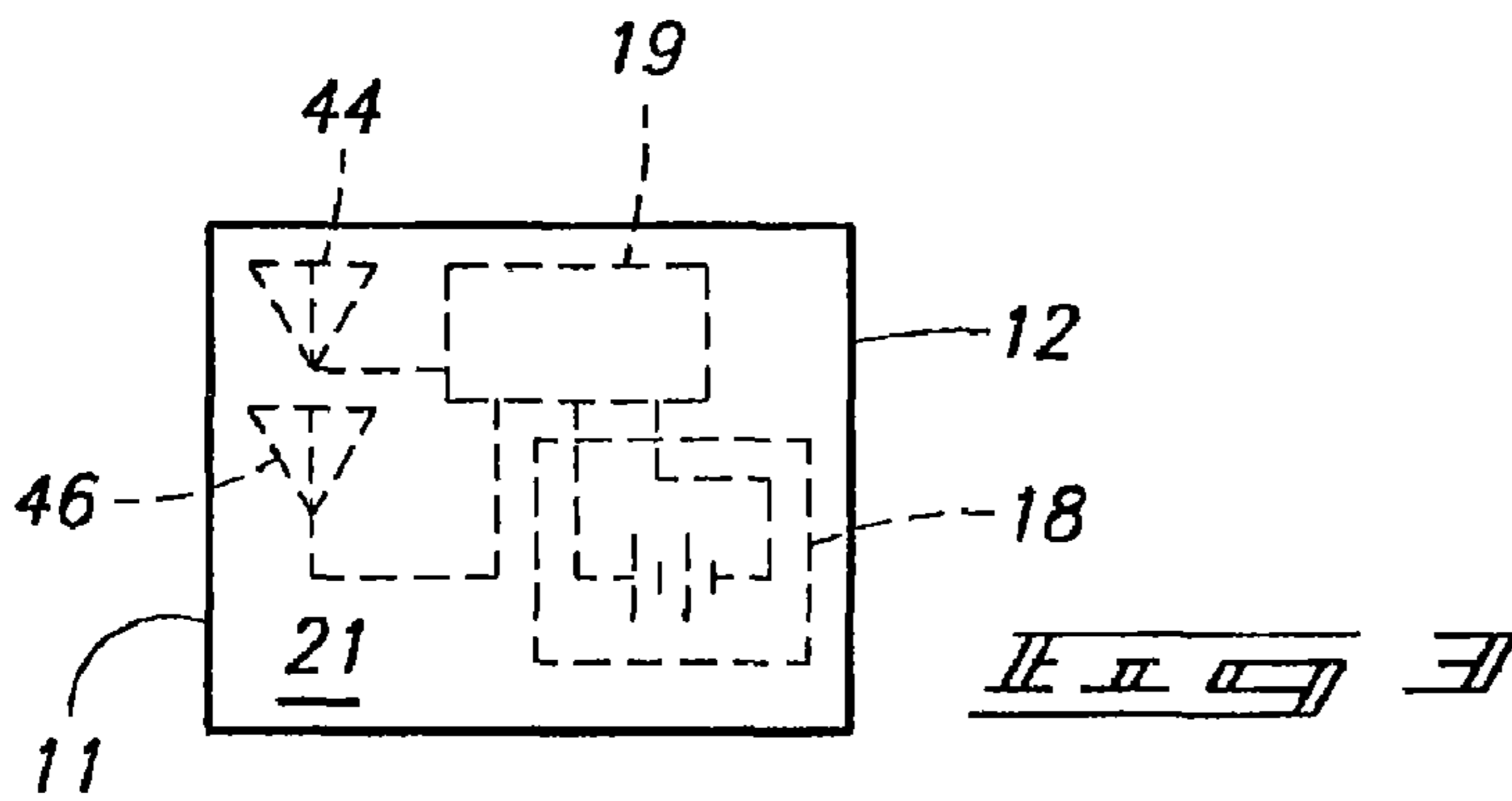
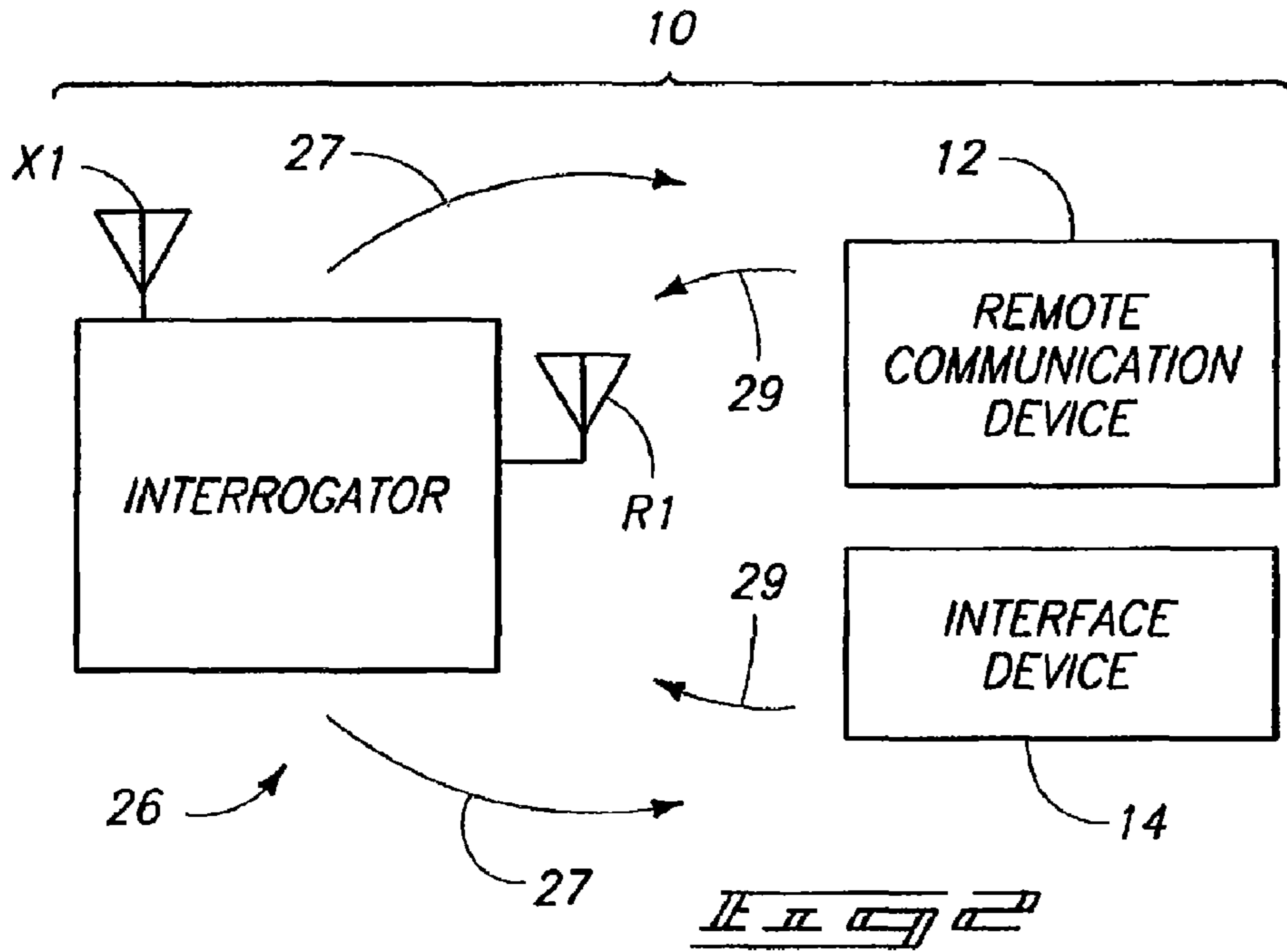
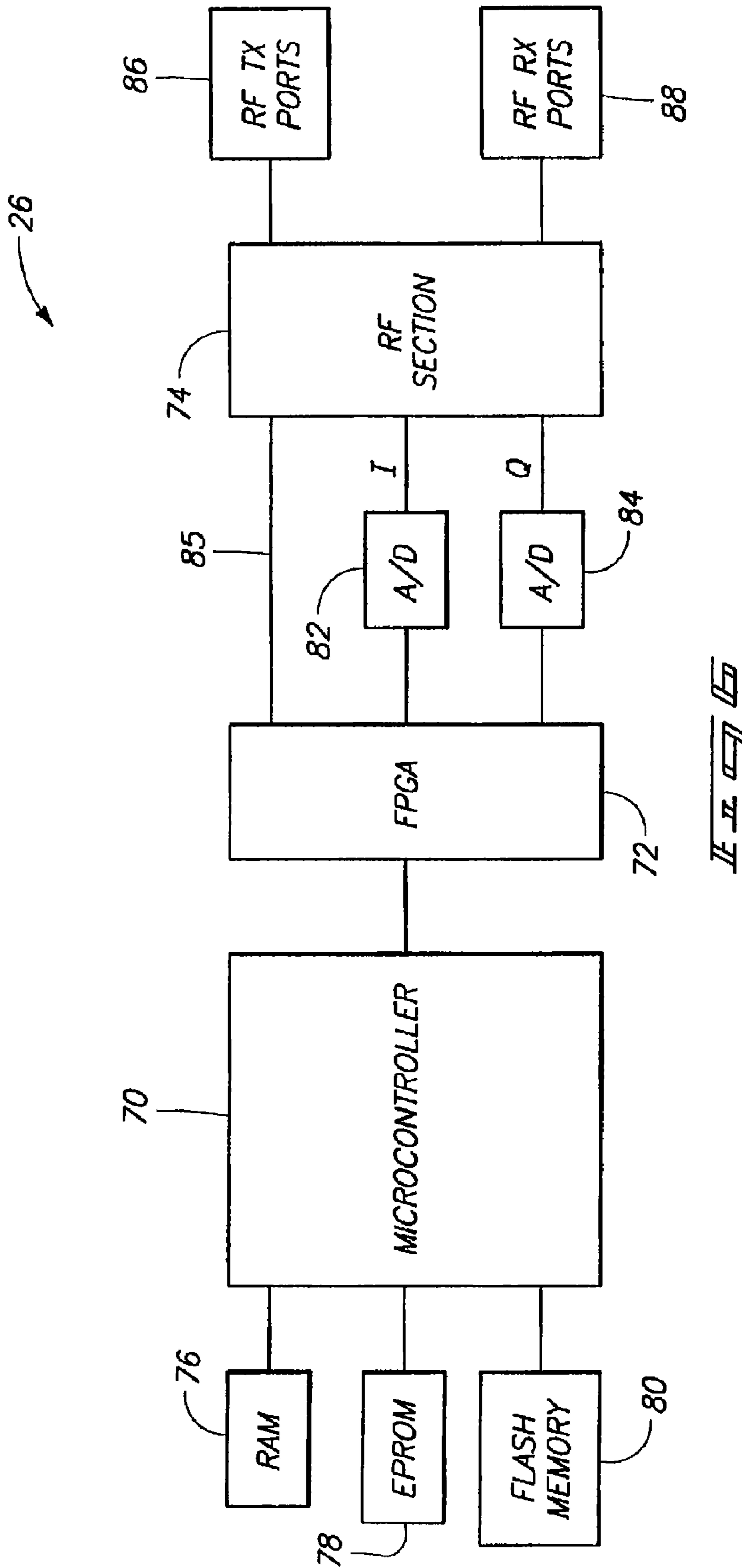
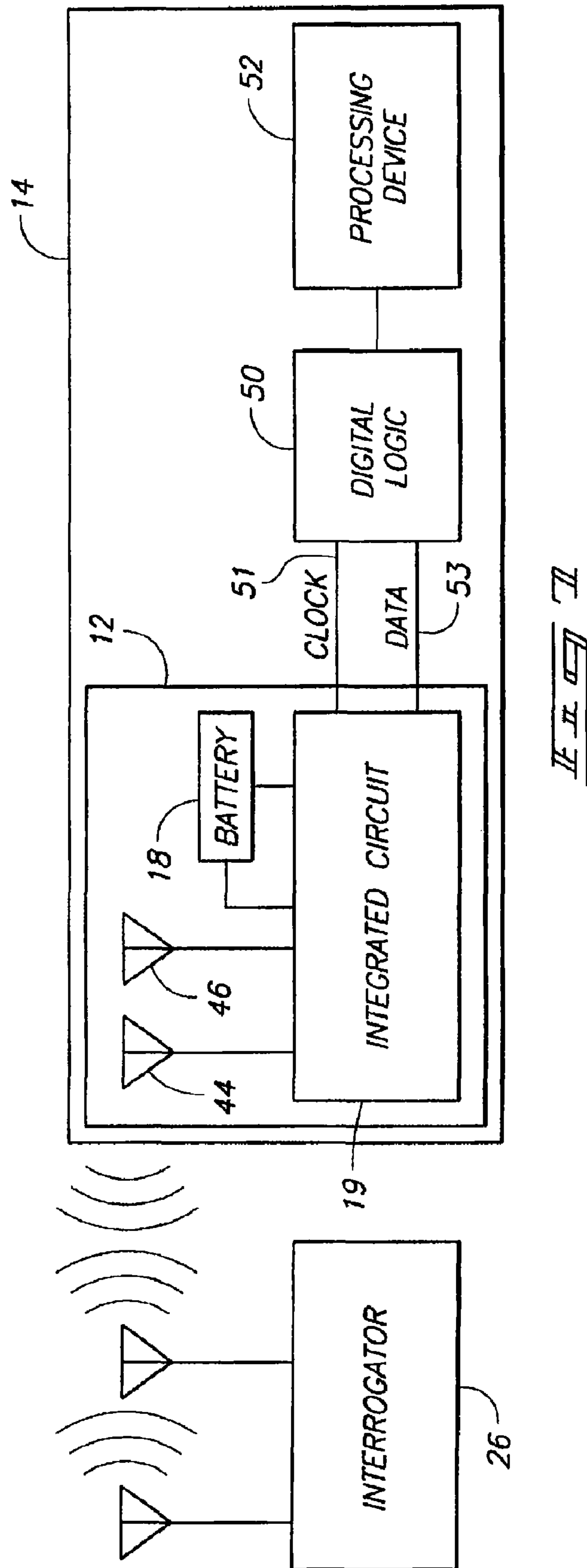


Fig. 1







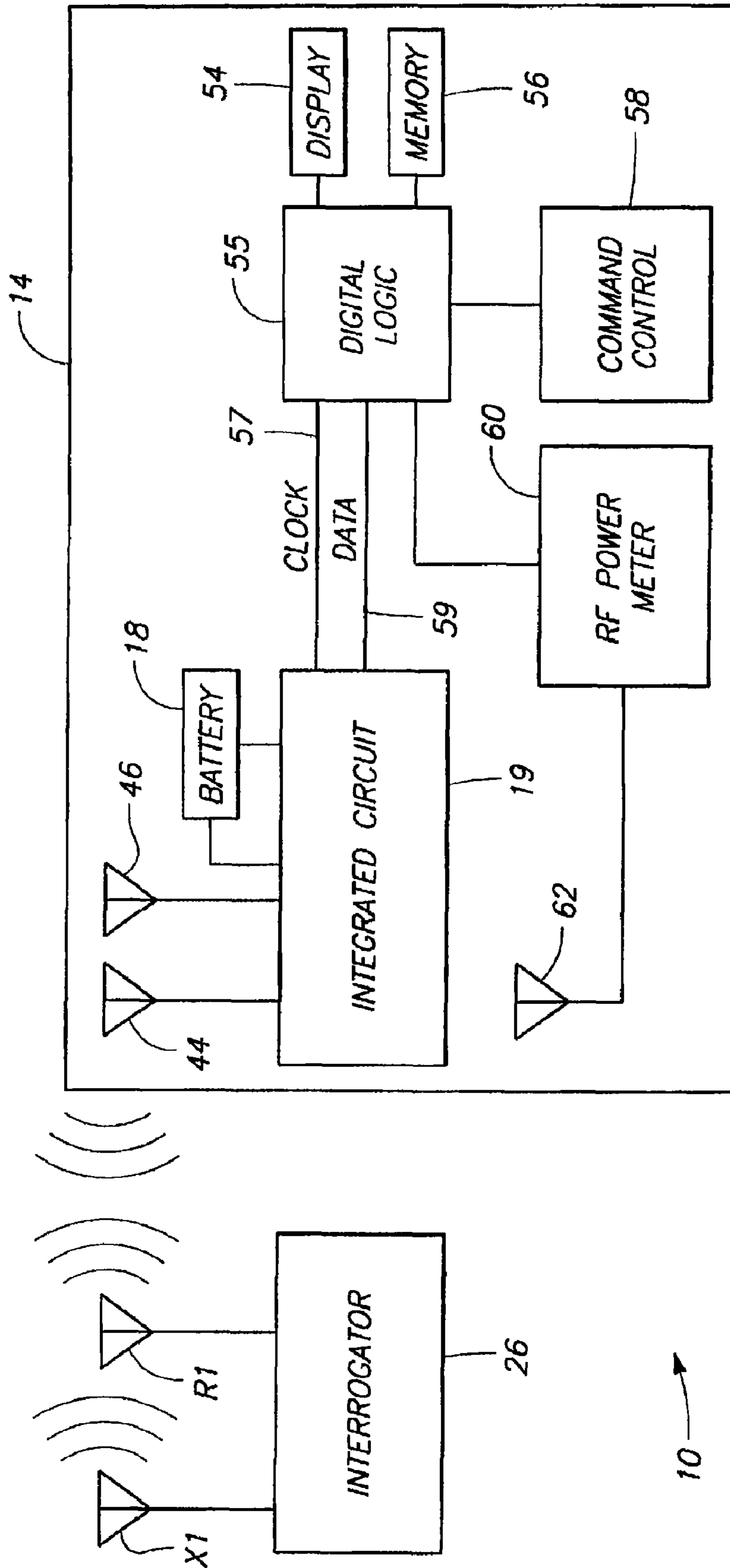
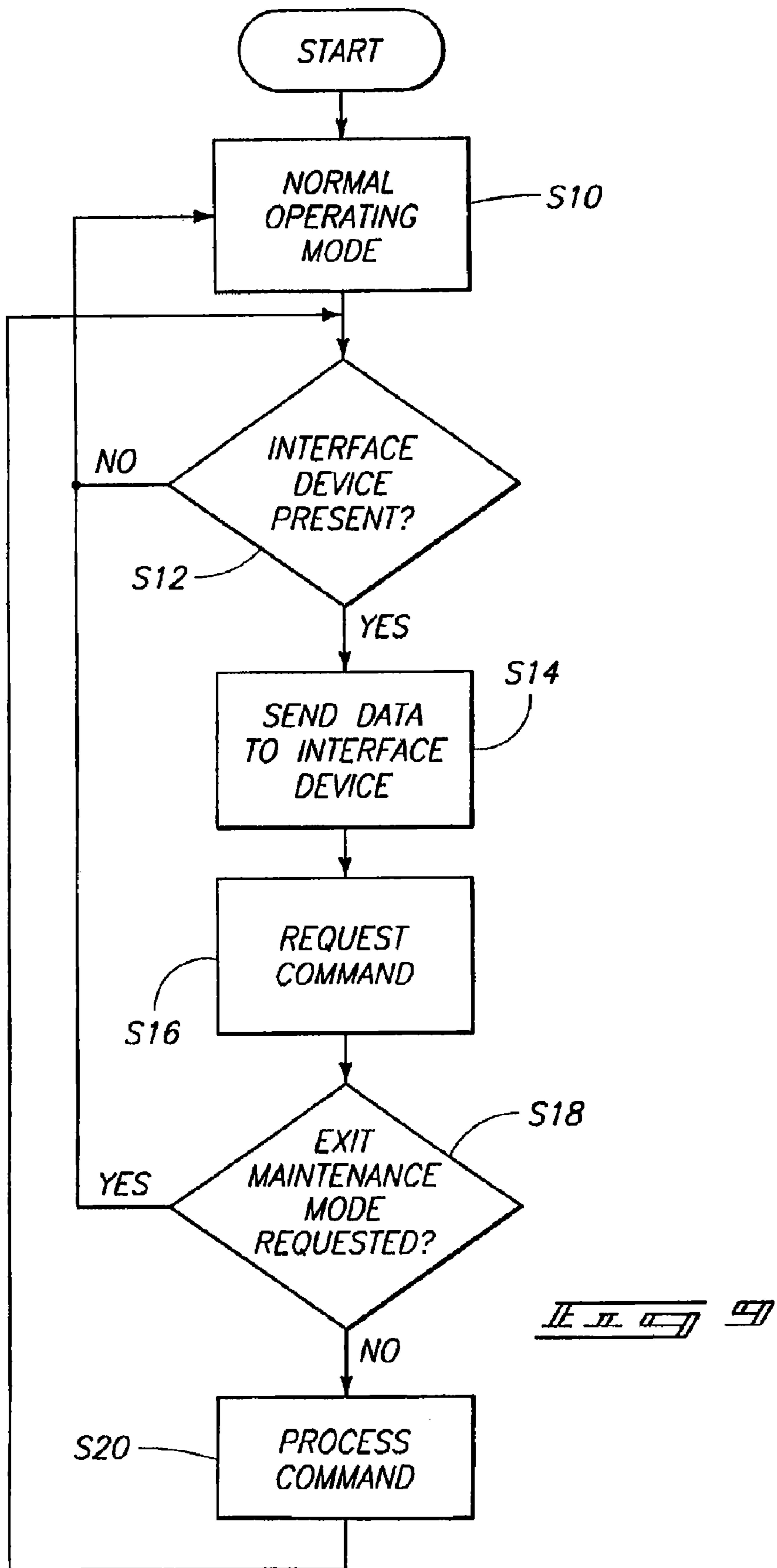


FIG. 6B



WIRELESS COMMUNICATION SYSTEMS AND METHODS

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

RELATED REISSUE APPLICATIONS

The present application is a continuation application of U.S. patent application Ser. No. 10/893,101, filed Jul. 16, 2004, issued as U.S. Pat. No. Re. 41,916 on Nov. 9, 2010, which is a reissue application of U.S. Pat. No. 6,420,961 having U.S. patent application Ser. No. 09/079,449, filed May 14, 1998, the disclosures of which are incorporated herein by reference. More than one reissue application has been filed for the reissue of U.S. Pat. No. 6,420,961. The reissue applications are the initial reissue application Ser. No. 10/893,101, filed Jul. 16, 2004, a continuation reissue application Ser. No. 11/858,291, filed Sep. 20, 2007, a continuation reissue application Ser. No. 11/858,297, filed Sep. 20, 2007, a continuation reissue application Ser. No. 11/858,309, filed Sep. 20, 2007, another continuation reissue application Ser. No. 11/858,316, filed Sep. 20, 2007 a divisional reissue application Ser. No. 11/873,286, filed Oct. 16, 2007.

TECHNICAL FIELD

The present invention relates to wireless communication systems, interfacing devices, communication methods, methods of interfacing with an interrogator, and methods of operating an interrogator.

BACKGROUND OF THE INVENTION

Electronic identification systems typically comprise two devices which are configured to communicate with one another. Preferred configurations of the electronic identification systems are operable to provide such communications via a wireless medium.

One such configuration is described in U.S. patent application Ser. No. 08/705,043, filed Aug. 29, 1996, now U.S. Pat. No. 6,130,602, issued Oct. 10, 2000, assigned to the assignee of the present application, and incorporated herein by reference. This application discloses the use of a radio frequency (RF) communication system including communication devices. The disclosed communication devices include an interrogator and a remote transponder, such as a tag or card.

Such communication systems can be used in various applications such as identification configurations. The interrogator is configured to output a polling or interrogation signal which may comprise a radio frequency signal including a predefined code. The remote transponders of such a communication system are operable to transmit an identification signal responsive to receiving an appropriate polling or interrogation signal.

More specifically, the appropriate transponders are configured to recognize the predefined code. The transponders receiving the code subsequently output a particular identification signal which is associated with the transmitting transponder. Following transmission of the polling signal, the interrogator is configured to receive the identification signals enabling detection of the presence of corresponding transponders.

Such communication systems are useable in identification applications such as inventory or other object monitoring. For example, a remote identification device is attached to an object of interest. Responsive to receiving the appropriate polling signal, the identification device is equipped to output an identification signal. Generating the identification signal identifies the presence or location of the identification device and the article or object attached thereto.

Often it is desirable to access information which may be stored within the interrogator unit. Such information can be generated responsive to communications with the remote devices. The information can comprise qualitative as well as quantitative information regarding communications with remote transponders. In addition, it may be desirable to modify the interrogator after a period of time. It may be desired to change performance or operational characteristics of the interrogator. However, in numerous applications, access to the interrogator may be difficult or involve a considerable amount of time. Therefore, a need exists to provide improved access to interrogators of electronic identification systems.

SUMMARY OF THE INVENTION

The present invention includes wireless communication systems, interfacing devices, communication methods, methods of interfacing with an interrogator, and methods of operating an interrogator.

According to one aspect of the present invention, a wireless communication system is provided. The wireless communication system includes at least one remote communication device, and an interrogator configured to output a forward link wireless communication and receive a reply link wireless communication from the remote communication device responsive to the forward link wireless communication. The system additionally includes an interface device configured to interface with the interrogator using a wireless medium. The interrogator is configured to receive control information from the interface device.

In a second aspect of the invention, a system for performing radio frequency communications is disclosed. In one embodiment, the system includes a first device having one or more first antennas, a first integrated circuit communicatively coupled to the one or more and configured to communicate in a first mode and a second mode. The system also includes a second device having one or more second antennas and a second integrated circuit communicatively coupled to the one or more second antennas to communicate a first command to the first device using wireless communications. The first device is configured to receive identification numbers from radio frequency identification (RFID) tags in the first mode and is configured to wirelessly provide the identification numbers to the second device via a spread spectrum communications technique in the second mode.

In a third aspect of the invention, an interrogator is disclosed. In one embodiment, the interrogator includes one or more memories, a radio frequency (RF) section configured to handle two-way wireless communications with an interface device and a microcontroller communicatively coupled to the one or more memories and the RF section. The microcontroller is configured to operate in a first mode and a second mode with at least one of the first mode and the second mode allowing the interrogator to receive data via the RF section from at least one radio frequency device. The microcontroller determines identification information for at least one radio frequency device without presence of the interface device. The two-way wireless communications is configured to enable a

transfer of bits from the interrogator to the interface device and to enable a transfer of bits from the interface device to the interrogator. The microcontroller is also configured to receive control signals from the interface device via the RF section.

In a fourth aspect of the invention, a method for communicating data in a radio frequency system is disclosed. In one embodiment, the method includes detecting, by a first device, a second device via a wireless communication of data. The first device operates in a first mode enabled to wirelessly receive identification information from a plurality of remote communication devices via a communication technique. The first device is capable of operating in the first mode without the second device. The first device also includes one or more antennas to communicate with the remote communication devices and the second device. The method further includes receiving at the first device control signals from the second device and transferring data from the first device to the second device. The data includes the identification information and the first device is capable of using a spread spectrum communications technique.

According to some aspects of the invention, the interrogator is configured to operate as a slave device and master device depending upon the mode of operation of the communications system. The interrogator operates as a master during normal modes of operation, and as a slave during maintenance modes of operation.

A communication method according to another aspect of the present invention includes providing an interrogator and at least one remote communication device, and communicating intermediate the interrogator and the remote communication device. The method also includes providing an interface device, reading control information from the interface device using the interrogator, and communicating data intermediate the interrogator and the interface device responsive to the control information.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. 1 is an illustrative diagram illustrating one application of a communication system which embodies the present invention.

FIG. 2 is a block diagram of an exemplary communication system.

FIG. 3 is a front view of a radio frequency remote communication device according to one embodiment of the invention.

FIG. 4 is a front view of an employee badge according to another embodiment of the invention.

FIG. 5 is a circuit schematic of a transponder included in the remote communication device of FIG. 3.

FIG. 6 is a functional block diagram of an interrogator of the communication system.

FIG. 7 is a functional block diagram illustrating one embodiment of an interface device communicating with an interrogator of the communication system.

FIG. 8 illustrates another embodiment of an interface device communicating with the interrogator.

FIG. 9 is a flow diagram illustrating exemplary operations of the interrogator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts"(Article 1, Section 8).

Referring to FIG. 1, an interrogator 26 of a communication system is provided within a fuel dispenser. The illustrated application of the communication system is exemplary. Interrogator 26 can be utilized to monitor the presence of users accessing product from the dispenser via a wireless link as discussed below. Such users would be equipped with remote communication devices (not shown in FIG. 1) which are configured to communicate with interrogator 26.

Given the implementation of interrogator 26 within the dispenser assembly, a communication system according to the present invention is preferably utilized to conveniently interface with interrogator 26. In particular, data may be communicated via a wireless link intermediate interface devices (also not shown in FIG. 1) and interrogator 26.

FIG. 2 illustrates a wireless communication system 10 embodying the invention. Communication system 10 comprises an electronic identification system in the embodiment described herein. Communication system 10 can be utilized in the dispenser application described above as well as other communication applications.

The depicted communication system 10 includes an interrogator 26. Communication system 10 further includes an electronic wireless remote communications device 12, such as the device disclosed in U.S. patent application Ser. No. 08/705,043, filed Aug. 29, 1996. Devices 12 can be referred to as radio frequency identification devices (RFID) or remote intelligent communication (RIC) devices. Plural remote communication devices 12 typically communicate with interrogator 26 although only one such device 12 is illustrated in FIG. 2. In one embodiment, wireless remote communications device 12 comprises a wireless identification device such as the MicroStamp (™) integrated circuit available from Micron Communications, Inc., 3176 S. Denver Way, Boise, Id. 83705. Such a remote communication device 12 can be referred to as a tag or card as illustrated below.

In the embodiment illustrated in FIG. 2, multiple communications devices 12 can be employed; however, there is typically no communication between multiple devices 12. Instead, the multiple communications devices 12 communicate with interrogator 26. Multiple communications devices 12 can be used in the same field of an interrogator 26 (i.e., within communications range of interrogator 26). Similarly, multiple interrogators 26 can be in proximity to one or more of devices 12.

The above described system 10 is advantageous over prior art devices that utilize magnetic field effect systems because, with system 10, a greater range can be achieved, and more information can be obtained (instead of just an identification number). As a result, such a system 10 can be used, for example, to monitor large warehouse inventories having many unique products needing individual discrimination to determine the presence of particular items within a large lot of tagged products.

Communication system 10 of the present invention also includes an interface device 14. Interface device 14 is also referred to as a maintenance or calibration device or tag. Interrogator 26 is configured to communicate with one or more remote communication devices 12 during a normal mode of operation. As described in detail below, interrogator

26 is configured to communicate with interface device 14 during maintenance and/or calibration modes of operation.

Communications during the normal mode of operation typically include communicating data of a first clearance level intermediate devices 12 and interrogator 26. Such data can include tag or device 12 identification information, associated product information (i.e., data regarding the product to which the tag is attached), etc.

Communications during the maintenance mode typically provide communications of data having a clearance level higher than first level data. The maintenance mode communications are provided intermediate interrogator 26 and interface device 14. Exemplary higher level data includes software update code and update hardware configuration information read from interface device 14 into interrogator 26. Such update data can be utilized to reconfigure interrogator 26.

Other exemplary higher level information includes operational profile information (e.g., temperature profile) or status information of interrogator 26, and log files including data regarding communications of remote communication devices 12 with interrogator 26. Higher level information can additionally include RF power information corresponding to wireless communications of system 10. Further, interface device 14 can write or output command or control information to interrogator 26 to operate or stimulate interrogator 26. Interrogator 26 can read the control information and thereafter communicate data with device 14.

Remote communication device 12 and interface device 14 are configured to interface with interrogator 26 using a wireless medium in one embodiment. Interrogator 26 communicates with the communication device 12 and interface device 14 via an electromagnetic link, such as an RF link (e.g., at microwave frequencies) in the described embodiment. Interrogator 26 is configured to output forward link wireless communications 27. Further, interrogator 26 is operable to receive reply link wireless communications 29 from devices 12, 14 responsive to outputting of forward link communication 27.

In particular, interrogator unit 26 includes a plurality of antennas X1, R1, as well as transmitting and receiving circuitry, similar to that implemented in devices 12 described below. Antenna X1 comprises a transmit antenna and antenna R1 comprises a receive antenna individually connected to interrogator 26. In operation, interrogator 26 transmits the interrogation signal or forward link command 27 via antenna X1. Communication device 12 and interface device 14 are operable to receive the incoming forward link signal. Upon receiving signal 27, communication device 12 and interface device 14 are operable to respond by generating and transmitting a responsive reply or return signal 29. The interrogator 26 is described in greater detail below.

In one embodiment, the responsive signal 29 is encoded with information that uniquely identifies, or labels the particular device 12, 14 that is transmitting, so as to identify any object or person with which communications device 12 is associated, or identify device 14 as a maintenance device.

The reply link wireless communication can be outputted by remote communication device 12 or interface device 14 according to the operational mode of communication system 10. In the described embodiment, remote device 12 and interface device 14 are configured to output an identification signal within reply link communications 29 responsive to receiving a forward link wireless communication 27. Interrogator 26 is configured to receive and recognize the identification signal within the return or reply link communication 29. The identification signal can be utilized to identify interface device 14 as a maintenance or calibration device, or identify the particular transmitting communication device 12.

Interrogator 26 is configured to communicate with remote device 12 in normal operational modes. Typical radio frequency communications occur intermediate interrogator 26 and remote communication devices 12 for use in identification systems and product monitoring as exemplary applications.

Responsive to identifying a responding device as an interface device 14, interrogator 26 is configured to operate in a maintenance or calibration mode of operation. Operation of interrogator 26 in the maintenance/calibration mode of operation provides interfacing of interrogator 26 with interface device 14. In this mode, higher level data can be communicated intermediate interface device 14 and interrogator 26. Interface device 14 is configured to load data into interrogator 26 and retrieve data from interrogator 26 using a wireless medium. Wireless communications of devices 12, 14 with interrogator 26 occur utilizing radio frequency (RF) configurations in the described embodiment of the invention. Other configurations such as infrared, acoustic, etc. are possible.

The maintenance/calibration mode of operation can be defined as a master/slave relationship wherein interface device 14 operates as the master and interrogator 26 operates as a slave device. During normal modes of operation, interrogator 26 typically operates as the master device while remote communication devices 12 operate as slave devices.

Referring to FIG. 3, one embodiment of remote communication device 12 is illustrated. The depicted communication device 12 includes a transponder 16 having a receiver and a transmitter as described below. Communication device 12 further includes a power source 18 connected to transponder 16 to supply operational power to transponder 16.

In the illustrated embodiment, transponder 16 is in the form of an integrated circuit. However, in alternative embodiments, all of the circuitry of transponder 16 is not necessarily all included in a single integrated circuit.

Power source 18 is a thin film battery in the illustrated embodiment, however, in alternative embodiments, other forms of power sources can be employed. If the power source 18 is a battery, the battery can take any suitable form. Preferably, the battery type will be selected depending on weight, size, and life requirements for a particular application. In one embodiment, battery 18 is a thin profile button-type cell forming a small, thin energy cell more commonly utilized in watches and small electronic devices requiring a thin profile. A conventional button-type cell has a pair of electrodes, an anode formed by one face and a cathode formed by an opposite face. In an alternative embodiment, the battery comprises a series connected pair of button type cells.

Communications device 12 further includes at least one antenna connected to transponder 16 for wireless transmission and reception. In the illustrated embodiment, communication device 12 includes at least one receive antenna 44 connected to transponder 16 for radio frequency reception by transponder 16, and at least one transmit antenna 46 connected to transponder 16 for radio frequency transmission by transponder 16. The described receive antenna 44 comprises a loop antenna and the transmit antenna 46 comprises a dipole.

The communications device 12 can be included in any appropriate housing or packaging. FIG. 3 shows but one example of a housing in the form of a miniature housing 11 encasing the device 12 to define a tag which can be supported by an object (e.g., hung from an object, affixed to an object, etc.).

Referring to FIG. 4, an alternative housing is illustrated. FIG. 4 shows a housing in the form of a card 13. Card 13 preferably comprises plastic or other suitable material. Plas-

tic card **13** houses communication device **12** to define an employee identification badge including the communication device **12**. In one embodiment, the front face of card **13** has visual identification features such as an employee photograph or a fingerprint in addition to identifying text.

Although two particular types of housings have been disclosed, the communications device **12** can be included in any appropriate housing. Communications device **12** is preferably of a small size that lends itself to applications employing small housings, such as cards, miniature tags, etc. Larger housings can also be employed. The communications device **12**, provided in any appropriate housing, can be supported from or attached to an object in any desired manner.

FIG. **5** is a high level circuit schematic of the transponder **16** utilized in the devices of FIGS. **2-4**. In the embodiment shown in FIG. **5**, transponder **16** is implemented within a monolithic integrated circuit **19**. In particular, the integrated circuit preferably comprises a small outline integrated circuit (SOIC) package. In the illustrated embodiment, the integrated circuit **19** comprises a single die, having a size of 209×116 mils², including a receiver **30**, transmitter **32**, microcontroller or microprocessor **34**, a wake up timer and logic circuit **36**, a clock recovery and data recovery circuit **38**, and a bias voltage and current generator **42**. Receiver **30** and transmitter **32** comprise wireless communication circuitry configured to communicate wireless signals.

In one embodiment, the communications devices **12** switch between a "sleep" mode of operation, and higher power modes to conserve energy and extend battery life during periods of time where no interrogation signal **27** is received by devices **12**, using the wake up timer and logic circuitry **36**.

In one embodiment, a spread spectrum processing circuit **40** is included in transponder **16**. In this embodiment, signals transmitted and received by interrogator **26**, and transmitted and received by communications device **12** and interface device **14** are modulated spread spectrum signals. Many modulation techniques minimize required transmission bandwidth. However, the spread spectrum modulation techniques employed in the illustrated embodiment require a transmission bandwidth that is up to several orders of magnitude greater than the minimum required signal bandwidth. Although spread spectrum modulation techniques are bandwidth inefficient in single user applications, they are advantageous where there are multiple users, as is the case with the preferred radio frequency identification communication system **10** of the present invention.

The spread spectrum modulation technique of the illustrated embodiment is advantageous because the interrogator signal can be distinguished from other signals (e.g., radar, microwave ovens, etc.) operating at the same frequency. The spread spectrum signals transmitted by communications device **12**, interface device **14** and interrogator **26** are pseudo random and have noise-like properties when compared with the digital command or reply. The illustrated embodiment employs direct sequence spread spectrum (DSSS) modulation.

In operations, interrogator **26** sends out a command that is spread around a certain center frequency (e.g., 2.44 GHz). After the interrogator transmits the command, and is expecting a response, the interrogator switches to a CW mode (continuous wave mode) for backscatter communications. In the continuous wave mode, interrogator **26** does not transmit any information. Instead, the interrogator just transmits 2.44 GHz radiation. In other words, the signal transmitted by the interrogator is not modulated. After communications device **12** or interface device **14** receives the forward link communication

from interrogator **26**, communications device **12** or interface device **14** (if present) processes the command.

If communications device **12** and/or interface device **14** is in a backscatter mode, it alternately reflects or does not reflect the signal from the interrogator to send its reply. For example, in the illustrated embodiment, two halves of a dipole antenna are either shorted together or isolated from each other to send a reply. Alternatively, devices **12**, **14** can communicate in an active mode.

In one embodiment, the clock for transponder **16** is extracted from the incoming message itself by clock recovery and data recovery circuitry **38**. This clock is recovered from the incoming message, and used for timing for microcontroller **34** and all the other clock circuitry on the chip, and also for deriving the transmitter carrier or the subcarrier, depending on whether the transmitter is operating in active mode or backscatter mode.

In addition to recovering a clock, the clock recovery and data recovery circuit **38** also performs data recovery on valid incoming signals. The valid spread spectrum incoming signal is passed through the spread spectrum processing circuit **40**, and the spread spectrum processing circuit **40** extracts the actual ones and zeros of data from the incoming signal. More particularly, the spread spectrum processing circuit **40** takes chips from the spread spectrum signal, and reduces individual thirty-one chip sections down to a bit of one or zero, which is passed to microcontroller **34**.

Microcontroller **34** includes a serial processor, or I/O facility that receives the bits from spread spectrum processing circuit **40**. The microcontroller **34** performs further error correction. More particularly, a modified hamming code is employed, where each eight bits of data is accompanied by five check bits used by the microcontroller **34** for error correction. Microcontroller **34** further includes a memory, and after performing the data correction, microcontroller **34** stores bytes of the data bits in memory. These bytes contain a command sent by the interrogator **26**. Microcontroller **34** is configured to respond to the command.

For example, interrogator **26** may send a command requesting that any communication device **12** or interface device **14** in the field respond with the device's identification number. Status information can also be returned to interrogator **26** from communication devices **12**. Interrogator **26** can be configured to enter the maintenance or calibration mode responsive to receiving a reply from interface device **14**.

Communications from interrogator **26** (i.e., forward link communications) and devices **12**, **14** (i.e., return link communications) have a similar format. More particularly, the forward and reply communications begin with a preamble, followed by a Barker or start code, followed by actual data in the described embodiment. The incoming forward link message and outgoing reply preferably also include a check sum or redundancy code so that transponder **16** or interrogator **26** can confirm receipt of the entire message or reply.

Communication devices **12** typically include an identification sequence identifying the particular tag or device **12** sending the reply. Such implements the identification operations of communication system **10**. Interface devices **14** can include an identifying sequence or signal which specifies the communicating device as an interface maintenance and/or calibration tag **14**. Following identification of an interface device **14**, interrogator **26** can be configured to enter the calibration or maintenance mode of operation.

After sending a command, interrogator **26** sends a continuous unmodulated RF signal with an approximate frequency of 2.44 GHz. Return link data can be Differential Phase Shift Key (DPSK) modulated onto a square wave subcarrier with a

frequency of approximately 600 kHz (e.g., 596.1 kHz in one embodiment). A data **0** corresponds to one phase and data **1** corresponds to another, shifted 180 degrees from the first phase. The subcarrier is used to modulate antenna impedance of transponder **16**. For a simple dipole, a switch between the two halves of the dipole antenna is opened and closed. When the switch is closed, the antenna becomes the electrical equivalent of a single half-wavelength antenna that reflects a portion of the power being transmitted by the interrogator. When the switch is open, the antenna becomes the electrical equivalent of two quarter-wavelength antennas that reflect very little of the power transmitted by the interrogator. In one embodiment, the dipole antenna is a printed microstrip half wavelength dipole antenna.

Referring to FIG. 6, one embodiment of interrogator **26** is illustrated. The depicted interrogator **26** includes a microcontroller **70**, a field programmable gate array (FPGA) **72**, and RF section **74**. In the depicted embodiment, microcontroller **70** comprises a MC68340 microcontroller available from Motorola, Inc. FPGA **72** comprises a XC4028 device available from Xilinx, Inc.

RAM **76**, EPROM **78** and flash memory **80** are coupled with microcontroller **70** in the depicted embodiment. Microcontroller **70** is configured to access an applications program for controlling the interrogator **26** and interpreting responses from devices **12**, **14**. The processor of microcontroller **70** is configured to control communication operations with remote communication devices **12** during normal modes of operation. The applications program can also include a library of radio frequency identification device applications or functions. These functions effect radio frequency communications between interrogator **26** and communications device **12** and interface device **14**.

Plural analog to digital converters **82**, **84** are implemented intermediate FPGA **72** and RF section **74** for both in-phase (I) and quadrature (Q) communication lines. Plural RF transmit (TX) ports **86** and plural RF receive (RX) ports **88** are coupled with RF section **74** in the depicted embodiment. Providing plural TX ports and RX ports **86**, **88** enables interrogator **26** to minimize the effects of multipath when communicating with plural remote communication devices **12**, **14**.

RF section **74** is configured to handle wireless (e.g., radio frequency) communications with interface device **14** and remote communication devices **12**. Analog to digital converters **82**, **84** provide received analog RF signals into a digital format for application to FPGA **72**. Digital signals output from FPGA **72** are converted to RF signals by RF section **74**.

FPGA **72** is configured to format forward link communications received from microcontroller **70** into a proper format for application to RF section **74** for communication. Further, FPGA **72** is configured to demodulate reply link communications received from remote communication devices **12** and interface **14** via RF section **74**. Such demodulated reply link signals can be applied to microcontroller **70** for processing. An additional connection **85** is provided intermediate FPGA **72** and RF section **74**. Such can be utilized to transmit phase lock loop (PLL) information, antenna diversity selection information and other necessary communication information.

Microcontroller **70** is configured to control operations of interrogator **26** including outputting of forward link communications and receiving reply link communications. EPROM **78** is configured to store original code and settings selected for the particular application of communication system **10**. Flash memory **80** is configured to receive software code updates forwarded from interface device **14** during maintenance modes of operation. Such software updates can include

user code in one embodiment. In addition, hardware updates can be uploaded from interface device **14** to interrogator **26**. Such hardware updates can be utilized to reconfigure FPGA **72**.

RAM device **76** is configured to store data during operations of communication system **10**. Such data can include information regarding or corresponding to communications with associated remote communication devices **12** and status information of interrogator **26** during normal modes of operation. In addition, interrogator **26** can be configured to store other information regarding communication system **10** operations depending upon the particular application. Such information can be retrieved and received by interface device **14** during maintenance and calibration modes of operation.

Referring to FIG. 7, a first configuration of interface device **14** is shown interfacing with interrogator **26**. The depicted interface device **14** comprises a remote communication device **12** coupled with digital logic **50** and a processing device **52**.

Interrogator **26** and interface device **14** are operable to communicate via a wireless medium (e.g., RF link). In certain embodiments, interrogator **26** and remote communication device **12** of interface device **14** are configured to communicate using backscatter communications. Integrated circuit **19** includes a backscatter modulator in one embodiment. Remote communication device **12** of device **14** includes a processor and wireless communication circuitry coupled to the processor and configured to communicate wireless signals.

Responsive to the reception of a forward link communication from interrogator **26**, transponder of integrated circuit **19** of interface device **14** is configured to output an identification signal within the reply link communication identifying interface device **14**. Interrogator **26** detects device **14** using the identification signal. Thereafter, communications within communication system **10** can proceed in the maintenance and/or calibration mode of operation. Processing device **52** can act as a master to control communication operations between interface device **14** and interrogator **26**, and interrogator **26** operates in a slave mode during the maintenance/calibration modes of operation in the described embodiment.

Digital logic **50** is configured to interface with a variety of remote communication device **12** configurations. Digital logic **50** can interface with existing tag, stamp, card and other remote communication device configurations. Interfacing with existing remote communication device configurations permits the remote communication devices **12** to perform in a similar manner to other remote communication devices **12** within the communication systems **10** utilized for identification or other communication purposes.

Digital logic **50** receives clock information from transponder of integrated circuit **19** via connection **51**. A bi-directional serial data path **53** couples integrated circuit **19** and digital logic **50**. Data path **53** can be referred to as a digital port. Remote communication device **12** utilized within interface device **14** is configured to provide access of the clock signal and bi-directional data signal for interfacing with digital logic **50** and processing device **52**.

In the depicted arrangement, processing device **52** comprises a notebook computer utilizing a Pentium(TM) processor available from Intel Corporation. Digital logic **50** comprises an interface providing bi-directional communication of data between remote communication device **12** and processing device **52**. Processing device **52** is coupled with the processor of device **12** and is operable to output data to device **12** and/or receive data from device **12** and interrogator **26**.

11

Interface device **14** and interrogator **26** are configured to communicate data therebetween. Depending upon the particular application, communicated data can be tailored to the particular operating environment. In addition, flexibility is permitted wherein software can be loaded into interrogator **26** using processing device **52** and the associated RF link intermediate interface device **14** and interrogator **26**.

Processing device **52** can be utilized to program commands for operating interrogator **26**. Interrogator **26** is configured to read higher level data commands from processing device **52** utilizing data connection **53** intermediate processing device **52** and integrated circuit **19** and the RF link between device **14** and interrogator **26**. In another embodiment, the higher level data (e.g., software code updates) may be provided using processing device **52** and communicated to interrogator **26** using remote communication device **12** of device **14**. The higher level data can be loaded into interrogator **26** utilizing the wireless medium or RF link. Such data comprising updated software can include improvements for existing design configurations. Responsive to commands outputted from processing device **52** of interface device **14**, stored higher level data within RAM **76** can be downloaded to and received by interface device **14**. Processing device **52** can be configured to store received data from interrogator **26** for storage, analysis and display.

Processing device **52** comprises a data collector in one embodiment which is configured to interface with a variety of form factors of the remote communication devices (e.g., tags, cards, etc.) **12** via a digital data port upon device **12**. Such enables a given interrogator installation to be tested and accessed using the specific form factor of remote communication device **12** to be utilized in the communication system installation. The remote communication device **12** of interface device **14** can be powered utilizing battery power or an external power source.

Referring to FIG. **8**, communications of another interface device **14** configuration with interrogator **26** are described. The depicted interface device **14** is intended to be a self-contained hand-held maintenance, calibration and monitoring device. Preferably, the depicted interface device **14** is portable for field use.

The illustrated interface device **14** comprises an integrated circuit **19** and battery **18** coupled with corresponding circuitry. In particular, such corresponding circuitry includes digital logic **55** coupled via a clock connection **57** and bidirectional data line **59** with integrated circuit **19**.

A display **54** and memory **56** are additionally coupled with digital logic **55**. Display **54** can comprise a liquid crystal display and memory **56** can comprise SRAM memory. Display **54** includes a sixteen character display in the described embodiment. Display **54** is coupled with wireless communications circuitry of transponder **16** via digital logic **50** and is configured to display data for viewing by an operator. Memory **56** comprises a 512 kbyte battery backed SRAM in the described embodiment. Memory **56** is operable to store data to be outputted to and/or received data from interrogator **26**. A command control **58** is also illustrated coupled with digital logic **55**. An RF power meter **60** is connected with a corresponding RF antenna **62** and transponder of integrated circuit **19**. Power meter **60** is configured to monitor the power of wireless communications intermediate interface device **14** and interrogator **26**.

The transponder of integrated circuit **19** includes wireless communication circuitry configured to communicate wireless signals with interrogator **26** as described previously. The wireless communication circuitry of the transponder is configured to, in a preferred embodiment, output data to interro-

12

gator **26** and receive data from interrogator **26**. In other configurations, only unidirectional communications are provided intermediate the transponder of device **14** and interrogator **26**. Digital logic **55** coupled with integrated circuit **19**, display **54**, memory **56**, command control **58**, and RF power meter **60** is configured to route communications intermediate the appropriate component and the transponder of integrated circuit **19**.

Command control **58** is configured to control the selection of commands outputted to interrogator **26**. In particular, in the described embodiment, interrogator **26** is configured to follow a variety of commands once the maintenance or calibration mode of operation has been entered. A user of interface device **14** can input a desired command utilizing command control **58**. In one embodiment of interface device **14**, command control **58** comprises a test number select enabling one hundred different tests or commands to be communicated to interrogator **26**.

For example, the user may specify that new software is to be uploaded to interrogator **26**. Following inputting of the command using command control **58** and transmission to interrogator **26**, interrogator **26** is configured to receive or read the updated software stored in memory **56** of interface device **14** via the RF link.

In the described embodiment, memory **56** is configured to store either data to be outputted to interrogator **26** or data received from interrogator **26**. Such data can include higher level data as described previously.

Responsive to a predefined command entered utilizing command control **58**, interrogator **26** is operable to monitor the radio frequency (RF) power intermediate interface device **14** and interrogator **26**. RF power meter **60** is configured to measure the RF field strength of antennas of interrogator **26**. Such an interface device **14** is configured to verify antenna installations of interrogator **26**. The information can be determined utilizing RF power meter **60** and dedicated antenna **62**. Interrogator **26** can instruct RF power meter **60** to monitor the power level and display the results using display **54** responsive to an appropriate command from command control **58**. Further, interrogator **26** can adjust communications responsive to data received from meter **60**. Interface device **14** can also be configured to transfer large amounts of data to/from interrogator **26** via a wireless medium utilizing transponder of integrated circuit **19**.

Referring to FIG. **9**, a flow diagram is provided depicting operation of interrogator **26** within a normal mode and maintenance/calibration mode of operation in accordance with one embodiment of the invention.

At step **S10**, interrogator **26** communicates with remote communication devices **12** during the normal operating mode. First level data regarding the communications and/or interrogator status information can be collected within interrogator **26** during the normal mode of operation. Proceeding to step **S12**, interrogator **26** can determine whether an interface device **14** is present. Interrogator **26** monitors for the presence of the identification signal from interface device **14**. In particular, interface device **14** is configured to output an identification signal within the reply link responsive to receiving the forward link communication signal from interrogator **26**. If no interface devices are detected at step **S12**, interrogator **26** continues to operate in the normal operating mode of step **S10**.

If an identification signal from a corresponding interface device **14** is detected at step **S12**, interrogator **26** enters the maintenance/calibration modes of operation. Communications are established intermediate device **14** and interrogator **26** following detection of device **14**. In the illustrated operation of interrogator **26**, interrogator **26** outputs or downloads

13

data to interface device 14 at step S14 responsive to the identification signal or other detection of device 14. Such data can include higher level data such as tag data corresponding communications with remote communication devices 12, status information of interrogator 26 (e.g., accumulation of first level data), etc.

Interrogator 26 is thereafter configured to request a command from interface device 14 at step S16. As such, interrogator 26 can be considered to be controlled by interface device 14. Such operation illustrates operation of interrogator 26 as a slave during the maintenance/calibration modes of operation. At step S18, interrogator 26 monitors whether interface device 14 has requested exiting of the maintenance mode of operation. Interrogator 26 returns to the normal operating mode at step S10 if such a command is received. If an exit request is not detected, interrogator 26 proceeds to step S20 to process the command received from interface device 14.

Thereafter, interrogator 26 proceeds to step S12 to determine whether the interface device 14 is still present within communications range. Alternatively, at step S18, the interrogator 26 can monitor for the presence of a timeout condition wherein no command is received from interface device 14. In a preferred embodiment, interrogator 26 is thereafter configured to return to normal operating mode S10 if a sufficient period of inactivity occurs or an exit command from interface device 14 is received. Interrogator 26 can communicate with device 12 before and after communicating with device 14.

For other configurations (e.g., installations concerned about security), a hardware or software based switch could be utilized to provide interrogator 26 into the maintenance/calibration mode of operation.

The present invention facilitates access to interrogators of communication systems, such as electronic identification systems. This is important since the interrogators may be located in inaccessible locations. Further, the present invention avoids the need to disassemble the interrogator (or the device wherein the interrogator is implemented) to establish a hard wire link with the interrogator. It is believed that the invention will reduce labor utilized to access interrogator information, and simplify the maintenance/calibration modes of operation minimizing the need for specialized technicians. Further, the impact upon ongoing operations performed by the interrogator are minimized through the use of non-invasive access techniques.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

What is claimed is:

[1. A system comprising:
an interrogator capable of operating in a normal mode and a maintenance mode;
wireless communication circuitry configured to communicate wireless signals including at least one of outputting data to the interrogator and receiving data from the interrogator; and
a command control coupled with the wireless communication circuitry and being configured to output control signals to control the selection of operation of the interrogator between the normal mode and the maintenance mode.]

14

[2. The system according to claim 1 wherein the wireless communication circuitry and command control are implemented within an interface device.]

[3. The system according to claim 1 further comprising memory coupled with the wireless communication circuitry and configured to store at least one of data to be outputted and received data.]

[4. The system according to claim 1 further comprising a display device coupled with the wireless communication circuitry and configured to display data.]

[5. The system according to claim 1 further comprising an RF power meter configured to monitor the power of wireless communications of the wireless communication circuitry.]

[6. The system according to claim 5 wherein the interrogator is operable to receive data from the RF power meter and adjust communications responsive to the received data.]

[7. A wireless communication system comprising:

at least one remote communication device;

an interrogator configured to output a forward link wireless communication and receive a reply link wireless communication from the remote communication device responsive to the forward link wireless communication; and

a maintenance device configured to interface with the interrogator using a wireless medium, the interrogator configured to detect the presence of the maintenance device and output data to the maintenance device responsive to the detection.]

[8. A communication method comprising:

providing an interrogator and at least one remote communication device;

communicating intermediate the interrogator and the remote communication device;

providing an interface device;

detecting the presence of the interface device using the interrogator;

reading control information from the interface device using the interrogator; and

communicating data between the interrogator and the interface device responsive to the control information.]

[9. The method according to claim 8 further comprising displaying data using the interface device.]

[10. The method according to claim 8 further comprising communicating information from the interrogator to the interface device responsive to the detecting.]

[11. The method according to claim 8 further comprising establishing communications intermediate the interrogator and the interface device responsive to the detecting.]

[12. The method according to claim 8 further comprising:

monitoring RF power of communications intermediate the interface device and the interrogator; and

adjusting communication power of the interrogator responsive to the monitoring.]

[13. The method according to claim 8 further comprising storing data corresponding to at least one of the interrogator and the remote communication device using the interrogator.]

[14. The method according to claim 8 wherein the communicating intermediate the interrogator and interface device comprises communicating using a wireless medium.]

[15. The method according to claim 8 wherein the communicating with the remote communication device comprises communicating before and after the communicating with the interface device.]

[16. The method according to claim 8 wherein the communicating data with the interface device comprises reading data regarding the communications of the interrogator and the remote communication device from the interrogator.]

15

[17. The method according to claim 8 wherein the communicating data with the interface device comprises writing data configured to control communications with the remote communication devices to the interrogator.]

[18. The method according to claim 8 wherein the communicating comprise communicatings using backscatter communications.]

[19. The method according to claim 8 wherein the communicating data comprises at least one of writing data to the interrogator and reading data from the interrogator.]

[20. The method according to claim 8 wherein the communicating data comprises reading interrogator status information from the interrogator.]

[21. The method according to claim 8 wherein the providing the interface device comprises coupling a processing device with a remote communication device.]

[22. A communication method comprising:
providing an interrogator and at least one remote communication device;

communicating intermediate the interrogator and the remote communication device;

providing an interface device;

detecting the presence of the interface device using the interrogator; and

communicating data intermediate the interrogator and the interface device responsive to the detecting.]

23. A system for performing radio frequency communications, the system comprising:

a first device comprising:

one or more first antennas; and

a first integrated circuit communicatively coupled to the one or more first antennas to communicate via the one or more first antennas using wireless communications, the first integrated circuit being configured to communicate in a first mode and a second mode; and

a second device comprising:

one or more second antennas; and

a second integrated circuit communicatively coupled to the one or more second antennas to communicate a first command to the first device via the one or more second antennas using wireless communications;

wherein the first device is configured to receive identification numbers from a plurality of radio frequency identification (RFID) tags in the first mode;

wherein the first device is configured to wirelessly provide the identification numbers to the second device via a spread spectrum communications technique in the second mode, the first device capable of receiving the identification numbers from the plurality of RFID tags without participation by the second device; and

wherein the one or more first antennas of the first device include an antenna to communicate with the plurality of the RFID tags and a separate antenna to communicate with the second device.

24. The system of claim 23, wherein at least one of the first device and the second device is an interrogator.

25. The system of claim 23, wherein at least one of the first device and the second device is a portable device.

26. The system of claim 23, wherein the first device and the second device are configured to communicate via broadband communications.

27. The system of claim 23, wherein at least one of the plurality of RFID tags is configured to communicate via backscatter.

28. The system of claim 23, wherein the first device is further configured to operate in a third mode, the third mode being a sleep mode to conserve power.

16

29. The system of claim 23, wherein at least one of the first device and the second device further comprises a battery.

30. The system of claim 23, wherein the each of the plurality of RFID tags corresponds to a product.

31. An interrogator comprising:

one or more memories;

a radio frequency (RF) section configured to handle two-way wireless communications with an interface device; and

a microcontroller communicatively coupled to the one or more memories and the RF section, the microcontroller configured to operate in a first mode and a second mode, at least one of the first mode and the second mode allowing the interrogator to receive data via the RF section from at least one radio frequency device;

wherein

the microcontroller determines identification information for each of at least one radio frequency device without presence of the interface device; and

the two-way wireless communications is configured to enable a transfer of a plurality of bits from the interrogator to the interface device; and to enable a transfer of a plurality of bits from the interface device to the interrogator; and

wherein the microcontroller is configured to receive control signals from the interface device via the RF section.

32. The interrogator of claim 31, wherein the two-way wireless communications includes communicating via wireless broadband communications.

33. The interrogator of claim 31, wherein the identification information is provided from the interrogator to the interface device.

34. A system for performing radio frequency communications, the system comprising:

a first device comprising:

one or more first antennas; and

a first integrated circuit communicatively coupled to the one or more first antennas to communicate via the one or more first antennas using wireless communications, the first integrated circuit being configured to communicate in a first mode and a second mode; and

a second device comprising:

one or more second antennas; and

a second integrated circuit communicatively coupled to the one or more second antennas to communicate a first command to the first device via the one or more second antennas using wireless communications;

wherein the first device is configured to receive identification information from at least one radio frequency device in the first mode;

wherein the first device is configured to wirelessly provide the identification information to the second device via a spread spectrum communications technique in the second mode, the first device configured to receive the identification information from the least one radio frequency device without participation by the second device; and wherein the one or more first antennas of the first device includes an antenna to communicate with the at least one radio frequency device and a separate antenna to communicate with the second device.

35. A method for communicating data in a radio frequency system, the method comprising:

detecting, by a first device, a second device via a wireless communication of data, the first device operating in a first mode configured to wirelessly receive identification information from a plurality of remote communication

17

devices via a communication technique, the first device being capable of operating in the first mode without the second device, the first device including one or more antennas to communicate with the remote communication devices and the second device; 5

receiving at the first device control signals from the second device;

causing the first device to communicate in a second mode;

transferring data from the first device to the second device while the first device is in the second mode, the data including the identification information, the first device capable of using a spread spectrum communications technique; and 10

causing the first device to communicate in the first mode.

36. The method of claim 35, further comprising receiving at the first device configuration data from the second device. 15

37. The method of claim 36, wherein the configuration data comprises a software update code including a plurality of computer-executable instruction configured to be executed by the processing unit. 20

38. The method of claim 36, wherein the configuration data comprises configuration information related to the first device.

39. The method of claim 38, wherein the configuration information comprises hardware configuration. 25

40. The method of claim 38, wherein the configuration information comprises a user configurable setting.

41. The method of claim 38, wherein the configuration information comprises application settings. 30

42. The method of claim 35, wherein

the wireless communication of data is effected via a first wireless communications protocol; and

the transfer of data from the first device to the second device is effected via a second wireless communication protocol, the second protocol different from the first protocol. 35

43. The method of claim 42, wherein:

the wireless communication of data is effected via a first antenna module, and

the transfer of data from the first device to the second device is effected via a second antenna module. 40

44. A method for communicating data in a radio frequency system, the method comprising:

detecting, by a first device, a second device via a wireless communication of data, the first device operating in a first mode enabled to wirelessly receive identification information from a plurality of remote communication 45

18

devices via a communication technique, the first device being capable of operating in the first mode without the second device, the first device including one or more antennas to communicate with the remote communication devices and the second device;

receiving at the first device control signals from the second device; and

transferring data from the first device to the second device, the data including the identification information, the first device capable of using a spread spectrum communications technique.

45. The method of claim 44, wherein:

the wireless communication of data is effected via a first wireless communications protocol; and

the transfer of data from the first device to the second device is effected via a second wireless communication protocol, the second protocol being different from the first protocol.

46. The method of claim 45, wherein:

the wireless communication of data is effected via a first antenna module, and

the transfer of data from the first device to the second device is effected via a second antenna module.

47. The method of claim 45, further comprising:

causing the first device to communicate in a second mode;

receiving at the first device configuration data from the second device while the first device is in the second mode; and

causing the first device to communicate in the first mode.

48. The method of claim 44, further comprising:

causing the first device to communicate in a second mode;

receiving at the first device configuration data from the second device while the first device is in the second mode; and

causing the first device to communicate in the first mode.

49. The method of claim 48, wherein the configuration data comprises a software update code including a plurality of computer-executable instruction configured to be executed by the processing unit.

50. The method of claim 48, wherein the configuration data comprises configuration information related to the first device.

51. The method of claim 50, wherein the configuration information comprises hardware configuration.

52. The method of claim 50, wherein the configuration information comprises user configurable settings.

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