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(54) **SYSTEMS AND METHODS OF PROVIDING WIRELESS POWER USING RECEIVER DEVICE SENSOR INPUTS**

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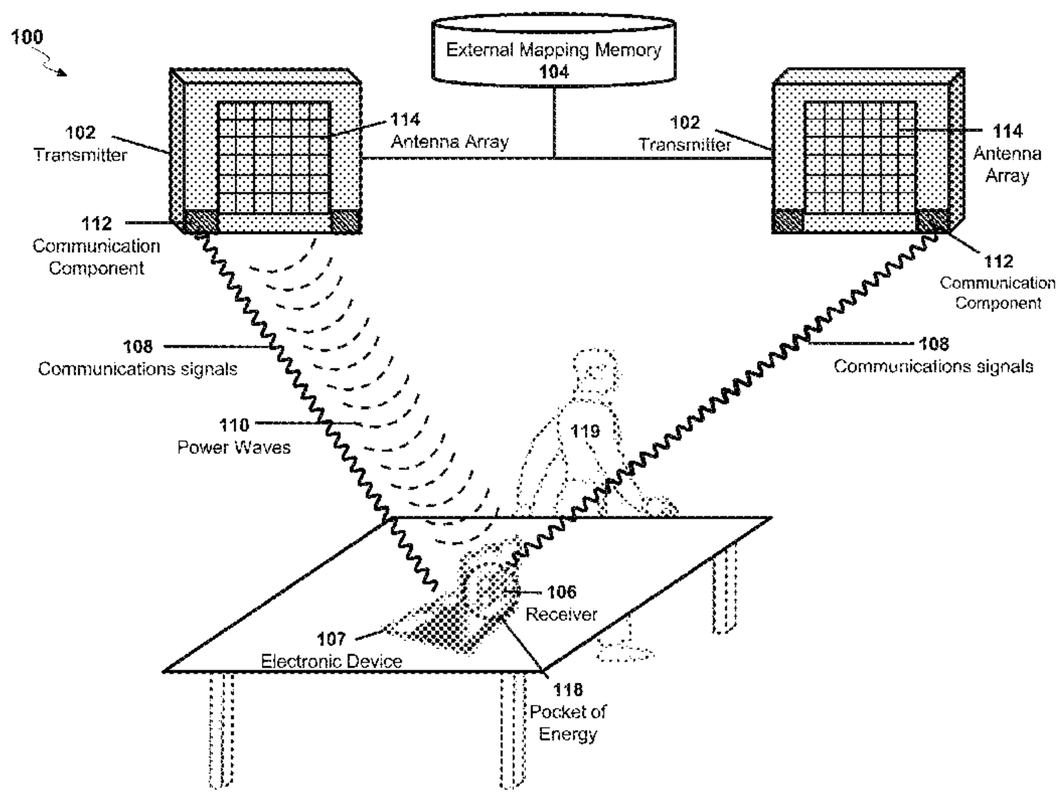
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(57) **ABSTRACT**

A method for wireless power transmission is performed at a wireless power transmitter. The method includes: (i) requesting sensor data from a receiver device; (ii) receiving sensor data from the receiver device in response to the request, wherein the sensor data is generated by one or more sensors of the receiver device; and (iii) determining whether the receiver device is in a proscribed state for wireless power reception based on the received sensor data. The method further includes, in accordance with determining that the receiver device is not in the proscribed state: transmitting, by antennas of the wireless power transmitter, a plurality of wireless power transmission waves to the receiver device so that each wireless power transmission wave of the plurality of wireless power transmission waves constructively interferes with at least one other wireless power transmission wave of the plurality of wireless power transmission waves.

24 Claims, 5 Drawing Sheets



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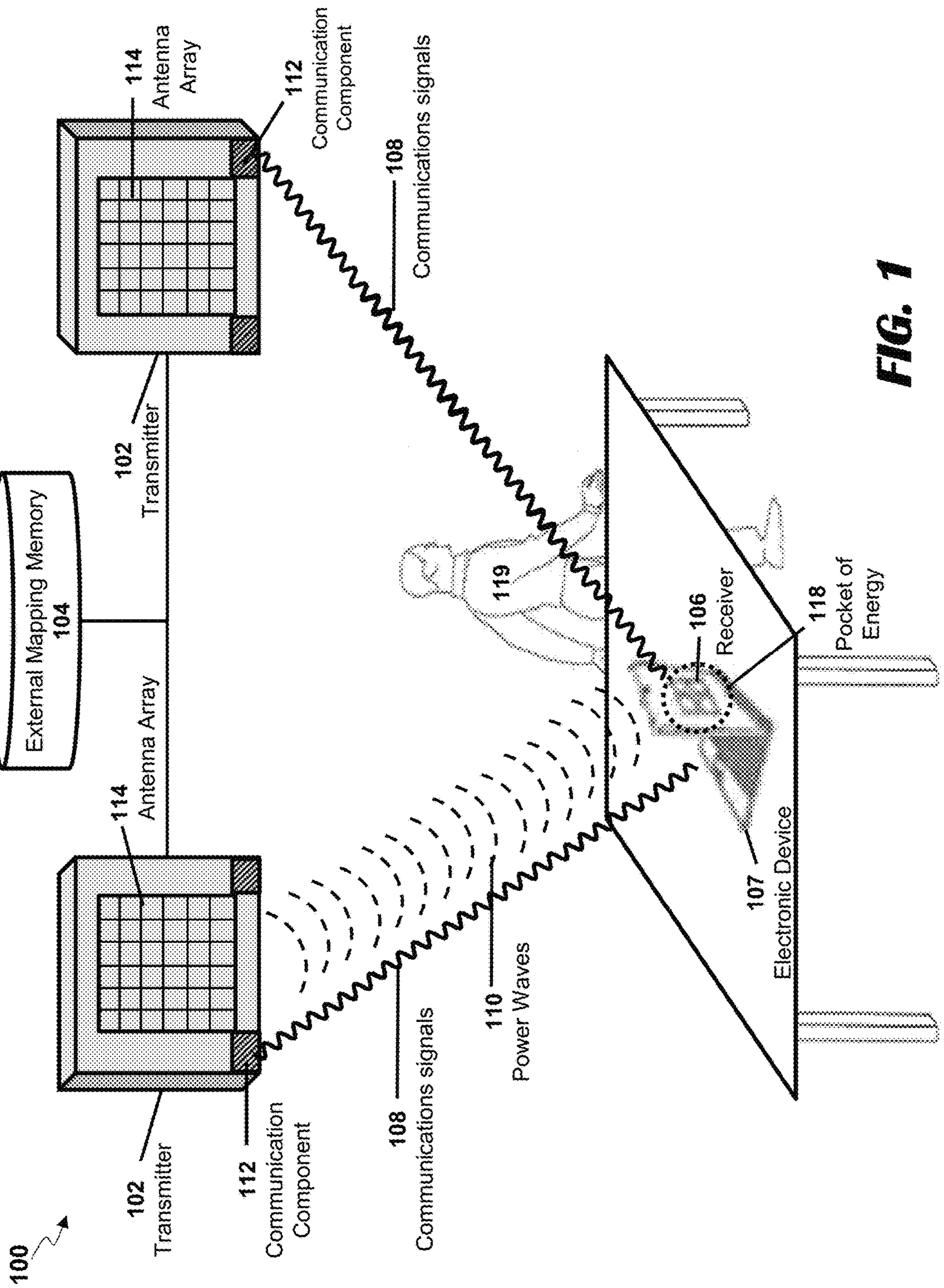

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102 Transmitter
112 Communication Component
108 Communications signals
110 Power Waves
114 Antenna Array
External Mapping Memory 104
102 Transmitter
114 Antenna Array
112 Communication Component
108 Communications signals
119
106 Receiver
118 Pocket of Energy
107 Electronic Device

FIG. 1

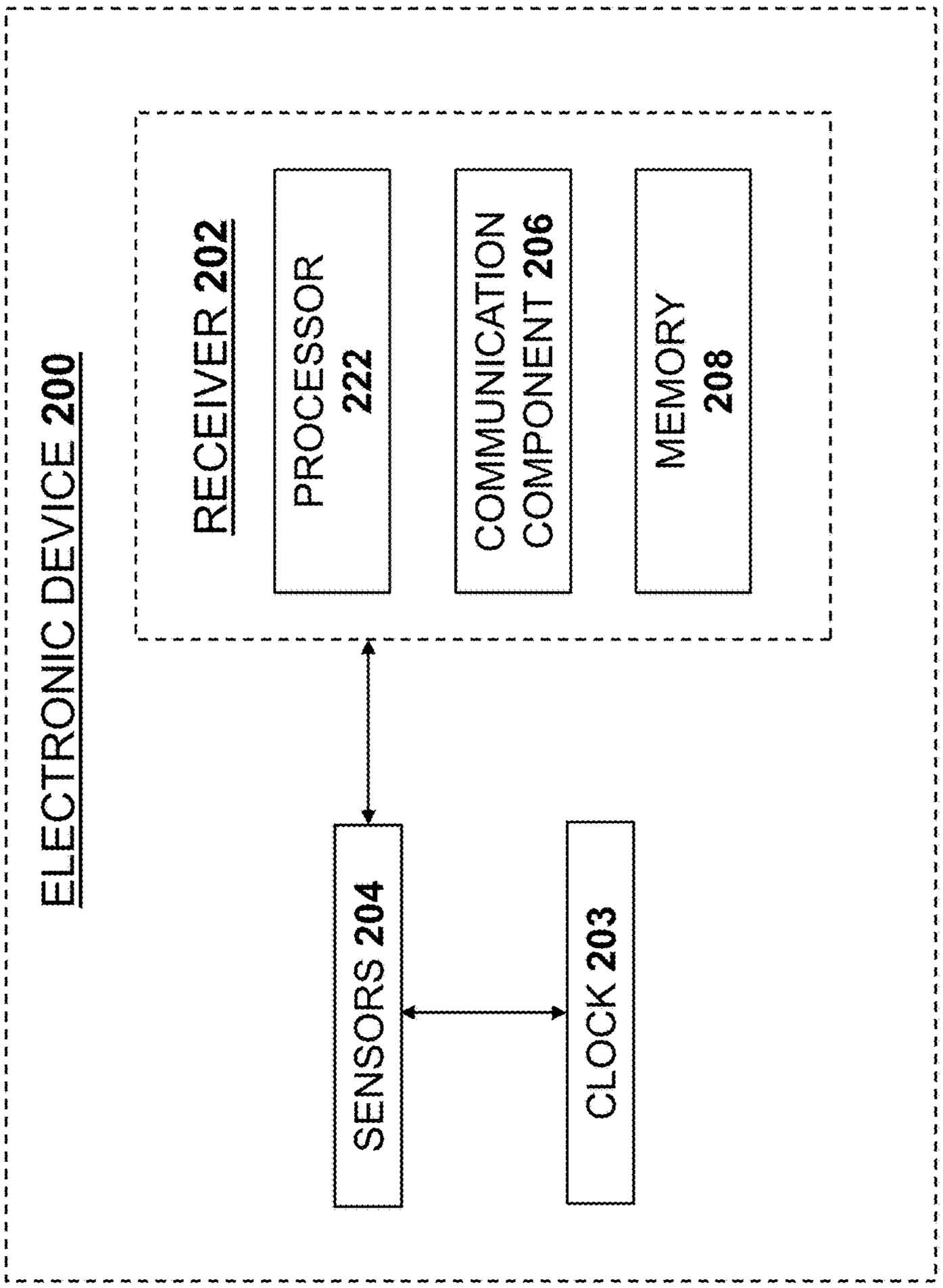

ELECTRONIC DEVICE 200
RECEIVER 202
PROCESSOR 222
COMMUNICATION COMPONENT 206
MEMORY 208
SENSORS 204
CLOCK 203

FIG. 2

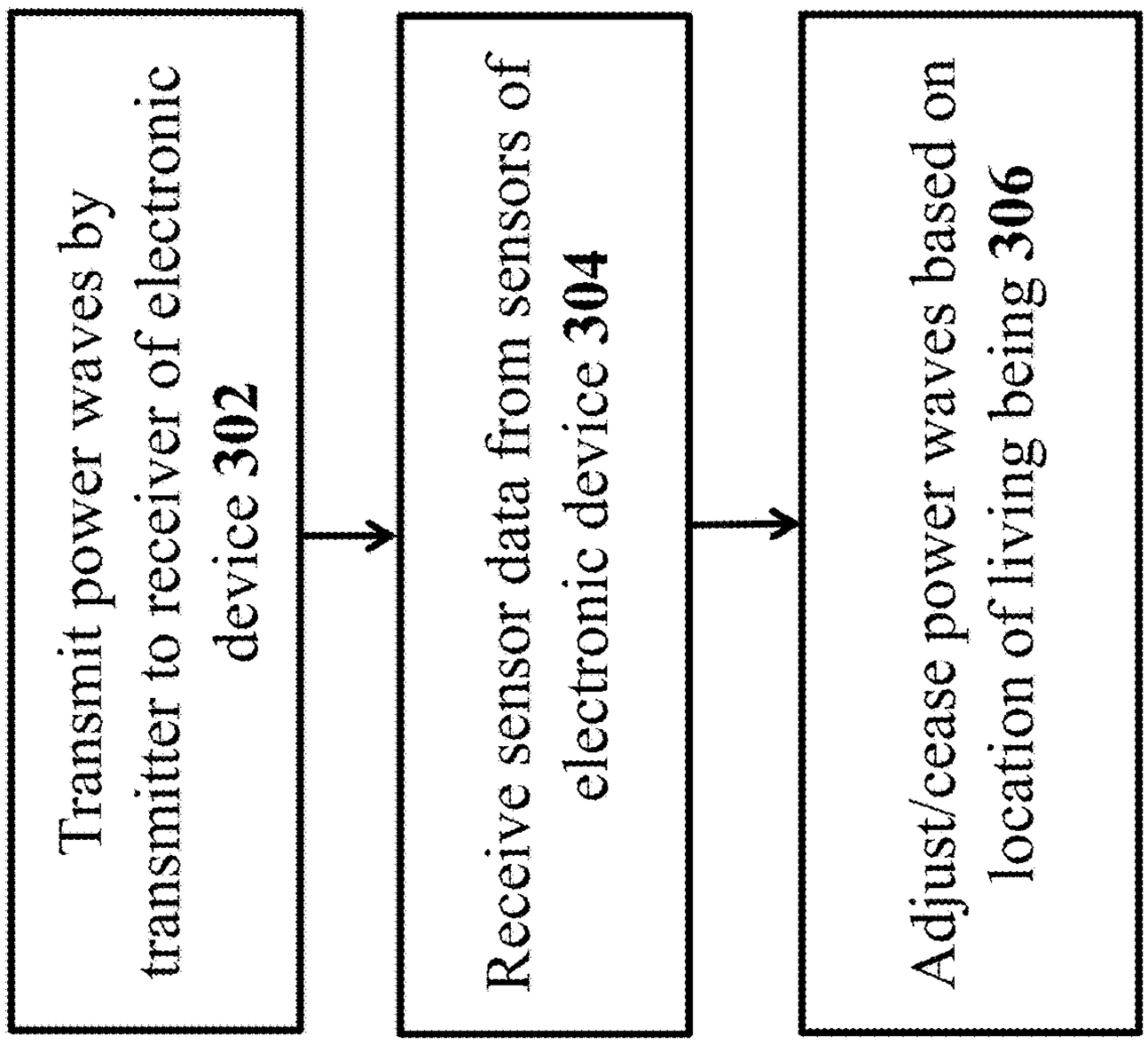

Transmit power waves by transmitter to receiver of electronic device 302
Receive sensor data from sensors of electronic device 304
Adjust/cease power waves based on location of living being 306
300

FIG. 3

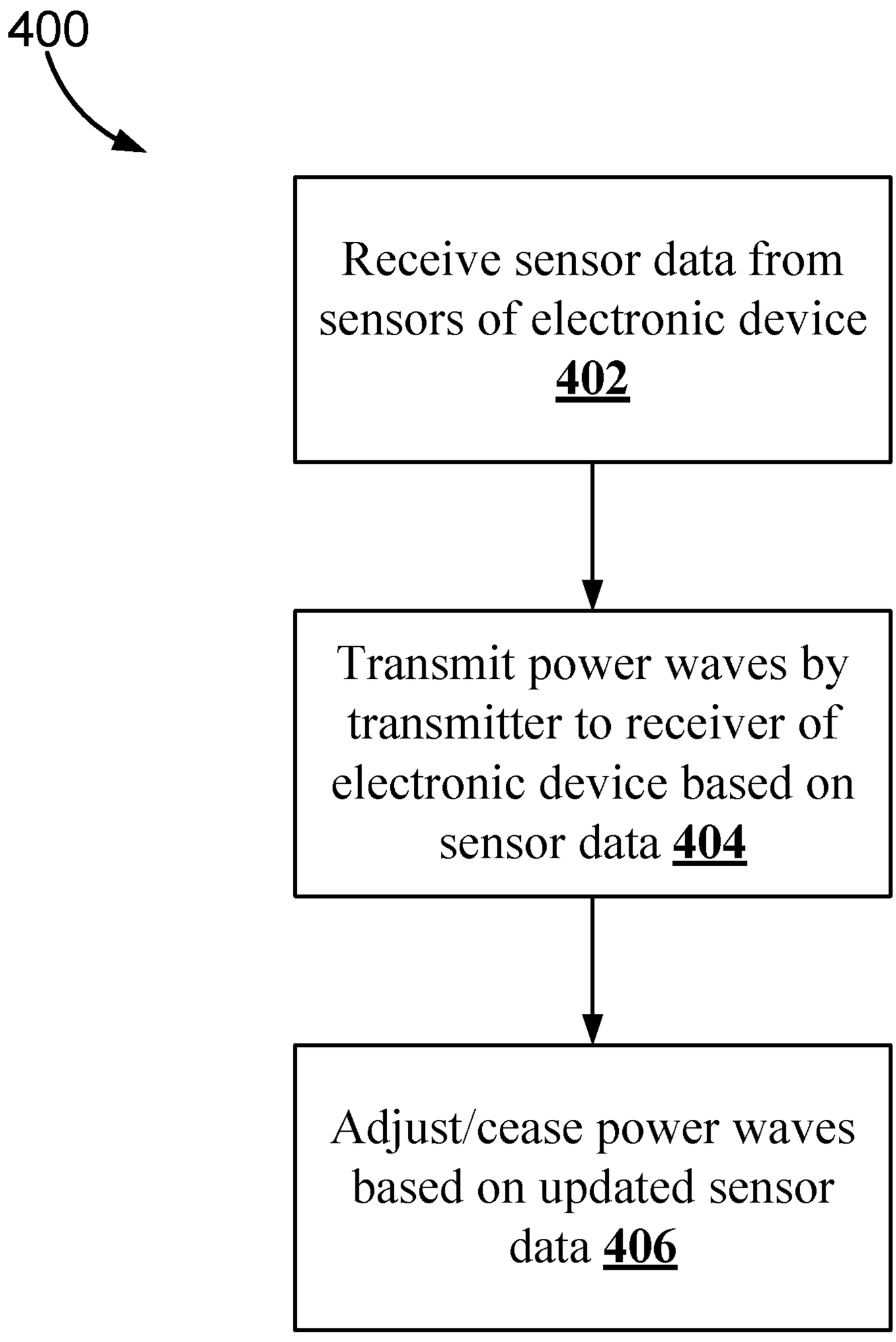

400
Receive sensor data from sensors of electronic device 402
Transmit power waves by transmitter to receiver of electronic device based on sensor data 404
Adjust/cease power waves based on updated sensor data 406

FIG. 4

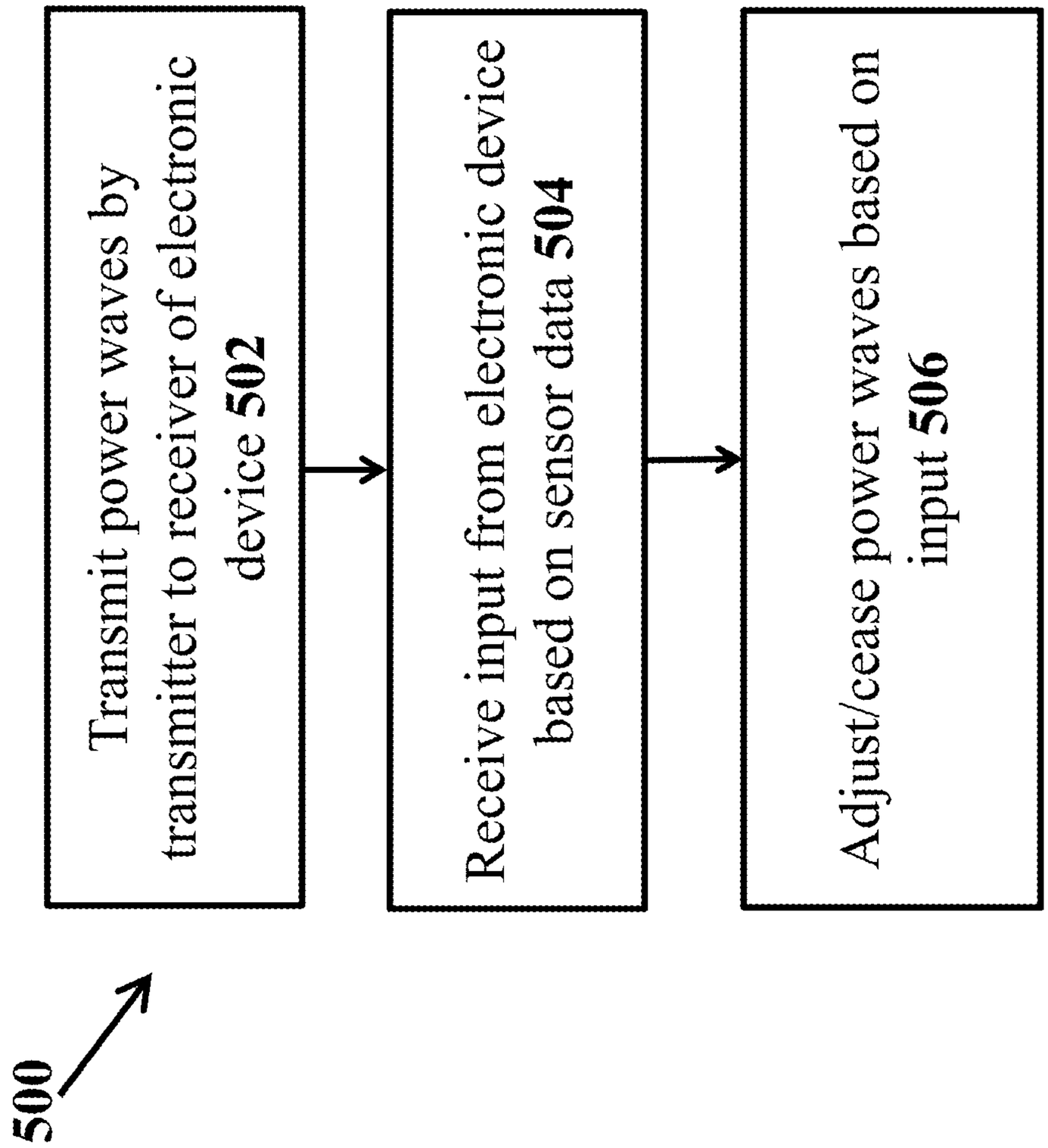

Transmit power waves by transmitter to receiver of electronic device 502
Receive input from electronic device based on sensor data 504
Adjust/cease power waves based on input 506
500

FIG. 5

SYSTEMS AND METHODS OF PROVIDING WIRELESS POWER USING RECEIVER DEVICE SENSOR INPUTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This non-provisional patent application claims the benefit of U.S. Provisional Patent Application Ser. No. 62/272,571, entitled "Systems and Methods of Providing Wireless Power Using Receiver Device Sensor Inputs," filed Dec. 29, 2015, which is incorporated by reference herein in its entirety.

This application is a continuation-in-part of U.S. patent application Ser. No. 14/856,337, entitled "Systems and Methods for Wireless Power Charging," filed Sep. 16, 2015, which is incorporated by reference herein in its entirety.

This application is a continuation-in-part of U.S. patent application Ser. No. 14/584,412, entitled "System and Method for Providing Health Safety in a Wireless Power Transmission System," filed Dec. 29, 2014, which is a continuation-in-part of U.S. patent application Ser. No. 14/330,939, entitled "System and Method for Providing Health Safety in a Wireless Power Transmission System," filed Jul. 14, 2014, each of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

This application generally relates to wireless power transmission systems.

BACKGROUND

Numerous attempts have been made to wirelessly transmit energy to electronic devices, where a receiver device can receive the transmission and convert it to electrical energy. However, most conventional techniques are unable to transmit energy at any meaningful distance. For example, magnetic resonance provides electric power to devices without requiring an electronic device to be wired to a power resonator. However, the electronic device is required to be proximately located to a coil of the power resonator (i.e., within a magnetic field). Other conventional solutions may not contemplate user mobility for users who are charging their mobile devices or such solutions do not allow devices to be outside of a narrow window of operability.

Wirelessly powering a remote electronic device requires a means for identifying the location of electronic devices within a transmission field of a power-transmitting device. Conventional systems typically attempt to proximately locate an electronic device, so there are no capabilities for identifying and mapping the spectrum of available devices to charge, for example, in a large coffee shop, household, office building, or other three-dimensional space in which electrical devices could potentially move around. Moreover, what is needed is a system for managing power wave production, both for directionality purposes and power output modulation. Because many conventional systems do not contemplate a wide range of movement of the electronic devices they service, what is also needed is a means for dynamically and accurately tracking electronic devices that may be serviced by the power-transmitting devices.

Wireless power transmission may need to satisfy certain regulatory requirements. These devices transmitting wireless energy may be required to adhere to electromagnetic field (EMF) exposure protection standards for humans or other living beings. Maximum exposure limits are defined by US and European standards in terms of power density limits and electric field limits (as well as magnetic field limits). Some of these limits are established by the Federal Communications Commission (FCC) for Maximum Permissible Exposure (MPE), and some limits are established by European regulators for radiation exposure. Limits established by the FCC for MPE are codified at 47 CFR § 1. 1310. For electromagnetic field (EMF) frequencies in the microwave range, power density can be used to express an intensity of exposure. Power density is defined as power per unit area. For example, power density can be commonly expressed in terms of watts per square meter (W/m^2), milliwatts per square centimeter (mW/cm^2), or microwatts per square centimeter ($\mu W/cm^2$).

Accordingly, it is desirable to appropriately administer the systems and methods for wireless power transmission to satisfy these regulatory requirements. What is needed is a means for wireless power transmission that incorporates various safety techniques to ensure that humans or other living beings within a transmission field are not exposed to EMF energy near or above regulatory limits or other nominal limits. What is needed is a means for monitoring and tracking objects within a transmission field in real-time and providing a means for controlling the production of power waves to adaptively adjust to the environment within the transmission field.

SUMMARY

Disclosed herein are systems and methods intended to address the shortcomings in the art and may provide additional or alternative advantages as well. Embodiments disclosed herein may generate and transmit power waves that, as result of their physical waveform characteristics (e.g., frequency, amplitude, phase, gain, direction), converge at a predetermined location in a transmission field to generate a pocket of energy. Receivers associated with an electronic device being powered by the wireless charging system may extract energy from the pocket of energy and then convert that energy into usable electric power for the electronic device associated with a receiver. The pocket of energy may manifest as a three-dimensional field (e.g., transmission field), where energy may be received and converted by receivers positioned within or nearby a pocket of energy. In some embodiments, transmitters may perform adaptive pocket forming by adjusting transmission of the power waves to regulate power levels based on data obtained from sensors of an electronic device being charged. Additionally, in order to further identify people, objects, or other items populated within the transmitter's field of view, electronic device sensors may generate sensor data that may be processed to identify areas that the power waves should avoid. This sensor data may be an additional or alternative form of data that may be used along with transmitter sensor and camera data to identify people, objects, or other items populated within the transmitter's field of view.

In an embodiment, a method for wireless power transmission comprises transmitting, by a transmitter, power waves that converge to form constructive interference at a location associated with a receiver; receiving, by the transmitter, sensor data from one or more sensors of the electronic device representative of at least one of a proscribed orientation circumstance of the electronic device, a proscribed motion circumstance of the electronic device, and a proscribed ambient light circumstance of the electronic device; and adjusting, by the transmitter, a power level of the power waves upon receiving at least one of the proscribed

orientation circumstance of the electronic device, the proscribed motion circumstance of the electronic device, and the proscribed ambient light circumstance of the electronic device. In addition to the types of sensor data enumerated above, the electronic device may include other sensors and it may communicate the associated data from these sensors as well.

In another embodiment, a transmitter for wireless power transmission comprises a processor configured to control transmission of power waves that converge to form constructive interference at a location associated with a receiver; and a memory operatively coupled with and readable by the processor and having stored therein machine-readable instructions that when executed by the processor cause the processor to: receive sensor data from one or more sensors of the electronic device representative of at least one of orientation, motion, and ambient light; and adjust a power level of the power waves upon receiving sensor data representative of at least one of orientation, motion, and ambient light that is similar to a proscribed circumstance.

Additional features and advantages of an embodiment will be set forth in the description which follows, and in part will be apparent from the description. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the exemplary embodiments in the written description and claims hereof as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings constitute a part of this specification and illustrate embodiments of the invention. The present disclosure can be better understood by referring to the following figures. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the disclosure.

FIG. **1** shows components of an exemplary wireless power transmission system, according to an exemplary embodiment.

FIG. **2** shows an exemplary electronic device having a receiver of a wireless power transmission system, according to an exemplary embodiment.

FIG. **3** is a flow diagram illustrating a method of identifying objects within a transmission field of a transmitter of a wireless power transmission system, according to an exemplary embodiment.

FIG. **4** is a flow diagram illustrating a method of transmitting power waves to or nearby receivers coupled to or integrated into electronic devices located within a transmission field of one or more transmitters of a wireless power transmission system, according to an exemplary embodiment.

FIG. **5** is a flow diagram illustrating a method of transmission of power waves to receivers of electronic devices within a transmission field of a transmitter of a wireless

DETAILED DESCRIPTION

The present disclosure is here described in detail with reference to embodiments illustrated in the drawings, which form a part here. Other embodiments may be used and/or other changes may be made without departing from the spirit or scope of the present disclosure. The illustrative embodiments described in the detailed description are not meant to be limiting of the subject matter presented here.

In a wireless power transmission system, the transmitters are devices that comprise, or are otherwise associated with, various components and circuits responsible for, e.g., generating and transmitting power waves, forming pockets of energy at locations in a transmission field, monitoring the conditions of the transmission field, and generating null spaces where needed. The transmitter may generate and transmit power waves for pocket-forming based on location of one or more receivers and/or execute null steering based on the location of one or more sensitive objects, such as humans and animals, or sensitive medical devices, within a transmission field of the transmitter.

The transmitter comprises antennas that are configured to transmit power waves having certain physical waveform characteristics. The power waves may be transmitted to receivers within a transmission field of the transmitters in the form of any physical media capable of propagating through space and being converted into electrical energy for charging the one or more electronic devices. Examples of the physical media may include radio frequency (RF) waves, infrared, acoustics, electromagnetic fields, and ultrasound. The power transmission signals may include any radio signal and may have any frequency or wavelength. It should be appreciated by one skilled in the art that the wireless charging techniques are not limited to RF wave transmission techniques and may include alternative or additional techniques for transmitting energy to the receivers.

FIG. **1** shows components of an exemplary wireless power transmission system **100**. The exemplary system **100** may include transmitters **102**, an external mapping memory **104**, a receiver **106**, and an electronic device **107** to be charged. The transmitters **102** may send various types of waves such as communication signals **108** and power waves **110**, into a transmission field, which may be the two or three-dimensional space into which the transmitters **102** may transmit the power waves **110**.

The transmitters **102** may transmit the power waves **110**, which may be captured by the receiver **106** configured to convert the energy of the power waves **110** into electrical energy, for the electronic device **107** associated with the receiver **106**. The receiver **106** may include circuitry that may convert the captured power waves **110** into electrical energy on behalf of the electronic device **107** associated with the receiver **106**. In some embodiments, the transmitters **102** may transmit the power waves **110** to the electronic device **107** by manipulating characteristics of the power waves **110** (e.g., phase, gain, direction, frequency) in response to receiving one or more sensor readings (sensor data) from one or more sensors of the electronic device **107**. In other embodiments, the receiver **106** may be located in a case, external to the electronic device **107**, wherein the case is coupled to the electronic device **107** via any one of a multitude of potential electrical and/or data connection points.

The sensor data may include data from one or more sensors, such as a sensor for time, orientation, motion, and ambient light. The sensor data from one or more sensors may be analyzed to determine if it is similar to a particular condition As referred to herein, a condition involving orientation where a power level should be adjusted or ceased based on that orientation may be referred to as a proscribed orientation circumstance of the electronic device **107**. A condition involving motion where a power level should be adjusted or ceased based on that motion may be referred to as a proscribed motion circumstance of the electronic device

107. A condition involving ambient light where a power level should be adjusted or ceased based on that ambient light may be referred to as a proscribed ambient light circumstance of the electronic device **107**. Still other conditions may result from a combination of data from one or more sensors, such as ambient light and orientation and/or time since the electronic device last experienced movement.

In some embodiments, the transmitters **102** may transmit the power waves **110** into the transmission field by manipulating characteristics of the power waves **110** (e.g., phase, gain, direction, frequency) based on the location associated with one or more sensitive objects such as humans **119** with respect to the receiver **106** and/or the transmitters **102**. In some implementations, the transmitters **102** may manipulate the characteristics of the power waves **110** so that the trajectories of the power waves **110** cause the power waves **110** to converge at a predetermined location within a transmission field (e.g., a 3D location or region in space), resulting in constructive or destructive interference. The location of sensitive objects may be used in conjunction with the sensor data received from the one or more sensors of the electronic device. In some embodiments, data contained within the communications signals **108**, for example, may contain location data associated with one or more objects, such as humans **119**, received by the receiver **106**, and may be used by the transmitter processor to determine how the transmitter **102** may transmit safe and effective power waves **110**. The transmitter **102** may transmit safe and effective power waves **110** that generate a pocket of energy **118**, from which the receiver **106** may capture energy and convert it to useable alternating current (AC) or direct current (DC) electricity. Using the communications signal **108**, the transmitter **102** may communicate data that may be used, e.g., to identify the receiver **106** within the transmission field, determine whether the electronic device **107** or users are authorized to receive wireless charging services from the system **100**, poll receivers to transmit back certain sensor data, determine safe and effective waveform characteristics for the power waves **110**, and hone the placement of the pocket of energy **118**, among other possible functions.

The transmitters **102** may comprise or be associated with one or more transmitter processors (not shown), a communications component **112**, and an antenna array **114**. The one or more transmitter processors may control, manage, and otherwise govern the various processes, functions, and components of the transmitters **102**. The one or more transmitter processors may be configured to process and communicate various types of data (e.g., data obtained from sensors in the electronic device **107**, data associated with the receiver **106**, data associated with the one or more objects such as humans **119**). Additionally or alternatively, a transmitter processor of the transmitters **102** may manage execution of various processes and functions of the transmitters **102**, and may manage the components of the transmitters **102**. For example, the transmitter processor may determine an interval at which a beacon signal may be broadcast by a communication component **112** to identify the receiver **106** that may inhabit the transmission field.

The communication component **112** may effectuate wired and/or wireless communications to and from the receiver **106** of the system **100**. In some cases, the communication component **112** may be an embedded component of the transmitter **102**; and, in some cases, the communication component **112** may be attached to the transmitter **102** through any wired or wireless communications medium. The communication component **112** may comprise electromechanical components (e.g., processor, antenna) that allow the communication component **112** to communicate various types of data with one or more receivers **106** via the communications signals **108**. In some implementations, the communications signals **108** may represent a distinct channel for hosting communications, independent from the power waves **110**. The data may be communicated using the communications signals **108**, based on predetermined wired or wireless protocols and associated hardware and software technology. The communications component **112** may operate based on any number of communication protocols, such as Bluetooth®, Wireless Fidelity (Wi-Fi), Near-Field Communications (NFC), ZigBee, and others. In some other embodiments the communications signals may occupy the same frequency band as the power waves.

A communications component (shown in FIG. **1**) of the receiver **106** may use the communications signal **108** to communicate data obtained from one or more sensors that may be used to alert transmitters **102** of the orientation, motion, or ambient light conditions, e.g., by transmitting the proscribed orientation circumstance of the electronic device **107**, the proscribed motion circumstance of the electronic device **107**, and/or the proscribed ambient light circumstance of the electronic device **107**, and/or the timing of the last such circumstance, to determine whether the transmitter **102** can safely transmit effective power waves **110**. In some embodiments, the communications component of the receiver **106** may use the communications signal **108** to communicate data that may be used to alert transmitters **102** that the receiver **106** has entered, or is about to enter, the transmission field, provide the location data generated that is associated with the one or more sensitive objects such as humans **119**, provide information about the electronic device **107** being charged by the receiver **103**, indicate the effectiveness of the power waves **110**, and provide updated transmission parameters that the transmitters **102** may use to adjust the power waves **110**, as well as other types of useful data. As an example, the communications component **112** of the transmitter **102** may communicate (i.e., send and receive) different types of data containing various types of information. Non-limiting examples of the information may include a beacon message, a transmitter identifier (TX ID), a device identifier (device ID) for an electronic device **107**, a user identifier (user ID), the battery level for the device **107**, applications being currently used (e.g., phone call application) by the device **107**, the receiver's **106** location in the transmission field, the amount of time since the device last experienced motion or a change in orientation, the objects **120** location in the transmission field, orientation sensor data, motion sensor data, ambient light sensor data, the proscribed orientation circumstance of the electronic device **107**, the proscribed motion circumstance of the electronic device **107**, and the proscribed ambient light circumstance of the electronic device **107**, and other such information.

The antenna array **114** of the transmitters **102**, which may be a set of one or more antennas, is configured to transmit the power waves **110**. In some embodiments, the antenna array **114** may comprise antennas, which may be configurable "tiles" comprising an antenna and may include an integrated circuit controlling the behavior of the antenna, where the antenna generates the power waves **110** having predetermined characteristics (e.g., amplitude, frequency, trajectory, phase). An antenna of the antenna array **114** may transmit a series of the power waves **110** having the predetermined characteristics, such that the power waves **110** arrive at a given location within the transmission field in a manner that they create a pocket of energy. Taken together,

the antennas of the antenna array **114** may transmit the power waves **110** that converge at the given location (usually where the receiver **106** is detected) and due to their respective characteristics, form a constructive interference pattern shown as a pocket of energy **118**, from which the receiver **106** may collect energy and generate electricity. It should be appreciated that, although the exemplary system **100** describes radio-frequency based power waves **110**, additional or alternative transmitting arrays or elements and/or wave-based technologies may be used (e.g., ultrasonic, infrared, magnetic resonance) to wirelessly transmit power from the transmitter **102** to the receiver **106**.

The sensor data may be interpreted by the receiver **106** or electronic device **107**, and a processed version of the data may be transmitted to the transmitter **102** to adjust the power wave transmission accordingly. Alternatively, the sensor data may be interpreted by processors associated with the transmitter **102**, from which the transmitter **102** may determine how the antennas of the antenna array **114** should form and transmit the power waves **110**. When determining how the power waves should be formed, the transmitter **102** determines waveform characteristics for each of the power waves **110** to be transmitted from each of the respective antennas of the antenna array **114**. Non-limiting examples of waveform characteristics for the power waves **110** may include: amplitude, phase, gain, frequency, and direction, among others.

In one embodiment, upon determining that the receiver **106** should not receive power waves, the transmitter **102** can generate a null space rather than a pocket of energy at a particular location. The transmitter **102** identifies a subset of antennas from the antenna array **114** that sends the power waves **110** that form destructive interference patterns, thereby diminishing or eliminating the amount of energy concentrated at the location.

Although the exemplary embodiments described herein mention the use of RF-based wave transmission technologies, it should be appreciated that the wireless charging techniques that might be employed are not be limited to such RF-based technologies and techniques. Rather, it should be appreciated that there are additional or alternative wireless charging techniques, which may include any number of technologies and techniques for wirelessly transmitting energy to a receiver that is capable of converting the transmitted energy to electrical power. Non-limiting exemplary transmission techniques for energy that can be converted by a receiving device into electrical power may include: ultrasound, microwave, laser light, infrared, or other forms of electromagnetic energy.

In some embodiments, control systems of transmitters **102** adhere to electromagnetic field (EMF) exposure protection standards for human subjects. Maximum exposure limits are defined by US and European standards in terms of power density limits and electric field limits (as well as magnetic field limits). These include, for example, limits established by the Federal Communications Commission (FCC) for MPE, and limits established by European regulators for radiation exposure. Limits established by the FCC for MPE are codified at 47 CFR § 1.1310. For electromagnetic field (EMF) frequencies in the microwave range, power density can be used to express an intensity of exposure. Power density is defined as power per unit area. For example, power density can be commonly expressed in terms of watts per square meter (W/m2), milliwatts per square centimeter (mW/cm2), or microwatts per square centimeter (μW/cm2).

In some embodiments, the present systems and methods for wireless power transmission **100** incorporate various safety techniques to ensure that human occupants in or near a transmission field are not exposed to EMF energy near or above regulatory limits or other nominal limits. One safety method is to include a margin of error (e.g., about 10% to 20%) beyond the nominal limits, so that human subjects are not exposed to power levels at or near the EMF exposure limits. A second safety method can provide staged protection measures, such as reduction or termination of wireless power transmission if humans (and in some embodiments, other living beings or sensitive objects) move toward a pocket of energy with power density levels exceeding EMF exposure limits.

FIG. **2** shows an exemplary electronic device **200** having a receiver **202** of a wireless power transmission system, according to an exemplary embodiment. The electronic device **200** coupled to the receiver **202** may be any electrical device that requires continuous electrical energy or that requires power from a battery. The receiver **202** may be permanently integrated into the electronic device **200**, or the receiver **202** may be detachably coupled to the electronic device **200**, which, in some cases, may result in a single integrated product or unit. As an example, the electronic device **200** may be placed into a protective sleeve comprising embedded receivers **202** that are detachably coupled to the device's power supply input. Non-limiting examples of electronic devices **200** may include laptops, mobile phones, smartphones, tablets, music players, toys, batteries, flashlights, lamps, electronic watches, cameras, gaming consoles, appliances, GPS devices, and wearable devices or so-called "wearable" (e.g., fitness bracelets, pedometers, smart watch), among other types of electrical devices **200**.

Electronic devices **200** may comprise embedded or associated sensors **204** such as accelerometers, gyroscopes, and/or ambient light sensors, which may act as a sensor data source for a transmitter. Electronic device **200** may further include a clock **203**, which determines the passage of time between various sensor related circumstances, such as motion, orientation, acceleration, and/or changes in lighting circumstances. In some embodiments, the sensor data can supplement heat-map data and/or mapping data, as generated by sensors associated with the transmitter, to determine how the transmitter may safely and effectively transmit power waves. In some embodiments, heat-map data may be generated by transmitter processors to identify receivers located in a transmission field. For example, the transmitter processor may determine an interval at which a beacon signal may be broadcast by a communications component of the transmitter, to identify receivers that may inhabit the transmission field. The transmitter processor may generate heat-mapping data from communications signals received by the communications component. Determinations of how to adjust power wave transmissions may be based upon the clock and/or sensor data from one or more sensors, and proscribed circumstances may be based upon sensor data from one or more sensors.

The accelerometer may provide sensor data to indicate that the electronic device is moving, whereby the transmitter may determine that it should cease transmission when it appears that a human or other sensitive object is moving the electronic device. Even small movements detected by an accelerometer may indicate that the electronic device may be in the presence or being held by a human being, so transmission should cease. The accelerometer of the electronic device **200** can be a Micro-Electro-Mechanical Sensors (MEMS) used to detect motion and/or measure non-

gravitational acceleration of the electronic device **200**. The accelerometer may measure acceleration of the electronic device **200** in one, two, or three orthogonal axes. When the electronic device **200** goes from a standstill to any velocity, the accelerometer responds to the vibrations associated with such movement. The accelerometer may use microscopic crystals that go under stress when vibrations occur, and from that stress, a voltage is generated to create a reading on any acceleration, and thereby measure linear acceleration of movement of the electronic device **200**. Accordingly, the accelerometer can gauge the movement of an electronic device **200**.

The output of the accelerometer of the electronic device **200** can be processed to determine if the sensor data is substantially similar to a proscribed motion circumstance of the electronic device **200**, which may correspond to any motion or a particular motion of the electronic device **200**. The detection of motion of the electronic device **200** may indicate that the electronic device **200** is being moved by its user. The proscribed motion circumstance may indicate a risk that the transmission of power waves to charge or power the electronic device **200** may expose the user to unsafe or undesirable radiation levels as the user is less than a predefined proximity to the electronic device **200**.

A gyroscope can determine orientation of the electronic device, whereby a particular orientation may be associated with an interaction with a sensitive object (e.g., a human holding a phone to his head or a phone in a pocket), whereas other orientations may be associated with a lack of interaction with a sensitive object (e.g., laying horizontal, especially when in conjunction with lack of movement determined by the accelerometer and further when in conjunction with the passage of a threshold time period since movement last occurred). The time-period of the lack of movement of the electronic device may be determined by the clock **203**. Even small movements detected by a gyroscope may indicate that the electronic device may be in the presence of or may being held by a human being, so transmission should cease. The gyroscope of the electronic device **200** can measure a rate of rotation of the electronic device **200** around a particular axis and is able to sense motion including both vertical and horizontal rotation of the electronic device **200**. When gauging the rate of rotation around the roll axis of the electronic device **200**, the gyroscope identifies an actual value until the electronic device **200** stabilizes out. Accordingly, by using the principles of angular momentum, the gyroscope can indicate orientation of the electronic device **200**. The gyroscope can provide data over a period of time to indicate a rotation of the electronic device over that period, whereby a rotation may indicate that it is in the presence of a human or other sensitive object. The period or passage of time that corresponds to period of the rotation of the electronic device may be measured by the clock **203**. The clock **203** may further measure the passage of time between various other sensor related circumstances, such as motion, orientation, acceleration, and/or changes in lighting circumstances. The measured period of the time by the clock **203** may indicate a time-period during which there is a risk that the transmission of power waves to charge or power the electronic device **200** may expose the user to unsafe or undesirable radiation levels as the user may be less than a pre-defined proximity to the electronic device **200**.

Although described in the exemplary embodiment as sensor data, it is intended that the sensor data is not limited to raw sensor data and can include data that is processed by a processor associated with the sensor, processed by the receiver, processed by the transmitter, or any other processor. The sensor data can include information derived from the sensor, and processed sensor data can include determinations based upon the sensor data. For example, the gyroscope of the electronic device **200** may provide raw data such as an orientation in X-plane, Y-plane, and Z planes, and processed sensor data from the gyroscope may include a determination of the orientation or a circumstance involving that orientation of the electronic device **200**.

The use of the accelerometer and/gyroscope data of the electronic device **200** may generate a proscribed orientation circumstance of the electronic device **200** that corresponds to a substantially vertical orientation of the electronic device **200**. In one instance, a vertical or near vertical orientation of the electronic device **200** indicates that the electronic device **200** is being held in the vertical orientation by a user near the user's head. In another instance, a vertical or near vertical orientation of the electronic device **200** indicates that the electronic device **200** is being carried by a user in the vertical orientation, e.g., in the user's pocket or in a case, holster, or other carrier. In another instance, a vertical orientation indicates that the electronic device is in a cradle for charging, so accelerometer data, particularly when combined with clock data obtained from the clock **203**, will indicate that despite the vertical orientation, the electronic device is stationary. In another instance, a near perfect horizontal orientation of the electronic device **200** may indicate that the device is positioned on top of a surface, such as a table, counter or desk. The proscribed orientation circumstance may then be used to determine risk regarding the transmission of power waves to charge or power the electronic device **200** that may expose the user to unsafe or undesirable radiation levels.

In order to simplify the description above, reference has been made to an accelerometer and gyroscope, each in a singular sense. In practice, the electronic device **200** may have a three-dimensional accelerometer or three accelerometers with mutually orthogonal sensitive axes, often referred to as a 3-D accelerometer. The electronic device may have an X-axis accelerometer, Y-axis accelerometer, and Z-axis accelerometer. Similarly, the electronic device **200** also has a 3-D gyroscope or an X-axis gyroscope, Y-axis gyroscope, and Z-axis gyroscope.

The ambient light sensor measures intensity of visible light received by the sensor, and a lack of ambient light may indicate that the electronic device is in a pocket or may be face-down on a table. In an embodiment, the ambient light sensor includes photo diodes that are sensitive to different spectra of visible light, to more accurately measure intensity of light received by the ambient light sensor. The output of the ambient light sensor includes a proscribed ambient light circumstance of the electronic device. The proscribed ambient light circumstance includes an ambient light reading that has a low intensity in comparison with one or more other ambient light readings acquired near the electronic device. A low intensity measurement by an ambient light sensor indicates low ambient light in a room, and the electronic devices including the ambient light sensors may increase screen brightness to compensate. However, where an ambient light sensor from an electronic device detects a low intensity of light, whereas one or more ambient light readings acquired near the electronic device have a higher intensity, the low intensity light reading from the user light may indicate that the electronic device is in a user's pocket or otherwise carried by the user with the electronic device covered. The ambient light sensor can provide data over a period of time to indicate whether the electronic device has a changed amount of ambient light, which may indicate, for

example, that the electronic device has become or is no longer in a pocket or face down on a table. Such data may also be combined with clock data to determine whether a threshold passage of time has elapsed in which no change in ambient light has been observed. The proscribed ambient light circumstance therefore may indicate a risk that the transmission of the power waves to charge or power the electronic device may expose the user to unsafe or undesirable radiation levels.

The electronic device **200** or the associated receiver **202**, are also associated with a communications component **206** capable of communicating with a transmitter. The communications component **206** may use communications signal to communicate data obtained from the sensors **204** that may be used to, e.g., alert transmitters of the proscribed orientation circumstance of the electronic device **200**, the proscribed motion circumstance of the electronic device **200**, and the proscribed ambient light circumstance of the electronic device **200** to determine how the transmitter may safely and effectively transmit power waves. On receiving the proscribed orientation circumstance of the electronic device **200**, the proscribed motion circumstance of the electronic device **200**, and/or the proscribed ambient light circumstance of the electronic device **200**, and/or data regarding the temporal nature of such circumstances, the transmitter can adjust or cease transmission of the power waves.

To enable the transmitter to locate and identify the electrical device **200**, a user may communicate to the transmitter, data obtained from the sensors **204** which may be recorded into an memory **208**. For example, the user may provide data using the communications component **206** or may provide data via an electronic device (e.g., laptop, smartphone, administrative computer or server) that is in communication with the transmitter or memory **208**. The electronic device may execute an administrative software application that permits the user, via a graphical user interface (GUI), to generate information of the proscribed orientation circumstance of the electronic device **200**, the proscribed motion circumstance of the electronic device **200**, and the proscribed ambient light circumstance of the electronic device **200**, and/or data regarding the temporal nature of such circumstances. The information of the proscribed orientation circumstance of the electronic device **200**, the proscribed motion circumstance of the electronic device **200**, and the proscribed ambient light circumstance of the electronic device **200** may then be stored as mapping data (e.g., sensor data) into the memory **208** for retrieval by one or more processors (e.g., receiver processor **222**, sensor processor, electronic device processor). In addition to proscribed orientation circumstance of the electronic device **200**, the proscribed motion circumstance of the electronic device **200**, and the proscribed ambient light circumstance of the electronic device **200**, exemplary information may also include location data for the electronic device **200**, level of power usage of the electronic device **200**, duration of power usage of the electronic device **200**, power transfer schedule of the electronic device **200**, data regarding the temporal nature of the sensor data, and authentication credentials of the electronic device **200**.

FIG. **3** is a flow diagram **300** illustrating a method of adjusting transmission of power waves to receivers of electronic devices within a transmission field of a transmitter of a wireless power transmission system, according to an exemplary embodiment. The transmitter of the wireless power transmission system may receive sensor data from one or more sensors of the electronic device. The electronic device is operatively coupled to the receiver for receiving power waves transmitted by a transmitter. The sensor data from the electronic device may include orientation data, motion data, and/or ambient light data, or may be representative of one or more proscribed circumstance that may indicate when a living being or sensitive object, such as a human, may be interacting with the electronic device and thus in close proximity to a pocket of energy, power waves, and/or the transmitter. In some embodiments, the proscribed circumstances may include a proscribed orientation circumstance, a proscribed motion circumstance, and/or a proscribed ambient light circumstance of the electronic device. In response to the sensor data received from the sensors of the electronic device, a processor of the transmitter processes the sensor data and may reduce intensity of power waves, terminate transmission of power waves, or may form a null space at or near the electronic device, among a number of additional or alternative actions.

At step **302**, a transmitter transmits power waves that converge in three dimensional space to form a constructive interference pattern at the receiver. In some embodiments, multiple transmitters and/or multiple receivers may power various electronic devices. The receiver may be separable from the electronic device or integrated with the electronic device.

At step **304**, the transmitter receives sensor data from one or more sensors of the electronic device. In an embodiment, the electronic device may include one or more sensors. The one or more sensors may be selected from a group consisting of an accelerometer, a gyroscope, and an ambient light sensor. Each of the one or more sensors may work independently to produce sensor data. In some embodiment, each of the one or more sensors work together to produce sensor data.

Operationally, before a link between the transmitter and the receiver is established and wireless power charging has commenced, the transmitter may request sensor data from the receiver, or may request a function of the sensor data that the electronic device is collecting, before starting sending wireless power waves to the receiver. If some of the proscribed conditions are met, the transmitter may decide that the receiver is near a human being or a sensitive object and may not initiate wireless power charging. Similarly, the receiver may make the determination that a human being is near and refrain from initiating wireless power transfer.

A proscribed orientation circumstance of the electronic device generated by the one or more sensors corresponds to an orientation of the electronic device. For example, the proscribed orientation circumstance may indicate that the electronic device is in a vertical or near vertical orientation, which could be indicative of cell phone being placed against the head of a human. In another instance, a vertical or near vertical orientation of the electronic device indicates that the electronic device is being carried by a user in the vertical orientation, e.g., in the user's pocket or in a case, holster, or other carrier. In another instance, a near perfect horizontal orientation of the electronic device **200** may indicate that the device is positioned on top of a surface, such as a table, counter or desk. The proscribed orientation circumstance may then be used to determine risk regarding the transmission of power waves to charge or power the electronic device that may expose the user to unsafe or undesirable radiation levels.

The orientation of the electronic device may indicate that the transmitter should increase the power waves transmitted to the electronic device. For example, an orientation circumstance of the electronic device generated by the one or

more sensors corresponds to an orientation of the electronic device in which the electronic device has a substantially horizontal orientation. A horizontal orientation of the electronic device may indicate that the electronic device has been left at that location for a period of time and may require charging or powering, especially when the orientation remains unchanged for a period of time. Furthermore, this orientation circumstance tends to indicate that the electronic device is not being held or carried by a user, and the power waves may be transmitted.

A proscribed motion circumstance of the electronic device corresponds to motion of the electronic device. The motion of the electronic device is determined from processing of the sensor data obtained from an accelerometer of the electronic device. The detection of motion of the electronic device indicates that the electronic device is being moved by a user. The proscribed motion circumstance and other proscribed circumstances therefore may indicate a risk that the transmission of power waves to charge or power the electronic device may expose the user to unsafe or undesirable radiation levels. In another embodiment, a proscribed motion circumstance of the electronic device includes a motion of the electronic device represented by the sensor data received from the electronic device, in combination with one or more additional sensor data that indicate presence of a living being.

A proscribed ambient light circumstance of the electronic device includes an ambient light reading of an ambient light sensor that has a low intensity in comparison with one or more other ambient light readings acquired near the electronic device. A low intensity measurement by an ambient light sensor indicates low ambient light in a room, and the electronic devices including the ambient light sensors may increase screen brightness to compensate. However, where an ambient light sensor from an electronic device detects a low intensity of light, whereas one or more ambient light readings acquired near the electronic device have a higher intensity, the low intensity light reading from the user light may indicate that the electronic device is in a user's pocket or otherwise carried by the user with the electronic device covered. This proscribed ambient light circumstance therefore may indicate a risk that the transmission of the power waves to charge or power the electronic device may expose the user to unsafe or undesirable radiation levels.

It should be understood by someone skilled in the art that that proscribed conditions related to motion, orientation, ambient light, heat sensors, magnetic sensors, or any other kind of sensors may be used as individual indicators or may be used in combination to indicate proscribed conditions that indicate a human being or a sensitive object is near a receiver. One or more proscribed conditions of the sensors may be combined along with time lapse indicators also. In addition, the considering of proscribed conditions, or sensor outputs, generated by one or more sensors may be processed according to a function to obtain a proscribed condition indicative of a human being being nearby. The function may be a single variable or multi variable function. The function may be a linear or non-linear function.

Temporal input to the decision making, regardless of what other sensors are used, may be a safety feature. The proscribed conditions may indicate that the receiver is placed on a horizontal surface and it is not moving, and therefore likely to have been placed on a table and may be appropriately charged. However the temporal input, such as a timer, which may also include a hysteresis, may also be included to assure that there was enough time for a human being to move away from the receiver after placing it on the table before generating the proscribed condition signal to trigger wireless charging.

It should be understood by someone skilled in the art that the sensors may be included in the electronic device or they may be included in the receiver, or both. It should also be understood that the receiver may be an integral part of the electronic device or may be removably connected to the electronic device. Communication of signals maybe from the electronic device to the transmitter or may be from a separate transmitter of the receiver to the transmitter of the power waves.

It should be understood by someone skilled in the art that the sensor outputs may be used in determining presence of proscribed conditions as the sensor data is generated, or a time average of multiple sensor outputs may be used in determining the proscribed condition exists.

In some embodiments, the transmitter receives the sensor data at different points in time from the one or more sensors of the electronic device. The one or more proscribed circumstances is then calculated based upon the sensor data obtained over a period of time. In one embodiment, a proscribed motion circumstance may be represented by a change of value of the sensor data over the different points in time and thereby indicating a motion of the electronic device. In another embodiment, a proscribed orientation circumstance of the electronic device is a change in orientation of the electronic device indicated by the sensor data at different points in time. In another embodiment, clocking data is generated to determine the period of time since the last change in any of the above described sensor circumstances described above.

In another embodiment, the transmitter receives the sensor data from the one or more sensors of the electronic device representative of at least two of the proscribed orientation circumstance of the electronic device, the proscribed motion circumstance of the electronic device, the proscribed ambient light circumstance of the electronic device and the time that has elapsed since the last change in the respective sensor circumstances described above. In another embodiment, the transmitter receives the sensor data from an orientation sensor of the electronic device, wherein the orientation sensor output is representative of both a proscribed orientation circumstance of the electronic device and a proscribed motion circumstance of the electronic device.

At step **306**, transmitter may adjust (e.g., increase, decrease, or cease) transmission based upon a likely proximity of a living being or sensitive object with the power waves or electronic device. In some embodiments, the transmitter reduces the power level of the power waves. In other embodiments, the transmitter terminates transmission of the power waves. In other embodiments in this circumstance, the transmitter terminates transmission of the power waves to the location of the electronic device. In further embodiments, the transmitter forms a null space in the power waves at the location of the electronic device.

FIG. **4** is a flow diagram illustrating a method **400** of transmitting power waves to or nearby receivers coupled to or integrated into electronic devices located within a transmission field of one or more transmitters of a wireless power transmission system, according to an exemplary embodiment.

At step **402**, a transmitter receives sensor data from one or more sensors of the electronic device. In an embodiment, the electronic device may include one or more sensors. It should be understood by someone skilled in the art that the

sensors may be included in the electronic device or they may be included in the receiver, or both. It should also be understood that the receiver may be an integral part of the electronic device or may be removably connected to the electronic device.

The one or more sensors may be selected from a group consisting of an accelerometer, a gyroscope, and an ambient light sensor. Each of the one or more sensors may work independently to produce sensor data. In some embodiment, each of the one or more sensors work together to produce sensor data. The sensor data may be used in determining presence of proscribed conditions as the sensor data is generated, or a time average of multiple sensor outputs may be used in determining the proscribed condition exists.

In some embodiments, the transmitter receives the sensor data at different points in time from the one or more sensors of the electronic device. The one or more proscribed circumstances may then be calculated based upon the sensor data obtained over a period of time. In one embodiment, a proscribed motion circumstance may be represented by a change of value of the sensor data over the different points in time and thereby indicating a motion of the electronic device. In another embodiment, a proscribed orientation circumstance of the electronic device is a change in orientation of the electronic device indicated by the sensor data at different points in time. In another embodiment, clocking data may be generated to determine the period of time since the last change according to one or more sensor-related circumstances described above.

At step **404**, the transmitter transmits power waves that converge in a three-dimensional space to form a constructive interference pattern at the receiver based on the sensor data. In some embodiments, multiple transmitters and/or multiple receivers may power various electronic devices. The receiver may be separable from the electronic device or integrated with the electronic device.

At step **406**, the transmitter may receive updated sensor data at different points in time from the one or more sensors of the electronic device, and may adjust (e.g., increase, decrease, or cease) transmission based upon the updated sensor data. For example, when the updated sensor data indicates a likely proximity of a living being or sensitive object with the power waves or electronic device, the transmitter may adjust (e.g., increase, decrease, or cease) transmission. In some embodiments, the transmitter reduces the power level of the power waves. In other embodiments, the transmitter terminates transmission of the power waves. In other embodiments in this circumstance, the transmitter terminates transmission of the power waves to the location of the electronic device. In further embodiments, the transmitter forms a null space in the power waves at the location of the electronic device.

FIG. **5** is a flow diagram **500** illustrating a method of transmitting power waves to receivers coupled to or integrated into electronic devices located within a transmission field of a transmitter of a wireless

At step **502**, a transmitter transmits power waves that converge in three dimensional space to form a constructive interference pattern at or proximate to the location of the receiver. In some embodiments, multiple transmitters and/or multiple receivers may power various electronic devices. The receiver may be separable from the electronic device or integrated with the electronic device.

At step **504**, the transmitter receives input from the electronic device. The input is determined by the electronic device based on sensor data. In an embodiment, the electronic device may include one or more sensors. It should be understood by someone skilled in the art that the sensors may be included in the electronic device or they may be included in the receiver, or both. It should also be understood that the receiver may be an integral part of the electronic device or may be removably connected to the electronic device.

The one or more sensors may be selected from a group consisting of an accelerometer, a gyroscope, and an ambient light sensor. Each of the one or more sensors may work independently to produce sensor data that is processed by the electronic device. In some embodiment, each of the one or more sensors work together to produce sensor data. The sensor data from the electronic device may include orientation data, motion data, and/or ambient light data, or may be representative of one or more proscribed circumstance that may indicate when a living being or sensitive object, such as a human, may be interacting with the electronic device and thus in close proximity to a pocket of energy, power waves, and/or the transmitter. In some embodiments, the proscribed circumstances may include a proscribed orientation circumstance, a proscribed motion circumstance, and/or a proscribed ambient light circumstance of the electronic device.

In response to the sensor data received from the sensors, a processor of the electronic device may process the sensor data and determine whether to reduce intensity of power waves, terminate transmission of power waves, or may form a null space at or near the electronic device, among a number of additional or alternative actions. Based on the determinations whether to reduce intensity of power waves, terminate transmission of power waves, or may form a null space at or near the electronic device, the electronic device generate an input comprising instructions to reduce intensity of power waves, terminate transmission of power waves, or may form a null space at or near the electronic device and send it to the transmitter.

At step **506**, the transmitter, based on the input received from the electronic device, adjust (e.g., increase, decrease, or cease) transmission based upon a likely proximity of a living being or sensitive object with the power waves or electronic device. In some embodiments, the transmitter reduces the power level of the power waves. In other embodiments, the transmitter terminates transmission of the power waves. In other embodiments in this circumstance, the transmitter terminates transmission of the power waves to the location of the electronic device. In further embodiments, the transmitter forms a null space in the power waves at the location of the electronic device.

The foregoing method descriptions and the process flow diagrams are provided merely as illustrative examples and are not intended to require or imply that the steps of the various embodiments must be performed in the order presented. As will be appreciated by one of skill in the art the steps in the foregoing embodiments may be performed in any order. Words such as "then," "next," etc. are not intended to limit the order of the steps; these words are simply used to guide the reader through the description of the methods. Although process flow diagrams may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination may correspond to a return of the function to the calling function or the main function.

The various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

Embodiments implemented in computer software may be implemented in software, firmware, middleware, microcode, hardware description languages, or any combination thereof. A code segment or machine-executable instructions may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

The actual software code or specialized control hardware used to implement these systems and methods is not limiting of the invention. Thus, the operation and behavior of the systems and methods were described without reference to the specific software code being understood that software and control hardware can be designed to implement the systems and methods based on the description herein.

What is claimed is:

1. A method for wireless power transmission comprising:

at a wireless power transmitter comprising a communications component, antennas that are distinct from the communications component, and one or more processors:

requesting, via the communications component, sensor data from a receiver device;

receiving, via the communications component, sensor data from the receiver device in response to the request, wherein the sensor data is generated by one or more sensors of the receiver device;

determining, by the one or more processors, whether the receiver device is in a proscribed state for wireless power reception based, on the received sensor data; and

in accordance with determining that the receiver device is not in the proscribed state: transmitting, by antennas of the wireless power transmitter, a plurality of wireless power transmission waves to the receiver device so that each wireless power transmission wave of the plurality of wireless power transmission waves constructively interferes with at least one other wireless power transmission wave of the plurality of wireless power transmission waves.

2. The method of claim **1**, wherein the one or more sensors are selected from the group consisting of an accelerometer, a gyroscope, an orientation sensor, and an ambient light sensor.

3. The method of claim **1**, wherein determining whether the receiver device is not in the proscribed state comprises determining that the receiver device is positioned in a substantially horizontal orientation based on the received sensor data.

4. The method of claim **3**, wherein:

the received sensor data includes orientation data for first and second points in time;

the receiver device is positioned in a substantially horizontal orientation at the first point in time; and

determining that the receiver device is positioned in the substantially horizontal orientation comprises determining that differences, if any, in first orientation data from the first point in time as compared to second orientation data from the second period of time do not satisfy an orientation-change threshold.

5. The method of claim **1**, wherein determining whether the receiver device is not in the proscribed state comprises determining that the receiver device is stationary based on the received sensor data.

6. The method of claim **5**, wherein:

the received sensor data includes motion data for at least two different points in time, and

determining that the receiver device is stationary comprises determining that differences, if any, in respective motion data from the at least two different points in time do not satisfy a movement-detection threshold.

7. The method of claim **1**, wherein determining whether the receiver device is not in the proscribed state comprises determining that an ambient light reading included in the received sensor data satisfies a light-detection threshold.

8. The method of claim **1**, further comprising, at the wireless power transmitter:

in accordance with determining that the receiver device is in the proscribed state, forgoing transmission of the plurality of wireless power transmission waves.

9. The method of claim **1**, further comprising, at the wireless power transmitter while transmitting the plurality of wireless power transmission waves:

requesting, via the communications component, additional sensor data from the receiver device;

receiving, via the communications component, additional sensor data from the receiver device in response to the request, wherein the additional sensor data is generated by the one or more sensors of the receiver device;

determining, by the one or more processors, whether the receiver device is in the proscribed state for wireless power reception based on the additional sensor data; and

in accordance with determining that the receiver device is in the proscribed state for wireless power reception based on the additional sensor data, ceasing transmission of the plurality of wireless power transmission waves.

10. The method of claim **9**, further comprising, at the wireless power transmitter while transmitting the plurality of wireless power transmission waves:

in accordance with determining based on the additional sensor data that (i) the receiver device is not in the proscribed state and (ii) the receiver device has changed location, adjusting at least one characteristic of the plurality of wireless power transmission waves.

11. The method of claim **10**, wherein the at least one characteristic is selected from the group consisting of phase, gain, direction, amplitude, and frequency.

12. A wireless power transmitter comprising:

a communications component;

antennas that are distinct from the communications component;

one or more processors; and

memory storing one or more programs that are configured for execution by the one or more processors, the one or more programs including instructions for:

requesting, by the communications component, sensor data from a receiver device;

receiving, by the communications component, sensor data from the receiver device in response to the request, wherein the sensor data is generated by one or more sensors of the receiver device;

determining, by the one or more processors, whether the receiver device is in a proscribed state for wireless power reception based on the received sensor data; and

transmitting, by the antennas, a plurality of wireless power transmission waves to the receiver device in accordance with determining that the receiver device is not in the proscribed state so that each wireless power transmission wave of the plurality of wireless power transmission waves constructively interferes with at least one other wireless power transmission wave of the plurality of wireless power transmission waves.

13. The wireless power transmitter of claim **12**, wherein the one or more sensors are selected from the group consisting of an accelerometer, a gyroscope, an orientation sensor, and an ambient light sensor.

14. The wireless power transmitter of claim **12**, wherein determining whether the receiver device is not in the proscribed state comprises determining that the receiver device is positioned in a substantially horizontal orientation based on the received sensor data.

15. The wireless power transmitter of claim **14**, wherein:

the received sensor data includes orientation data for first and second points in time;

the receiver device is positioned in a substantially horizontal orientation at the first point in time; and

determining that the receiver device is positioned in the substantially horizontal orientation comprises determining that differences, if any, in first orientation data from the first point in time as compared to second orientation data from the second period of time do not satisfy an orientation-change threshold.

16. The wireless power transmitter of claim **12**, wherein determining whether the receiver device is not in the proscribed state comprises determining that the receiver device is stationary based on the received sensor data.

17. The wireless power transmitter of claim **16**, wherein:

the received sensor data includes motion data for at least two different points in time, and

determining that the receiver device is stationary comprises determining that differences, if any, in respective motion data from the at least two different points in time do not satisfy a movement-detection threshold.

18. The wireless power transmitter of claim **12**, wherein determining whether the receiver device is in the pre-approved state comprises determining that an ambient light reading included in the received sensor data satisfies a light-detection threshold.

19. The wireless power transmitter of claim **12**, wherein the one or more programs further include instructions for:

in accordance with determining that the receiver device is in the proscribed state, forgoing transmission of the plurality of wireless power transmission waves.

20. The wireless power transmitter of claim **12**, wherein the one or more programs further include instructions for, while transmitting the plurality of wireless power transmission waves:

requesting, via the communications component, additional sensor data from the receiver device;

receiving, via the communications component, additional sensor data from the receiver device in response to the request, wherein the additional sensor data is generated by the one or more sensors of the receiver device;

determining, by the one or more processors, whether the receiver device is in the proscribed state for wireless power reception based on the additional sensor data; and

in accordance with determining that the receiver device is in the proscribed state for wireless power reception based on the additional sensor data, ceasing transmission of the plurality of wireless power transmission waves.

21. The wireless power transmitter of claim **19**, wherein the one or more programs further include instructions for, while transmitting the plurality of wireless power transmission waves:

in accordance with determining based on the additional sensor data that (i) the receiver device is not in the proscribed state and (ii) the receiver device has changed location, adjusting at least one characteristic of the plurality of wireless power transmission waves.

22. The wireless power transmitter of claim **20**, wherein the at least one characteristic is selected from the group consisting of phase, gain, direction, amplitude, and frequency.

23. The method of claim **9**, further comprising, at the wireless power transmitter while transmitting the plurality of wireless power transmission waves:

in accordance with determining based on the additional sensor data that (i) the receiver device is not in the proscribed state and (ii) the receiver device has changed orientation, adjusting at least one characteristic of the plurality of wireless power transmission waves.

24. The wireless power transmitter of claim **19**, wherein the one or more programs further include instructions for, while transmitting the plurality of wireless power transmission waves:

in accordance with determining based on the additional sensor data that (i) the receiver device is not in the proscribed state and (ii) the receiver device has changed orientation, adjusting at least one characteristic of the plurality of wireless power transmission waves.

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