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(54) **WIRELESS CHARGING TRANSMITTERS THAT USE SENSOR DATA TO ADJUST TRANSMISSION OF POWER WAVES**

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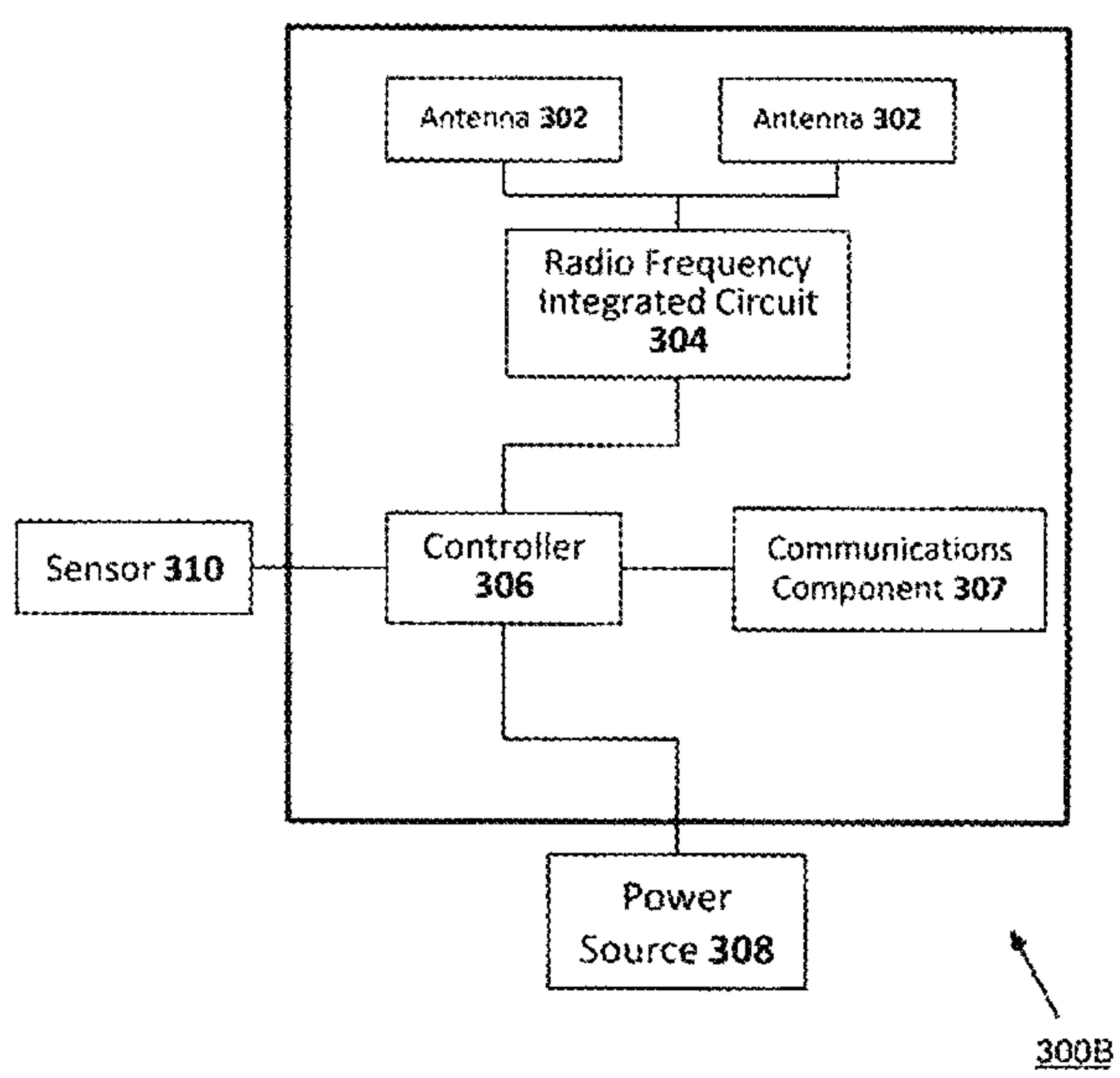
(57) **ABSTRACT**

Disclosed herein are examples of wireless charging transmitters and methods. As one example, a wireless charging transmitter includes a sensor to detect the presence of a receiver device and/or a living being and the sensor generates data according to the presence detected. The wireless charging transmitter also includes an array of antennas configured to transmit power waves to the receiver device and a surface layer that is adjacent to the array of antennas. The transmitted power waves converge to form a constructive interference pattern at a non-zero distance from the surface layer. The non-zero distance being based on the sensor data. Further, the phases and amplitudes of the transmitted power waves are determined based, at least in part, on the sensor data.

20 Claims, 10 Drawing Sheets



Related U.S. Application Data

continuation-in-part of application No. 14/861,285, filed on Sep. 22, 2015, now Pat. No. 9,948,135, which is a continuation-in-part of application No. 14/585, 341, filed on Dec. 30, 2014, now Pat. No. 9,812,890, which is a continuation-in-part of application No. 13/939,706, filed on Jul. 11, 2013, now Pat. No. 9,143,000.

(58) **Field of Classification Search**
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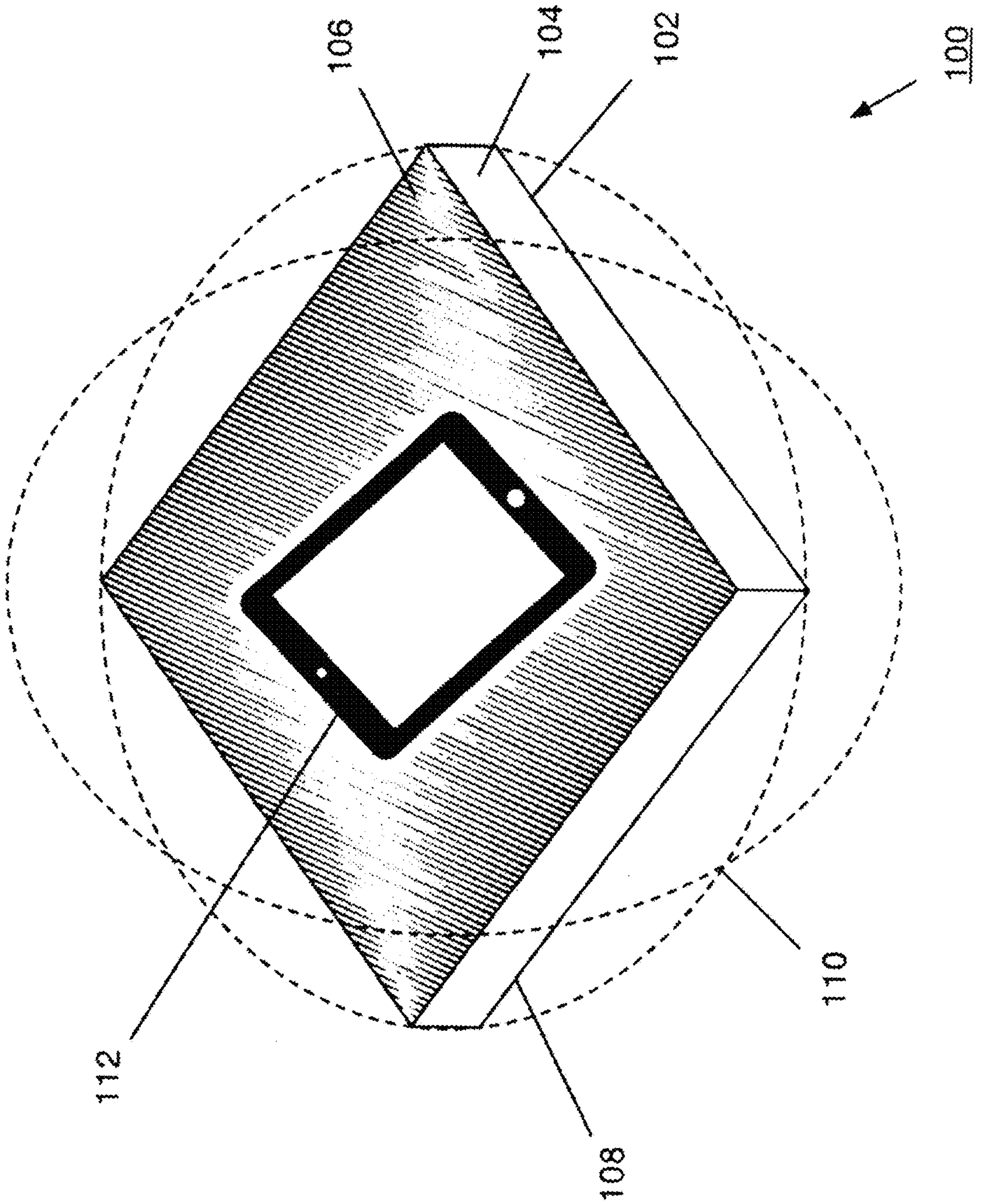

FIG. 1

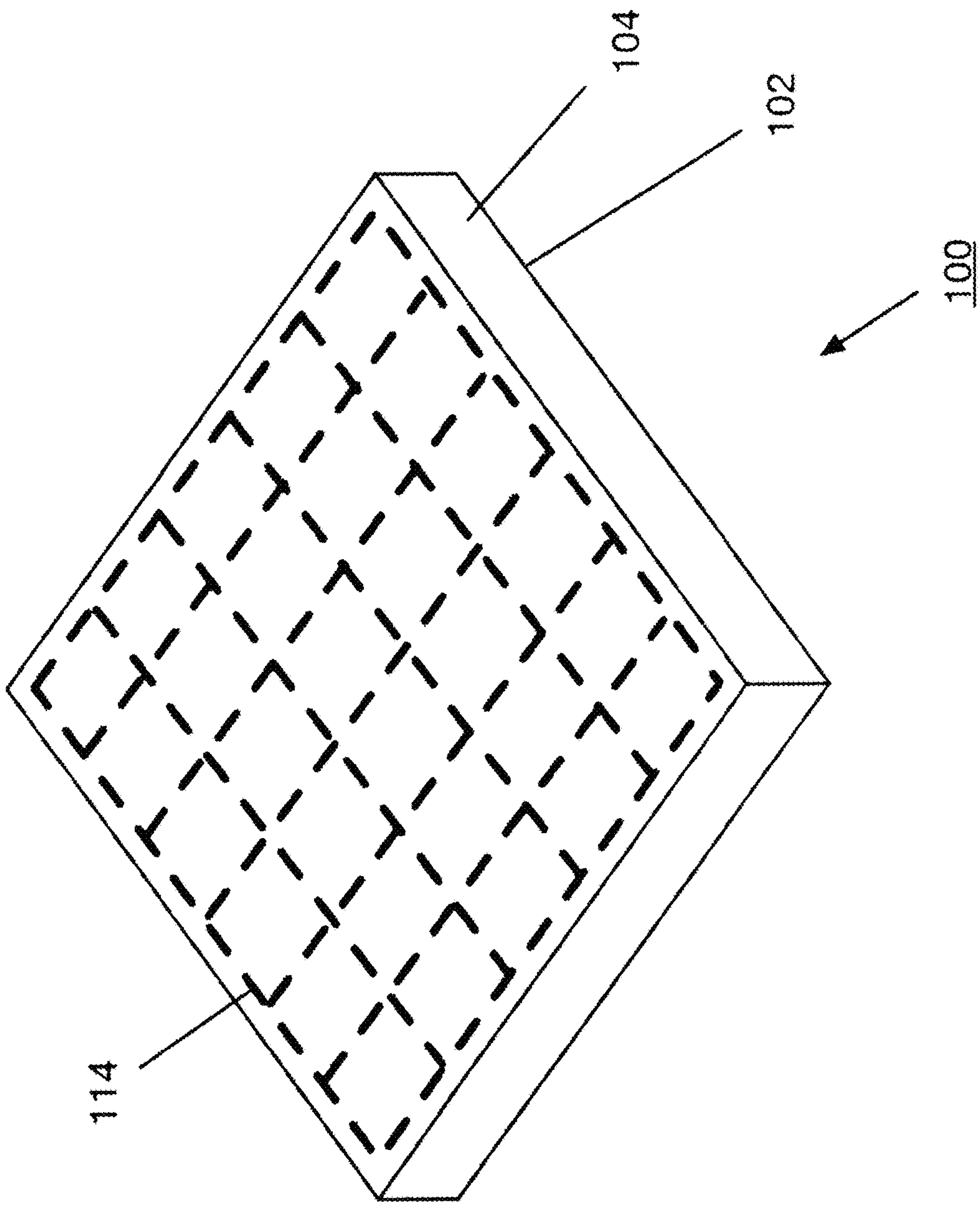

FIG. 2

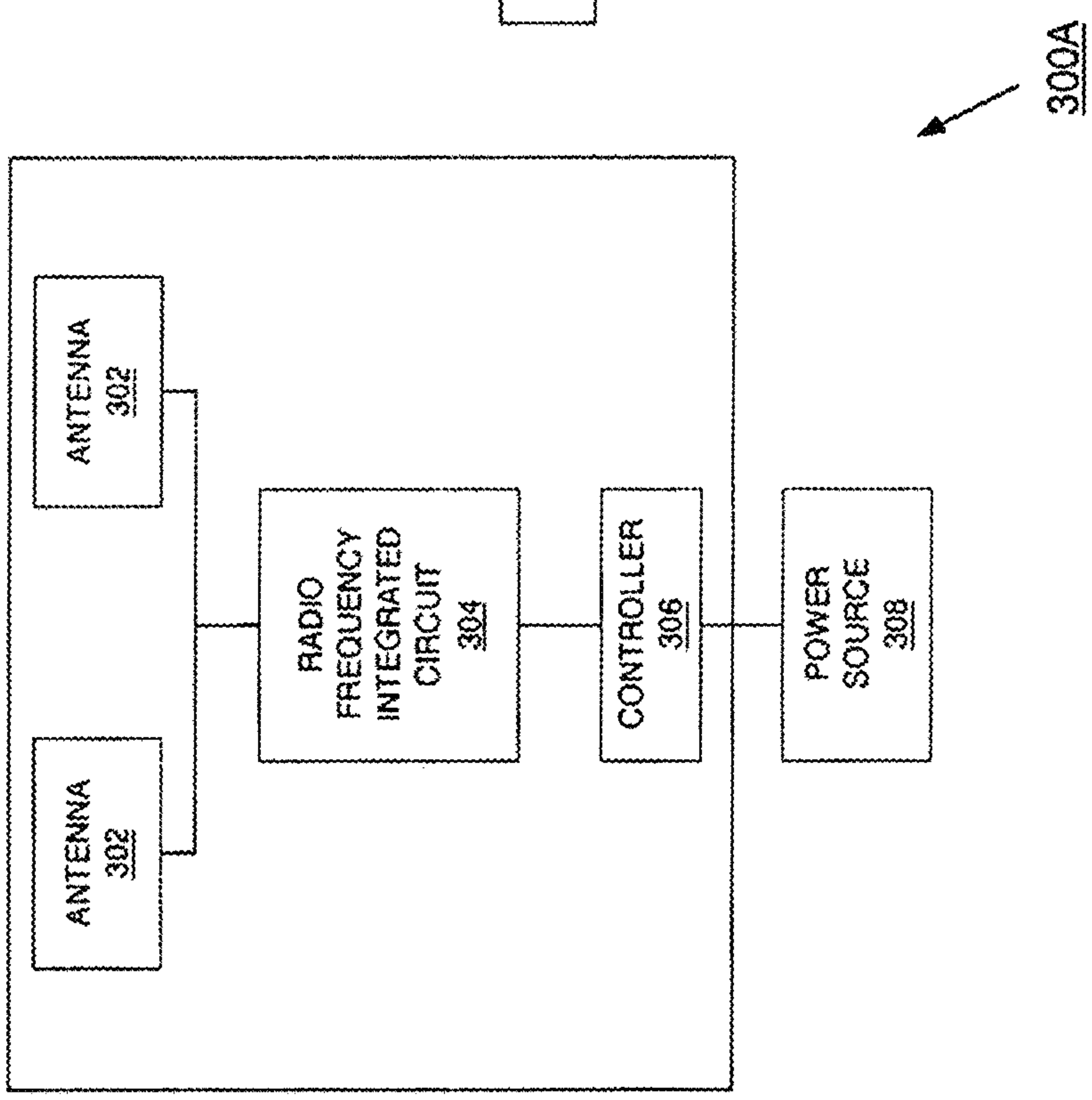
300A
ANTENNA 302
ANTENNA 302
RADIO FREQUENCY INTEGRATED CIRCUIT 304
CONTROLLER 306
POWER SOURCE 308

FIG. 3A

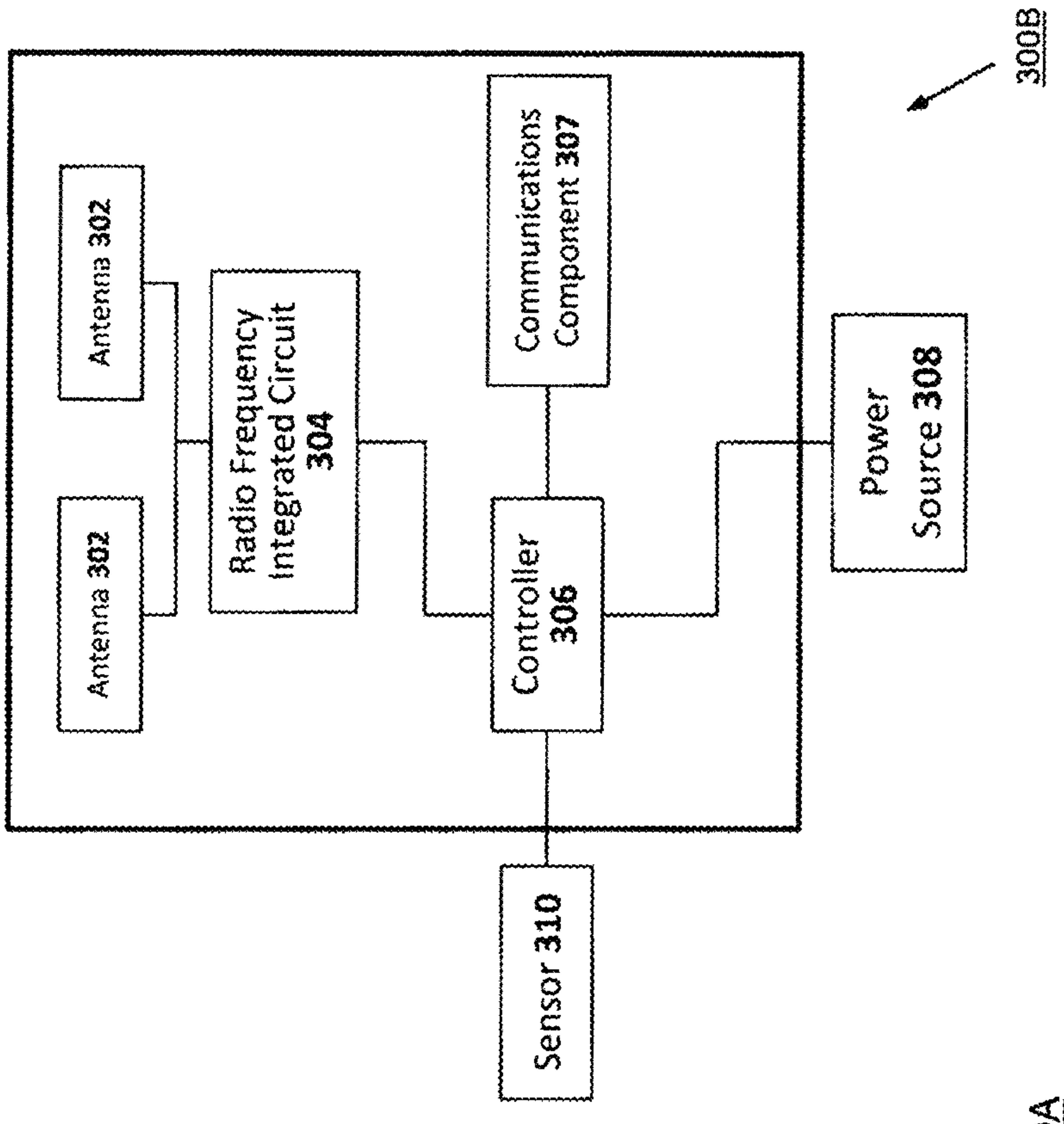
300B
Antenna 302
Antenna 302
Radio Frequency Integrated Circuit 304
Communications Component 307
Controller 306
Power Source 308
Sensor 310

FIG. 3B

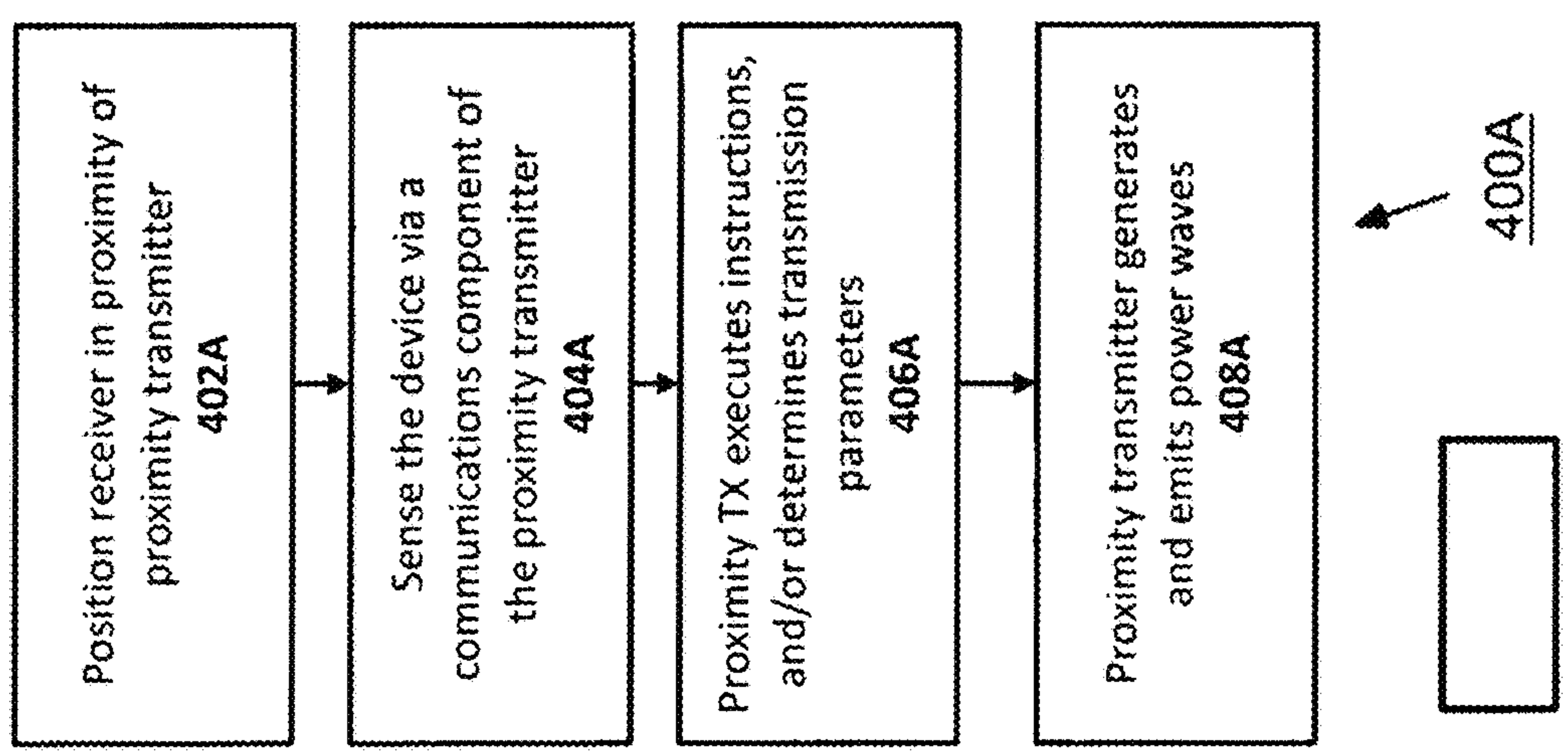
Position receiver in proximity of proximity transmitter
402A
Sense the device via a communications component of the proximity transmitter
404A
Proximity TX executes instructions, and/or determines transmission parameters
406A
Proximity transmitter generates and emits power waves
408A
400A

FIG. 4A

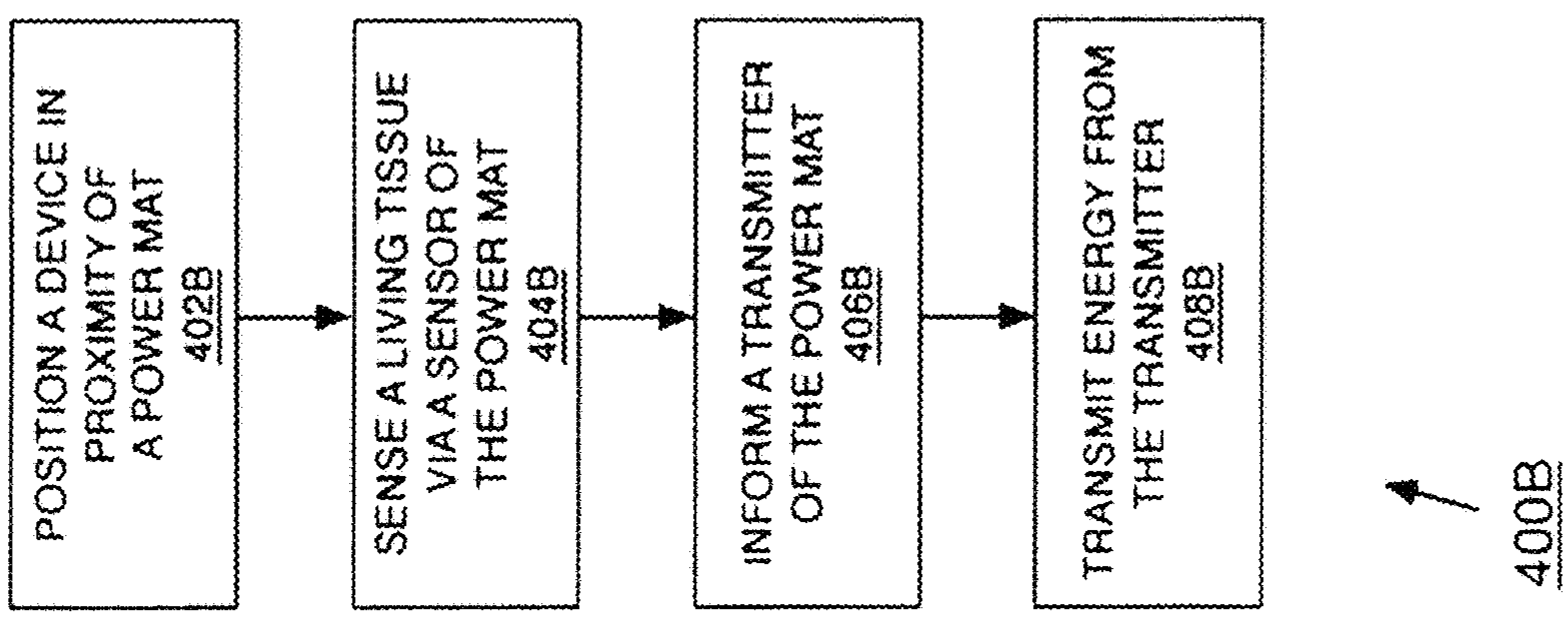
POSITION A DEVICE IN PROXIMITY OF A POWER MAT
402B
SENSE A LIVING TISSUE VIA A SENSOR OF THE POWER MAT
404B
INFORM A TRANSMITTER OF THE POWER MAT
406B
TRANSMIT ENERGY FROM THE TRANSMITTER
408B
400B

FIG. 4B

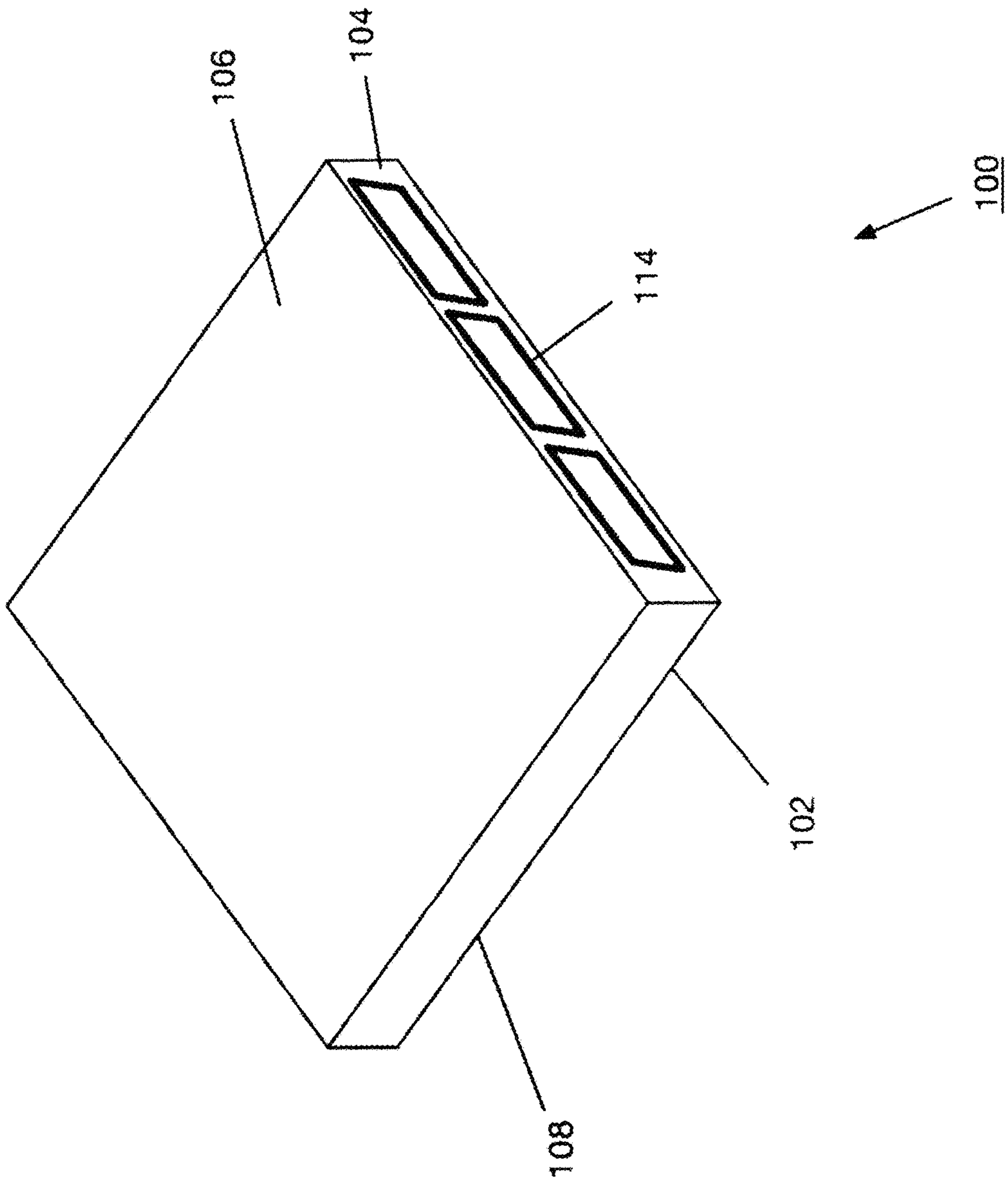

FIG. 5

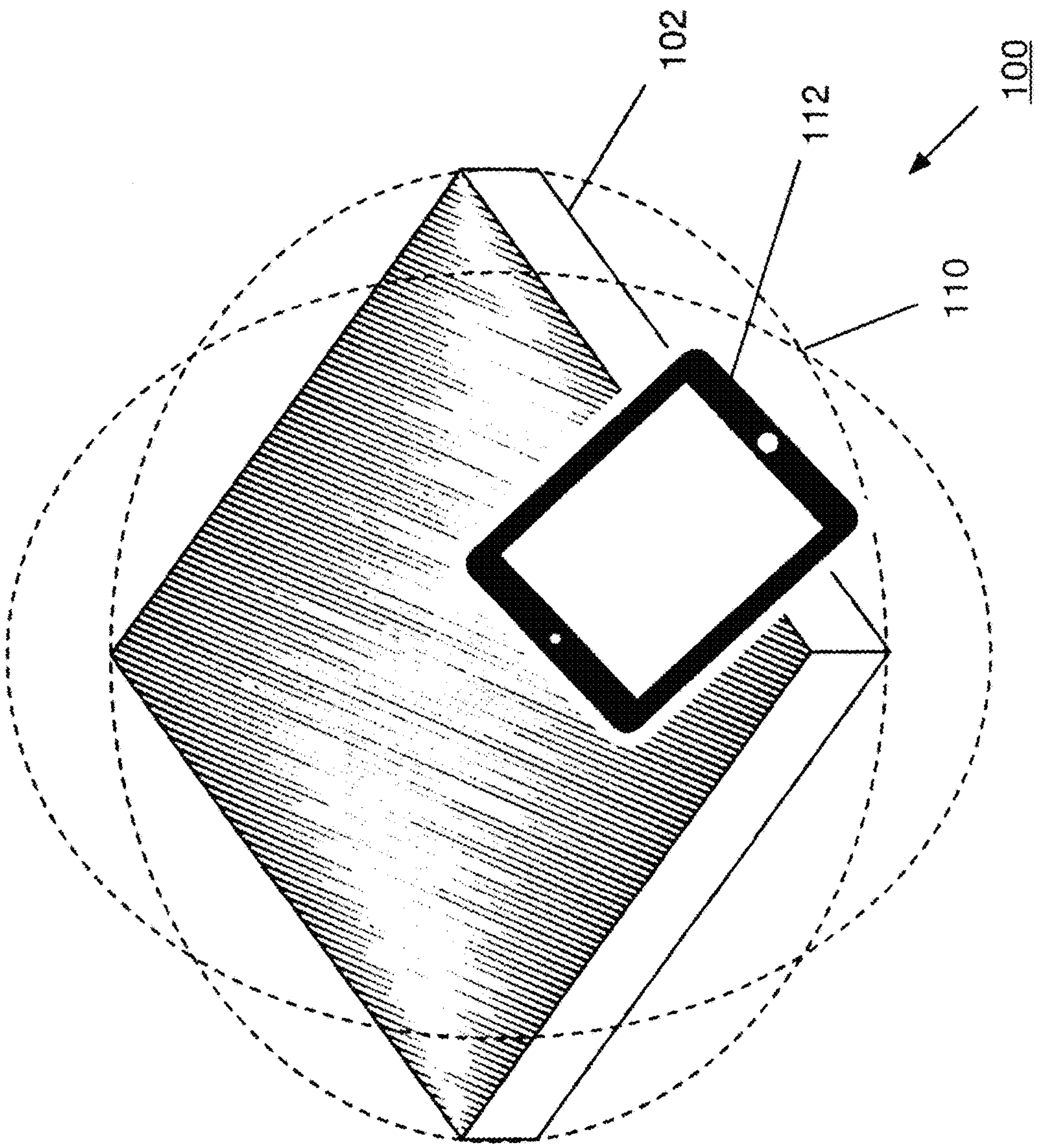

FIG. 6

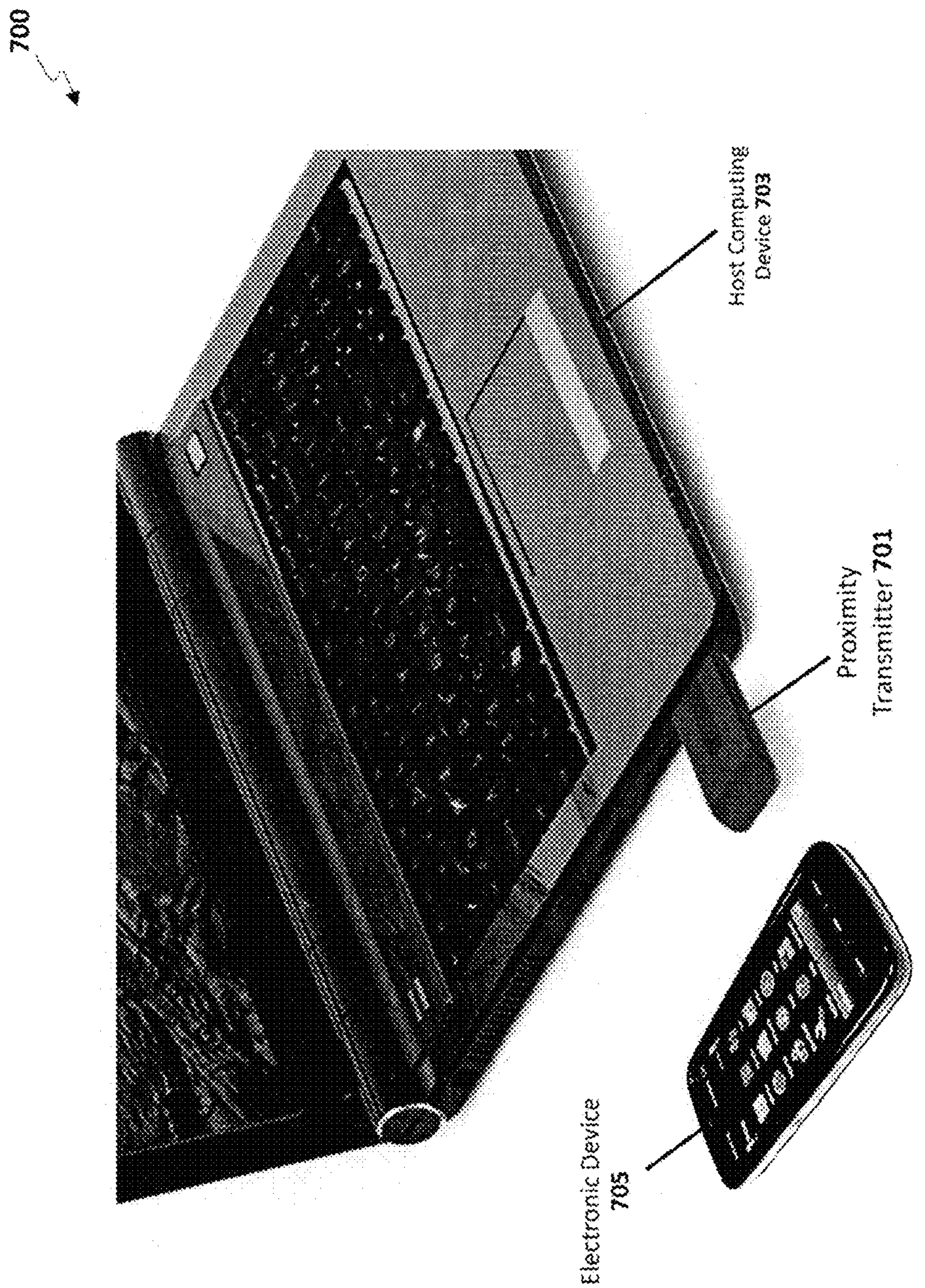
700
Host Computing Device 703
Proximity Transmitter 701
Electronic Device 705

FIG. 7

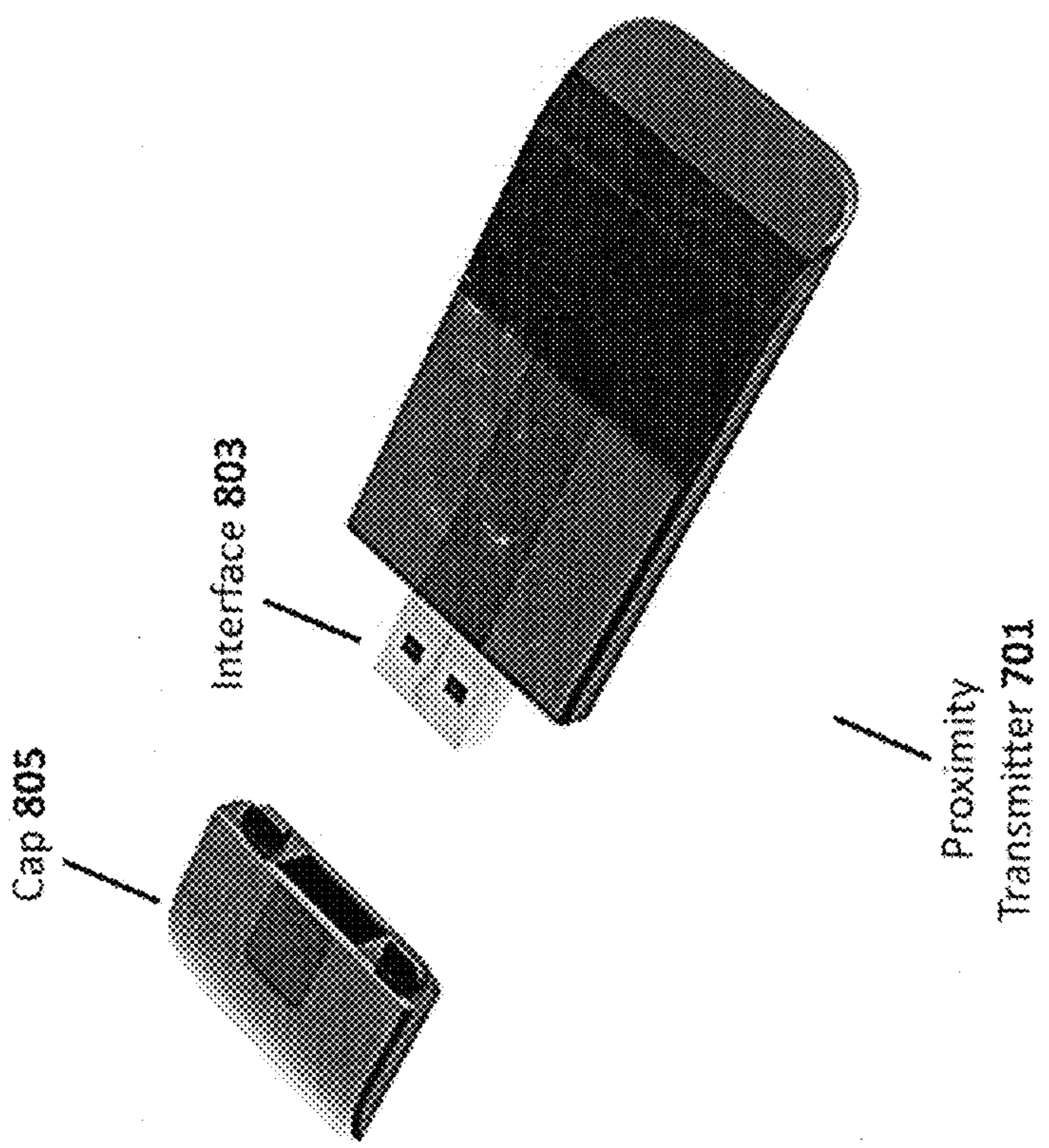
Cap 805
Interface 803
Proximity Transmitter 701

FIG. 8A

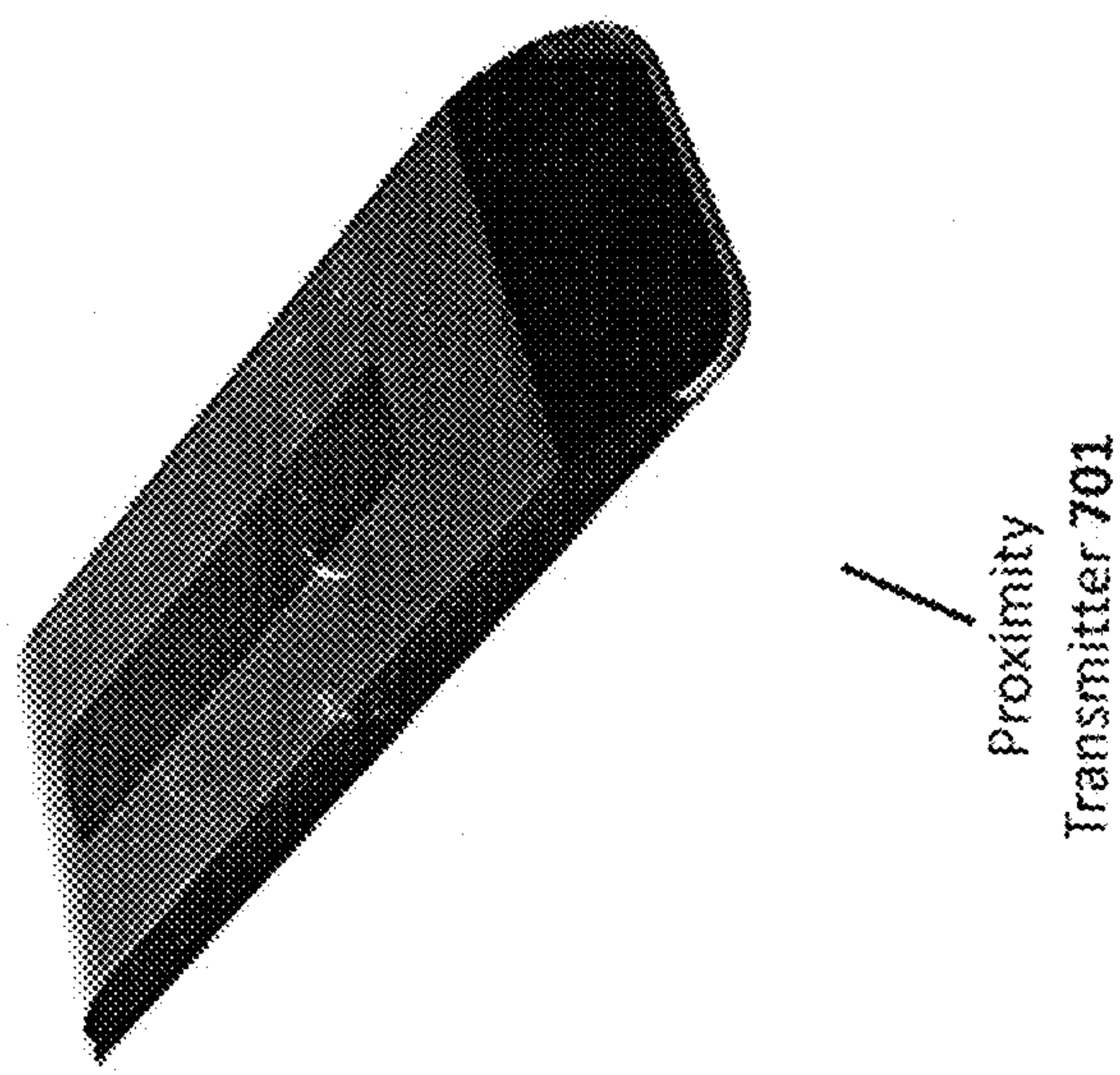
Proximity Transmitter 701

FIG. 8B

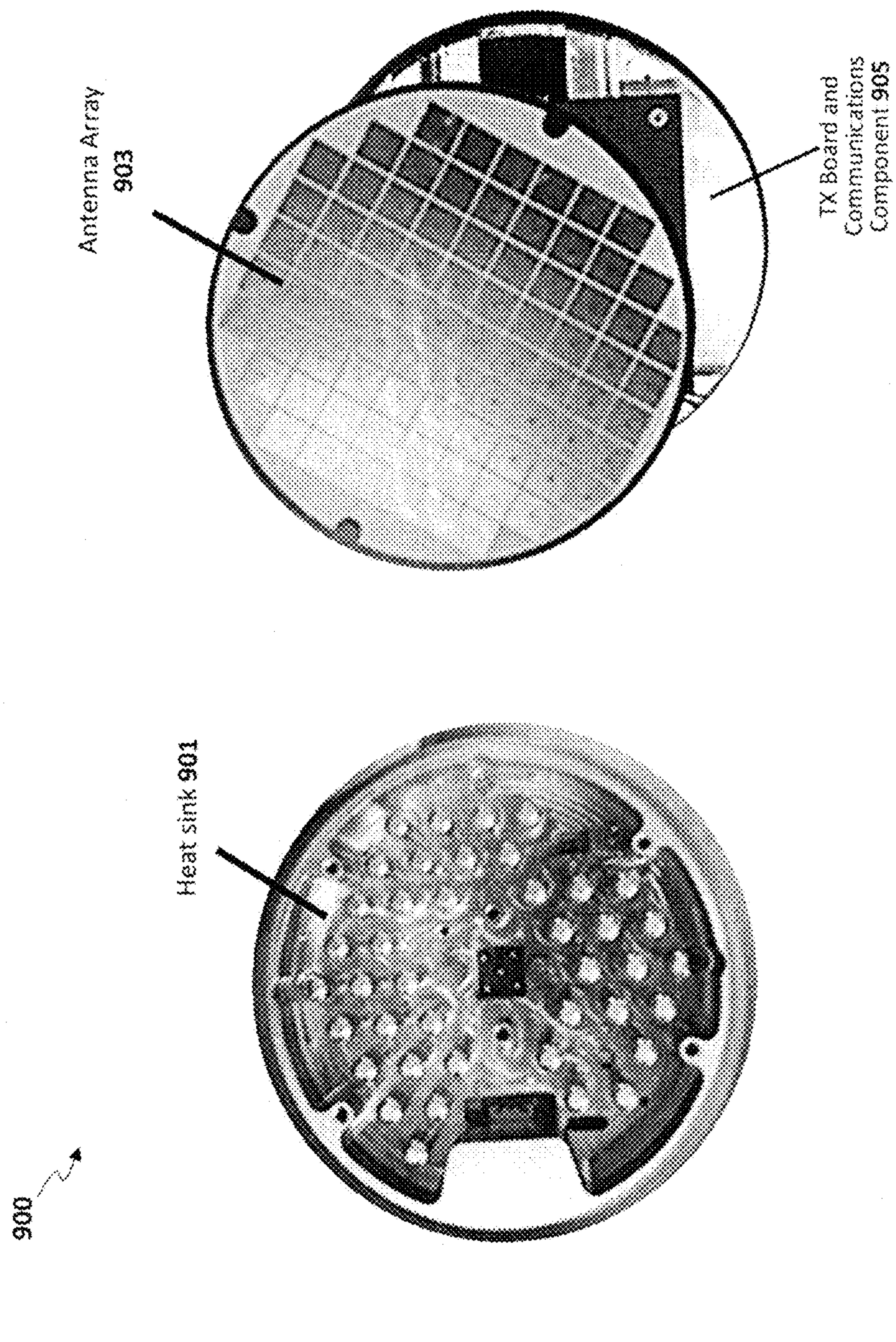
Antenna Array
903
TX Board and
Communications
Component 905
Heat sink 901
900

FIG. 9

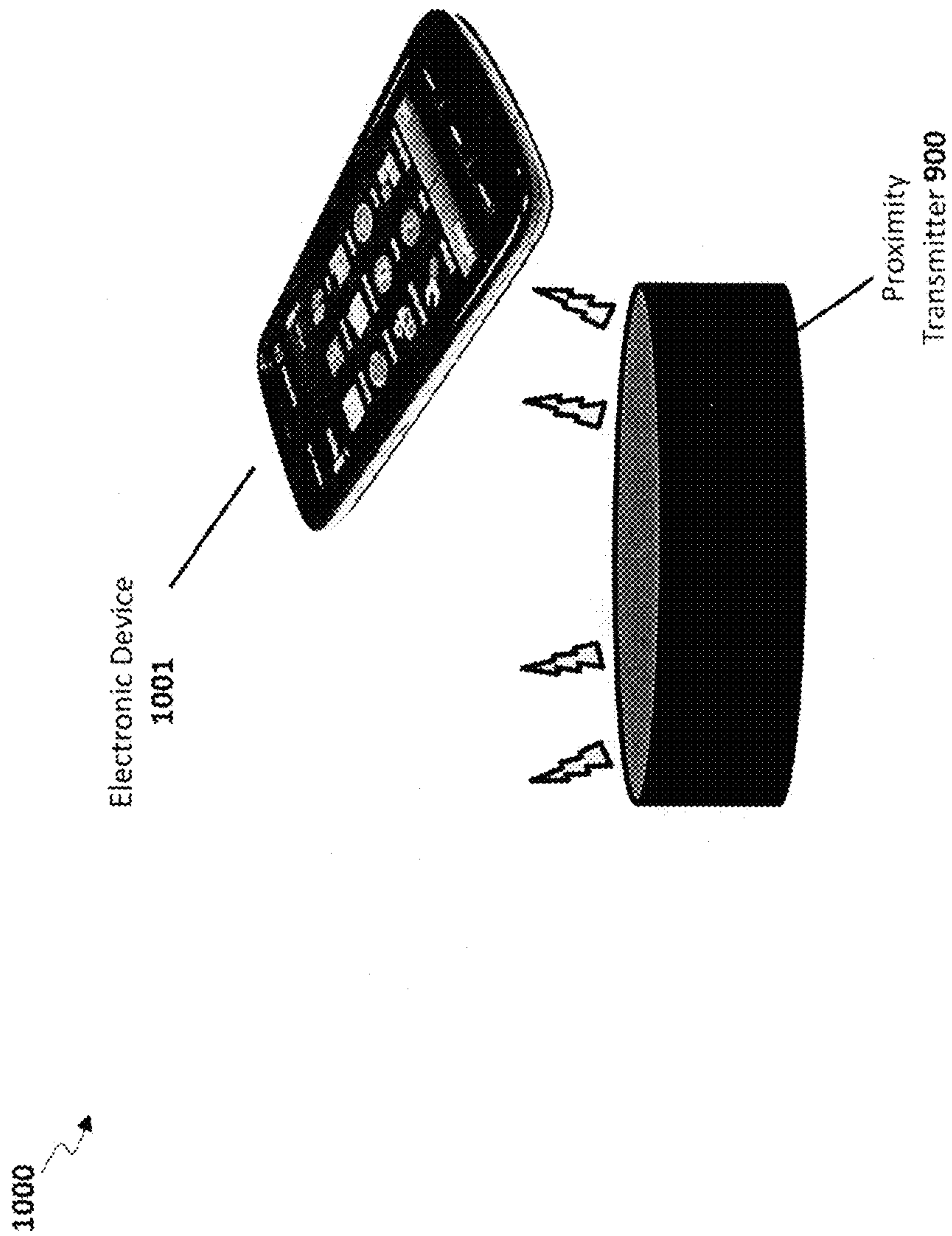

FIG. 10

WIRELESS CHARGING TRANSMITTERS THAT USE SENSOR DATA TO ADJUST TRANSMISSION OF POWER WAVES

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/757,568, filed on Dec. 24, 2015, entitled "Proximity transmitters for wireless power charging systems," which is hereby incorporated by reference in its entirety.

U.S. patent application Ser. No. 14/757,568 is a continuation-in-part of U.S. patent application Ser. No. 14/585,341, filed on Dec. 30, 2014, which is a continuation-in-part of U.S. patent application Ser. No. 13/939,706, filed on Jul. 11, 2013, each of which is hereby incorporated by reference in its respective entirety.

U.S. patent application Ser. No. 14/757,568 is also a continuation-in-part of U.S. patent application Ser. No. 14/861,285, filed on Sep. 22, 2015, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

Generally, the present disclosure relates to wireless charging. More particularly, the present disclosure relates to wireless charging transmitters.

BACKGROUND

Electronic devices, such as laptop computers, smartphones, portable gaming devices, tablets, or others, require power to operate. This state of being may entail having to charge electronic equipment at least once a day, or in high-use or power-hungry electronic devices, more than once a day. Such activity may be tedious and may present a burden to some users. For example, a user may be required to carry chargers in case his electronic equipment is lacking power. In addition, some users have to find available power sources to connect to, which is time consuming. Lastly, some users must plug into a wall or some other power supply to be able to charge their electronic device. However, such activity may render electronic devices inoperable or not portable during charging.

Some conventional solutions include an inductive charging pad, which may employ magnetic induction or resonating coils. Nevertheless, such a solution may still require that electronic devices may have to be placed in a specific place on the inductive charging pad for powering. Therefore, electronic devices may not sufficiently charge or may not receive a charge if not oriented properly on the inductive charging pad.

Accordingly, there is a desire for a charging pad with that allows for wireless charging without requiring a particular orientation and providing a sufficient charge. As such, what is needed is a means for transmitting energy through an alternative means for wireless power charging other than conventional magnetic induction. Consequently, what is needed are systems and methods for transmitting energy through waveforms of various types.

SUMMARY

Disclosed herein are systems and methods addressing the shortcomings in the art, and may also provide additional or alternative advantages as well. The embodiments described herein provide a wireless charging proximity transmitter configured to intelligently generate and transmit waveforms of various types, such as radio-frequency waves and ultrasound waves, among others. The wireless charging transmitter may be used for providing energy to a receiver that is proximately located to the transmitter. The receiver may be associated with, coupled to, and/or may be a component of, an electrical device that is intended to receive the power from the wave-based energy produced by the wireless proximity transmitter for operating the electrical device and/or charging its battery.

In one embodiment, a wireless charging proximity transmitter comprises an array of one or more antennas; and a surface layer proximate to the array of antennas, wherein the transmitter is configured to transmit one or more power waves to a receiver in response to a device associated with the receiver being within a proximity threshold of the surface layer of the proximity transmitter. Depending on the distance of the surface layer from the array of antennas and on other system parameters, the waves may exhibit varying levels of convergence. For example the waves may converge to form a pocket of energy at the surface layer, or they may loosely converge to form a general area at or near the surface layer in which the power waves are present.

In another embodiment, a wireless charging proximity transmitter comprises a housing comprising: an upper surface layer; a lower surface layer; at least one side wall extending from the lower surface layer to the upper surface layer; an array of one or more antennas positioned between the lower surface layer and the upper surface layer; and a controller configured to transmit one or more power waves from the array of one or more antennas, the one or more power waves transmitted to converge at a location of a device associated with a receiver upon identifying the device within a proximity threshold from a portion of the upper surface layer of the proximity transmitter. Depending on the distance of the surface layer from the array of antennas and on other system parameters, the waves may exhibit varying levels of convergence. For example the waves may converge to form a pocket of energy at the surface layer, or they may loosely converge to form a general area at or near the surface layer in which the power waves are present.

In another embodiment, a transmitter device for wireless power charging, the transmitter comprising: an interface of a type of connection configured to couple to a computing device at a corresponding interface of the type of connection of the computing device, and to receive electrical current from the computing device via the corresponding interface of the computing device; and a first set of one or more antennas configured to transmit one or more power waves to the receiver when the device associated with the receiver is within a proximity threshold to the transmitter. Communications signals from the receiver indicating a location of the receiver with respect to the transmitter may indicate physical location, such as distance and direction, or relative location expressed in a coordinate system, or alternatively may indicate only proximity as may be expressed as distance, power level, or other measurement.

In another embodiment, a method of wireless charging, the method comprising: receiving, by a proximity transmitter comprising an interface configured to couple the proximity transmitter at a corresponding interface of a computing device, electric current from a computing device via a corresponding interface between the computing device and the interface transmitter device; and transmitting, by a first set of one or more antennas of the proximity transmitter, one or more power waves at a direction of a device associated with a receiver when the device associated with the receiver is a distance from the proximity transmitter satisfying a proximity threshold.

Numerous other aspects, features and benefits of the present disclosure may be made apparent from the following detailed description taken together with the drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present disclosure are described by way of example with reference to the accompanying figures, which are schematic and may not be drawn to scale. Unless indicated as representing prior art, the figures represent aspects of the present disclosure.

FIG. **1** illustrates a wireless charging proximity transmitter transmitting one or more power waves such that the one or more power waves converge in a three dimensional space to form one or more pockets of energy, in accordance with an embodiment of the present disclosure.

FIG. **2** illustrates a charging proximity transmitter comprising an antenna array positioned on a top of the proximity transmitter, in accordance with an embodiment the present disclosure.

FIG. **3**A illustrates a schematic diagram of a charging proximity transmitter, in accordance with an embodiment of the present disclosure.

FIG. **3**B illustrates a schematic diagram of a charging proximity transmitter with a sensor, in accordance with an embodiment of the present disclosure.

FIG. **4**A illustrates a flowchart of a method of operating a charging proximity transmitter with a device sensor, in accordance with an embodiment of the present disclosure.

FIG. **4**B illustrates a flowchart of a method of operating a charging proximity transmitter with a living tissue sensor, in accordance with an embodiment of the present disclosure.

FIG. **5** illustrates a charging proximity transmitter comprising a sidewall with an antenna array, in accordance with an embodiment of the present disclosure.

FIG. **6** illustrates a charging proximity transmitter transmitting one or more power waves such that the one or more power waves converge in a three dimensional space to form one or more pockets of energy, in accordance with an embodiment of the present disclosure.

FIG. **7** shows a system for wireless power charging according to an exemplary embodiment.

FIG. **8**A and FIG. **8**B are enlarged, perspective views of the exemplary proximity transmitter shown in FIG. **7**.

FIG. **9** shows components of a proximity transmitter device, according to an exemplary embodiment.

FIG. **10** shows a wireless charging system, according to an exemplary embodiment.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, which may not be to scale or to proportion, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings and claims are not meant to be limiting. Other embodiments may be used and/or and other changes may be made without departing from the spirit or scope of the present disclosure.

FIG. **1** illustrates a proximity transmitter **100** transmitting one or more power waves such that the one or more power waves converge in a three dimensional space to form one or more pockets of energy, in accordance with an embodiment of the present disclosure. A proximity transmitter **100** comprises a housing **102** defined via a plurality of sidewalls **104**, a top **106**, and a bottom **108**. The top **106** extends over the bottom **108**. The sidewalls **104** span between the top **106** and the bottom **108**. At least one of the sidewalls **104**, the top **106**, or the bottom **108** includes a surface layer, whether internal to the housing **102** or external to the housing **102**. The surface layer may be any size. For example, the surface layer can be 6 inches in length, 1 inch in height, and 0.5 inch thick (6"×1"×0.5"), but nearly any other combination of sizes may possible. Moreover, the surface layer and other components of the proximity transmitter **100** can be of any shape or combination of shapes. For example, the surface layer or other component can be shaped as a rectangle, a triangle, a circle, an oval, a trapezoid, a parallelogram, or any other two dimensional (2D) shape. As another example, the top **106** can comprise an upper squared surface layer and the bottom **108** can having a rectangular shape that is comparatively broader and wider than the squared shape of the top **106**.

The housing **102** comprises plastic, but can comprise at least one other material, whether additionally or alternatively, such as wood, metal, rubber, glass, or others. The housing **102** has a shape of a cube, but other shapes are possible, such as a cuboid, a sphere, a hemisphere, a dome, a cone, a pyramid, or any other polygonal shape, whether having an open-shape or a closed-shape. In some embodiments, the housing **102** is at least one of waterproof, water-repellant, or water-resistant.

The housing **102** houses various components of a transmitter **100**, which transmits one or more controlled radio frequency (RF) waves in at least one direction. However, note that an omnidirectional transmission is possible as well. The RF waves may converge at a particular location in space. The RF waves may be controlled through phase and/or relative amplitude adjustments to form constructive and destructive interference patterns (pocket-forming) at specific locations in space. Accordingly, one or more pockets of energy **110** are generated by forming constructive interference patterns, whereas null-spaces may be generated by forming destructive interference patterns. Therefore, if a device **112** comprises a receiver, then the receiver may interface with the one or more pockets of energy **110** generated by the transmitter and thus effectively receive wireless power transmission from the transmitter **100**.

The proximity transmitter **100** may transmit or broadcast power waves to the receiver associated with the device **112**. Although some embodiments disclosed herein describe one or more power waves as radio frequency (RF) waves, power waves may be other types of waves capable of carrying energy, capable of being propagated through space, and capable of being converted into a source of electrical energy. The transmitter may transmit the power waves as a single collective of power waves directed at the receiver. In some embodiments, one or more transmitters may transmit a plurality of power waves that are propagated in multiple directions and may deflect off of physical obstructions, such as walls. The power waves may converge at a location in 3D space, forming the one or more pockets of energy **110**. The receiver of the device **112**, whether within a boundary of or via interfacing with the one or more pockets of energy **110**, may capture and covert the power waves into a useable source of energy. The transmitter may control pocket-forming based on phase and/or relative amplitude adjustments of power waves, to form constructive interference patterns.

Depending on the distance of the surface layer from the antennas or array of antennas, as well as other potential system parameters, the power waves may exhibit varying levels of convergence, or sometime none at all. For example, the power waves may converge to form a pocket of energy **110** at the surface layer, or the power waves may loosely converge to form a general area at or near the surface layer in which the power waves are present. In some implementations, the device may receive a sufficient collection of waves directed at the receiver that the receiver may receive enough energy to charge the electronic device without requiring the power waves to form a constructive interference pattern or form a pocket of energy **110**.

Although some embodiments recite a use of RF wave transmission techniques, the wireless charging techniques should not be limited to RF wave transmission techniques. Rather, possible wireless charging techniques may include any number of alternative or additional techniques for transmitting energy to a receiver converting the transmitted energy to electrical power. Non-limiting example 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 or non-electromagnetic energy. In the case of ultrasound, for example, one or more transducer elements may be disposed so as to form a transducer array that transmits ultrasound waves toward a receiving device that receives the ultrasound waves and converts them to electrical power. In addition, although a transmitter can be shown as a single unit comprising potentially multiple transmitters (transmit array), both for RF transmission of power and for other power transmission methods mentioned in this paragraph, the transmit arrays can comprise multiple transmitters that are physically spread around a room rather than being in a compact regular structure.

The transmitter includes an antenna array where the antennas are used for sending the power waves. The surface layer can be proximate to the array of antennas. For example, the array of antennas can be positioned between the lower rectangular surface layer and the upper rectangular surface layer and along a plane parallel to the lower rectangular surface and the upper rectangular surface. Each antenna sends power transmission waves where the transmitter applies a different phase and amplitude to the signal transmitted from different antennas. Similar to the formation of pockets of energy, the transmitter can form a phased array of delayed versions of the signal to be transmitted, apply different amplitudes to the delayed versions of the signal, and send the signals from appropriate antennas. For a sinusoidal waveform, such as an RF signal, ultrasound, microwave, or other periodic signal, delaying the signal is analogous to applying a phase shift to the signal.

The one or more pockets of energy **110** may be formed by creating constructive interference patterns of power waves transmitted by the transmitter. For example, the transmitter can be configured to transmit power waves which can converge in a constructive interference pattern at the surface layer of the housing **102**. For example, the constructive interference pattern is formed at the surface layer of the housing **102** or the constructive interference pattern is formed proximate to the surface layer of the housing **102**. The pockets of energy **110** may manifest from the constructive interference pattern as a three-dimensional field where energy may be harvested by the receiver located within the pocket of energy **110**. The pocket of energy **110** produced by transmitter during pocket-forming may be harvested by the receiver, converted to an electrical current, and then provided to the device **112** associated with the receiver. In some embodiments, there may be multiple transmitters. In some embodiments, a subset of the antennas of the antenna array can transmit the power waves to a receiver on the surface layer of the housing **102**. In some embodiments, the subset of the antennas of the array that transmit the power waves to the receiver on the surface layer of the housing **102** are directly below the receiver. In some embodiments, at least one antenna of the subset of the antennas of the array that transmit the power waves to the receiver on the surface layer of the housing **102** is not directly below the receiver. In some embodiments, the receiver is located externally to the device **112**, and may be connected to the device **112** through one or more wires or otherwise attached to the device **112**. For instance, the receiver may be situated in an external case that is permanently or removably attached to the device **112**, thereby forming a connection with the device **112** that allows the device **112** to receive power from the receiver. Note that the power waves can comprise waves of various types, such as RF waves, ultrasound waves, microwaves, or others. In addition, in embodiments where RF waves are used, it should be appreciated that most any frequency for the waves may be used, including the range of roughly 900 MHz to roughly 100 GHz. For instance, one skilled in the art would appreciate that the power waves may be transmitted using nearly any industrial, scientific, and medical (ISM) radio band, such as 900 MHZ, 2.4 GHZ, 5 GHz, 24 GHz, or more.

Note that although the device **112** is a tablet computer, any type of any device, which comprises the receiver, can be placed on the housing **102**. Further, note that although the device **112** is positioned centrally on the top **106** of the housing **102**, the device **112** can be positioned anywhere on the housing **102** or in a local proximity of the housing **102**, such as within about twelve (12) inches or less from the housing **102** in order to charge wirelessly. In some embodiments, the housing **102** comprises at least two transmitters.

FIG. **2** illustrates a proximity transmitter **100** comprising an antenna array positioned on a top of the proximity transmitter **100**, in accordance with an embodiment the present disclosure. The top **106** comprises an array of antenna elements **114**, which can operate as a single antenna. Note that the array of antenna elements **114** includes at least one antenna element, but array may comprise any number of antenna elements **114**. The top **106** may comprise any number of arrays. In the exemplary embodiment, the top **106** comprises a single array of antenna elements **114**. The array of antenna elements **114** may be embedded into the structure of the top **106** or may be coupled to the top **106**, which can be accomplished through any permanent or removable means, such as mating or fastening. The array of antenna elements **114** are part of the transmitter **100**, such that the array of antenna elements **114** transmit one or more RF waves, as described herein. In some embodiments, a transmitter **100** may comprise multiple physically distinct arrays of antenna elements **114**, and may manage and feed power to each of the arrays. In yet other embodiments, the antenna elements may be located in, along, adjacent to or aligned with one or more sidewalls **104**.

In operation, one or more pockets of energy **110** may be formed by creating constructive interference where the power transmission waves add constructively to form a pocket of energy within close proximity to the transmitter **100**. In some instances, the proximity is such that the constructive interference patterns may not accumulate to form a pocket of energy. But in such instances, the proximity transmitter **100** may be configured to provide additional power waves to the receiver so that the receiver can receive and rectify enough energy for the electronic device coupled to the receiver. Through a separate communication channel from the power transmission waves, using any number of wireless communications protocols (e.g., Wi-Fi, Bluetooth®, ZigBee®) the receiver and transmitter **100** may continually communicate the power levels being received by the receiver and the power levels required by the electrical device, to continually adjust which, if any, of the antennas should be transmitting power waves and how much energy those waves should contain.

Around pockets of energy, or at particular locations in space where pockets of energy are undesired, the proximity transmitter **100** may generate and transmit power waves that result in one or more transmission nulls, which may be generated by creating destructive interference patterns. A transmission null in a particular physical location may refer to areas or regions of space where pockets of energy do not form because of destructive interference patterns of power transmission waves. In some embodiments, the housing **102** contains an interior space, where one or more antennas or antenna elements are positioned. In some embodiments, the array of antenna elements **114** can be at least partially invisible, such as via being positioned underneath an outermost surface of the top **106**. However, in some embodiments, the array of antenna elements **114** can be at least partially visible, such as via being positioned on top of the outermost surface of the top **106**.

FIG. **3**A illustrates a schematic diagram of a proximity transmitter **300***a*, in accordance with an embodiment of the present disclosure. A schematic diagram depicts a proximity transmitter **300**A capable of broadcasting wireless power waves, which may be RF waves, for wireless power transmission, as described herein. The transmitter **300**A may be responsible for performing tasks related to transmitting power waves, which may include pocket-forming, adaptive pocket-forming, and multiple pocket-forming. The transmitter **300**A includes one or more antenna elements **302**, one or more RFICs **304**, one or more controllers **306**, and one or more power sources **308**. The transmitter **300**A can include a housing or an enclosure to house or enclose the one or more antenna elements **302**, the one or more RFICs **304**, and the one or more controllers **306**. In some embodiments, the housing or the enclosure houses or encloses the one or more power sources **308**. The housing or the enclosure can be made of any suitable material which may allow for signal or wave transmission and/or reception, for example plastic or hard rubber. The various components of the transmitter **300**A may comprise, and/or may be manufactured using, meta-materials, micro-printing of circuits, nano-materials, and the like.

The one or more antenna elements **302** can be structured as the array of antenna elements **114**, as described herein. At least one antenna element of the antenna elements **302** can be used to transmit one or more power waves. In some embodiments, all of the array of the antenna elements **114** is used to transmit one or more power waves.

The one or more RFICs **304** is configured to control production and transmission of the power waves based on information related to power transmission and pocket-forming. The one or more RFICs **304** may automatically adjust the phase and/or relative magnitudes of the power waves as needed. Pocket-forming is accomplished by the transmitter **300**A transmitting the power waves in a manner that forms constructive interference patterns.

The one or more controllers **306** may comprise a processor running or having an ARM and/or a DSP architecture. ARM is a family of general purpose microprocessors based on a reduced instruction set computing (RISC). A digital signal processing (DSP) is a general purpose signal processing chip or technique which may provide a mathematical manipulation of an information signal to modify or improve the signal in some way, and can be characterized by the representation of discrete time, discrete frequency, and/or other discrete domain signals by a sequence of numbers or symbols and the processing of these signals. DSP may measure, filter, and/or compress continuous real-world analog signals. The first step may be conversion of the signal from an analog to a digital form, by sampling and then digitizing it using an analog-to-digital converter (ADC), which may convert the analog signal into a stream of discrete digital values. The one or more controllers **306** may also run Linux and/or any other operating system. The one or more controllers **306** may also be connected to Wi-Fi in order to provide information through a network.

The one or more controllers **306** may control a variety of features of the one or more RFICs **304**, such as, time emission of pocket-forming, direction of the pocket-forming, bounce angle, power intensity and the like. Furthermore, the one or more controllers **306** may control multiple pocket-forming over multiple receivers or over a single receiver. For example, the controller **306** can be configured to transmit one or more power waves from the array of antennas that converges in a constructive interference pattern at the upper rectangular surface layer of the housing **102** of the proximity transmitter **100** upon a receiver being placed upon the upper rectangular surface layer. The proximity transmitter **300**A may allow distance discrimination of wireless power transmission.

The one or more power sources **308** power the transmitter **300**A. The one or more power sources **308** may include AC or DC power supply. Voltage, power, and current intensity provided by the one or more power sources **308** may vary in dependency with the required power to be transmitted. Conversion of power to radio signal may be managed by the one or more controller **306** and carried out by the one or more RFICs **304** that may utilize a plurality of methods and components to produce radio signals in a wide variety of frequencies, wavelength, intensities, and other features. As an illustrative use of a variety of methods and components for radio signal generation, oscillators and piezoelectric crystals may be used to create and change radio frequencies in different antenna elements **114**. In addition, a variety of filters may be used for smoothing signals or for shaping frequency spectrum of the signal as well as amplifiers for increasing power to be transmitted. The transmitter **300**A may emit RF power waves that are pocket-forming with a power capability from few watts to a predetermined number of watts required by a particular chargeable electronic device. Each antenna may manage a certain power capacity. Such power capacity may be related with the application. In some embodiments, the one or more power sources **308** may be a mechanical power source, such as a crank, a chemical power source, such as a battery, or an electrical power source, such as a capacitor or a photovoltaic cell. In some embodiments, the proximity transmitter **100** can be powered via mains electricity, such as via a power cord plugged into a wall outlet, which can be selectively detachable from the proximity transmitter **100** or be permanently attached to the proximity transmitter **100**.

In one method of operation, the transmitter **300**A may transmit or otherwise broadcast controlled RF waves that converge at a location in three-dimensional space, thereby forming the one or more pockets of energy **110**. These RF waves may be controlled through phase and/or relative amplitude adjustments to form constructive or destructive interference patterns (i.e., pocket-forming). The one or more pockets of energy **110** may be two or three-dimensional fields that are created by forming constructive interference patterns; whereas transmission nulls may be a particular two or three-dimensional physical location that are generated by forming destructive interference patterns. Accordingly, a receiver may harvest electrical energy from the one or more pockets of energy **110** produced by pocket-forming for charging or powering a device coupled thereto.

In some embodiments, a communications component, as disclosed herein, is optional, but when used, the communication component is powered via the one or more power sources **308** and can be used to identify a location of the receiver, such as via communicating with the receiver, such as via a directional antenna. For example, the communications component can be a chip or circuitry configured to communicate over a short range communication protocol.

FIG. **3**B illustrates a schematic diagram of a proximity transmitter **300**B comprising or otherwise coupled to a communications component **307** and a sensor **310**, in accordance with an embodiment of the present disclosure. One skilled in the art would appreciate that communications component **307** and the sensor **310** may be physically associated with the transmitter **300**B in any number of combinations, as the communications component **307** and/or the sensor **310** may be connected to the proximity transmitter **300**B, or may be an integrated component of the proximity transmitter **300**B.

In some embodiments, the proximity transmitter **300**B may comprise a communications component **307**, which may include integrated circuits and antennas configured to allow the proximity transmitter **300**B to communicate with receivers or other devices using any number of wired or wireless protocols. Non-limiting examples of wired communications may include Ethernet, USB, PCI, Firewire, and the like. Non-limiting examples of wireless protocols may include Wi-Fi, Bluetooth®, ZigBee®, NFC, RFID, and the like. In operation, the communications component **307** of the proximity transmitter **300**B and a corresponding component of the receiver or electronic device may exchange communications signals containing operational data related to wireless charging and generating power waves, including operational instructions, measurements, and/or operational parameters. The controller **306** of the proximity transmitter **300**B may determine various modes of operation and/or how to appropriately generate and transmit power waves based on the operational data received by the communications component **307** via the communications signals.

As an example, the communications component **307** of the proximity transmitter **300**B may include a Bluetooth-enabled communications chip and antenna, which may communicate operational data with a receiver using communications signals conforming to Bluetooth® technology and protocols. In this example, the communications component **307** may detect the presence of the receiver based on Bluetooth-based data packets broadcasted by the receiver, or the receiver may transmit a "wake up" or "turn on" command to the proximity transmitter **300**B, which is captured by the communications component **307** and send to the controller **306** of the proximity transmitter **300**B which may in turn activate various power wave generate routines. A processor or other component of the proximity transmitter **300**B may continuously monitor for signals triggering proximity transmitter **300**B operation (e.g., "wake up" or "turn on" signals), or may periodically poll for such signals. As the proximity transmitter **300**B may limit the distance at which the power waves may effectively charge the receiver, the communications component **307** may determine whether the receiver is within a threshold distance from the proximity transmitter **300**B based on a signal strength of the communications signals or other parameters.

As another example, the communications component **307** of the proximity transmitter **300**B may include a Bluetooth-enabled communications chip and antenna, which may communicate operational data with a receiver using communications signals conforming to Bluetooth® technology and protocols. In this example, the communications component **307** may receive a number of operational parameters, such as a signal strength of the communications signals received from the receiver or an amount of power (e.g., voltage) being received by the receiver, to determine a location of the receiver with respect to the proximity transmitter **300**B. These values and/or the determined location of the receiver may then be used by the proximity transmitter **300**B to determine which, if any, antennas **302** to activate, and/or the physical characteristics of the power waves (e.g., frequency, amplitude, power level).

The sensor **310** may receive raw sensor data from various types of sensors and then sends the sensor data to the one or more controllers **306** of the proximity transmitter **300**B. In some implementations, the sensor **310** or related processor may execute a number of pre-processing routines on the raw sensor data. As such, the term "sensor data" may be used interchangeably with "raw sensor data" as it should be appreciated 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 **310**, processed by the transmitter **300**B, or any other processor. The sensor data can include information derived from the sensor **310**, and processed sensor data can include determinations based upon the sensor data.

In operation, the sensor data may help the transmitter **300**B determine various modes of operation and/or how to appropriately generate and transmit power waves, so that the transmitter **300**B may provide safe, reliable, and efficient wireless power to the receiver. As detailed herein, the sensor **310** may transmit sensor data collected during sensor operations for subsequent processing by a processor of the transmitter **300**B. Additionally or alternatively, one or more sensor processors may be connected to or housed within the sensor **310**. Sensor processors may comprise a microprocessor that executes various primary data processing routines, whereby the sensor data received at the transmitter processor has been partially or completely preprocessed as useable mapping data for generating power waves.

The sensor **310** can be optionally coupled to the one or more power sources **308**. Alternatively or additionally, the sensor **310** can comprise a power source, such as a mechanical power source, such as a crank, a chemical power source, such as a battery, or an electrical power source, such as a capacitor or a photovoltaic cell. For example, the housing **102** can comprise the transmitter **300**B, where the power source **308** is a first power source and the sensor **310** comprises a second power source, whether identical to or different from the first power source in power source manner, with the second power source being comprised in the housing **102**, whether internal to or external to the transmitter **300**B. Alternatively or additionally, the sensor **310** can operate without a power source, such as via being passive. However, note that the sensor **310** can be a passive sensor or an active sensor.

The sensor **310** can be positioned in any part or anywhere on or in the proximity transmitter **100**, whether unitary to or assembled therewith. For example, the housing **102** comprises at least one of the interior space, the sidewall **104**, the top **106**, or the bottom **108**, where at least one of the interior space, the sidewall **104**, the top **106**, or the bottom **108** comprises the sensor **310**. Alternatively the sensor can be positioned outside the housing in another enclosure, and may be connected to the controller of the proximity transmitter **100** via a wired connection.

In some embodiments, the sensor **310** is configured to sense the device **112**. Such sensing can be in the local proximity of the housing **102**, such as within about twelve (12) inches or less from the housing **102**. Accordingly, the sensor **310** can be a pressure sensor, a contact sensor, a thermal sensor, a static electricity sensor, a motion sensor, a magnetic sensor, or an electromagnetic spectrum sensor. Note that such listing is an example and other types of sensors can be used additionally or alternatively. For example, the sensor **310** can sense the device **112** placed on the housing **102** via a downward pressure of the device **112**, such as via a weight of the device **112**. For example, the sensor **310** can sense the device **112** via a contact of the device **112** with the housing **102**. For example, the sensor **310** can sense the device **112** via a thermal signature or a thermal fingerprint from the device **112**, such as via a heat emitted from a battery or a human hand heat remaining on the device **112** based on handling of the device **112**. For example, the sensor **310** can sense a static electricity being emitted from or resulting from the device **112** being placed in proximity with or contacting the housing **102**. For example, the sensor **310** can sense a motion of the device **312** with respect to the housing **102** or a motion resulting from the device **312** with respect to the housing **102**. For example, the sensor **310** can sense the device **112** via an electromagnetic radiation being emitted from the device **112**, such as a network signal, for instance a cellular signal, a Wi-Fi signal, a short range transmission protocol signal, or others. Note that a range of transmission of the transmitter **300**B and a range of sensing of the sensor **310** can be identical to or different from each other, whether in a dependent or an independent manner. In some embodiments, the transmitter **300**B is configured to transmit one or more power waves based at least in part on the sensor **310** sensing the device. For example, when the sensor **310** senses the device **112**, the sensor **310** communicates such information to the controller **306**, which in turn activates the one or more RFICs **304** to emit one or more power waves via the one or more antennas **302**. For example, the transmitter **30013** can comprise a sensor configured to determine a presence of a receiver on the surface layer. For example, the transmitter **300**B can be configured to transmit power waves upon a receiver being placed upon the surface layer of the housing **102**, such via the sensor **310**, which can sense or determine a presence of a receiver on the surface layer of the housing **102**. Note that such sensing can occur without using the optional communications component, as disclosed herein.

In some embodiments the sensor may be configured to detect humans or other living beings such as pets by detecting the heat generated using thermal sensors. This information may be used by the controller in deciding whether to transmit power transmission waves, whether to lower the transmit power, or it may be used to generate pockets of energy away from the living being, and/or to generate transmission nulls in locations of living beings in order to avoid sensing electromagnetic waves to that location.

Other types or configurations of sensors that can be used herewith are more fully described in U.S. patent application Ser. No. 14/861,285, filed on Sep. 22, 2015, entitled "Systems and Methods for Identifying Sensitive Objects in a Wireless Charging Transmission Field," which is incorporated by reference herein in its entirety.

In some embodiments, the one or more controllers **306** can select which antenna elements in the array of antenna elements **302** will transmit one or more power waves, such as via smart dynamic antenna selection, such as based on distance, transmission quality, or others. For example, the one or more controllers **306** can select which antenna elements **302** will transmit one or more power waves based on information received from the sensor **310** or based on a detection of the receiver, such as via a placement of the receiver onto the housing **102**. For example, such selection can be in an alternating manner, where a first antenna element is used and a second antenna element is not used, and then based on an occurrence of a certain condition, the first antenna element is not used, whereas the second antenna element is used.

FIG. **4**A illustrates a flowchart of a method of operating a proximity transmitter with a device sensor, in accordance with an embodiment of the present disclosure. A method **400**A comprises a plurality of blocks **402**A-**408**A.

In block **402**A, a receiver and associated electronic device may be positioned in proximity of the proximity transmitter. In some embodiments, proximity may include placing the receiver on top of, or otherwise in direct contact with, the proximity transmitter. And in some instances, proximity may include positioning the device within the local proximity of the proximity transmitter, such as within about twelve (12) inches of the proximity transmitter.

In block **404**A, the communications component **307** of the proximity transmitter may detect that the device is nearby or approaching based on communications signals received through a wired or wireless connection. The communications component may then determine whether the to begin generating power waves, which antennas should generate the power waves, and/or the characteristics of the power waves. In some instances, the controller may use this data collected by the communications component to determine whether the receiver has entered a threshold distance to begin transmitting power waves. The controller may then determine which antennas are generally proximate to or in contact with the receiver and thus which antennas should be activated.

In block **406**A, the proximity transmitter may execute one or more instructions and/or determines transmission parameters based on operation data received by the communications component, from the receiver. For example, after the communications component detects or otherwise receives a wirelessly broadcasted data packet from the receiver, the controller may automatically begin determining the location of the receiver, or may begin transmitting power waves. As another example, the proximity transmitter may begin determining the location of the receiver, or the distance of the receiver, based on the signal strength of the communications signals or other data reported from the receiver. The proximity transmitter may also begin determining the effective antennas and waveform characteristics to use when transmitting power waves to the receiver.

In block **408**A, the transmitter transmits one or more power waves to the device based on the operational data or operational parameters received by the communications component.

FIG. **4**B illustrates a flowchart of a method of operating a proximity transmitter with a living tissue sensor, in accordance with an embodiment of the present disclosure. A method **400**A comprises a plurality of blocks **402**A-**408**A.

In block **402**B, the device is positioned in proximity of the proximity transmitter. Such positioning can be on the proximity transmitter **100** or in the local proximity of the proximity transmitter, such as within about twelve (12) inches of the proximity transmitter.

In block **404**B, the sensor of the proximity transmitter senses the living beings. For example, the sensor can be a pressure sensor, a contact sensor, a thermal sensor, a static electricity sensor, a motion sensor, or an electromagnetic spectrum sensor.

In block **406**B, the sensor informs the transmitter of a presence of the living beings. Such informing can be wired or wireless.

In block **408**B, the transmitter controls the one or more RFICs **304** to emit away or around or in different direction or cease from emitting or not emit one or more power waves via the one or more antennas such that one or more power waves avoid the living beings. Therefore, the transmitter operates such that the one or more pockets of energy avoid the living beings based on being informed via the sensor.

FIG. **5** illustrates a proximity transmitter **100** comprising a sidewall **104** with an antenna array, in accordance with an embodiment of the present disclosure. The sidewall **104** of the housing **102** comprises the array of antenna elements **114**, which can operate as a single antenna. Such configuration can be via the array of antenna elements **114** being embedded in the sidewall **104** or coupled to the sidewall **104**, which can be removable, such as via mating or fastening. Note that more than one sidewall **104** can comprise the array of antenna elements **114**, in any permutation or combination. For example, opposing or adjacent sidewalls **104** can comprise the array of antenna elements **114**. The array of antenna elements **114** are part of the transmitter such that the array of antenna elements **114** transmit one or more RF waves, as described herein. The one or more pockets of energy **110** may be a 3D field of energy that are created by forming constructive interference patterns where the power transmission waves accumulate, around which one or more corresponding transmission null in a particular physical location may be generated by destructive interference patterns. A transmission null in a particular physical location may refer to areas or regions of space where pockets of energy do not form because of destructive interference patterns of power transmission waves.

In some embodiments, the bottom **108** of the housing **102** comprises the array of antenna elements **114**, which can operate as a single antenna. Such configuration can be via the array of antenna elements **114** being embedded in the bottom **108** or coupled to the bottom **108**, which can be removably, such as via mating or fastening.

In some embodiments, the array of antenna elements **114** can be at least partially invisible, such as via being positioned underneath an outermost surface of at least one of the bottom **108** or the sidewall **104**. However, in some embodiments, the array of antenna elements **114** can be at least partially visible, such as via being positioned on top of the outermost surface of at least one of the bottom **108** or the sidewall **104**.

FIG. **6** illustrates a proximity transmitter transmitting one or more power waves such that the one or more power waves converge in a three dimensional space to form one or more pockets of energy, in accordance with an embodiment of the present disclosure. Note that the device **112** is not centrally or specifically aligned/oriented/positioned on the housing **102** to be wirelessly charged via the transmitter of the proximity transmitter **100**. Rather, the device **112** can be positioned anywhere on the housing **102** to be wirelessly charged or in the local proximity of the housing **102** to be wirelessly charged, whether with a use of a sensor or communications component, or without the use of the sensor or communications component.

FIG. **7** shows a system **700** for wireless power charging according to an exemplary embodiment. In the exemplary system **700**, the proximity transmitter **701** may be a USB device that couples to a computer **703** or other type of computing device, and may provide wireless power to an electronic device **705**, which in the exemplary system **700** comprises an integrated receiver component.

A proximity transmitter **701** may have nearly any form factor or shape. In the system **700** shown in FIG. **7**, the proximity transmitter **700** may be a USB device that couples to the computer **703** through a USB port. The proximity transmitter **700** may be directly coupled to the computer **703**, as the USB components and transmission components (e.g., antennas, integrated circuits, controller) are integrated into a common housing. However, in some embodiments, the transmission components may be in a separate housing, such that a USB wire couples the proximity transmitter **701** to the computer **703**.

The proximity transmitter **701** may comprise any number of wireless transmission components, but may additionally or alternatively capitalize on components of the computer **703**. For example, the proximity transmitter **701** may not comprise a communications component, but may instead communicate operational data with the receiver through the computer's communications components, such as the computer's Bluetooth® or Wi-Fi antennas, among others. The proximity transmitter **701** may also draw power from the computer **703** as a power source. It should be appreciated that the proximity transmitter **701** may be coupled to the computer **703** through any type of data port of a computing device **703** that may facilitate wired data and/or power exchanges between the proximity transmitter **701** and the computing device **703**, and should not be considered to be limited solely to USB ports.

In some embodiments, the proximity transmitter **701** may comprise an antenna array underneath or on the top surface that may transmit power waves within an inch from the top surface of the proximity transmitter **701**. In such embodiments, the proximity transmitter **701** may function as a platform or stand for the electronic device **705**, and the antennas may transmit power waves to antennas of the receiver integrated into the electronic device **705**.

In some embodiment, the proximity transmitter **701** may comprise antennas situated along the sidewalls of the proximity transmitter **701**, whereby the antennas may transmit power waves to the receiver of an electronic device **705**, in a direction other than or in addition to directly over top of the proximity transmitter **701**. Advantageously, this may allow the proximity transmitter to provide power to an electronic device **705** situated nearby a proximity transmitter **701** and computing device **703**, within a threshold distance of the proximity transmitter **701**. In many cases, the proximity transmitter **701** may be configured with a threshold distance may be within the range of about one millimeter to about twelve inches. One having skill in the art would appreciate that the threshold distance may vary, and would not necessarily be limited to these distances. It should also be appreciated that the threshold distance in operation is not always exact, as there may be some slight natural variation in waves received and identified by the communications components. The communications components of the proximity transmitter **701** and the receiver may exchange communications signals to determine whether the receiver of the electronic device **705** is within the threshold distance to the proximity transmitter **701**. For embodiments where the receiver is an integrated component of the electronic device **705**, like the exemplary embodiment shown in FIG. **7**, the communications component of the receiver may include one or more of the native communications components of the electronic device **705**. Similarly, in some embodiments, the proximity transmitter **701** may use one or more communications components native to the computing device **703**.

FIG. **8**A and FIG. **8**B are enlarged, perspective views of the exemplary proximity transmitter **701** shown in FIG. **7**. FIG. **8**A shows additional details for the proximity transmitter **701**, including an interface **803** and a protective cap **805**. FIG. **8**B shows an optional product form factor in which a cap **805** may be placed over the interface **803** to protect the operations of the interface **803**.

The interface **803** of the exemplary transmitter **701** is a "male" USB interface that allows the proximity transmitter to connect to any host device, such as a computer, through a corresponding USB port, either directly through a corresponding "female" USB interface on the host device or indirectly through a "female" to "male" connector. In some implementations, the proximity transmitter **701** may draw power through the port connection from the host device, using the host device as a power source. In some implementations, the proximity transmitter **701** may transmit data and/or instructions related to the operation of the power transmitter **701**. In some cases, in order to communicate data and/or instructions, the proximity transmitter **701** may upload and install pre-stored drivers or other software modules to the electronic device, or may instruct the host device to download such drivers or software. One having skill in the art would recognize that the interface **803** may be of any interface type and corresponding port that would allow the proximity transmitter **701** to draw power from the host device and/or would allow the proximity transmitter **701** and host device to exchange operational data and/or operational instructions. Non-limiting examples of the types of interfaces **803** and corresponding ports and protocols allowing peripheral devices to interchangeably connect with host devices may include: Firewire, Thunderbolt, PCI, Ethernet, and the like. Furthermore, the proximity transmitter **701** may operate by interfacing with computing devices of different operating systems, processors, or peripherals. This may involve installing or downloading drivers (e.g., software modules) that configure such devices to communicate with the proximity transmitter **701**.

FIG. **9** shows components of a proximity transmitter **900** device, according to an exemplary embodiment. The exemplary proximity transmitter **900** may comprise a heat sink **901**, array of one or more antennas (antenna array **903**), and one or more circuit boards **905**. The circuit boards **905** may comprise any number of circuits, antennas, processors, or other components capable of performing the various tasks described herein. For example, the circuit boards **905** may include a controller that manages operation of the proximity transmitter **900**, such as determining which, if any, antennas of an antenna array **903** should be transmitting power waves, and the characteristics of those power waves. As another example, the one or more circuit boards **905** may include a communications component, such as a Bluetooth® chip and associated antenna, allowing the proximity transmitter to detect receivers, determine whether receivers are within a proximity threshold, and/or to exchange operational data with receivers through some wired-based or wireless communications protocol. It should be understood that additional or alternative components may be included on the one or more circuit boards **905** of the exemplary proximity transmitter **900**.

An antenna array **903** may comprise one or more antennas of one or more antenna types, each configured to transmit power waves generated by circuits, such as waveform generators, of a circuit board **905**. In some cases, the antenna array **903** may transmit the power waves such that the power waves generate constructive interference patterns at some area in front of the antennas, and within some proximity of the proximity transmitter **900**. In some cases, rather than directing the power waves to some convergence point, the antenna array **903** may transmit the power waves as a collection of power waves originating from one or more of the antennas. As an example, in some circumstances there may not be enough distance between the antennas and the receiver to allow the power waves to converge at a particular point, or the antennas may not be configured to adjust the vectors of the power waves, and so a subset of antennas in front of, or in contact with, the receiver may be selected to transmit power waves as a collection of power waves. In some embodiments and in similar circumstances, the antenna array **903** may be slightly concave with respect to a housing surface covering the antenna array **903**, and thus the power waves may be generally transmitted at slightly acute angles with respect a middle axis of the antenna array **903**, as opposed to alternative embodiments where the antennas are situated parallel to the housing surface covering the antenna array **903**.

A heat sink **901** may be a metal construct or other material that may alleviate the amount of heat generated by components of the proximity transmitter **900** during operation. In some circumstances, but not always, a proximity transmitter **900** may generate heat due to the electrical current fed through the circuitry from a power source; this heat might eventually damage components of the transmitter **900**, such as the circuitry on the boards **905**. The heat sink **901** may be a permanent or detachable component, and may comprise metal, ceramic or other material, configured to dissipate the heat generated by the proximity transmitter **900** components.

FIG. **10** shows a wireless charging system **1000**, according to an exemplary embodiment. The exemplary system **1000** may comprise the exemplary proximity transmitter **900** shown in FIG. **9**, and an electronic device **1001**. The proximity transmitter **900** may be the product of assembling the components shown in FIG. **9**, as well as any number of additional or alternative components. The electronic device **1001** may be any device requiring electric energy and capable of being coupled to or comprising a receiver. In the exemplary embodiment, the electronic device **1001** may be smartphone comprising an integrated receiver.

In operation, the proximity transmitter **900** may detect the presence of the electronic device when the proximity transmitter **900** receives one or more wireless communications signals, such as Bluetooth® or Wi-Fi signals. Based on operational data received in the communications signals, such as signal strength, response time, or some other location data indicating the location and/or proximity of the electronic device **1001**, the proximity transmitter **900** may determine whether the electronic device is within a proximity threshold distance from the antenna array. Additionally or alternatively, the proximity transmitter may comprise a sensor, such as a capacitive sensor to sense presence of the electronic device, magnetic sensor for detecting the magnetic waves produced by the electronic device **1001** or a pressure sensor, used to determine a proximity threshold or to determine that the electronic device is in contact with the exterior housing of the proximity transmitter **900**. When the proximity transmitter **900** determines that the receiver is within the threshold proximity or is in contact with the proximity transmitter **900** may generate and transmit power waves. In some cases, the proximity transmitter **900** may identify a subset of antennas for transmitting power waves. This may be advantageous in circumstances where the electronic device **1001** does not cover the entire antenna array. This may also be advantageous in circumstances where the proximity transmitter **900** comprises antenna arrays directed outward in different directions of the proximity transmitter **900**, thus power transmitter **900** may identify which antenna array to activate based on where the electronic device is located with respect to the proximity transmitter **900**.

In some implementations, a receiver, such as the receiver integrated into the electronic device **1001**, may be relocated away from the proximity transmitter **900**, but may then switch to receiving power waves from non-proximity transmitters (not shown), which may be transmitter devices configured to transmit power waves into a transmission field, but without the proximity limitations of a proximity transmitter **900**. Descriptions and examples of non-proximity transmitters may be found in U.S. patent application Ser. No. 14/860,991, filed Sep. 22, 2015, entitled "Systems and Methods for Generating and Transmitting Wireless Power Transmission Waves," which is incorporated by reference herein in its entirety. In such implementations, when the electronic device **1001** is moved away from the proximity of the proximity transmitter **900**, or when some other operational condition is violated (e.g., a person's hand is detected between the electronic device **1001** and the antenna array of the proximity transmitter **900**), the electronic device **1001** may then communicate with a non-proximity transmitter. When the electronic device **1001** enters the transmission field of the non-proximity transmitter, and when any operational conditions are satisfied (e.g., the person is not within a threshold distance to the power waves of the non-proximity transmitter), the receiver of the electronic device may then begin receiving power waves from the non-proximity transmitter. Conversely, when an electronic device **1001** receiving wireless power from a non-proximity transmitter is moved within proximity parameters (e.g., proximity threshold) of a proximity transmitter **900**, the receiver of the electronic device **1001** may discontinue receiving power from the non-proximity transmitter and start receiving power from the proximity transmitter **900**. Furthermore, in some embodiments, a receiver may receive power from both a non-proximity transmitter and a proximity transmitter **900** at the same time. In such embodiments, the energy pocket formed at or about the receiver is a combination of the energy pocket created by the non-proximity transmitter as well as the pocket of energy created by the proximity transmitter. Additional descriptions and examples of receivers receiving power from one or more transmitters may be found in U.S. Provisional Patent Application Ser. No. 62/387,466, entitled "Cluster Management of Transmitters in a Wireless Power Transmission System," filed on Dec. 24, 2015.

While various aspects and embodiments have been disclosed herein, other aspects and embodiments are contemplated. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. A wireless charging transmitter comprising:
one or more sensors configured to:
detect a living being in proximity to the wireless charging transmitter; and
generate sensor data based on detecting the living being;
an array of antennas configured to transmit power waves to a receiver device; and
a surface layer that is adjacent to the array of antennas, wherein:
the transmitted power waves converge to form a constructive interference pattern at a non-zero distance from the surface layer, the non-zero distance being based at least in part on the sensor data;
phases and amplitudes of the transmitted power waves are determined based, at least in part, on the sensor data; and
the wireless charging transmitter is further configured to lower a power level of the transmitted power waves in response to the one or more sensors detecting the living being.

2. The wireless charging transmitter according to claim **1**, wherein the wireless charging transmitter is further configured to cease transmitting the power waves in response to the one or more sensors detecting the living being.

3. The wireless charging transmitter according to claim **1**, wherein the wireless charging transmitter is further configured to create transmission nulls at a location of the living being.

4. The wireless charging transmitter according to claim **1**, further comprising a communications component configured to receive operational data from the receiver device; and
the phases and amplitudes of the transmitted power waves are also determined based at least in part on the operational data.

5. The wireless charging transmitter according to claim **1**, wherein the wireless charging transmitter is configured to transmit the power waves to the receiver device upon the one or more sensors detecting the receiver device being placed on the surface layer.

6. The wireless charging transmitter according to claim **1**, wherein when the receiver device is positioned on the surface layer:
the wireless charging transmitter is configured to select a subset of the antennas of the array for transmitting the power waves to the receiver device.

7. The wireless charging transmitter according to claim **6**, wherein the subset of the antennas is directly below the receiver device.

8. The wireless charging transmitter according to claim **1**, wherein the one or more sensors are selected from the group consisting of a pressure sensor, a magnetic sensor, a contact sensor, a thermal sensor, a static electricity sensor, and a motion sensor.

9. The wireless charging transmitter according to claim **1**, wherein the power waves are radio frequency power waves.

10. A method of wirelessly transmitting power comprising:
at a wireless charging transmitter comprising one or more sensors, an array of antennas, and a surface layer that is adjacent to the array of antennas:
detecting, by the one or more sensors, a living being in proximity to the wireless charging transmitter;
generating, by the one or more sensors, sensor data based on the detecting of the living being;

determining phases and amplitudes for power waves to be transmitted by the array of antennas based at least in part on the sensor data;

transmitting, by the array of antennas, power waves to the receiver device, wherein the transmitted power waves (i) have the determined phases and amplitudes, and (ii) converge to form a constructive interference pattern at a non-zero distance from the surface layer, the non-zero distance being based at least in part on the sensor data; and

in response to the one or more sensors detecting the living being, lowering a power level of the transmitted power waves.

11. The method of claim **10**, further comprising, in response to the one or more sensors detecting the living being, ceasing to transmit the power waves.

12. The method of claim **10**, further comprising creating, by the wireless transmitter, transmission nulls at a location of the living being.

13. The method of claim **10**, wherein:

the transmitter also includes a communications component, and

the method further comprises receiving, by the communications component, operational data from the receiver device, wherein the phases and amplitudes of the transmitted power waves are also based at least in part on the operational data.

14. The method of claim **10**, further comprising transmitting, by the wireless charging transmitter, the power waves to the receiver device upon the one or more sensors detecting the receiver device being placed on the surface layer.

15. The method of claim **10**, further comprising, in response to detecting the receiver device positioned on the surface layer:

selecting, by the wireless charging transmitter, a subset of the antennas of the array for transmitting the power waves to the receiver device that is positioned on the surface layer.

16. The method of claim **15**, wherein the subset of the antennas is directly below the receiver device.

17. The method of claim **10**, wherein the one or more sensors are selected from the group consisting of a pressure sensor, a magnetic sensor, a contact sensor, a thermal sensor, a static electricity sensor, and a motion sensor.

18. The method of claim **10**, wherein the power waves are radio frequency power waves.

19. A system of wireless power transmission, the system comprising:

a wireless charging transmitter comprising:

one or more sensors configured to:

detect a living being in proximity to the wireless charging transmitter; and

generate sensor data based on detecting the living being;

an array of antennas configured to transmit power waves to a receiver device; and

a surface layer that is adjacent to the array of antennas; and

a controller that is in communication with the wireless power transmitter and is configured to:

determine phases and amplitudes for power waves to be transmitted by the array of antennas based at least in part on the sensor data; and

transmit, by the array of antennas, power waves to the receiver device, wherein the transmitted power waves (i) have the determined phases and amplitudes, and (ii) converge to form a constructive interference pattern at a non-zero distance from the surface layer, the non-zero distance being based at least in part on the sensor data; and

in response to the one or more sensors detecting the living being, lower a power level of the transmitted power waves.

20. The system of claim **19**, wherein the controller is configured to: in response to detecting the receiver device positioned on the surface layer:

select, by the wireless charging transmitter, a subset of the antennas of the array for transmitting the power waves to the receiver device that is positioned on the surface layer.

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