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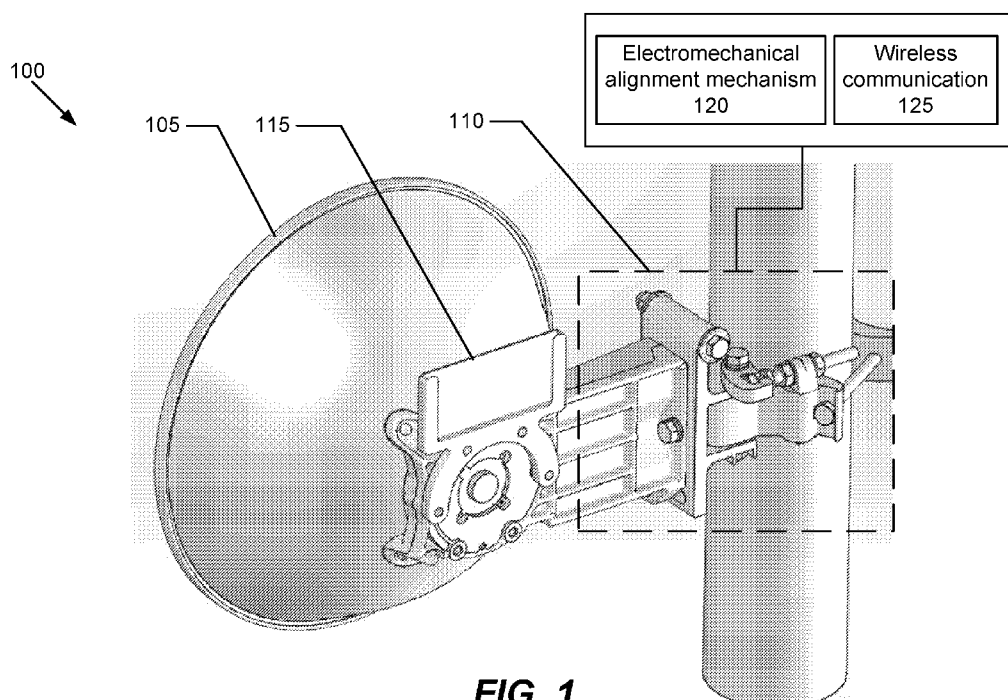


FIG. 1

(57) Abstract: An apparatus includes a directional component, a holder coupled to the directional component and configured to receive a mobile terminal, and an alignment component coupled to the directional component. The alignment component may be configured to adjust an orientation of the directional component based on directional information generated by the mobile terminal.



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ALIGNMENT APPARATUS USING A MOBILE TERMINAL AND METHODS OF OPERATING THE SAME

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to U.S. Provisional Patent Application Serial No. 62/449,805, filed January 24, 2017, the entire content of which is incorporated by reference herein as if set forth in its entirety.

BACKGROUND

[0002] The present disclosure relates generally to alignment systems and, more particularly, to alignment systems for antenna structures used in microwave communication systems.

[0003] Microwave transmission is the transmission of information or energy by electromagnetic waves whose wavelengths are measured in units of centimeters. These electromagnetic waves are called microwaves. This part of the radio spectrum ranges across a frequency band of approximately 1.0 GHz to approximately 300 GHz. These frequencies correspond to wavelengths in a range of approximately 30 centimeters to 0.1 centimeters.

[0004] Microwave communication systems may be used for point-to-point communication because the small wavelength of the electromagnetic waves may allow relatively small sized antennas to direct the electromagnetic waves into narrow beams, which may be pointed directly at a receiving antenna. This may allow nearby microwave communication equipment to use the same frequencies without interfering with each other as lower frequency electromagnetic wave systems may do. In addition, the high frequency of microwaves may give the microwave band a relatively large capacity for carrying information. The microwave band has a bandwidth approximately 30 times that of the rest of the radio spectrum below it. Microwave communication systems, however, are limited to line of sight propagation as the electromagnetic waves cannot pass around hills, mountains, structures, or other obstacles in the way that lower frequency radio waves can propagate.

SUMMARY

[0005] In some embodiments of the inventive concept, an apparatus comprises a directional component, a holder coupled to the directional component and configured to receive a mobile terminal, and an alignment component coupled to the directional component. The alignment component may be configured to adjust an orientation of the directional component based on directional information generated by the mobile terminal.

[0006] In other embodiments, the alignment component further comprises a wireless communication module that is configured to receive the directional information generated by the mobile terminal.

[0007] In still other embodiments, the wireless communication module comprises at least one of a cellular module, a Wi-Fi module, a Bluetooth module, and a Wireless Local Area Network (WLAN) interface module.

[0008] In still other embodiments, the alignment component further comprises an electromechanical alignment mechanism that is configured to adjust the orientation of the directional component responsive to the directional information that is received via the wireless communication module.

[0009] In still other embodiments, the directional component is an antenna. The antenna may comprise a reflector that is configured to direct radio waves transmitted from the antenna.

[0010] In still other embodiments, the holder is further configured to align a display face of the mobile terminal so as to be substantially parallel with a plane defined by an outer circumference of the reflector.

[0011] In still other embodiments, the antenna is a microwave antenna.

[0012] In further embodiments of the inventive concept, a mobile terminal comprises an environmental sensor that is configured to generate directional information based on an orientation of the mobile terminal, a target interface that is configured to receive target position information, an alignment correction module that is configured to determine a difference between a pointing direction based on the directional information and a pointing direction that is aimed at the target position based on the target position information, and a user feedback module that is configured to communicate the difference between the directional information and the target position information.

[0013] In still further embodiments, the user feedback module is further configured to communicate to a display a written description of the difference between the pointing direction based on the directional information and the pointing direction that is aimed at the target position based on the target position information.

[0014] In still further embodiments, the user feedback module is further configured to communicate to a speaker an audible description of the difference between the pointing direction based on the directional information and the pointing direction that is aimed at the target position based on the target position information.

[0015] In still further embodiments, the user feedback module is further configured to communicate to a display an iconic description of the difference between the pointing direction based on the directional information and the pointing direction that is aimed at the target position based on the target position information.

[0016] In still further embodiments, the environmental sensor comprises a movement detector that is configured to generate data that are indicative of movement of the mobile terminal, the directional information being based on the data that are indicative of the movement of the mobile terminal.

[0017] In still further embodiments, the movement detector comprises at least one accelerometer that is configured to generate the data that are indicative of movement of the mobile terminal.

[0018] In still further embodiments, the movement detector further comprises a gyroscope that is configured to generate data that are indicative of rotational movement of the mobile terminal, the directional information being based on the data that are indicative of the rotational movement of the mobile terminal.

[0019] In still further embodiments, the movement detector comprises a Global Positioning System (GPS) module that is configured to generate GPS data, the directional information being based on the GPS data.

[0020] In still further embodiments, the environmental sensor comprises a microphone that is configured to capture audio information from the surrounding environment.

[0021] In still further embodiments, the target interface, alignment correction module, and user feedback module are configured to be enabled responsive to the audio information comprising antenna alignment access information, and the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

[0022] In still further embodiments, the environmental sensor comprises a camera and/or a video recorder that is configured to capture graphic and/or video information from the surrounding environment.

[0023] In still further embodiments, the target interface, alignment correction module, and user feedback module are configured to be enabled responsive to the graphic and/or video information comprising antenna alignment access information, and the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

[0024] In still further embodiments, the target interface, alignment correction module, and user feedback module are configured to be enabled responsive to input of antenna alignment access information via the target interface, and the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

[0025] In still further embodiments, the target position information comprises Global Positioning System (GPS) information received from a target apparatus.

[0026] In other embodiments of the inventive concept, a method comprises placing a mobile terminal into a holder coupled to a directional component of an apparatus, inputting target position information into a target interface of the mobile terminal, receiving a difference between a direction pointing at the target position and a pointing direction of the mobile terminal based on an orientation of the mobile terminal, and adjusting an orientation of the directional component based on the difference between a pointing direction that is aimed at the target position and a pointing direction of the mobile terminal.

[0027] In still other embodiments, adjusting the orientation of the directional component comprises manually adjusting the orientation of the directional component.

[0028] In still other embodiments, adjusting the orientation of the directional component comprises electromechanically adjusting the orientation of the directional component responsive to the difference between the pointing direction that is aimed at the target position and the pointing direction of the mobile terminal.

[0029] In still other embodiments, the apparatus is an antenna and, the method further comprises inputting antenna alignment access information via the target interface of the mobile terminal. The antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

[0030] In still other embodiments, inputting target position information into the target interface of the mobile terminal comprises receiving Global Positioning System (GPS) information from a target apparatus.

[0031] In further embodiments of the inventive concept, a method of operating a mobile terminal comprises generating directional information based on an orientation of the mobile terminal, receiving target position information, determining a difference between a pointing direction of the mobile terminal based on the directional information and a pointing direction aimed at the target position, and communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

[0032] In still further embodiments, communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating to a display a written description of the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

[0033] In still further embodiments, communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating to a speaker an audible description of the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

[0034] In still further embodiments, communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating to a display an iconic description of the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

[0035] In still further embodiments, the mobile terminal is coupled to an antenna and communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position to an electromechanical alignment mechanism that is configured to adjust an orientation of the antenna.

[0036] In still further embodiments, the mobile terminal is coupled to an antenna and the method further comprises receiving antenna alignment access information. The antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

[0037] In still further embodiments, receiving the target position information comprises receiving Global Positioning System (GPS) information from a target apparatus.

[0038] It is noted that aspects described with respect to one embodiment may be incorporated in different embodiments although not specifically described relative thereto. That is, all embodiments and/or features of any embodiments can be combined in any way and/or combination. Moreover, other apparatus, methods, systems, and/or articles of manufacture according to embodiments of the inventive subject matter will be or become apparent to one with skill in the art upon review of the following drawings and detailed description. It is intended that all such additional apparatus, systems, methods, and/or articles

of manufacture be included within this description, be within the scope of the present inventive subject matter, and be protected by the accompanying claims. It is further intended that all embodiments disclosed herein can be implemented separately or combined in any way and/or combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] Other features of embodiments will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

[0040] FIG. 1 is a perspective view of an alignment apparatus that uses a mobile terminal according to some embodiments of the inventive concept;

[0041] FIG. 2 is a perspective view of a holder of FIG. 1 that is used to hold a mobile terminal according to some embodiments of the inventive concept;

[0042] FIG. 3 is a block diagram that illustrates a mobile terminal that can be used with the alignment apparatus of FIG. 1 according to some embodiments of the inventive concept;

[0043] FIG. 4 is a flowchart that illustrates operations for using the alignment apparatus of FIG. 1 and the mobile terminal of FIG. 3 according to some embodiments of the inventive concept;

[0044] FIG. 5 is a flowchart that illustrates operations of the mobile terminal of FIG. 3 according to some embodiments of the inventive concept;

[0045] FIG. 6 is a flowchart that illustrates operations of the mobile terminal of FIG. 3 and the alignment apparatus of FIG. 1 according to some embodiments of the inventive concept; and

[0046] FIGS. 7A and 7B are diagrams of a mobile terminal display that illustrate communication between the mobile terminal of FIG. 3 and a user in operating the mobile terminal of FIG. 3 according to some embodiments of the inventive concept.

DETAILED DESCRIPTION

[0047] In the following detailed description, numerous specific details are set forth to provide a thorough understanding of embodiments of the present disclosure. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In some instances, well-known methods, procedures, components and circuits have not been described in detail so as not to obscure the present disclosure. It is intended that all embodiments disclosed herein can be implemented separately or combined

in any way and/or combination. Aspects described with respect to one embodiment may be incorporated in different embodiments although not specifically described relative thereto. That is, all embodiments and/or features of any embodiments can be combined in any way and/or combination.

[0048] As used herein, the term "mobile terminal" or "mobile device" may include a satellite or cellular radiotelephone with or without a multi-line display; a Personal Communications System (PCS) terminal that may combine a cellular radiotelephone with data processing, facsimile and data communications capabilities; a PDA or smart phone that can include a radiotelephone, pager, Internet/intranet access, Web browser, organizer, calendar, camera, and/or a global positioning system (GPS) receiver; and a conventional tablet, laptop, and/or palmtop receiver or other appliance that includes a radiotelephone transceiver. Mobile terminals or mobile devices may also be referred to as "pervasive computing" devices.

[0049] Certain types apparatus are designed to be aligned with another object or point of reference to carry out one or more functions. For example, as described above, microwave antennas communicate via line of sight propagation as the electromagnetic waves cannot pass around structures in the way that lower frequency radio waves are able to. Thus, to form a link, one microwave antenna may be aligned with another microwave antenna. Such an alignment is typically done by one or more technicians through the use of received signal strength measurements at each antenna comprising a link. A technician may manually adjust the azimuth and/or elevation angles of each antenna until a maximum value for the received signal strength is received at each end of the link. This alignment technique, however, often relies on the skill of the individual technician and can be both time consuming and difficult to produce consistent results.

[0050] Some embodiments of the inventive concept may provide an alignment apparatus that uses a mobile terminal, such as a cellular phone, tablet, laptop, or the like, to facilitate the alignment of an apparatus, such as a microwave antenna. In particular, the alignment apparatus may make use of the movement detector functionality that may be provided in a mobile terminal, such as one or more accelerometers, a gyroscope, and/or a Global Positioning System (GPS) module, which may be used to generate directional information based on an orientation of the mobile terminal, i.e., a pointing direction of the mobile terminal. An alignment module that executes on the mobile terminal may determine a difference between the directional information (i.e., pointing direction of the mobile terminal) and a pointing direction that is aimed at a target position (e.g., a point of reference, such as a location of an antenna, to determine if an apparatus is aimed at the target). The mobile

terminal may communicate feedback to a user to indicate how to adjust the aim of the apparatus at a target through textual prompts on a display, audio instructions, and/or through iconic representation of the alignment of the apparatus with a target. In some embodiments, a user may make manual adjustments to the orientation of an apparatus based on feedback received via the mobile terminal. In other embodiments, the mobile terminal may communicate with an electromechanical alignment mechanism using a short-range wireless protocol to automate the alignment process. In other embodiments of the inventive concept, the alignment application that executes on the mobile terminal may be configured to collect various data about the apparatus that is being aligned. For example, when the apparatus to be aligned is an antenna, such as a microwave antenna, the alignment application may collect information, such as the type and/or manufacturer of the antenna, the date when the antenna was installed, the geographic location of the antenna, and other information that may be useful to an antenna manufacturer in understanding the landscape of products that are installed in the field.

[0051] FIG. 1 is a perspective view of an alignment apparatus that uses a mobile terminal according to some embodiments of the inventive concept. In the example of FIG. 1, the alignment apparatus 100 is applied to a microwave antenna. It will be understood that the alignment apparatus 100 can be applied to other types of apparatus and devices that may be configured for alignment in a particular orientation. As shown in FIG. 1, the alignment apparatus 100 comprises a directional component 105, which is a microwave antenna structure that is coupled to a support structure (here a pole) using an alignment component 110. The alignment component 110 comprises various hardware components that can be adjusted to change the azimuth angle and/or the elevation angle of the directional component 105 so as to align the directional component with another point of reference, such as another microwave antenna. The alignment apparatus 100 further comprises a holder 115, which is configured to receive a mobile terminal, such as a mobile phone, tablet, laptop, and the like. In the example of FIG. 1, the holder 115 may attach to the back of the directional component 105, which is a reflector that is configured to direct radio waves, so that a face of a mobile terminal received therein is oriented to be in parallel with a plane defined by an outer circumference of the directional component 105 (reflector). The mobile terminal may include movement detector functionality, such as one or more accelerometers, a gyroscope, and/or a GPS module, which may be used to generate directional information, i.e., a pointing direction of the mobile terminal, based on an orientation of the mobile terminal. An alignment module that executes on the mobile terminal may determine a difference between

the directional information and a pointing direction that is aimed at a target position, e.g., a point of reference, such as a location of an antenna, to determine if the directional component 105 (reflector) is aimed at the target. The mobile terminal may facilitate alignment of the directional component 105 with a target by communicating feedback to a user to assist the user in adjusting the aim of the directional component 105. In accordance with various embodiments of the inventive concept, the mobile terminal may provide a user with textual prompts on a display, audio instructions, and/or an iconic representation of the alignment of the directional component with the target.

[0052] In some embodiments of the inventive concept, a user, such as a technician, may manually adjust the various hardware components comprising the alignment component 110 to change the orientation of the directional component 105 based on the feedback provided by the mobile terminal carried in the holder 115. In other embodiments, the alignment component 110 may comprise an electromechanical alignment mechanism 120 that is configured to manipulate the hardware components of the alignment component 110 to change the orientation of the directional component 105 responsive to a signal generated by the mobile terminal representative of the difference between the directional information generated by the mobile terminal and a pointing direction that is aimed at a target position. A wireless communication module 125 may provide communication functionality between the alignment component 110 and the mobile terminal. In accordance with various embodiments of the inventive concept, the wireless communication module 125 may provide short range wireless communication functionality through use of a Wi-Fi module, a Bluetooth module, and/or a Wireless Local Area Network (WLAN) module. The wireless communication module 125 may also provide cellular communication functionality to allow the alignment component 110 to be accessed over the Internet.

[0053] FIG. 2 is a perspective view of a holder for the mobile terminal of FIG. 1 according to some embodiments of the inventive concept. As shown in FIG. 2, the holder 200 includes a cradle portion 205 and an attachment portion 210. The cradle portion 205 shown in FIG. 2 is configured to orient the mobile terminal in a landscape display format. It will be understood, however, that the cradle portion 205 may be configured to orient the mobile terminal 205 in any desired display format. The attachment portion 210 may be configured in a suitable manner to facilitate attachment of the holder 200 to the hardware comprising the directional component 105.

[0054] Referring now to FIG. 3, an exemplary mobile terminal 300 that may be used with the alignment apparatus 100 of FIG. 1, according to some embodiments of the inventive

concept, includes a movement detector 301, a video recorder 302, a camera 305, a microphone 310, a keyboard/keypad 315, a speaker 320, a display 325, a transceiver 330, and a memory 335 that communicate with a processor 340. The transceiver 330 comprises a transmitter circuit 345 and a receiver circuit 350, which respectively transmit outgoing radio frequency signals to base station transceivers and receive incoming radio frequency signals from the base station transceivers via an antenna 355. The radio frequency signals transmitted between the mobile terminal 300 and the base station transceivers may comprise both traffic and control signals (*e.g.*, paging signals/messages for incoming calls), which are used to establish and maintain communication with another party or destination. The radio frequency signals may also comprise packet data information, such as, for example, cellular digital packet data (CDPD) information. The transceiver 330 may further comprise a short-range communication module 352, which may provide support for Wi-Fi, Bluetooth, and/or a WLAN communication protocols to communicate with, for example, the wireless communication module 125 of the alignment component 110 of FIG. 1. The movement detector 301 may comprise one or more accelerometers, a gyroscope for detecting rotational movement, and/or a GPS module. The movement detector 301, video recorder 302, camera 305, and/or microphone 310 may be referred to as environmental sensors that are configured to obtain information associated with the environment surrounding the mobile terminal 300. The foregoing components of the mobile terminal 300 may be included in many conventional mobile terminals and their functionality is generally known to those skilled in the art.

[0055] The processor 340 communicates with the memory 335 via an address/data bus. The processor 340 may be, for example, a commercially available or custom microprocessor. The memory 335 is representative of the one or more memory devices containing the software and data used to facilitate alignment of an apparatus with a target in accordance with some embodiments of the inventive concept. The memory 335 may include, but is not limited to, the following types of devices: cache, ROM, PROM, EPROM, EEPROM, flash, SRAM, and DRAM.

[0056] As shown in FIG. 3, the memory 335 may contain up to three or more categories of software and/or data: an operating system 365, an alignment module 367, and a communication module 390. The operating system 365 generally controls the operation of the mobile terminal 300. In particular, the operating system 365 may manage the mobile terminal's software and/or hardware resources and may coordinate execution of programs by the processor 340.

[0057] The alignment module 367 may be configured to facilitate the alignment of an apparatus with a target in accordance with some embodiments of the inventive concept. The alignment module 367 comprises a target interface 370, an alignment correction module 375, a user feedback module 380, and an alignment control module 385. The target interface module 370 may be configured to receive the coordinates of a target or point of reference. For example, in the case of aligning an antenna, such as a microwave antenna, a user or technician may input the GPS coordinates of another microwave antenna that will be used as a target. The other microwave antenna may also communicate its location to the target interface module 370 of the mobile terminal 300 in accordance with other embodiments of the inventive concept.

[0058] The alignment correction module 375 may be configured to use directional information generated by the movement detector 301 to determine a difference between the orientation of the mobile terminal 300 and a target, i.e., whether the mobile terminal 300 is aimed at the target. The movement detector 301 may generate data that are indicative of movement of the mobile terminal, which can be processed by the alignment correction module 375 to interpret how the mobile terminal 300 is oriented relative to the target. For example, the accelerometers may generate data that are indicative of movement of the mobile terminal 300, a gyroscope may generate data that are indicative of rotational movement of the mobile terminal 300, and a GPS module may generate GPS data that are indicative of the location of the mobile terminal 300.

[0059] A user feedback module 380 may be configured to communicate feedback to a user or technician to indicate how to adjust the aim of the mobile terminal (and an apparatus to which the mobile terminal is attached) at a target through textual prompts on a display, audio instructions, and/or through iconic representation of the alignment of the mobile terminal/apparatus with a target.

[0060] As described above, a user or technician may manually adjust the alignment of an apparatus based on feedback received from the mobile terminal 300 through the user feedback module 380. In other embodiments of the inventive concept, an alignment control module 380 may use the cellular functionality and/or the short-range wireless communication functionality via the short-range module 352 to communicate with a wireless communication module 125 of an alignment component 110 to electromechanically adjust the orientation of an apparatus based on the difference between the orientation of the mobile terminal 300 and a target.

[0061] In other embodiments of the inventive concept, the target interface 370 may be configured to collect various data about the apparatus that is being aligned. For example, when the apparatus to be aligned is an antenna, such as a microwave antenna, the alignment module 367 may collect information, such as the type and/or manufacturer of the antenna, the date when the antenna was installed, the geographic location of the antenna, and other information that may be useful to an antenna manufacturer in understanding the landscape of products that are installed in the field. In some embodiments, target interface may be configured to read and interpret various codes including, but not limited to, bar codes, Universal Product Codes, QR codes, and the like through the camera 305 or a dedicated scanning component. The target interface 370 may require one or more such pieces of information be collected before the various sub-modules of the alignment module 367 are enabled. The target interface 370 may also interact with the environmental sensors including the video recorder 302, the camera 305, and/or the microphone 310 to collect information about the environment surrounding the apparatus to be aligned as well as the apparatus itself. This information may be useful in determining, for example, what may have caused the apparatus to become misaligned. The information may also provide details about the configuration of the apparatus, including features, model numbers, condition (deterioration and/or wear), and the like. All such information may be considered a pre-requisite for using the alignment module 367. In some embodiments, a user or technician agree to the collection of such data as part of a terms of use agreement provided through the target interface 367.

[0062] The communication module 390 may be configured to facilitate communication between the mobile terminal 300 and other devices.

[0063] Although FIG. 3 illustrates an exemplary software and hardware architecture that may be used for facilitating apparatus alignment using a mobile terminal according to some embodiments of the inventive concept, it will be understood that embodiments of the present invention are not limited to such a configuration, but are intended to encompass any configuration capable of carrying out the operations described herein.

[0064] Computer program code for carrying out operations of the mobile terminal 300 described above with respect to FIG. 3 may be written in a high-level programming language, such as Python, Java, C, and/or C++, for development convenience. In addition, computer program code for carrying out operations of embodiments of the present invention may also be written in other programming languages, such as, but not limited to, interpreted languages. Some modules or routines may be written in assembly language or even micro-code to enhance performance and/or memory usage. It will be further appreciated that the

functionality of any or all of the program modules may also be implemented using discrete hardware components, one or more application specific integrated circuits (ASICs), or a programmed digital signal processor or microcontroller.

[0065] Moreover, the functionality of the mobile device 300 of FIG. 3 may be implemented as a single processor system, a multi-processor system, a multi-core processor system, or even a network of processors, in accordance with various embodiments of the inventive subject matter. Each of these processor/computer systems may be referred to as a "processor" or "data processing system."

[0066] FIG. 4 is a flowchart that illustrates operations for using the alignment apparatus 100 of FIG. 1 and the mobile terminal 300 of FIG. 3 according to some embodiments of the inventive concept. Operations begin at block 400 where the mobile terminal 300 is placed into the holder 115 of FIG. 1 that is coupled to the directional component 105 of an apparatus, e.g., a microwave antenna. Target position information is input into the mobile terminal 300 via the target interface 370 at block 405. The target position information may be manually entered, such as, for example, entry of GPS coordinates of a target or, in other embodiments, the target position information may be received wirelessly from the target or from another device. A user or technician may receive a difference between a pointing direction aimed at the target position and directional information (representing the pointing direction of the mobile terminal 300) generated by the alignment correction module 375 of the mobile terminal 300. This difference may be communicated to the user or technician in various ways, including an audio description through the speaker 320 of the mobile terminal 300, a written description via the display 325 of the mobile terminal 300, and/or an iconic representation via the display 325 of the mobile terminal 300. FIG. 7A illustrates communication of the difference between a pointing direction aimed at the target position and the directional information corresponding to a pointing direction of the mobile terminal 300 via a written description. As shown in FIG. 7A, a mobile terminal 700 includes a display 705 with the message 710 for the user or technician to adjust the orientation of the apparatus to which the mobile terminal 700 is attached by panning right 2.7 degrees. FIG. 7B illustrates communication of the difference between a pointing direction aimed at the target position information and the directional information corresponding to a pointing direction of the mobile terminal 300 via an iconic representation. As shown in FIG. 7B, a mobile terminal 700 includes a display 705 with a bullseye 715 that represents a pointing direction aimed at the target position and a cursor 720 that represents the directional information corresponding to a pointing direction of the mobile terminal 700. The display graphically instructs a user or

technician how to adjust the orientation of the apparatus to which the mobile terminal 700 is attached to align the apparatus so as to be aimed at the target position. Returning to FIG. 4, the orientation of the directional component 105 of the apparatus may be adjusted at block 415 based on the difference between a pointing direction aimed at the target position and the directional information corresponding to a pointing direction of the mobile terminal 300. As described above, the orientation of the directional component 105 may be manually adjusted and/or electromechanically adjusted in accordance with various embodiments of the inventive concept.

[0067] FIG. 5 is a flowchart that illustrates operations of the mobile terminal 300 of FIG. 3 according to some embodiments of the inventive concept. Operations begin at block 500 where the alignment correction module 375 of the mobile terminal 300 generates directional information that represents a pointing direction of the mobile terminal 300 and a directional portion of an apparatus to which the mobile terminal 300 is attached. At block 505, the mobile terminal 300 receives target position information via the target interface 370. As described above, the target position information may be manually entered, such as, for example, GPS coordinates of a target or, in other embodiments, the target position information may be received wirelessly from the target or elsewhere. The alignment correction module 375 of the mobile terminal may determine a difference between a pointing direction aimed at the target position and directional information corresponding to a pointing direction of the mobile terminal 300 at block 510. As described above, this difference may be communicated to the user or technician in various ways, including an audio description through the speaker 320 of the mobile terminal 300, a written description via the display 325 of the mobile terminal 300, and/or an iconic representation through via the display 325 of the mobile terminal 300 at block 515.

[0068] FIG. 6 is a flowchart that illustrates operations for using the alignment apparatus 100 of FIG. 1 and the mobile terminal 300 of FIG. 3 according to some embodiments of the inventive concept. In particular, FIG. 6 illustrates operations for performing an initial coarse alignment of an apparatus with a target position followed by a more precise fine alignment. For example, an antenna technician may wish to get an initial coarse alignment with a target while at the bottom of an antenna tower before performing the more precise alignment after climbing the tower and accessing the antenna structure. Operations begin at block 600 where the mobile terminal 300 is placed a distance away from an apparatus. Target position information is input into the mobile terminal 300 via the target interface 370 at block 605. A user or technician may receive a first difference between a pointing direction aimed at the

target position and a pointing direction of the mobile terminal 300 generated by the alignment correction module 375 of the mobile terminal 300 at block 610. This difference may be communicated to the user or technician in various ways as described above. At block 615 the mobile terminal is placed into the holder 115 of FIG. 1 that is coupled to the directional component 105 of the apparatus. The orientation of the directional component 105 of the apparatus may be adjusted at block 620 based on the first difference between a pointing direction aimed at the target position and the directional information corresponding to a pointing direction of the mobile terminal 300 (i.e., the difference generated when the mobile terminal was remote the apparatus) to perform a coarse alignment of the apparatus. At block 625, a second difference between a pointing direction aimed at the target position and a pointing direction of the mobile terminal 300 generated by the alignment correction module 375 of the mobile terminal 300 is received. The orientation of the directional component 105 of the apparatus may be further adjusted at block 630 based on the second difference between a pointing direction aimed at the target position and the directional information corresponding to a pointing direction of the mobile terminal 300 to perform a fine alignment of the apparatus.

[0069] Some embodiments of an alignment apparatus that uses a mobile terminal described herein may provide a relatively low cost system for aligning an apparatus, such as a microwave antenna, with a target position, such as another microwave antenna. A mobile terminal may be configured with an alignment module or application that can be attached to an apparatus to be aligned using a holder designed to receive the mobile terminal. The movement detector functionality provided in a mobile terminal, such as accelerometers, a GPS unit, and/or a gyroscope may be used to improve the accuracy of an alignment as compared to conventional techniques that rely more heavily on the skill of a user or technician. The mobile terminal may also communicate with an electromechanical module associated with an alignment component (e.g., the adjustable alignment hardware) of an apparatus to be aligned to automate the alignment process. In addition, the alignment software and/or hardware module provided on the mobile terminal may be used to collect useful information about the apparatus being aligned along with the surrounding environment as a condition for using the alignment functionality.

[0070] Further Definitions and Embodiments:

[0071] In the above-description of various embodiments of the present disclosure, aspects of the present disclosure may be illustrated and described herein in any of a number of patentable classes or contexts including any new and useful process, machine, manufacture,

or composition of matter, or any new and useful improvement thereof. Accordingly, aspects of the present disclosure may be implemented entirely hardware, entirely software (including firmware, resident software, micro-code, etc.) or combining software and hardware implementation that may all generally be referred to herein as a "circuit," "module," "component," or "system." Furthermore, aspects of the present disclosure may take the form of a computer program product comprising one or more computer readable media having computer readable program code embodied thereon.

[0072] Any combination of one or more computer readable media may be used. The computer readable media may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an appropriate optical fiber with a repeater, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0073] A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device. Program code embodied on a computer readable signal medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

[0074] Computer program code for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Scala, Smalltalk, Eiffel, JADE, Emerald, C++, C#, VB.NET, Python or the like, conventional procedural

programming languages, such as the "C" programming language, Visual Basic, Fortran 2003, Perl, COBOL 2002, PHP, ABAP, dynamic programming languages such as Python, Ruby and Groovy, or other programming languages.

[0075] Aspects of the present disclosure are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable instruction execution apparatus, create a mechanism for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0076] These computer program instructions may also be stored in a computer readable medium that when executed can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions when stored in the computer readable medium produce an article of manufacture including instructions which when executed, cause a computer to implement the function/act specified in the flowchart and/or block diagram block or blocks. The computer program instructions may also be loaded onto a computer, other programmable instruction execution apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatuses or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0077] The flowchart and block diagrams in the figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various aspects of the present disclosure. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the

blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

[0078] The terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Like reference numbers signify like elements throughout the description of the figures.

[0079] Embodiments are described herein with reference to cross-sectional and perspective views that are schematic illustrations of idealized embodiments. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. Therefore, regions illustrated in the drawings are schematic in nature, and their shapes are not intended to limit the inventive concept.

[0080] The thicknesses of elements in the drawings may be exaggerated for the sake of clarity. Further, it will be understood that when an element is referred to as being "on" another element, the element may be formed directly on the other element, or there may be an intervening layer therebetween.

[0081] Terms such as "top," "bottom," "upper," "lower," "above," "below," and the like are used herein to describe the relative positions of elements or features. For example, when an upper part of a drawing is referred to as a "top" and a lower part of a drawing is referred to as a "bottom" for the sake of convenience, in practice, the "top" may also be called a "bottom" and the "bottom" may also be a "top" without departing from the teachings of the inventive concept.

[0082] Furthermore, throughout this disclosure, directional terms such as "upper," "intermediate," "lower," and the like may be used herein to describe the relationship of one

element or feature with another, and the inventive concept should not be limited by these terms. Accordingly, these terms such as "upper, " "intermediate, " "lower, " and the like may be replaced by other terms such as "first, " "second, " "third," and the like to describe the elements and features.

[0083] It will be understood that, although the terms "first," "second," etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. Thus, a first element could be termed a second element without departing from the teachings of the inventive concept.

[0084] The terminology used herein to describe embodiments of the invention is not intended to limit the scope of the inventive concept.

[0085] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this inventive concept belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and this specification and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0086] The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The aspects of the disclosure herein were chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to understand the disclosure with various modifications as are suited to the particular use contemplated.

WHAT IS CLAIMED IS:

1. An apparatus, comprising:
a directional component;
a holder coupled to the directional component and configured to receive a mobile terminal; and
an alignment component coupled to the directional component, the alignment component being configured to adjust an orientation of the directional component based on directional information generated by the mobile terminal.
2. The apparatus of Claim 1, wherein the alignment component further comprises a wireless communication module that is configured to receive the directional information generated by the mobile terminal.
3. The apparatus of Claim 2, wherein the wireless communication module comprises at least one of a cellular module, a Wi-Fi module, a Bluetooth module, and a Wireless Local Area Network (WLAN) interface module.
4. The apparatus of Claim 1, wherein the directional component is an antenna, the antenna comprising a reflector that is configured to direct radio waves.
5. The apparatus of Claim 4, wherein the holder is further configured to align a display face of the mobile terminal so as to be substantially parallel with a plane defined by an outer circumference of the reflector.
6. The apparatus of Claim 4, wherein the antenna is a microwave antenna.
7. A mobile terminal, comprising:

an environmental sensor that is configured to generate directional information based on an orientation of the mobile terminal;

a target interface that is configured to receive target position information;

an alignment correction module that is configured to determine a difference between a pointing direction based on the directional information and a pointing direction that is aimed at the target position based on the target position information; and

a user feedback module that is configured to communicate the difference between the directional information and the target position information.

8. The mobile terminal of Claim 7, wherein the user feedback module is further configured to communicate to a display a written description of the difference between the pointing direction based on the directional information and the pointing direction that is aimed at the target position based on the target position information.

9. The mobile terminal of Claim 7, wherein the user feedback module is further configured to communicate to a speaker an audible description of the difference between the pointing direction based on the directional information and the pointing direction that is aimed at the target position based on the target position information.

10. The mobile terminal of Claim 7, wherein the user feedback module is further configured to communicate to a display an iconic description of the difference between the pointing direction based on the directional information and the pointing direction that is aimed at the target position based on the target position information.

11. The mobile terminal of Claim 7, wherein the environmental sensor comprises a movement detector that is configured to generate data that are indicative of movement of the mobile terminal, the directional information being based on the data that are indicative of the movement of the mobile terminal.

12. The mobile terminal of Claim 11, wherein the movement detector comprises at least one accelerometer that is configured to generate the data that are indicative of movement of the mobile terminal.

13. The mobile terminal of Claim 12, wherein the movement detector further comprises a gyroscope that is configured to generate data that are indicative of rotational movement of the mobile terminal, the directional information being based on the data that are indicative of the rotational movement of the mobile terminal.

14. The mobile terminal of Claim 11, wherein the movement detector comprises a Global Positioning System (GPS) module that is configured to generate GPS data, the directional information being based on the GPS data.

15. The mobile terminal of Claim 7, wherein the environmental sensor comprises a microphone that is configured to capture audio information from the surrounding environment.

16. The mobile terminal of Claim 15, wherein the target interface, alignment correction module, and user feedback module are configured to be enabled responsive to the audio information comprising antenna alignment access information; and

wherein the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

17. The mobile terminal of Claim 7, wherein the environmental sensor comprises a camera and/or a video recorder that is configured to capture graphic and/or video information from the surrounding environment.

18. The mobile terminal of Claim 17, wherein the target interface, alignment correction module, and user feedback module are configured to be enabled responsive to the graphic and/or video information comprising antenna alignment access information; and

wherein the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

19. The mobile terminal of Claim 7, wherein the target interface, alignment correction module, and user feedback module are configured to be enabled responsive to input of antenna alignment access information via the target interface; and

wherein the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

20. The mobile terminal of Claim 7, wherein the target position information comprises Global Positioning System (GPS) information received from a target apparatus.

21. A method, comprising:
placing a mobile terminal into a holder coupled to a directional component of an apparatus;
inputting target position information into a target interface of the mobile terminal;
receiving a difference between a direction pointing at the target position and a pointing direction of the mobile terminal based on an orientation of the mobile terminal; and
adjusting an orientation of the directional component based on the difference between a pointing direction that is aimed at the target position and a pointing direction of the mobile terminal.

22. The method of Claim 21, wherein adjusting the orientation of the directional component comprises manually adjusting the orientation of the directional component.

23. The method of Claim 21, wherein the apparatus is an antenna, the method further comprising:
inputting antenna alignment access information via the target interface of the mobile terminal;
wherein the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

24. The method of Claim 21, wherein inputting target position information into the target interface of the mobile terminal comprises receiving Global Positioning System (GPS) information from a target apparatus.

25. A method of operating a mobile terminal, comprising:
generating directional information based on an orientation of the mobile terminal;
receiving target position information;
determining a difference between a pointing direction of the mobile terminal based on the directional information and a pointing direction aimed at the target position; and

communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

26. The method of Claim 25, wherein communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating to a display a written description of the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

27. The method of Claim 25, wherein communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating to a speaker an audible description of the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

28. The method of Claim 25, wherein communicating the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position comprises communicating to a display an iconic description of the difference between the pointing direction of the mobile terminal and the pointing direction aimed at the target position.

29. The method of Claim 25, wherein the mobile terminal is coupled to an antenna, the method further comprising:
receiving antenna alignment access information;
wherein the antenna alignment access information comprises at least one of a type of antenna, an antenna installation date, and a geographical location of the antenna.

30. The method of Claim 25, wherein receiving the target position information comprises receiving Global Positioning System (GPS) information from a target apparatus.

31. A method, comprising:
placing mobile terminal a distance away from an apparatus;
inputting target position information;

receiving a first difference between a pointing direction aimed at the target position and a pointing direction of the mobile terminal;

placing the mobile terminal into a holder that is coupled to a directional component of the apparatus;

adjusting an orientation of the directional component based on the first difference between the pointing direction aimed at the target position and the pointing direction of the mobile terminal;

receiving a second difference between the pointing direction aimed at the target position and the pointing direction of the mobile terminal responsive to adjusting the orientation; and

adjusting the orientation of the directional component based on the second difference between the pointing direction aimed at the target position and the pointing direction of the mobile terminal.

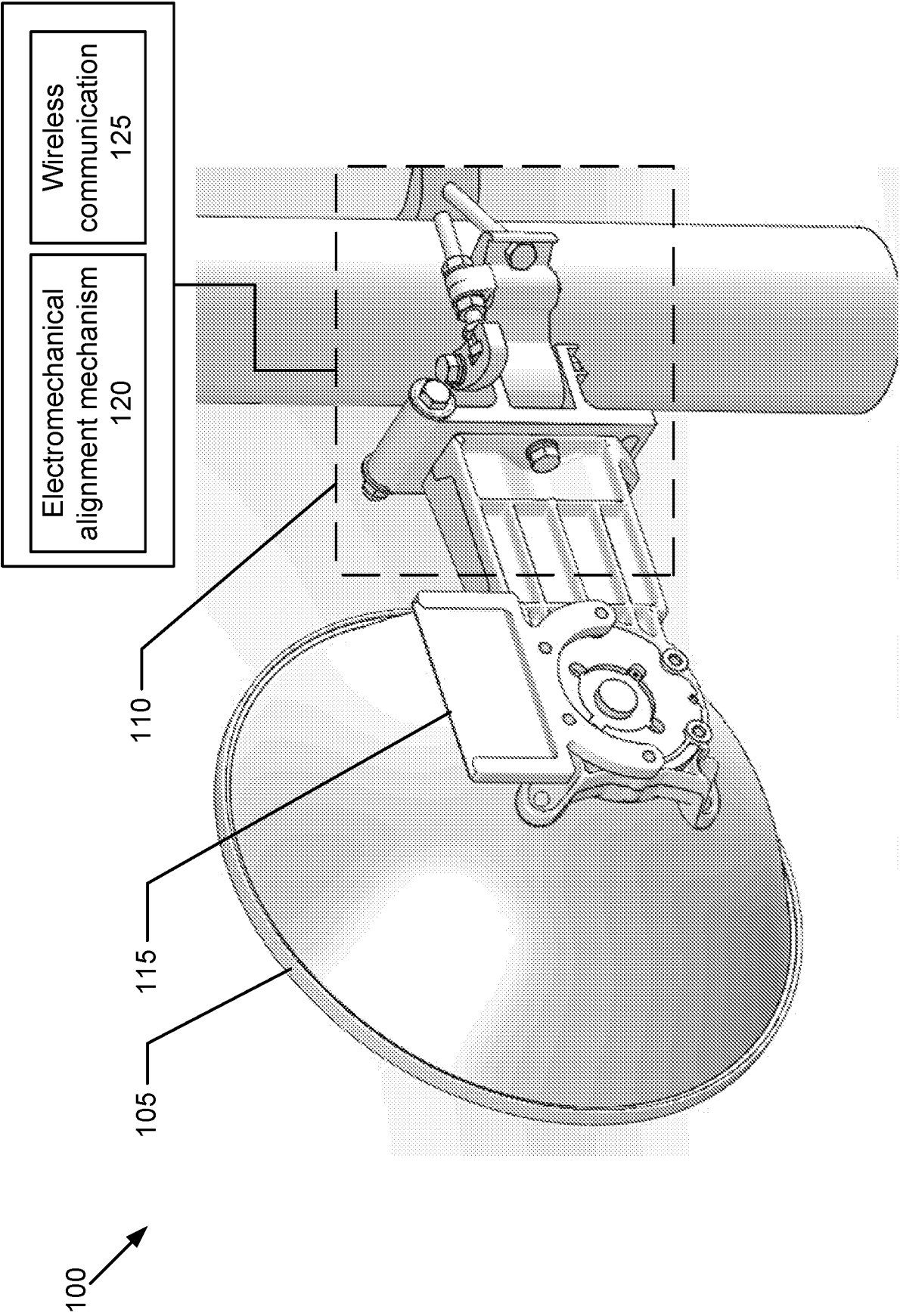


FIG. 1

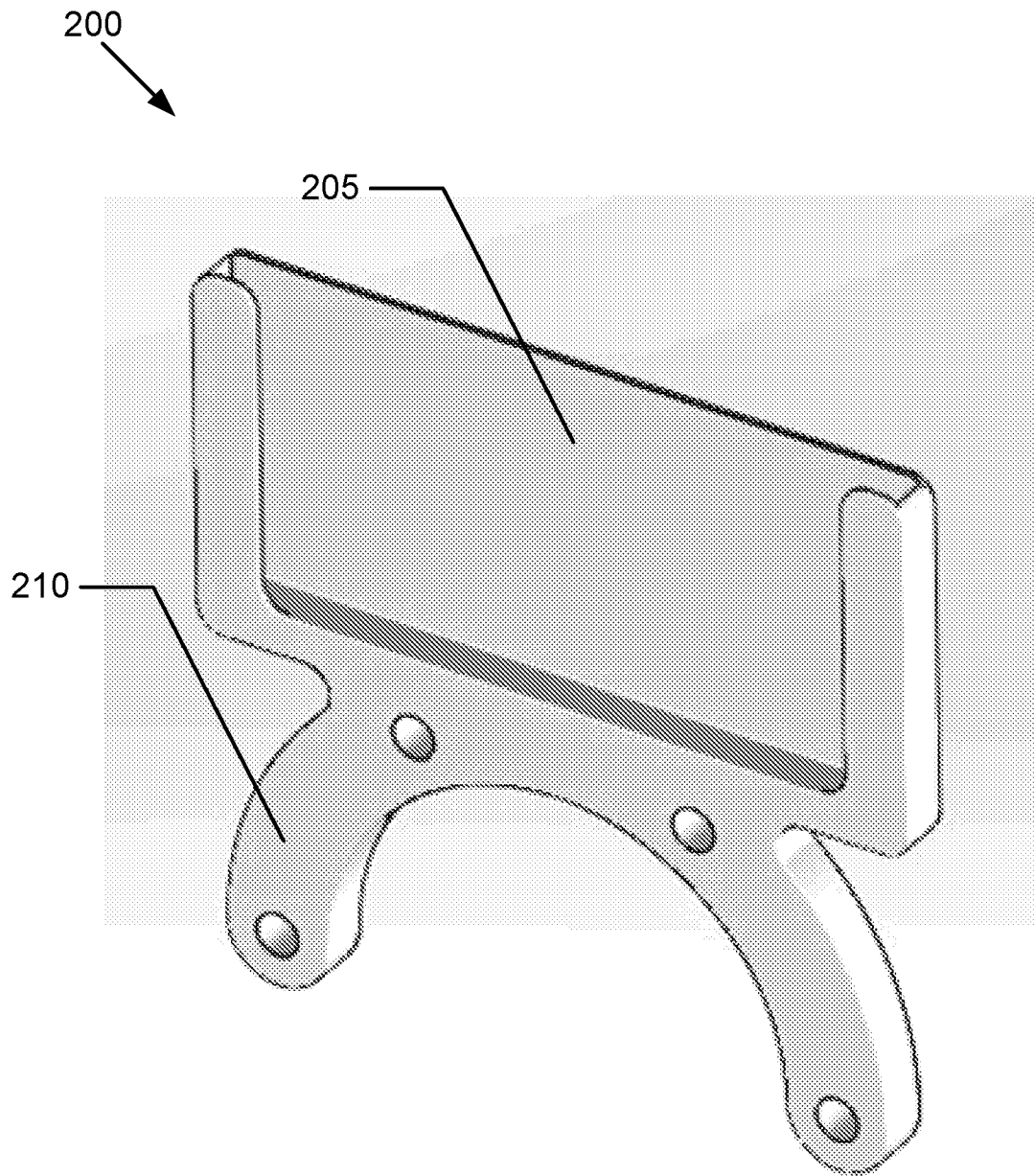
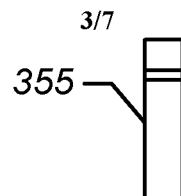
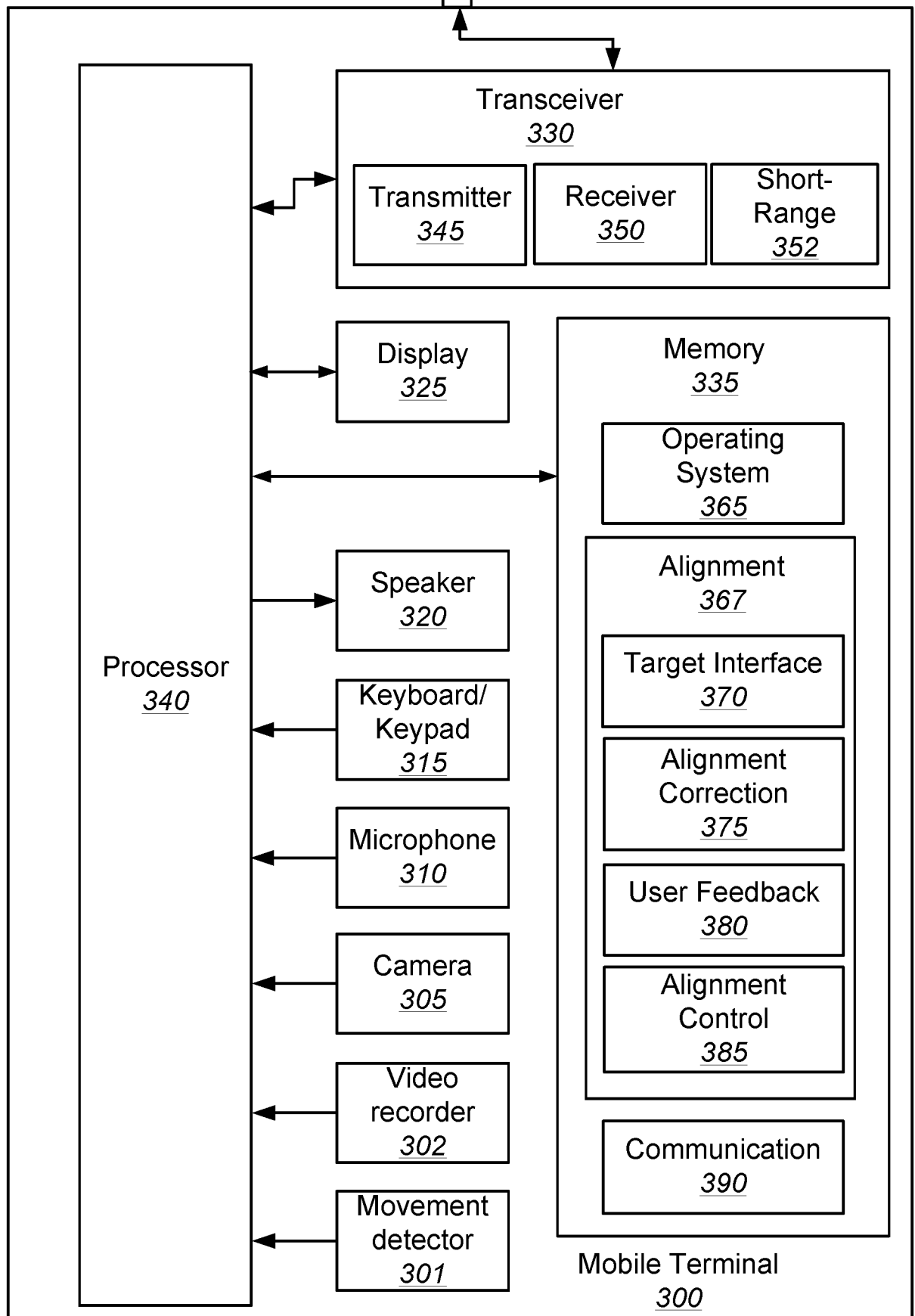
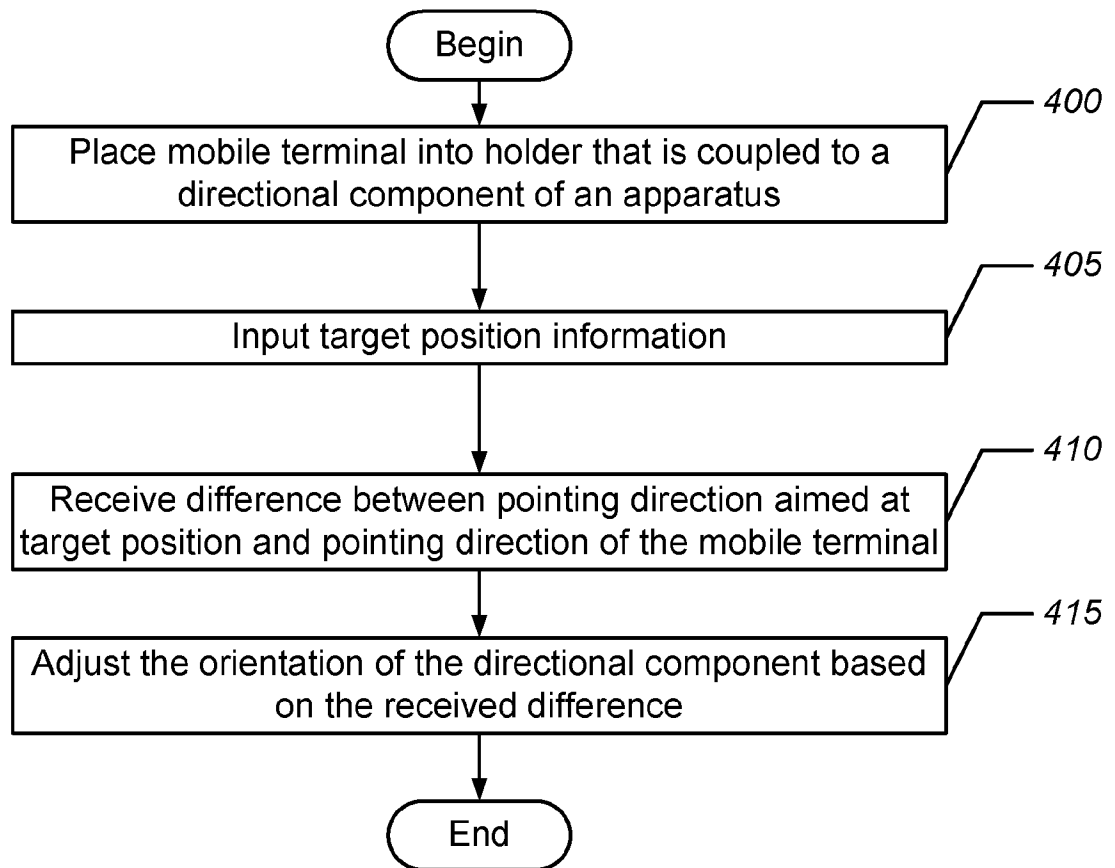
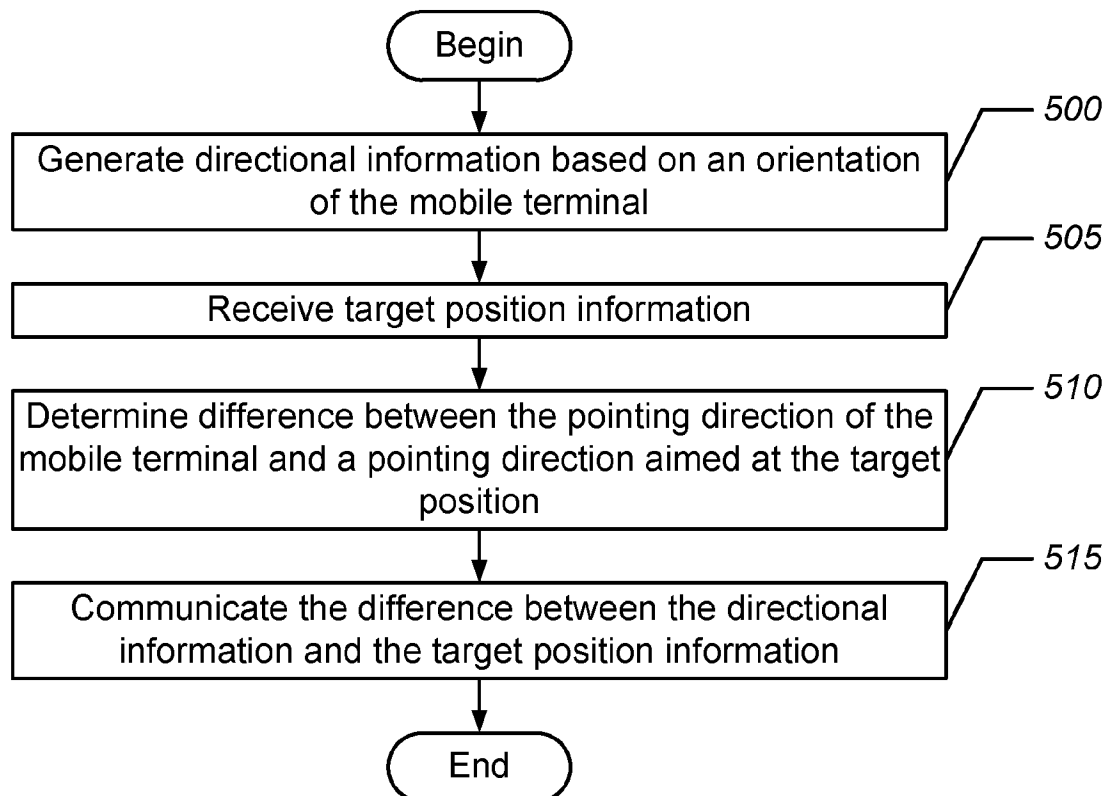
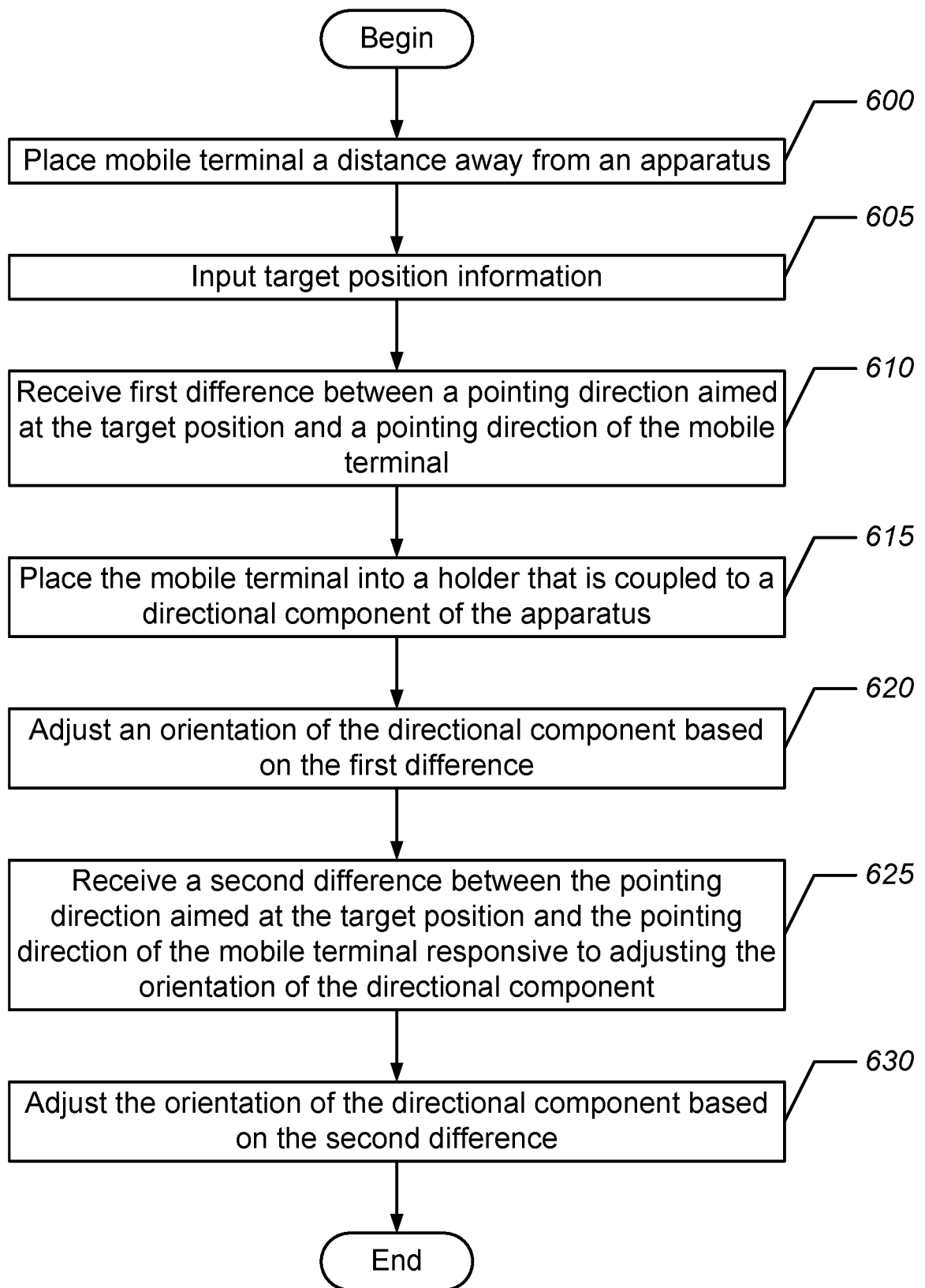
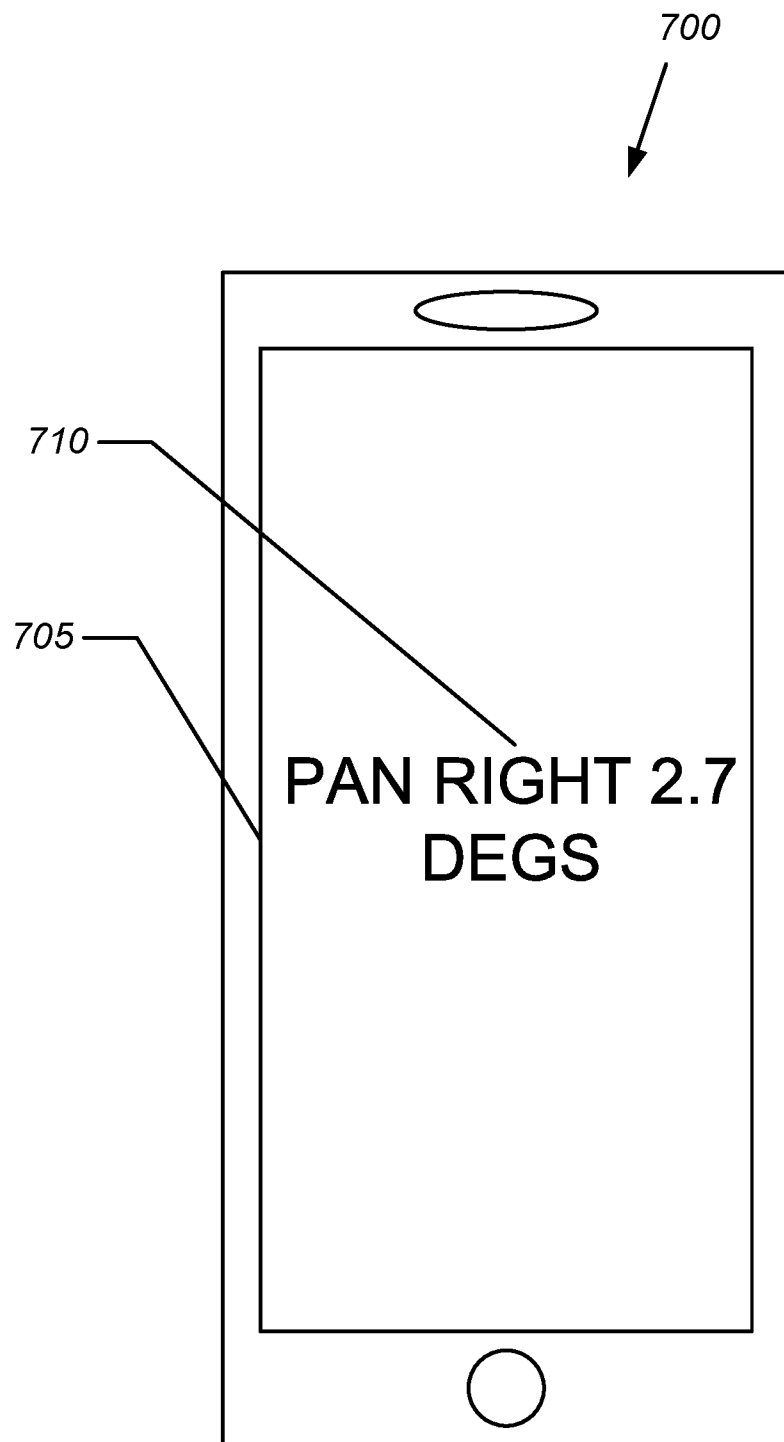


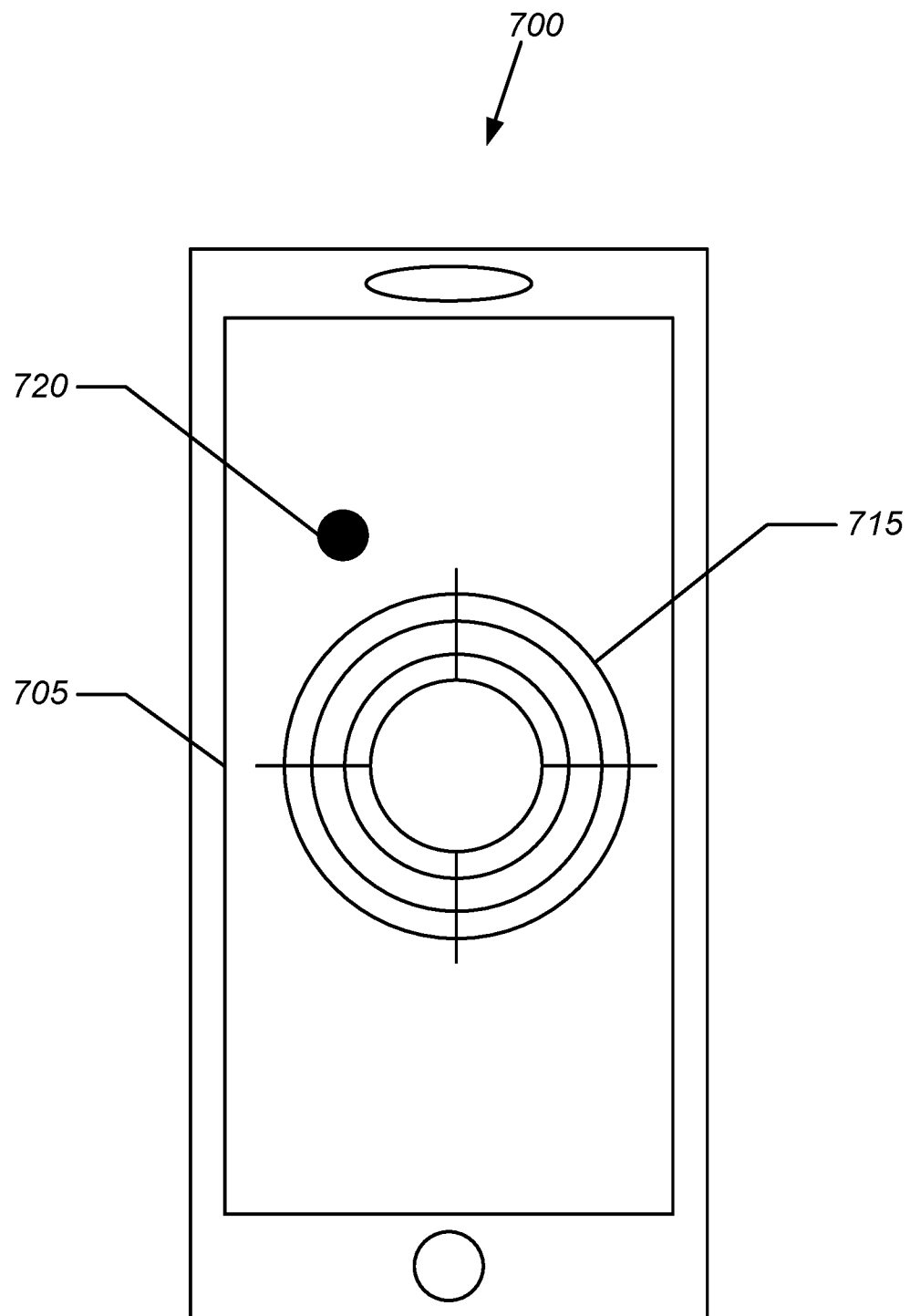
FIG. 2

**FIG. 3**

**FIG. 4****FIG. 5**

**FIG. 6**

**FIG. 7A**

**FIG. 7B**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/13787

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04M 1/737; H01Q 3/02 (2018.01)

CPC - H04B 1/3877; H04B 1/52; H04M 1/7253; H04M 2250/12; H01Q 3/02; H01Q 3/00; H01Q 3/12; H01Q 3/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 2015/0381293 A1 (Hardy et al.) 31 December 2015 (31.12.2015), para [0066]-[0068], [0073], [0075]-[0076], [0089], [0091]-[0093], [0095], [0099]-[100].	1-5, 7, 9-14, 19-25, 27-31 ----- 6, 15-18 ----- 8, 26
Y	US 2002/0090941 A1 (Zhang) 11 July 2002 (11.07.2002), para [0031].	6
Y	US 2013/0147923 A1 (Zhou et al.) 13 June 2013 (13.06.2013), para [0027], [0029]-[0030].	15-18
Y	US 2013/0271320 A1 (Trenise) 17 October 2013 (17.10.2013), para [0075].	16, 18
A	US 2008/0258971 A1 (Nichols et al.) 23 October 2008 (23.10.2008), para [0018]-[0026].	1-31
A	US 2013/0040655 A1 (Keidar) 14 February 2013 (14.02.2013), entire document.	1-31
A	US 8,193,983 B1 (Farmer) 05 June 2012 (05.06.2012), entire document.	1-31

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 April 2018

Date of mailing of the international search report

02 MAY 2018

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