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(54) Mobile wireless communications device including an antenna having a shorting plate

(57) A mobile wireless communications device may include a housing, a substrate (32) carried by the housing, and a ground plane (36) adjacent the substrate. The mobile wireless communications device may also include wireless communications circuitry, and first and second antennas (40,50) coupled to the wireless communications circuitry. The first antenna (40) may include a base electrical conductor (41) spaced above the substrate, and at least one feed leg (42a) extending downwardly from the base electrical conductor to the substrate. The first antenna may also include an electrically conductive shorting plate (43) extending downwardly from the base electrical conductor from a portion thereof adjacent the second antenna and coupled to the ground plane.

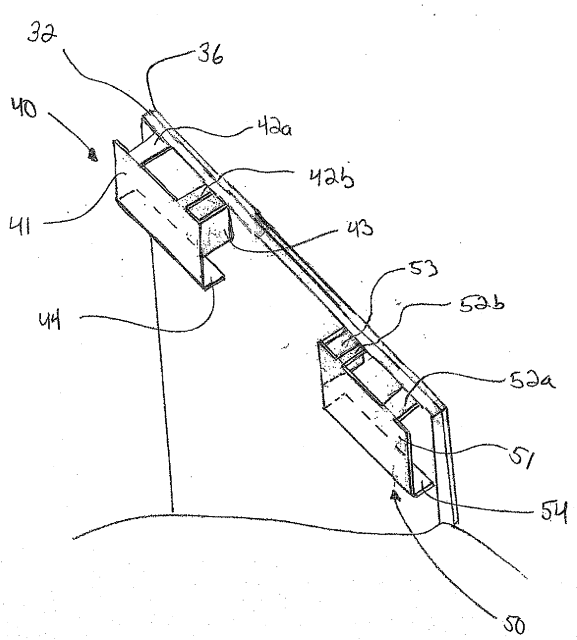

Fig. 3

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Description

Technical Field

[0001] The present disclosure generally relates to the field of wireless communications systems, and, more particularly, to mobile wireless communications devices and related methods.

Background

[0002] Mobile wireless communications systems continue to grow in popularity and have become an integral part of both personal and business communications. For example, cellular telephones allow users to place and receive voice calls almost anywhere they travel. Moreover, as cellular telephone technology has increased, so too has the functionality of cellular devices and the different types of devices available to users. For example, many cellular devices now incorporate personal digital assistant (PDA) features such as calendars, address books, task lists, etc. Moreover, such multi-function devices may also allow users to wirelessly send and receive electronic mail (email) messages and access the Internet via a cellular network and/or a wireless local area network (WLAN), for example.

[0003] Even so, as the functionality of cellular communications devices continues to increase, so too does the demand for smaller devices which are easier and more convenient for users to carry. One challenge this poses for cellular device manufacturers is designing antennas that provide desired operating characteristics within the relatively limited amount of space available for antennas.

Brief Description of the Drawings

[0004] FIG. 1 is a top plan view of a mobile wireless communications device including a first and second antenna in accordance with one example embodiment.

[0005] FIG. 2 is a schematic block diagram of the device of FIG. 1.

[0006] FIG. 3 is perspective view of a portion of a mobile wireless communications device including the first and second antennas of the device of FIG. 1.

[0007] FIG. 4 is a graph of simulated S-parameters for different first and second antennas including the first and second antennas of FIG. 3.

[0008] FIGS. 5a-5c are graphs of simulated gain for the first and second antennas of FIG. 3.

[0009] FIG. 6 is a schematic block diagram illustrating in more detail components that may be included in the mobile wireless communications device of FIG. 1.

Detailed Description

[0010] The present description is made with reference to the accompanying drawings, in which various embodiments are shown. However, many different embodiments may be used, and thus the description should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete. Like numbers refer to like elements throughout.

[0011] In accordance with one exemplary aspect, a mobile wireless communications device may include a housing, a substrate carried by the housing, and a ground plane, which may include a conductive material, adjacent the substrate. The mobile wireless communications device may also include wireless communications circuitry, and first and second antennas coupled to the wireless communications circuitry, for example. The first antenna may include a base electrical conductor spaced above the substrate, and at least one feed leg extending downwardly from the base electrical conductor to the substrate and coupled to the wireless communications circuitry. The first antenna may also include an electrically conductive shorting plate extending downwardly from the base electrical conductor from a portion thereof adjacent the second antenna and coupled to the ground plane, for example.

[0012] The first antenna may further include an electrically conductive lip extending downwardly from the base electrical conductor on a side edge thereof opposite the at least one feed leg, toward the substrate and spaced therefrom. The electrically conductive lip may extend downwardly from the side edge along an entire length thereof, for example. The electrically conductive shorting plate may extend downwardly along less than an entire length of the portion of the base electrical conductor, for example.

[0013] The second antenna may include a base electrical conductor spaced above the substrate, and at least one feed leg extending downwardly from the base conductor to the substrate. The second antenna may also include an electrically conductive shorting plate extending downwardly from the base electrical conductor from a portion thereof adjacent the first antenna and coupled to the ground plane, for example.

[0014] The second antenna may further include an electrically conductive lip extending downwardly from the base electrical conductor on a side edge thereof opposite the at least one feed leg, toward the substrate and spaced therefrom, for example.

The electrically conductive lip of the second antenna may extend downwardly from the side edge along an entire length thereof. The electrically conductive shorting plate of the second antenna may extend downwardly along less than an entire length of the portion of the base electrical conductor, for example.

[0015] The at least one feed leg may include a first feed leg extending downwardly from the base electrical conductor to the substrate. The at least one feed leg may also include a second feed leg extending downwardly from the base electrical conductor and coupled to the ground plane, for example.

[0016] A method aspect is directed to a method of mak-

ing a mobile wireless communications device. The mobile device may include a housing, a substrate carried by the housing, a ground plane adjacent the substrate, and wireless communications circuitry. The method may include forming first and second antennas on the substrate and coupled to the wireless communications circuitry, for example. Forming the first antenna may include a base electrical conductor spaced above the substrate, and forming at least one feed leg extending downwardly from the base electrical conductor to the substrate. Forming the first antenna may also include forming an electrically conductive shorting plate extending downwardly from the base electrical conductor from a portion thereof adjacent the second antenna and coupled to the ground plane.

[0017] Referring initially to FIGS. 1-3, a mobile wireless communications device **30** illustratively includes a housing **31** and a substrate **32,** for example, a printed circuit board (PCB) carried by the housing. The housing **31** has an upper portion and a lower portion. The substrate **32** may be a rigid PCB, or may be a flexible substrate or PCB, for example. In some embodiments wherein a PCB is used, the PCB may be replaced by or used in conjunction with a metal chassis or other substrate, as will be appreciated by those skilled in the art. A ground plane **36** is illustratively adjacent the substrate **32.** A conductive layer carried the substrate **32** may define the ground plane **36** (FIG. 2).

[0018] Wireless communications circuitry **33** is carried by the housing **31.** The wireless communications circuitry **33** may include, for example, a wireless transceiver **35.** The wireless communications circuitry may also include, in some embodiments, a satellite positioning signal receiver **34.** The satellite positioning signal receiver **34** may be a Global Positioning System (GPS) satellite receiver, for example. Of course, the mobile wireless communications device **30** may not include a satellite positioning receiver, or may include additional receivers and/or transmitters, for example, near-field communications (NFC) receivers and/or transmitters and wireless local area network receivers (e.g. 802.xx, WiFi). The satellite positioning receiver **34** or other or additional receivers and/or transmitters may not be part of the wireless communications circuitry **33,** as will be appreciated by those skilled in the art.

[0019] The exemplary device **30** further illustratively includes a display **60** and a plurality of control keys including an "off hook" (i.e., initiate phone call) key **61,** an "on hook" (i.e., discontinue phone call) key **62,** a menu key **63,** and a return or escape key **64.** Operation of the various device components and input keys, etc., will be described further below with reference to FIG. 6.

[0020] The device **30** further illustratively includes first and second antennas **40, 50** carried adjacent the upper portion of the housing **31** and positioned along a perimeter of the housing. In some embodiments, one or both of the first and second antennas **40, 50** may be carried adjacent another portion of the housing **31,** and may not be positioned along the perimeter of the housing. The first and second antennas **40, 50** are advantageously each a planar inverted F-antenna (PIFA) that may be tuned to different frequency bands, for example. The first and second antennas **40, 50** are particularly advantageous for use in a multiple-input and multiple-output (MIMO) antenna array to improve communication performance, for example. As will be appreciated by those skilled in the art, using multiple antennas, i.e. MIMO technology, may provide increased data throughput and link range with reduced additional bandwidth or transmit power, and may also provide increased spectral efficiency and link reliability or diversity.

[0021] The first antenna **40** illustratively includes a base electrical conductor **41** spaced above the substrate **32.** The base electrical conductor **41** may be flat, or contoured to fit within the housing **31,** for example. The first antenna **40** also includes a first feed leg **42a** extending downwardly from the base electrical conductor **41** to the substrate **32** and coupled to the wireless communication circuitry **33.** The first antenna **40** also includes a second feed leg **42b,** or ground leg, extending downwardly from the base electrical conductor **41** and coupled to the ground plane **36.** While the first and second feed legs **42a, 42b** are illustratively positioned along a first edge of the base electrical conductor **41** adjacent or facing the uppermost portion of the housing **31,** the first and second feed legs may be positioned to extend downwardly from other areas of the base electrical conductor to increase antenna performance. The first antenna **40** may include additional feed legs that may be coupled to the wireless communications circuitry **33.**

[0022] The first antenna **40** also includes an electrically conductive shorting plate **43** extending downwardly from the base electrical conductor **41** from a portion thereof adjacent the second antenna **50.** In other words, the electrically conductive shorting plate **43** faces the second antenna **50.** The electrically conductive shorting plate **43** is also coupled to the ground plane **36.** The electrically conductive shorting plate **43** illustratively extends downwardly along less than an entire length of the portion of the base electrical conductor **41.** In some embodiments, the electrically conductive shorting plate **43** may extend along the entire length of the portion of the base electrical conductor **41.**

[0023] The first antenna **40** also includes an electrically conductive lip **44** extending downwardly from the base electrical conductor **41** on a second edge thereof opposite the first and second feed legs **42a, 42b.** The electrically conductive lip **44** extends downwardly from the base electrical conductor **41** toward the substrate **32** and is spaced from the substrate. Illustratively, the electrically conductive lip **44** extends downwardly from the second edge of the base electrical conductor **41** along an entire length thereof. Of course, the electrically conductive lip **44** may extend less than entire length of the second edge of the base electrical conductor **41.**

[0024] The second antenna **50** illustratively includes a

mirror image arrangement of the same structural elements as the first antenna **40.** More particularly, the second antenna **50** includes a base electrical conductor **51** spaced above the substrate **32,** first and second feed legs **52a, 52b** extending downwardly from the base conductor to the substrate, and an electrically conductive shorting plate **53** extending downwardly from the base electrical conductor from a portion thereof adjacent the first antenna **40** and coupled to the ground plane **36.** The second antenna **50** also includes an electrically conductive lip **54** extending downwardly from the base electrical conductor **51** on a side edge thereof opposite the first and second feed legs **52a, 52b,** toward the substrate **32** and spaced therefrom.

[0025] Indeed, it may be preferred that elements of second antenna **50** be configured the same as the first antenna **40,** for example, so that the second antenna is a mirror image of the first antenna, as illustrated. Of course, the elements of the second antenna **50** may be configured differently from the respective elements of the first antenna **40** and/or may include more or less elements. For example, the electrically conductive lip **54** of the second antenna may not extend downwardly from the side edge along an entire length thereof, and/or the electrically conductive shorting plate **53** of the second antenna may not extend downwardly along less than an entire length of the portion of the base electrical conductor **51,** vis-à-vis the first antenna **40.** The elements of the first and second antennas **40, 50** may be configured in other configurations, as will be appreciated by those skilled in the art.

[0026] It will be appreciated by those skilled in the art that PIFAs may be used in mobile devices because of their increased bandwidth and increased efficiency. However, using multiple antennas in a mobile device may be increasingly difficult as the distance between the antennas is relatively small, which may result in increased mutual coupling between the antennas. While the isolation between the antennas may be increased, for example, by forming slots on the ground plane between the antenna elements and electromagnetic band gap (EBG) ground planes, these approaches generally occupy increased space on the limited substrate or PCB area, which may be reserved for other components. The first and second antennas **40, 50** advantageously reduce the mutual coupling between therebetween, especially in a relatively small or compact space, as in the housing **31,** for example.

[0027] The electrically conductive shorting plates **43, 53** extending downwardly from the base electrical conductor **41, 51** from the portion thereof adjacent the other antenna **50, 40,** respectively, advantageously reduce the mutual coupling therebetween. In particular, while the electrically conductive shorting plates **43, 53** may extend less than an entire length of the portion of the respective base electrical conductors **41, 51,** it is generally desirable that the electrically conductive shorting plates **43, 53** do not extend less than a quarter of the length of the respective base electrical conductors **41, 51.** Indeed, as will be appreciated by those skilled in the art, the electrically conductive shorting plates **43, 53** extending less than a quarter of the length may not provide adequate reduction of the mutual coupling.

[0028] Additionally, each electrically conductive shorting plate **43, 53,** also increases the resonance frequency of each antenna **40, 50.** More particularly, each antenna **40, 50** is extended vertically above the ground plane **36** from its edge. In particular, by adding approximately 2 millimeters to the electrically conductive shorting plate **43, 53,** the resonance frequency may be changed from 5 GHz to 5.5 GHz, for example.

[0029] Additionally, as will be appreciated by those skilled in the art, altering the shape, connecting, and/or disconnecting any of the electrically conductive shorting plates **43, 53** and the electrically conductive lips **44, 54,** changes the resonance frequencies of the first and second antennas **40, 50,** respectively. In particular, the electrically conductive lips **44, 54** adjust or account for any change in the resonance frequency that may be caused by the shorting plates **43, 53.** This way, the resonance frequencies of the first and second antennas **40, 50** may be "tuned" to operate in different frequency bands, for example.

[0030] The wireless communications circuitry **33** may also include a controller **38** or processor. The controller **38** may cooperate with the other components, for example, the first and second antennas **40, 50,** the satellite positioning signal receiver **34,** and the wireless transceiver **33** to coordinate and control operations of the mobile wireless communications device **30.** Operations may include mobile voice and data operations, including email and Internet data.

[0031] Referring now to the graph **70** in FIG. 4, the simulated S parameter for the antennas **40, 50** is graphed and indicated by lines **71** and **72,** respectively. Lines **73** and **74** indicate simulated results for first and second antennas that do not include the electrically conductive lip **44, 54.** Moreover, lines **75** and **76** indicate simulated results for first and second antennas that do not include both the electrically conductive shorting plate **43, 53** and the electrically conductive lip **44, 54.** As shown in the graph of FIG. 4, by adding the shorting plates **43, 53,** the mutual coupling between the antennas **40, 50** has been reduced by at least -10 dB.

[0032] Referring now to the graphs **81, 82,** and **83,** in FIGS. 5a-5c, respectively, the gains along three-axes (X, Y, Z) are illustrated. The Z axis is along the length of the substrate **32** with +Z pointing to the bottom of substrate (opposite the edge which the antennas **40, 50** are positioned), X is along the width and Y is along the depth or thickness. The graph **81** in FIG. 5a illustrates the simulated gain taken along the XY axes for the antennas **40, 50.** The graph **82** in FIG. 5b illustrates the simulated gain taken along the YZ axes for the antennas **40, 50.** The graph **83** in FIG. 5c illustrates the simulated gain taken along the XZ axes for the antennas **40, 50.** The gain is

simulated to be 7 dB at 5.6 GHz.

[0033] A method aspect is directed to a method of making a mobile wireless communications device **30.** The mobile device **30** includes a housing **31,** a substrate **32** carried by the housing, a ground plane **36** adjacent the substrate, and wireless communications circuitry **33.** The method includes forming first and second antennas **40, 50** on the substrate and coupled to the wireless communications circuitry **33,** for example. Forming the first antenna **40** includes forming a base electrical conductor **41** spaced above the substrate **32,** and forming at least one feed leg **42a** extending downwardly from the base electrical conductor to the substrate. Forming the first antenna **40** may also include forming an electrically conductive shorting plate **43** extending downwardly from the base electrical conductor **41** from a portion thereof adjacent the second antenna **50** and coupled to the ground plane **36.**

[0034] Example components of a mobile wireless communications device **1000** that may be used in accordance with the above-described embodiments are further described below with reference to FIG. 6. The device **1000** illustratively includes a housing **1200,** a keyboard or keypad **1400** and an output device **1600.** The output device shown is a display **1600,** which may comprise a full graphic LCD. Other types of output devices may alternatively be utilized. A processing device **1800** is contained within the housing **1200** and is coupled between the keypad **1400** and the display **1600.** The processing device **1800** controls the operation of the display **1600,** as well as the overall operation of the mobile device **1000,** in response to actuation of keys on the keypad **1400.**

[0035] The housing **1200** may be elongated vertically, or may take on other sizes and shapes (including clamshell housing structures). The keypad may include a mode selection key, or other hardware or software for switching between text entry and telephony entry.

[0036] In addition to the processing device **1800,** other parts of the mobile device **1000** are shown schematically in FIG. 6. These include a communications subsystem **1001;** a short-range communications subsystem **1020;** the keypad **1400** and the display **1600,** along with other input/output devices **1060, 1080, 1100** and **1120;** as well as memory devices **1160, 1180** and various other device subsystems **1201.** The mobile device **1000** may comprise a two-way RF communications device having data and, optionally, voice communications capabilities. In addition, the mobile device **1000** may have the capability to communicate with other computer systems via the Internet.

[0037] Operating system software executed by the processing device **1800** is stored in a persistent store, such as the flash memory **1160,** but may be stored in other types of memory devices, such as a read only memory (ROM) or similar storage element. In addition, system software, specific device applications, or parts thereof, may be temporarily loaded into a volatile store, such as the random access memory (RAM) **1180.** Communications signals received by the mobile device may also be stored in the RAM **1180.**

[0038] The processing device **1800,** in addition to its operating system functions, enables execution of software applications **1300A-1300N** on the device **1000.** A predetermined set of applications that control basic device operations, such as data and voice communications **1300A** and **1300B,** may be installed on the device **1000** during manufacture. In addition, a personal information manager (PIM) application may be installed during manufacture. The PIM may be capable of organizing and managing data items, such as e-mail, calendar events, voice mails, appointments, and task items. The PIM application may also be capable of sending and receiving data items via a wireless network **1401.** The PIM data items may be seamlessly integrated, synchronized and updated via the wireless network **1401** with corresponding data items stored or associated with a host computer system.

[0039] Communication functions, including data and voice communications, are performed through the communications subsystem **1001,** and possibly through the short-range communications subsystem. The communications subsystem **1001** includes a receiver **1500,** a transmitter **1520,** and one or more antennas **1540** and **1560.** In addition, the communications subsystem **1001** also includes a processing module, such as a digital signal processor (DSP) **1580,** and local oscillators (LOs) **1601.** The specific design and implementation of the communications subsystem **1001** is dependent upon the communications network in which the mobile device **1000** is intended to operate. For example, a mobile device **1000** may include a communications subsystem **1001** designed to operate with the Mobitex™, Data TAC™ or General Packet Radio Service (GPRS) mobile data communications networks, and also designed to operate with any of a variety of voice communications networks, such as AMPS, TDMA, CDMA, WCDMA, PCS, GSM, EDGE, etc. Other types of data and voice networks, both separate and integrated, may also be utilized with the mobile device **1000.** The mobile device **1000** may also be compliant with other communications standards such as 3GSM, 3GPP, UMTS, 4G, etc.

[0040] Network access requirements vary depending upon the type of communication system. For example, in the Mobitex and DataTAC networks, mobile devices are registered on the network using a unique personal identification number or PIN associated with each device. In GPRS networks, however, network access is associated with a subscriber or user of a device. A GPRS device therefore typically involves use of a subscriber identity module, commonly referred to as a SIM card, in order to operate on a GPRS network.

[0041] When required network registration or activation procedures have been completed, the mobile device **1000** may send and receive communications signals over the communication network **1401.** Signals received from the communications network **1401** by the antenna

1540 are routed to the receiver **1500,** which provides for signal amplification, frequency down conversion, filtering, channel selection, etc., and may also provide analog to digital conversion. Analog-to-digital conversion of the received signal allows the DSP **1580** to perform more complex communications functions, such as demodulation and decoding. In a similar manner, signals to be transmitted to the network **1401** are processed (e.g. modulated and encoded) by the DSP **1580** and are then provided to the transmitter **1520** for digital to analog conversion, frequency up conversion, filtering, amplification and transmission to the communication network **1401** (or networks) via the antenna **1560.**

[0042] In addition to processing communications signals, the DSP **1580** provides for control of the receiver **1500** and the transmitter **1520.** For example, gains applied to communications signals in the receiver **1500** and transmitter **1520** may be adaptively controlled through automatic gain control algorithms implemented in the DSP **1580.**

[0043] In a data communications mode, a received signal, such as a text message or web page download, is processed by the communications subsystem **1001** and is input to the processing device **1800.** The received signal is then further processed by the processing device **1800** for an output to the display **1600,** or alternatively to some other auxiliary I/O device **1060.** A device may also be used to compose data items, such as e-mail messages, using the keypad **1400** and/or some other auxiliary I/O device **1060,** such as a touchpad, a rocker switch, a thumb-wheel, or some other type of input device. The composed data items may then be transmitted over the communications network **1401** via the communications subsystem **1001.**

[0044] In a voice communications mode, overall operation of the device is substantially similar to the data communications mode, except that received signals are output to a speaker **1100,** and signals for transmission are generated by a microphone **1120.** Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on the device **1000.** In addition, the display **1600** may also be utilized in voice communications mode, for example to display the identity of a calling party, the duration of a voice call, or other voice call related information.

[0045] The short-range communications subsystem enables communication between the mobile device **1000** and other proximate systems or devices, which need not necessarily be similar devices. For example, the short-range communications subsystem may include an infrared device and associated circuits and components, a Bluetooth™ communications module to provide for communication with similarly-enabled systems and devices, or a near field communications (NFC) sensor for communicating with a NFC device or NFC tag via NFC communications.

[0046] Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.

Claims

1. A mobile wireless communications device (30) comprising:

   a housing (31);
   a substrate (32) carried by said housing (31);
   a ground plane (36) adjacent said substrate (32);
   wireless communications circuitry (33);
   first and second antennas (40, 50) coupled to said wireless communications circuitry (33); and
   said first antenna (40) comprising
   a base electrical conductor (41) spaced above said substrate (32),
   at least one feed leg extending downwardly from said base electrical conductor (41) to said substrate (32), and
   an electrically conductive shorting plate (43) extending downwardly from said base electrical conductor (41) from a portion thereof adjacent said second antenna (50) and coupled to said ground plane (36).

2. The mobile wireless communications device (30) according to Claim 1, wherein said first antenna (40) further comprises an electrically conductive lip (44) extending downwardly from said base electrical conductor (41) on a side edge thereof opposite said at least one feed leg (42a), toward said substrate (32) and spaced therefrom.

3. The mobile wireless communications device (30) according to Claim 2, wherein said electrically conductive lip (44) extends downwardly from the side edge along an entire length thereof.

4. The mobile wireless communications device (30) according to Claim 1, wherein said electrically conductive shorting plate (43) extends downwardly along less than an entire length of the portion of said base electrical conductor (41).

5. The mobile wireless communications device according to Claim 1, wherein said second antenna (50) comprises:

   a base electrical conductor (41) spaced above said substrate;
   at least one feed leg extending downwardly from said base conductor (41) to said substrate (32);

and
an electrically conductive shorting plate (43) extending downwardly from said base electrical conductor (41) from a portion thereof adjacent said first antenna (40) and coupled to said ground plane (36).

6. The mobile wireless communications device (30) according to Claim 5, wherein said second antenna (50) further comprises an electrically conductive lip (44) extending downwardly from said base electrical conductor (41) on a side edge thereof opposite said at least one feed leg (42a), toward said substrate (32) and spaced therefrom.

7. The mobile wireless communications device (30) according to Claim 6, wherein said electrically conductive lip (44) of said second antenna (50) extends downwardly from the side edge along an entire length thereof.

8. The mobile wireless communications device (30) according to Claim 6, wherein said electrically conductive shorting plate (43) of said second antenna (50) extends downwardly along less than an entire length of the portion of said base electrical conductor (41).

9. The mobile wireless communications device (30) according to Claim 1 wherein said at least one feed leg (42a) comprises:

a first feed leg extending downwardly from said base -electrical conductor (41) to said substrate (32); and
a second feed leg (42b) extending downwardly from said base electrical conductor (41) and coupled to said ground plane (36).

10. A method of making a mobile wireless communications device (30) comprising a housing (31), a substrate (32) carried by the housing (31), a ground plane (36) adjacent the substrate (32), and wireless communications circuitry (33), the method comprising:

forming first and second antennas (40, 50) on the substrate and coupled to the wireless communications circuitry (33):
forming the first antenna (40) comprising
forming a base electrical conductor (41) spaced above the substrate (32),
forming at least one feed leg (42a) extending downwardly from the base electrical conductor (41) to the substrate (32), and
forming an electrically conductive shorting plate (43) extending downwardly from the base electrical conductor (41) from a portion thereof adjacent the second antenna (50) and coupled to the ground plane (36).

11. The method according to Claim 10, wherein forming the first antenna (40) further comprises forming an electrically conductive lip (44) extending downwardly from the base electrical conductor (41) on a side edge thereof opposite the at least one feed leg (42a), toward the substrate (32) and spaced therefrom.

12. The method according to Claim 11, wherein forming the electrically conductive lip (44) comprises forming the electrically conductive lip (44) to extend downwardly from the side edge along an entire length thereof.

13. The method according to Claim 10, wherein forming electrically conductive shorting plate (43) comprises forming the electrically conductive plate (43) to extend downwardly along less than an entire length of the portion of the base electrical conductor (41).

14. The method according to Claim 10, wherein forming the second antenna (50) comprises:

forming a base electrical conductor (41) spaced above the substrate (32);
forming at least one feed leg (42a) extending downwardly from the base conductor (41) to the substrate (32); and
forming an electrically conductive shorting plate (43) extending downwardly from the base electrical conductor (41) from a portion thereof adjacent the first antenna (40) and coupled to the ground plane (36).

15. The method according to Claim 10, wherein forming the at least one feed leg (42a) comprises:

forming a first feed leg (42a) extending downwardly from the base electrical conductor (41) to the substrate (32); and
forming a second feed leg (42b) extending downwardly from the base electrical conductor (41) and to be coupled to the ground plane (36).

Amended claims in accordance with Rule 137(2) EPC.

1. A mobile wireless communications device (30) comprising:

a housing (31);
a substrate (32) carried by said housing (31);
a ground plane (36) adjacent said substrate (32);
wireless communications circuitry (33);
first and second antennas (40, 50) coupled to said wireless communications circuitry (33); and

said first antenna (40) comprising

a base electrical conductor (41) spaced above said substrate (32),
a first feed leg (42a) extending downwardly from said base electrical conductor (41) to said substrate (32) and coupled to said wireless communications circuitry,
a second feed leg (42b) extending downwardly from said base electrical conductor (41) and coupled to said ground plane (36), and
an electrically conductive shorting plate (43) extending downwardly from said base electrical conductor (41) from a portion thereof adjacent said second antenna (50) and coupled to said ground plane (36).

2. The mobile wireless communications device (30) according to Claim 1, wherein said first antenna (40) further comprises an electrically conductive lip (44) extending downwardly from said base electrical conductor (41) on a side edge thereof opposite said first and second feeds legs (42a, 42b) toward said substrate (32) and spaced therefrom.

3. The mobile wireless communications device (30) according to Claim 2, wherein said electrically conductive lip (44) extends downwardly from the side edge along an entire length thereof.

4. The mobile wireless communications device (30) according to Claim 1, wherein said electrically conductive shorting plate (43) extends downwardly along less than an entire length of the portion of said base electrical conductor (41).

5. The mobile wireless communications device according to Claim 1, wherein said second antenna (50) comprises:

a base electrical conductor (41) spaced above said substrate;
at least one feed leg extending downwardly from said base conductor (41) to said substrate (32); and
an electrically conductive shorting plate (43) extending downwardly from said base electrical conductor (41) from a portion thereof adjacent said first antenna (40) and coupled to said ground plane (36).

6. The mobile wireless communications device (30) according to Claim 5, wherein said second antenna (50) further comprises an electrically conductive lip (44) extending downwardly from said base electrical conductor (41) on a side edge thereof opposite said at least one feed leg (42a), toward said substrate (32) and spaced therefrom.

7. The mobile wireless communications device (30) according to Claim 6, wherein said electrically conductive lip (44) of said second antenna (50) extends downwardly from the side edge along an entire length thereof.

8. The mobile wireless communications device (30) according to Claim 6, wherein said electrically conductive shorting plate (43) of said second antenna (50) extends downwardly along less than an entire length of the portion of said base electrical conductor (41).

9. A method of making a mobile wireless communications device (30) comprising a housing (31), a substrate (32) carried by the housing (31), a ground plane (36) adjacent the substrate (32), and wireless communications circuitry (33), the method comprising:

forming first and second antennas (40, 50) on the substrate and coupled to the wireless communications circuitry (33);
forming the first antenna (40) comprising

forming a base electrical conductor (41) spaced above the substrate (32),
forming a first feed leg (42a) extending downwardly from the base electrical conductor (41) to the substrate (32) and to be coupled to the wireless communications circuitry,
forming a second feed leg (42b) extending downwardly from the base electrical conductor (41) and to be coupled to the ground plane (36), and
forming an electrically conductive shorting plate (43) extending downwardly from the base electrical conductor (41) from a portion thereof adjacent the second antenna (50) and coupled to the ground plane (36).

10. The method according to Claim 10, wherein forming the first antenna (40) further comprises forming an electrically conductive lip (44) extending downwardly from the base electrical conductor (41) on a side edge thereof opposite the first and second feed legs (42a, 42b), toward the substrate (32) and spaced therefrom.

11. The method according to Claim 11, wherein forming the electrically conductive lip (44) comprises forming the electrically conductive lip (44) to extend downwardly from the side edge along an entire length thereof.

12. The method according to Claim 10, wherein forming electrically conductive shorting plate (43) comprises forming the electrically conductive plate (43) to extend downwardly along less than an entire length of the portion of the base electrical conductor (41).

13. The method according to Claim 10, wherein forming the second antenna (50) comprises:

forming a base electrical conductor (41) spaced above the substrate (32);
forming at least one feed leg (42a) extending downwardly from the base conductor (41) to the substrate (32); and
forming an electrically conductive shorting plate (43) extending downwardly from the base electrical conductor (41) from a portion thereof adjacent the first antenna (40) and coupled to the ground plane (36).

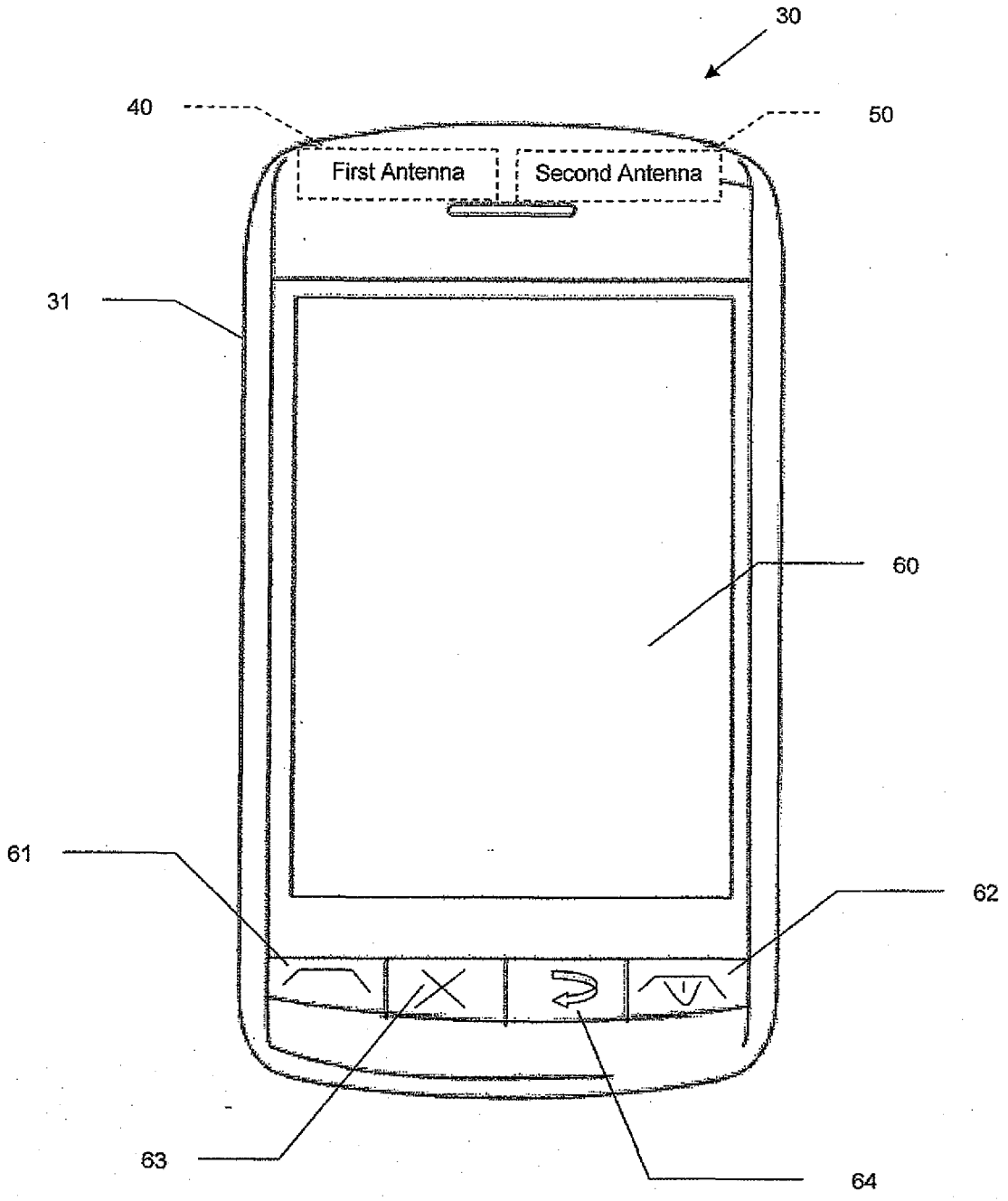

FIG. 1

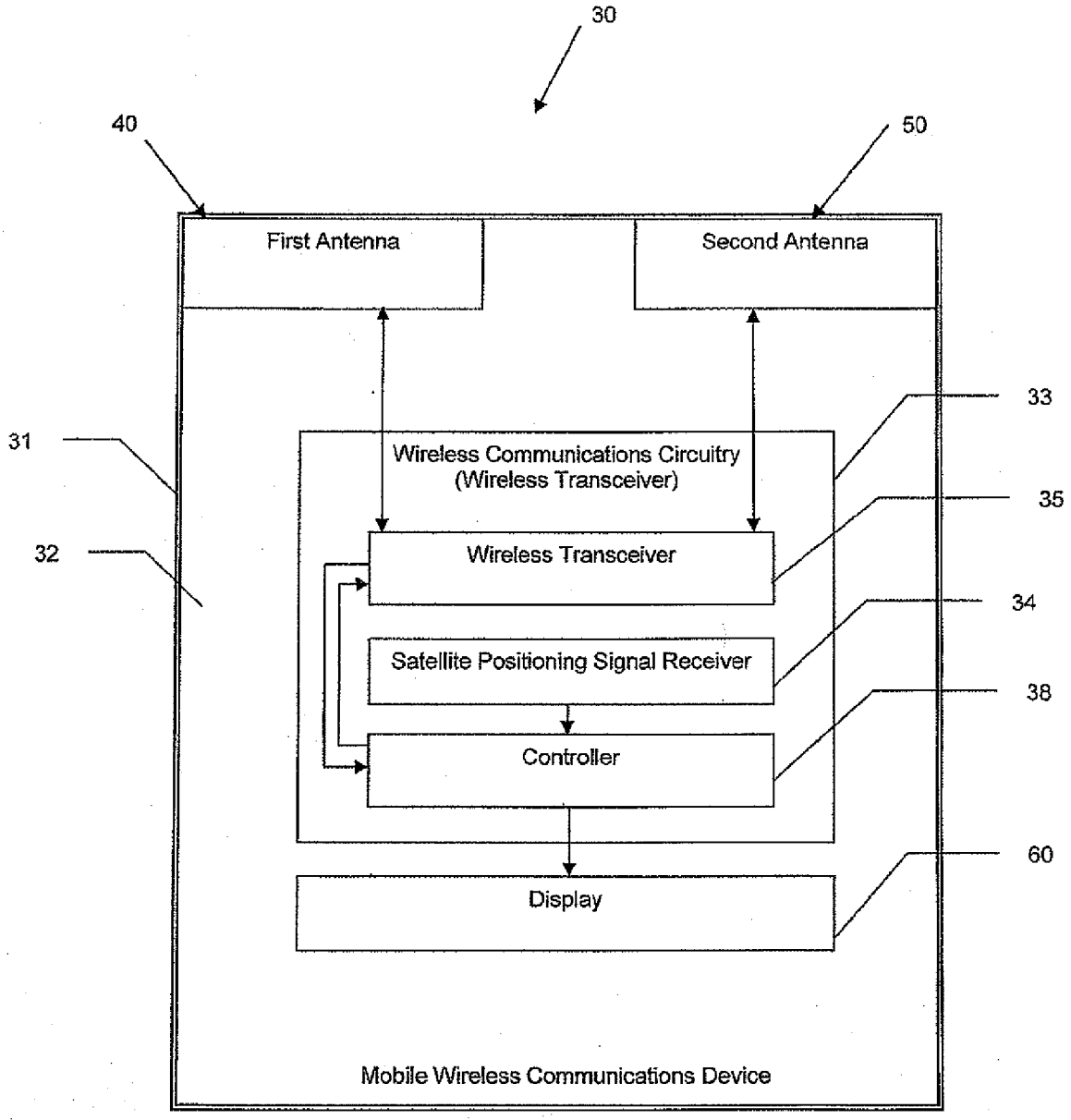
30
40
50
First Antenna
Second Antenna
31
33
Wireless Communications Circuitry
(Wireless Transceiver)
35
32
Wireless Transceiver
34
Satellite Positioning Signal Receiver
38
Controller
60
Display
Mobile Wireless Communications Device

FIG. 2

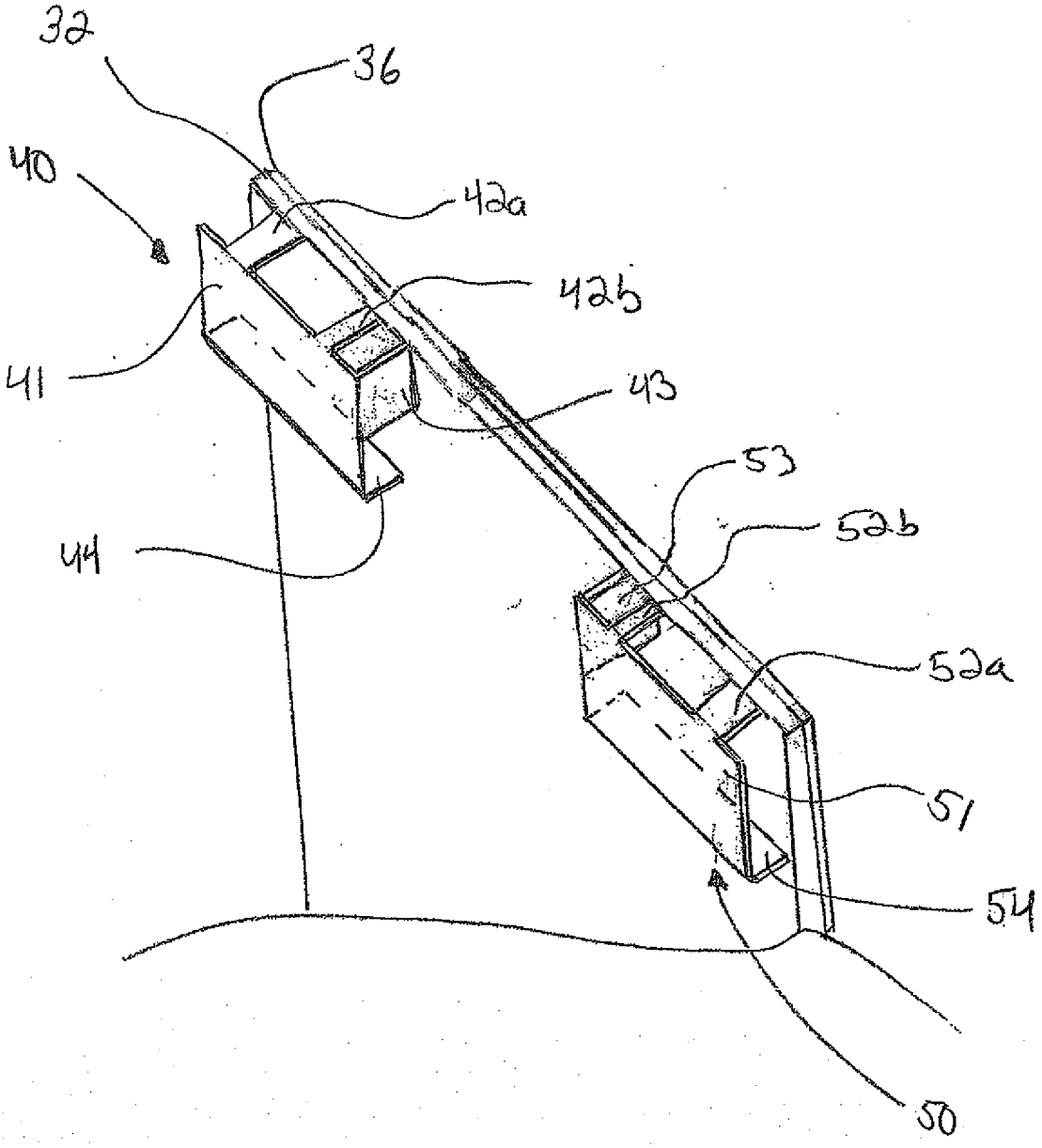

Fig. 3

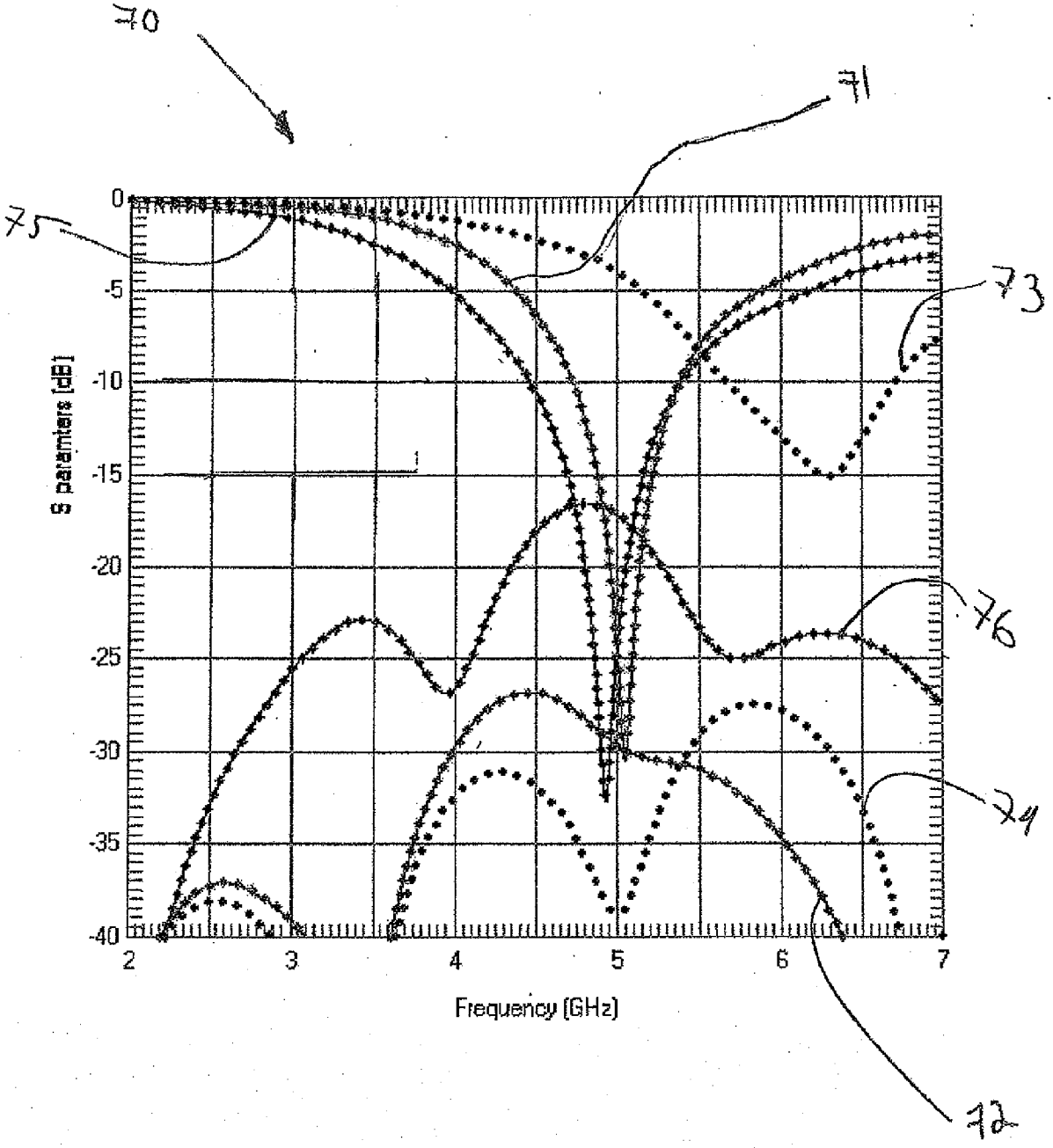
70
71
75
73
76
74
72
S parameters [dB]
Frequency [GHz]
0
-5
-10
-15
-20
-25
-30
-35
-40
2
3
4
5
6
7

Fig. 4

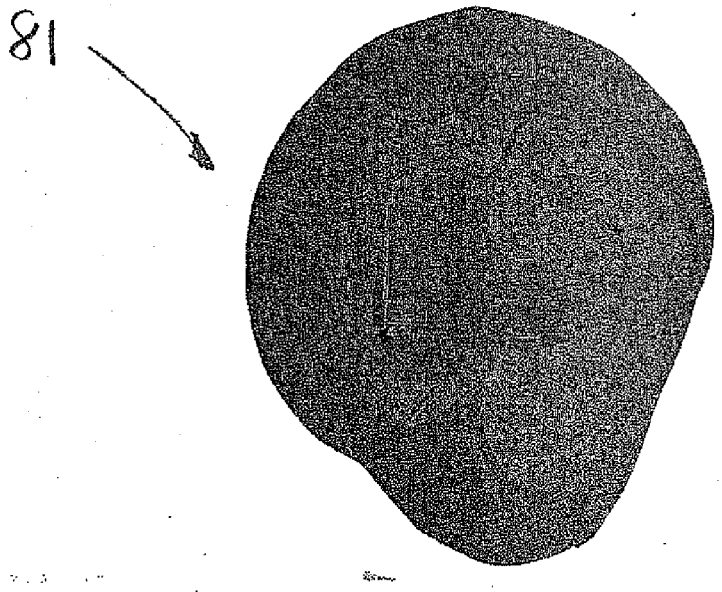

Fig. 5a

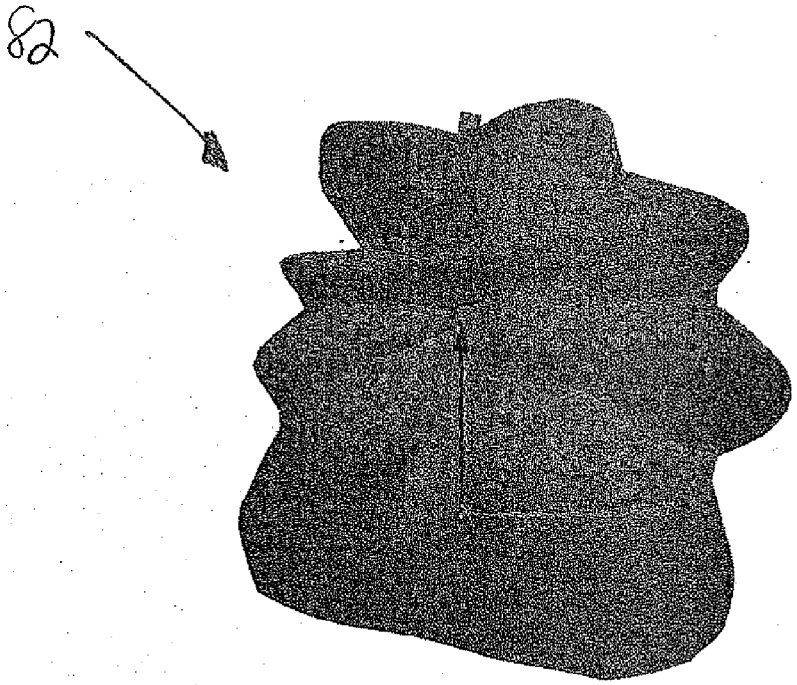

Fig. 5b

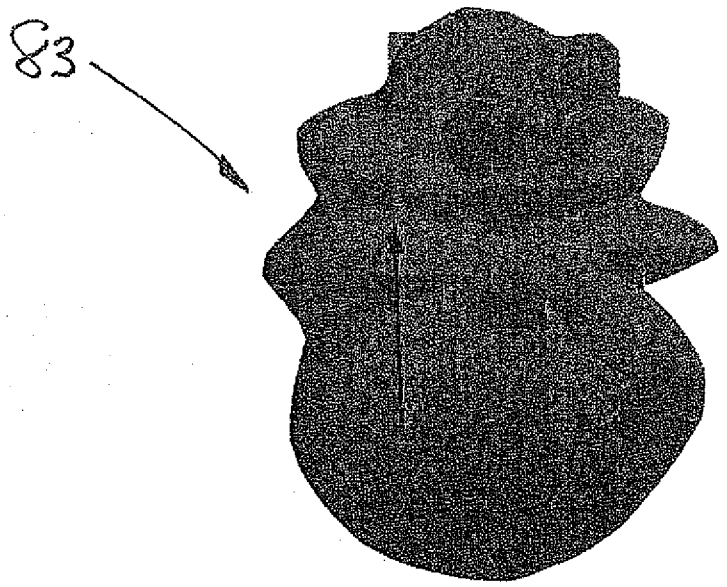

Fig. 5c

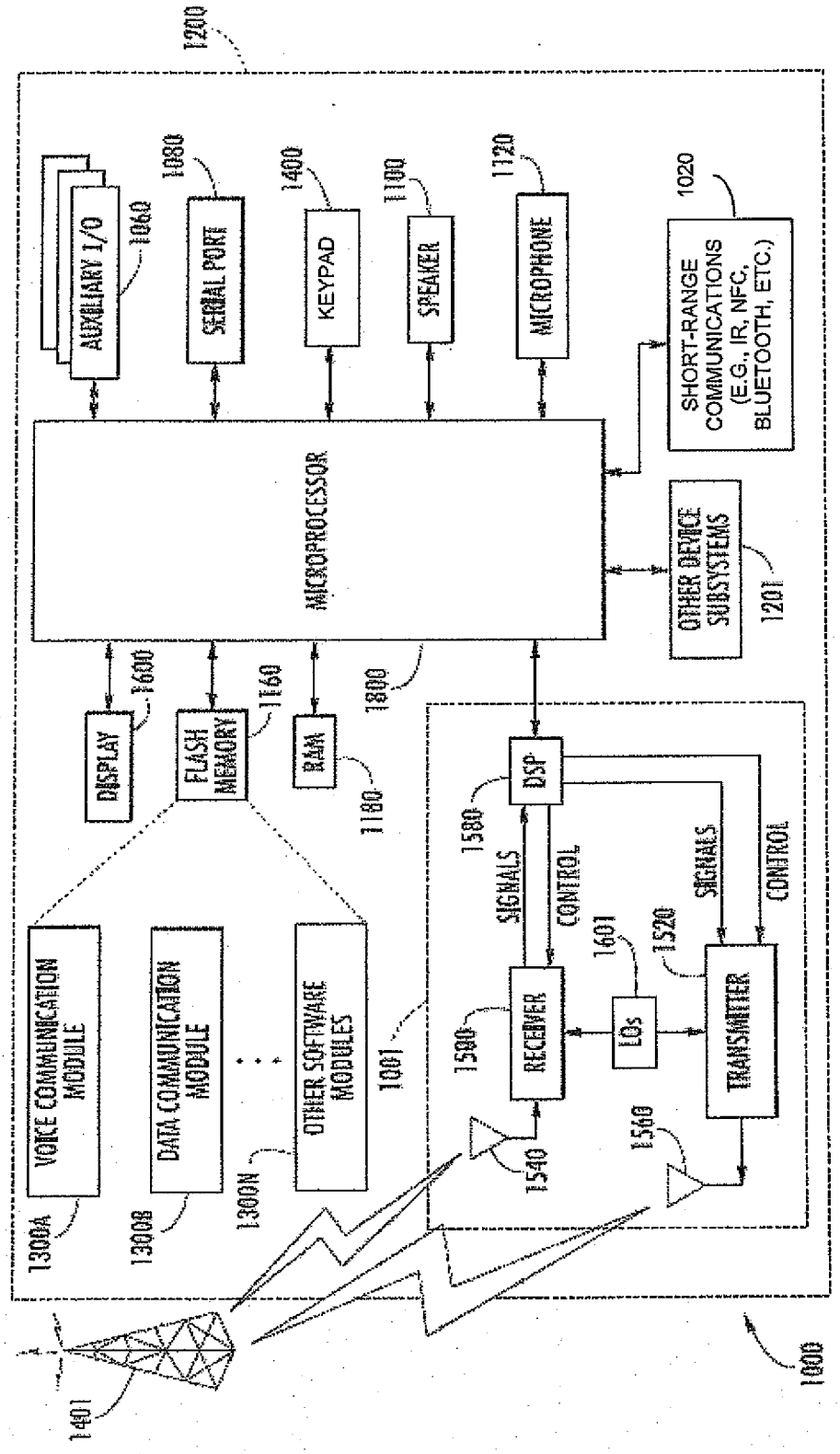
1200
AUXILIARY I/O
1060
SERIAL PORT
1080
KEYPAD
1400
SPEAKER
1100
MICROPHONE
1120
SHORT-RANGE COMMUNICATIONS (E.G., IR, NFC, BLUETOOTH, ETC.)
1020
MICROPROCESSOR
OTHER DEVICE SUBSYSTEMS
1201
1800
DISPLAY
1600
FLASH MEMORY
1160
RAM
1180
DSP
1580
SIGNALS
CONTROL
1601
1520
SIGNALS
CONTROL
RECEIVER
1590
LOs
TRANSMITTER
1540
1560
VOICE COMMUNICATION MODULE
1300A
DATA COMMUNICATION MODULE
1300B
OTHER SOFTWARE MODULES
1300N
1001
1401
1000

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 7352

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 October 2011	von Walter, Sven-Uwe

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24-10-2011

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