Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2788962 C 2016/01/19

(11)(21) 2 788 962

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 2012/09/06

(41) Mise à la disp. pub./Open to Public Insp.: 2013/03/09

(45) Date de délivrance/Issue Date: 2016/01/19

(30) Priorité/Priority: 2011/09/09 (EP11180792.1)

(51) Cl.Int./Int.Cl. *H01Q 13/10* (2006.01), *H01Q 1/38* (2006.01), *H04W 88/02* (2009.01)

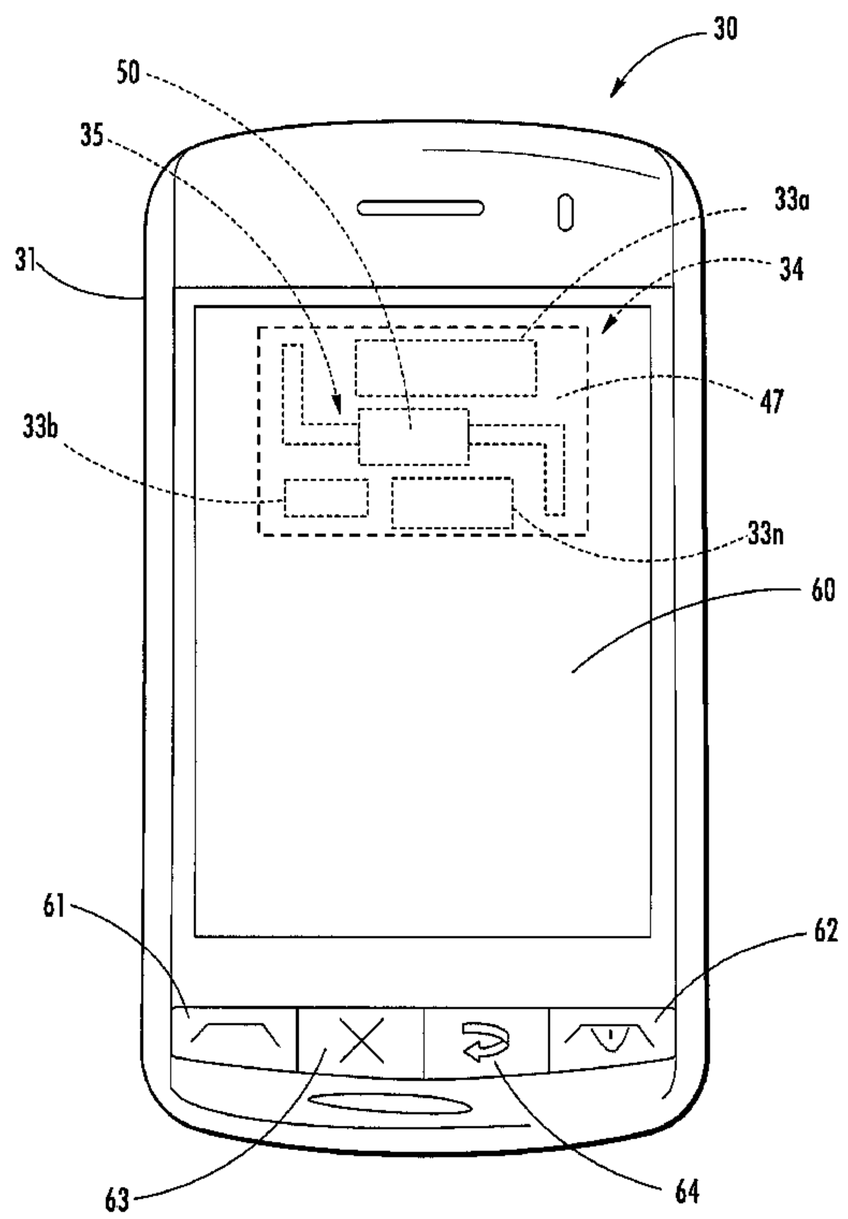
(72) Inventeurs/Inventors:
WHITMORE, JOHN ALFRED, CA;
MAN, YING TONG, CA

(73) Propriétaire/Owner:
BLACKBERRY LIMITED, CA

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : APPAREIL DE COMMUNICATION SANS FIL MOBILE DOTE D'UNE ANTENNE A FENTE ET METHODES CONNEXES

(54) Title: MOBILE WIRELESS COMMUNICATIONS DEVICE INCLUDING A SLOT ANTENNA AND RELATED METHODS



(57) Abrégé/Abstract:
A mobile wireless communications device may include a portable housing and a printed circuit board (PCB) carried by the portable housing. The mobile wireless communications device may also include at least one electronic component carried by the PCB and an electrically conductive enclosure coupled to the PCB and having a top spaced above the PCB over the at least one electronic component. The top of the electrically conductive enclosure may have a slot therein defining a slot antenna.

Abstract of the Disclosure

A mobile wireless communications device may include a portable housing and a printed circuit board (PCB) carried by the portable housing. The mobile wireless communications device may also include at least one electronic component carried by the PCB and an electrically conductive enclosure coupled to the PCB and having a top spaced above the PCB over the at least one electronic component. The top of the electrically conductive enclosure may have a slot therein defining a slot antenna.

MOBILE WIRELESS COMMUNICATIONS DEVICE INCLUDING A SLOT ANTENNA AND RELATED METHODS

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 of the Invention

[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 housings that cooperate with antennas to provide desired operating characteristics within the relatively limited amount of space available.

Brief Description of the Drawings

[0004] FIG. 1 is a top plan view of a mobile wireless communications device including an electrically conductive enclosure having a slot therein defining a slot antenna in accordance with one example embodiment.

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

[0006] FIG. 3 is a side schematic view of the portion of the device in FIG. 2.

[0007] FIG. 4 is a perspective view of a portion of a device including an antenna feed in accordance with another example embodiment.

[0008] FIG. 5 is a graph of measured return loss for a prototype mobile wireless communications device without a tuning element.

[0009] FIG. 6 is a graph of measured gain for the prototype mobile wireless communications device without a tuning element.

[0010] FIG. 7 is a graph of measured return loss for a prototype mobile wireless communications device with a FR-4 tuning element.

[0011] FIG. 8 is a graph of measured gain for the prototype mobile wireless communications device with the FR-4 tuning element.

[0012] FIG. 9 is a graph of measured return loss for a prototype mobile wireless communications device with a TDK ceramic tuning element.

[0013] FIG. 10 is a graph of measured gain for the prototype mobile wireless communications device with the TDK ceramic tuning element.

[0014] FIG. 11 is a schematic block diagram illustrating additional components that may be included in the mobile wireless communications device of FIG. 1.

Detailed Description of the Preferred Embodiments

[0015] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and 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, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout, and prime notation is used to indicate similar elements or steps in alternative embodiments.

[0016] In accordance with one exemplary aspect, a mobile wireless communications device may include a portable housing and a printed circuit board (PCB) carried by the portable housing. The mobile wireless communications device may also include at least one electronic component carried by the PCB and an electrically conductive enclosure coupled to the PCB and having a top spaced above the PCB over the at least one electronic component. The top of the electrically conductive enclosure may have a slot therein defining a slot antenna.

[0017] The mobile wireless communications device may further include a tuning element carried by the electrically conductive enclosure and being positioned over the slot, for example. The tuning element may include a dielectric material body. The

tuning element may further include a conductive material layer on the dielectric material body, for example.

[0018] The slot may include a base slot, and first and second parallel slots extending in opposite directions from the base slot. The base slot may have opposing ends, and the first and second parallel slots may extend from the opposing ends, for example.

[0019] The electrically conductive enclosure may further include a sidewall depending from the top, for example. The mobile wireless communications device may further include at least one antenna feed carried by the PCB and coupled to the electrically conductive enclosure adjacent the slot. The at least one antenna feed may include a pair of antenna feeds coupled to the electrically conductive enclosure on opposing sides of the slot, for example. The at least one antenna feed may include at least one of a flexible stripline and a spring contact.

[0020] The mobile wireless communications device of may further include a conductive layer carried by the PCB defining a ground plane, for example. The electrically conductive enclosure is carried above the ground plane.

[0021] A method aspect is directed to a method of making a mobile wireless communications device that may include a portable housing, a printed circuit board (PCB) carried by the portable housing, and at least one electronic component carried by the PCB. The method may include forming a slot in a top of an electrically conductive enclosure to be coupled to the PCB to form a slot antenna. The top may be spaced above the PCB over the at least one electronic component.

[0022] Referring initially to FIGS. 1-3, a mobile wireless communications device **30** illustratively includes a portable housing **31** a printed circuit board (PCB) **32**, carried by the portable housing. The PCB **32** also includes a conductive layer **46** defining a ground plane (FIG. 3).

[0023] 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. 11.

[0024] The wireless communications device **30** also includes electronic components **33a-33n** carried by PCB **32**. The electronic components **33a-33n** may include wireless communications circuitry configured to perform a wireless communications function, for example, wireless voice or data communications. Other circuitry, for example, discrete components, associated with the mobile wireless communications device **30** may also be carried by the PCB **32**.

[0025] An electrically conductive enclosure **34** is coupled to the PCB **32** and carried above the ground plane **46**. The electrically conductive enclosure **34** includes a top **47** spaced above PCB **32** over the electronic components **33a-33n**. The electrically conductive enclosure **34** also includes a sidewall **37** depending from the top **47**.

[0026] The top **47** of the electrically conductive enclosure **34** has a slot **35** therein defining a slot antenna. The slot **35** illustratively includes a base slot **36** having opposing ends **41**, **42**. First and second parallel slots **43**, **44** extend in opposite

directions from the opposing ends **41**, **42** of the base slot **36**. The slot **35** may extend in other directions, but it may be desirable that the slot does not "double over" on itself as this may reduce antenna efficiency and thus performance. The electrically conductive enclosure **34** may have additional slots or openings for ventilation, which may be relatively small compared to the slot **35**. Moreover, the electrically conductive enclosure **34** may have more than one slot therein defining more than one slot antenna.

[0027] The length of the slot **35** determines the operating frequency of the slot antenna. The position of the electrically conductive enclosure **34** with respect to the ground plane **46** is another variable that may affect performance of the slot antenna.

[0028] For the slot antenna to operate in the correct mode for the frequency of operation and to give the desired bandwidth, it is desirable that the slot **35** be the correct length, the electrically conductive enclosure **34** surrounding the slot **35** is large enough to support circulating currents around the slot, and the cavity, i.e. the distance of the slot and the electrically conductive enclosure **34** above the PCB **32**, has sufficient depth. Physical restraints of the mechanics of the mobile wireless communications device **30** may hamper obtaining of desired characteristics.

[0029] To compensate for the increased difficulty of obtaining desired characteristics because of the physical constraints, i.e. size, the mobile wireless communications device **30** includes a tuning element **50** carried by the electrically conductive enclosure **34**. The tuning member **50** loads the slot **35** as a parasitic element. The tuning element **50**

is illustratively positioned over the slot **35**, and more particularly, bridges or spans the slot **35**. The tuning member **50** includes a dielectric material body **51** and may have a relatively high dielectric constant, for example. For example, the dielectric material body **51** may be FR-4 dielectric material or a ceramic material. Of course, the dielectric material body **51** may include other dielectric materials.

[0030] The tuning element **50** may also optionally include a conductive material layer **52** on the dielectric material body **51**. The conductive material layer **52** may be copper, for example. The conductive material layer **52** may be another conductive material, as will be appreciated by those skilled in the art. More than one tuning element may be used, as will be appreciated by those skilled in the art.

[0031] The thickness of the tuning element **50** may be particularly useful for determining gain and return loss of the slot antenna. The height of the slot **35** and the tuning element **50** above the PCB **32** also determines the gain or return loss. The thickness of the tuning element **50** and the height of the tuning element and the slot **35** above the PCB may be the primary adjustments for determining gain or return loss. The position of the electrically conductive enclosure **34** in the X-Y plane on the ground plane **46**, and the X-Y position of the tuning element **50** may also determine the gain or return loss of the slot antenna. As will be appreciated by those skilled in the art, the height of the tuning element **50** and the electrically conductive enclosure **34** may be adjustable via an adjustment mechanism. This may accommodate in-situ adjustment and thus, different gain patterns, for example.

[0032] The slot antenna may be particularly useful for operating in the IEEE 802.11a frequency band of approximately 5.2 GHz to 5.8 GHz. As will be appreciated by those skilled in the art, mounting a slot antenna on the electrically conductive enclosure **34** advantageously helps ease the problem of finding the room or space within the portable housing **31**. As the IEEE 802.11a standard describes a single band antenna, moving it away from a clear area onto the PCB, for example, may be particularly useful as it would leave more room for multi-band antennas, which are typically more difficult to implement.

[0033] A pair of antenna feeds in the form of spring contacts **53a**, **53b** are carried by the PCB **32** and coupled to the electrically conductive enclosure **34** adjacent the slot **35**, and more particularly, on opposing sides of the slot.

[0034] The location where the pair of spring contacts **53a**, **53b** coupled to the electrically conductive enclosure **34** adjacent the slot **35** determines multiple resonances, as will be appreciated by those skilled in the art. In particular, one resonance may be obtained by coupling the pair of spring contacts **53a**, **53b** adjacent the center of the slot **35** with respect to its length. If the pair of spring contacts **53a**, **53b** are coupled off-center of the slot with respect to its length, multiple resonance may be obtained.

[0035] Referring now to FIG. 4 in another example embodiment, the antenna feeds are in the form of flexible striplines **53a'**, **53b'**. The flexible striplines **53a'**, **53b'** are illustratively bent over in a c-shape. An outer portion of one of the flexible striplines **53a'** is trimmed back to expose a center portion **55'**. The center portion **55'** couples to the electrically conductive enclosure **34'** adjacent the slot **35'** and crosses over the slot.

The second flexible stripline **53b'**, couples to the ground plane **46'**. In one embodiment, the second flexible stripline **53b'** is 53mm away from the first flexible stripline **53a'**. The second flexible stripline **53b'** does not cross the slot **35'**, but rather couples to the electrically conductive enclosure **34'**. The pair of antenna feeds **53a'**, **53b'** may be another type of feed, for example, pogo pins, or other mechanical structure and may be coupled in another arrangement, as will be appreciated by those skilled in the art.

[0036] Referring now to the graphs in FIGS. 5-6, a measured return loss graph and an antenna gain graph for a prototype mobile wireless communications device similar to that described above with respect to FIG. 1, but without a tuning element are respectively illustrated. Referring now the graphs in FIGS. 7-8, a measured return loss graph and antenna gain graph for the prototype mobile wireless communications device including a tuning element are respectively illustrated. The tuning element was a FR-4 dielectric material strip that measured 9 mm x 3 mm by 4 mm and was positioned in the center of the slot with respect to it length and width. A layer of copper was carried by the FR-4.

[0037] Referring now the graphs in FIGS. 9-10, a measured return loss graph and antenna gain graph for the prototype mobile wireless communications device including a tuning element are respectively illustrated. The tuning element was a TDK ceramic dielectric material that measured 30 mm x 8 mm by 1 mm and was positioned equally over the slot with respect to it length and width. The TDK ceramic dielectric material had a dielectric constant of 6.2.

[0038] A method aspect is directed to a method of making a mobile wireless communications device **30** that includes a portable housing **31**, a printed circuit board **32** (PCB) carried by the portable housing, and electronic components **33a-33n** carried by the PCB. The method also includes forming a slot **35** in a top **47** of an electrically conductive enclosure **34** to be coupled to the PCB **32** to form a slot antenna. The top **47** is to be spaced above the PCB **32** over the electronic components **33a-33n**.

[0039] 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. 11. 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**.

[0040] 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.

[0041] In addition to the processing device **1800**, other parts of the mobile device **1000** are shown schematically in FIG. 11. 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.

[0042] 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**.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] 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**.

[0047] 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**.

[0048] 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**.

[0049] 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.

[0050] 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.

[0051] 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.

THAT WHICH IS CLAIMED IS:

1. A mobile wireless communications device comprising:

a portable housing;

a printed circuit board (PCB) carried by said portable housing;

at least one electronic component carried by said PCB; and

an electrically conductive enclosure coupled to said PCB and having a top spaced above said PCB over said at least one electronic component;

the top of said electrically conductive enclosure having a slot therein defining a slot antenna; and

a tuning element carried by said electrically conductive enclosure and being positioned over the slot, wherein said tuning element comprises a dielectric material body.

2. The mobile wireless communications device of Claim 1, wherein said tuning element further comprises a conductive material layer on said dielectric material body.

3. The mobile wireless communications device of Claim 1, wherein the slot comprises a base slot, and first and second parallel slots extending in opposite directions from the base slot.

4. The mobile wireless communications device of Claim 3, wherein the base slot has opposing ends; and wherein the first and second parallel slots extend from the opposing ends.

5. The mobile wireless communications device of Claim 1, wherein said electrically conductive enclosure further comprises a sidewall depending from the top.

6. The mobile wireless communications device of Claim 1, further comprising at least one antenna feed carried by said PCB and coupled to said electrically conductive enclosure adjacent the slot.

7. The mobile wireless communications device of Claim 6, wherein said at least one antenna feed comprises a pair of antenna feeds coupled to said electrically conductive enclosure on opposing sides of the slot.

8. The mobile wireless communications device of Claim 1, further comprising a conductive layer carried by said PCB defining a ground plane; and wherein said electrically conductive enclosure is carried above said ground plane.

9. A method of making a mobile wireless communications device comprising a portable housing, a printed circuit board (PCB) carried by the portable housing, and at least one electronic component carried by the PCB, the method comprising:

forming a slot in a top of an electrically conductive enclosure to be coupled to the PCB to form a slot antenna, the top to be spaced above the PCB over the at least one electronic component; and

positioning a tuning element over the slot and carried by the electrically conductive enclosure, wherein the tuning element comprises a dielectric material body.

10. The method of Claim 9, wherein forming the slot comprises forming a base slot, and forming first and second parallel slots extending in opposite directions from the base slot.

11. The method of Claim 10, wherein the base slot has opposing ends; and wherein the first and second parallel slots extend from the opposing ends.

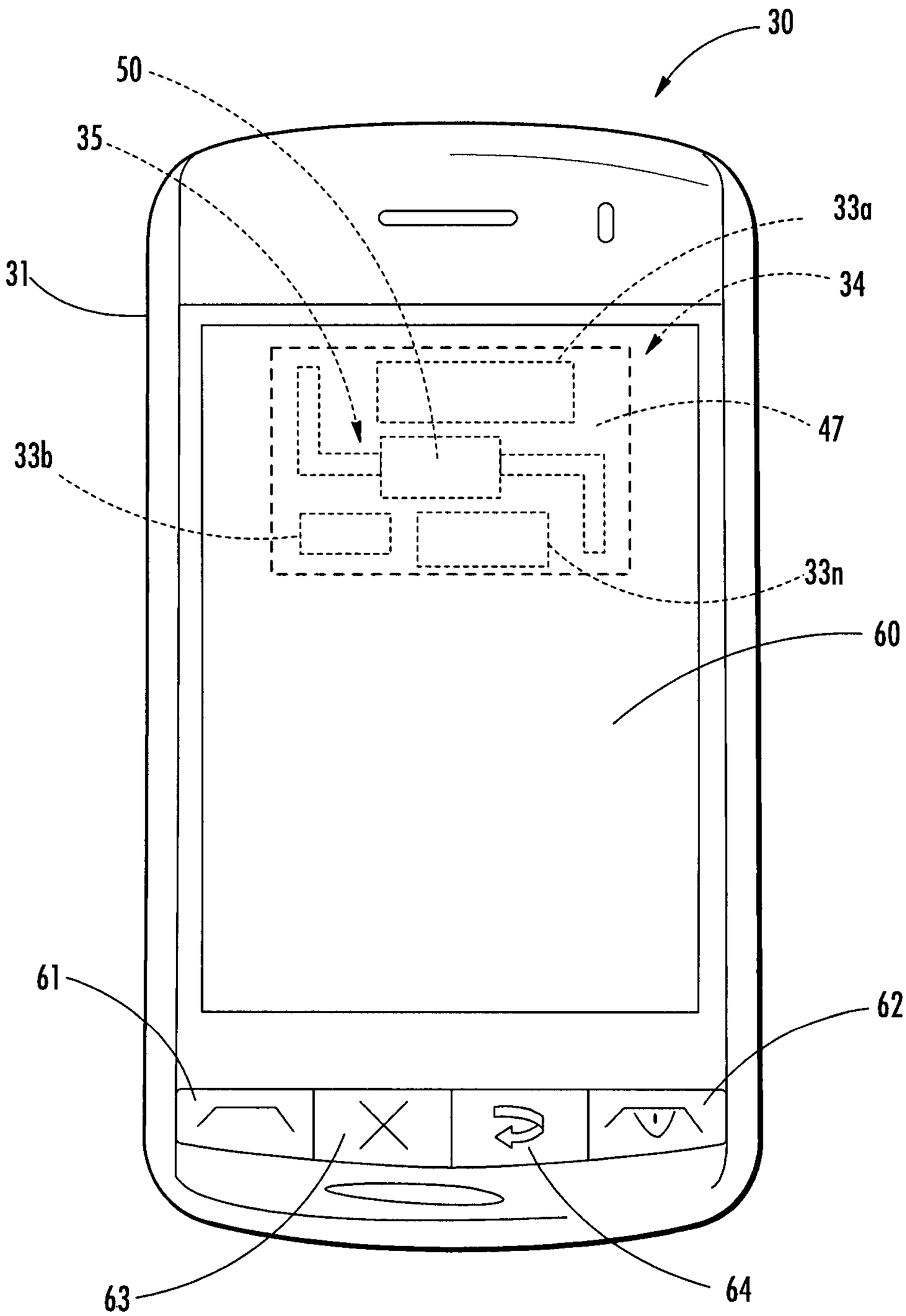


FIG. 1

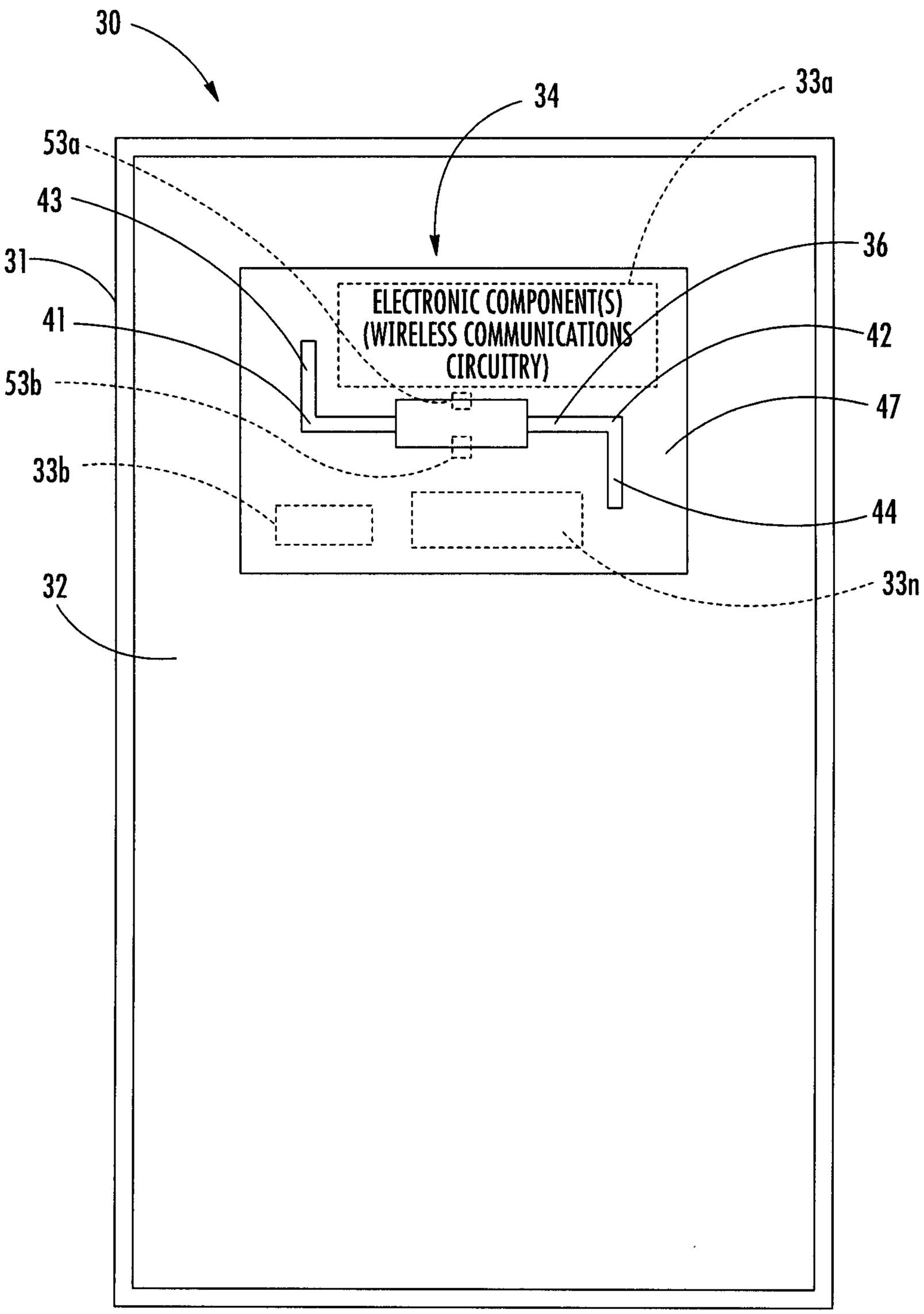

30
34
33a
53a
43
31
36
ELECTRONIC COMPONENT(S)
(WIRELESS COMMUNICATIONS
CIRCUITRY)
41
42
53b
47
33b
44
32
33n

FIG. 2

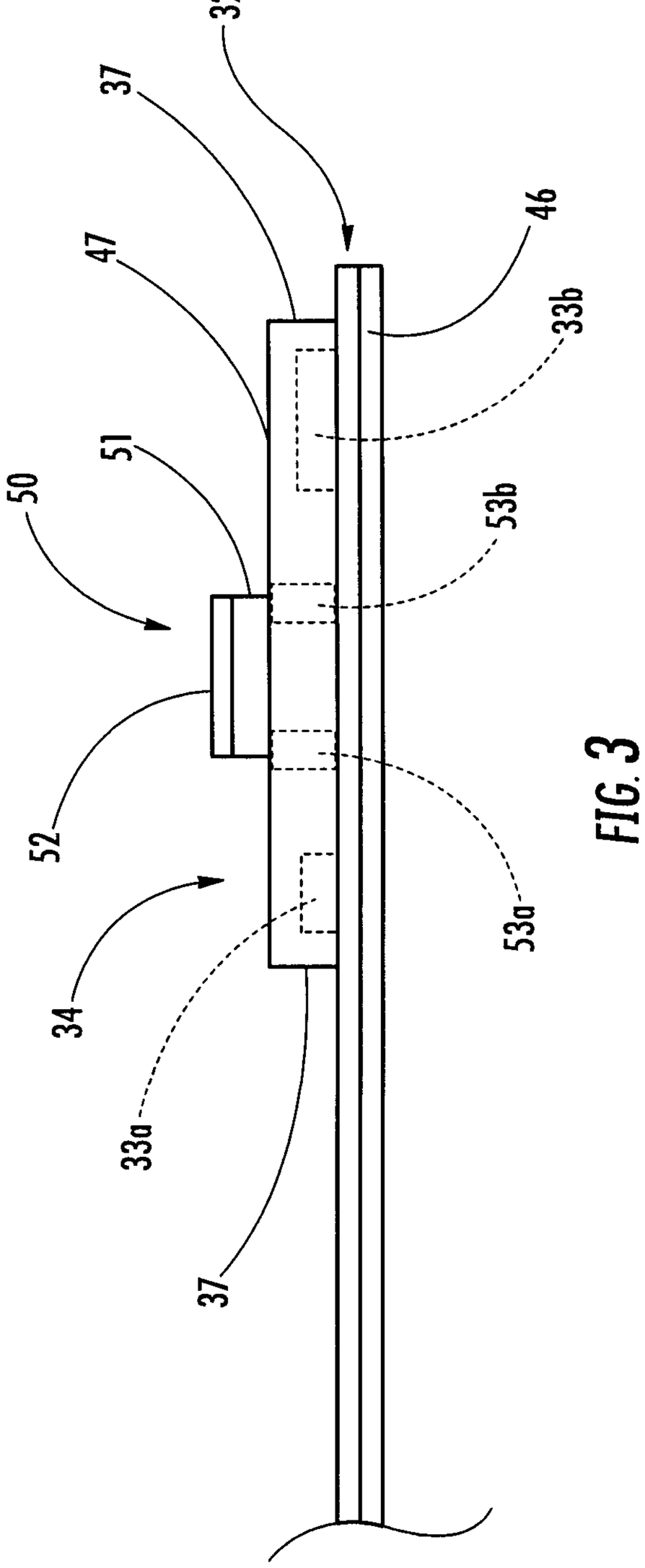


FIG. 3

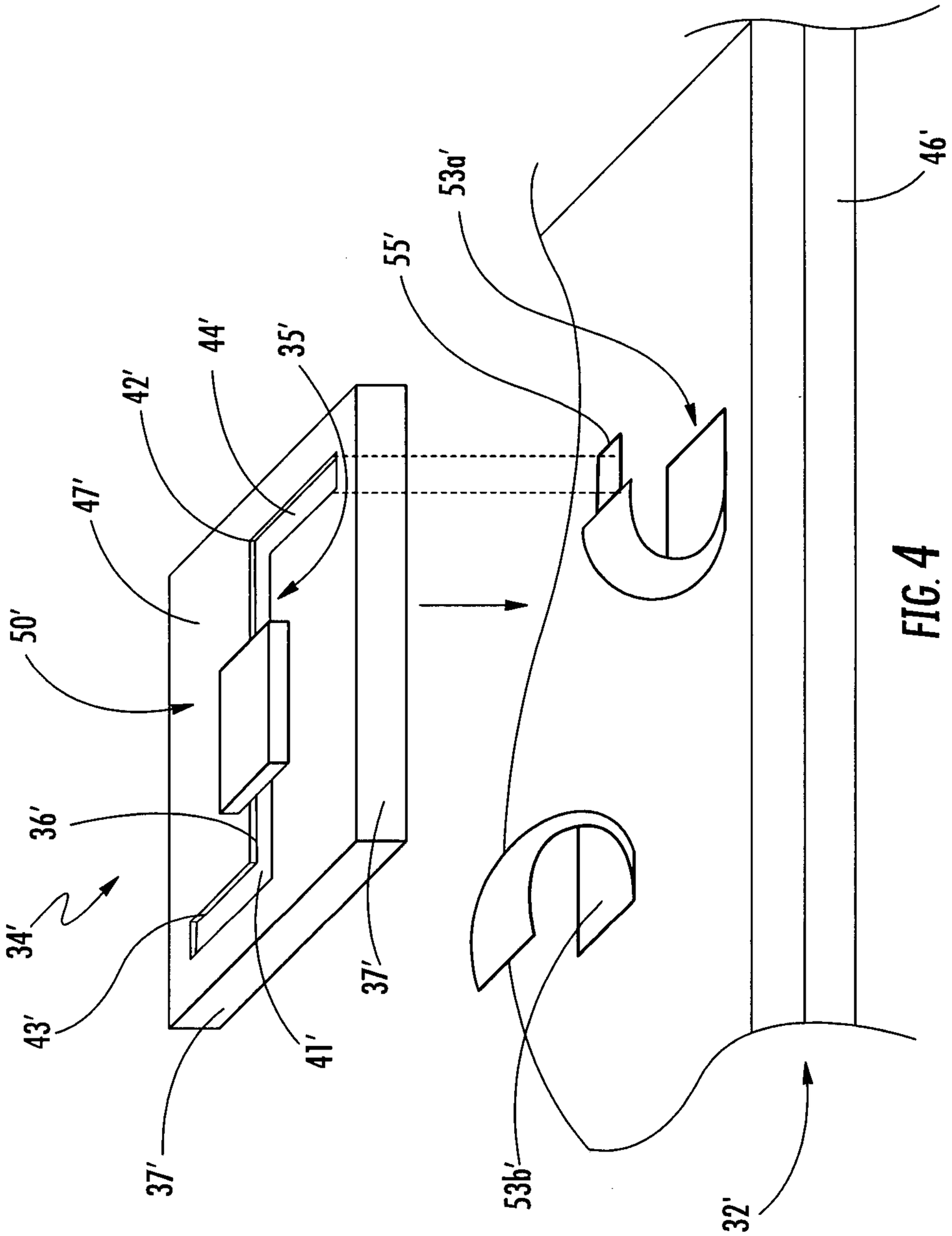


FIG. 4

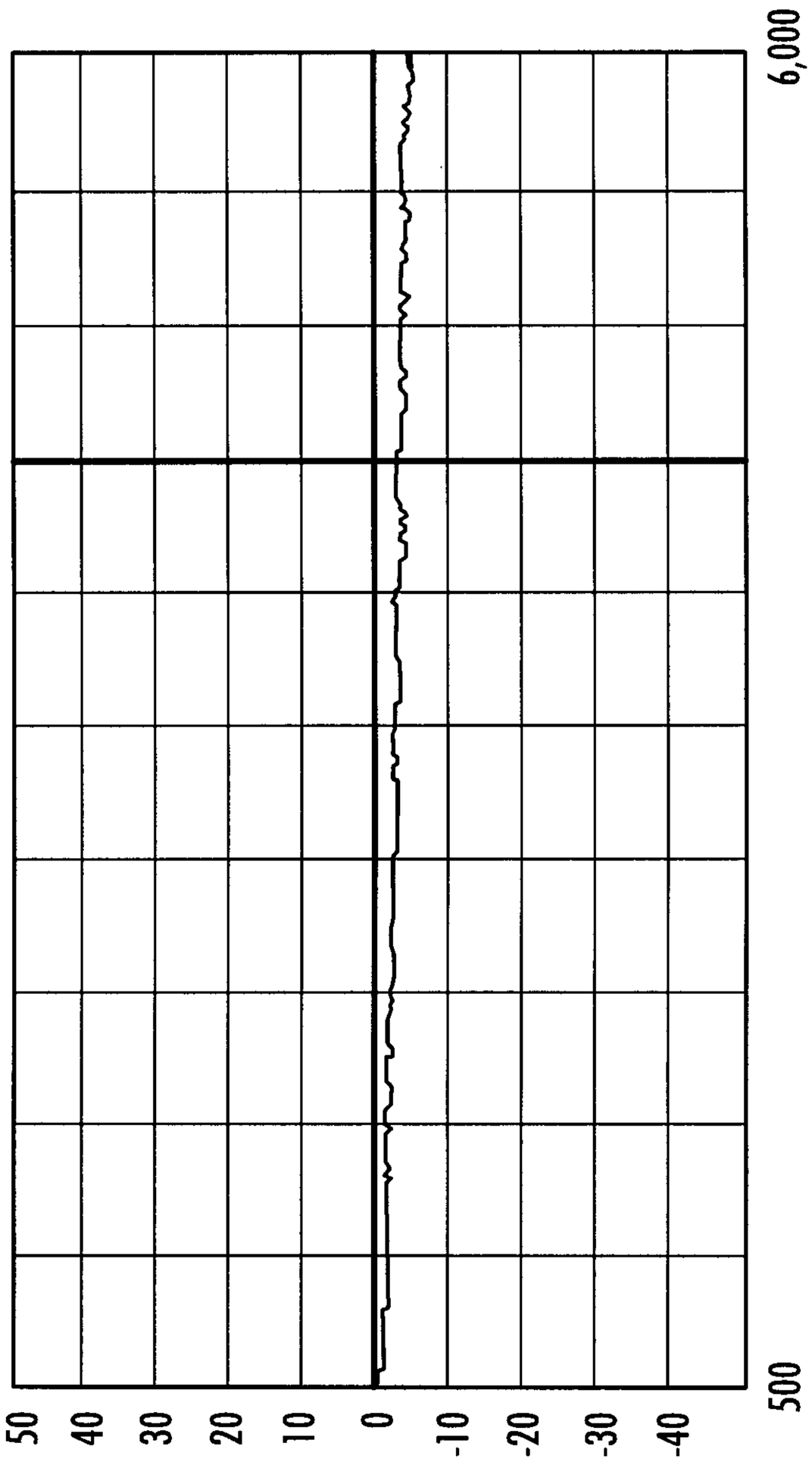


FIG. 5

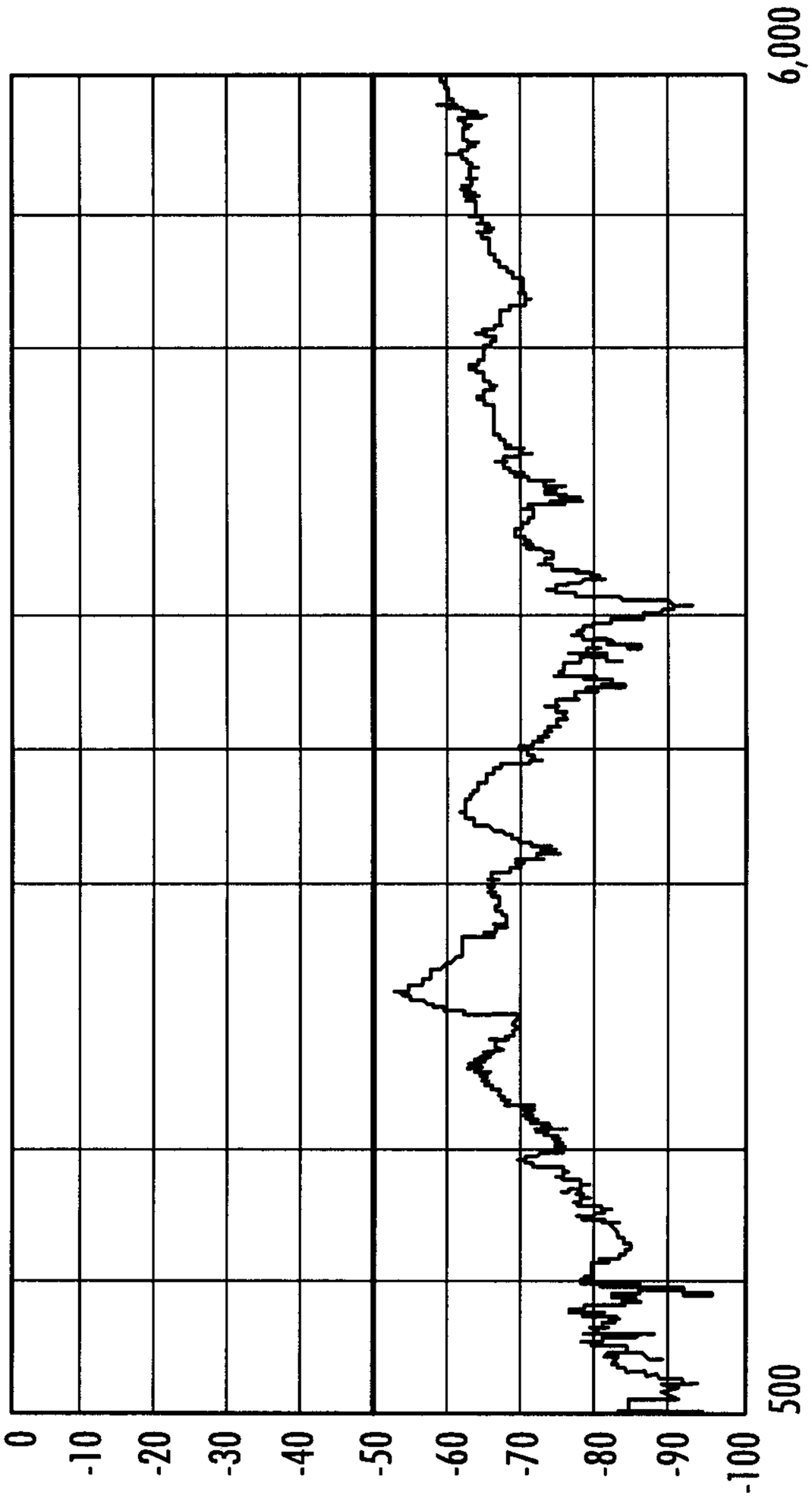


FIG. 6

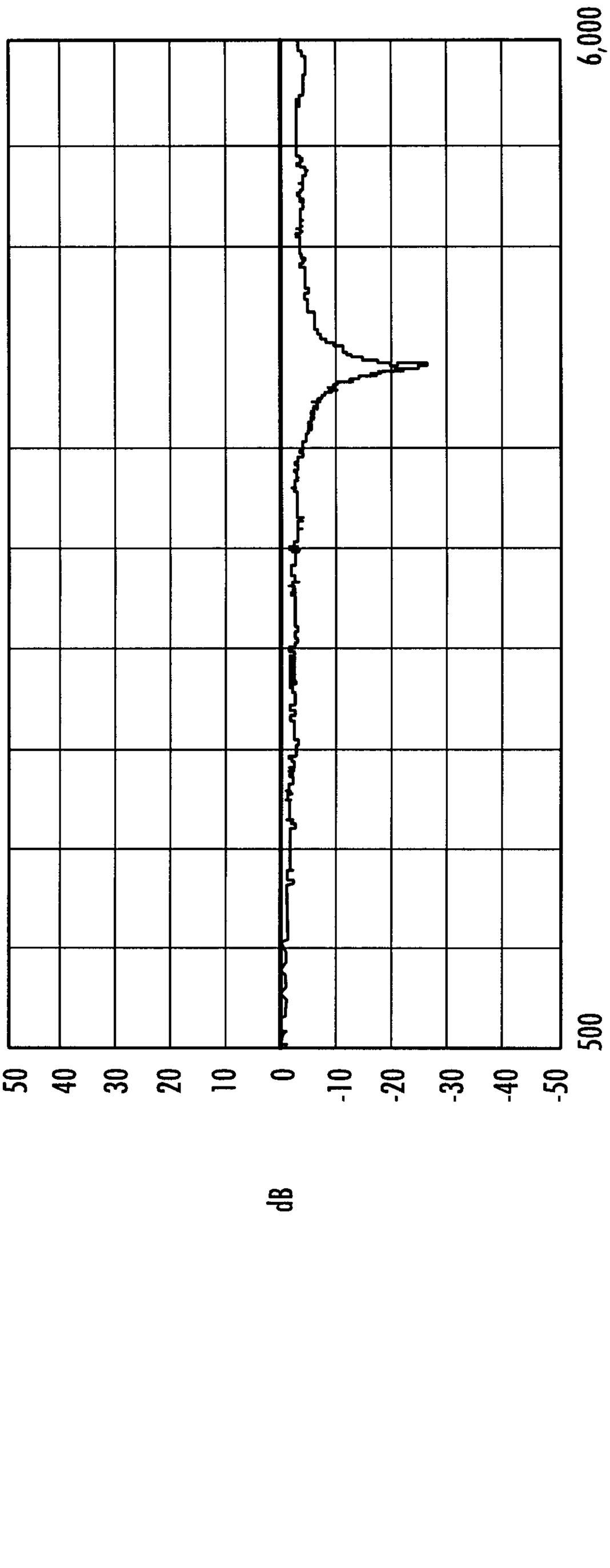


FIG. 7

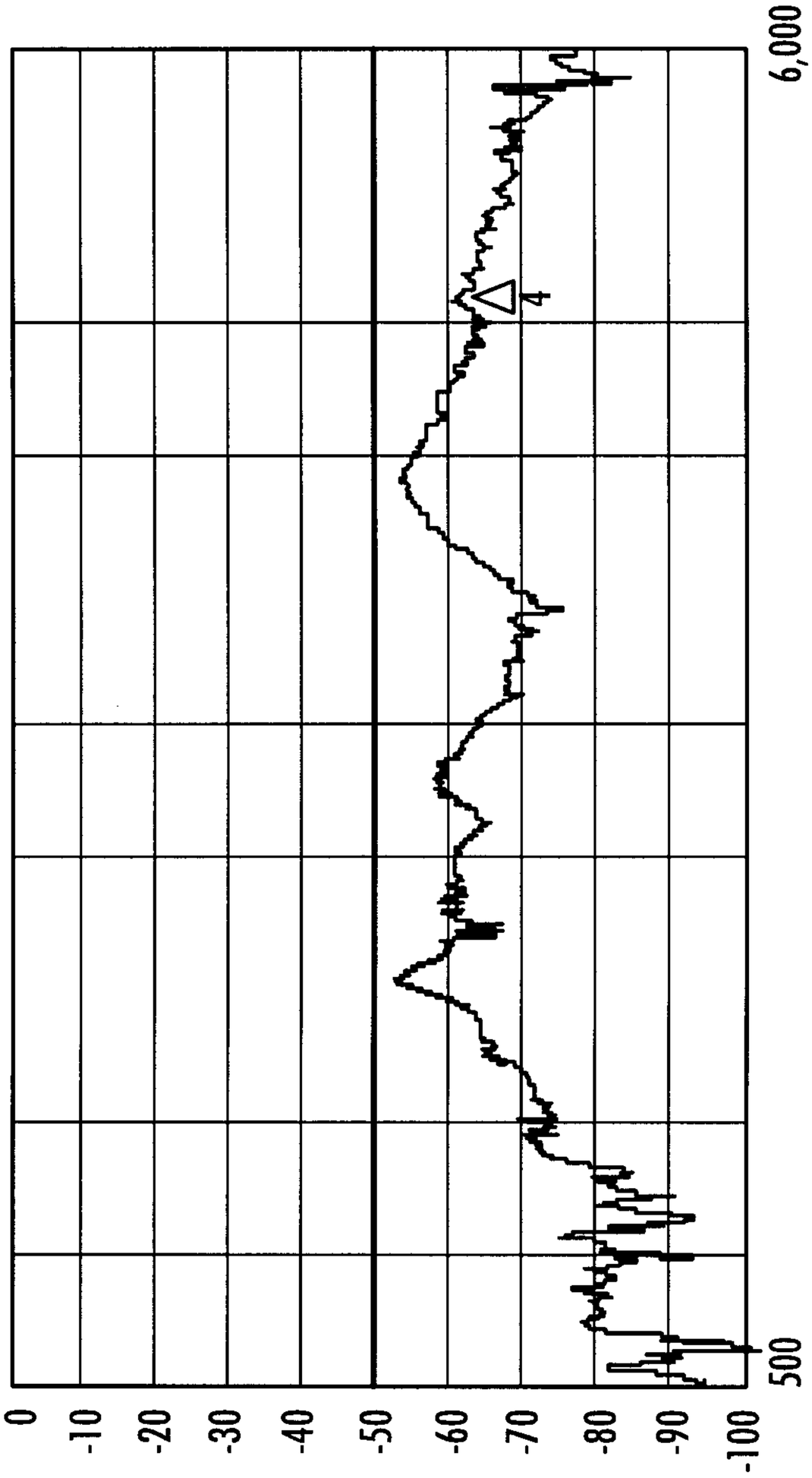


FIG. 8

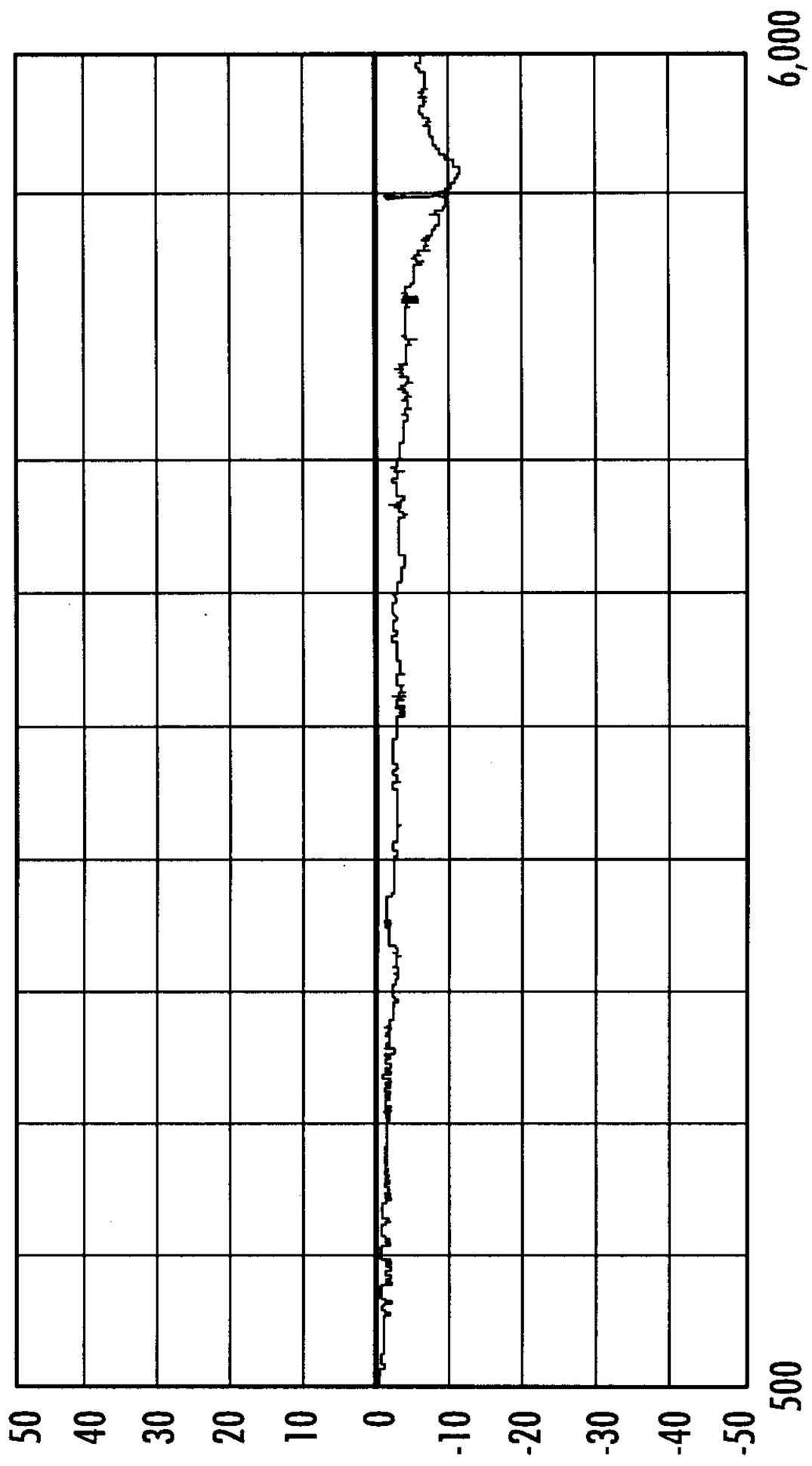


FIG. 9

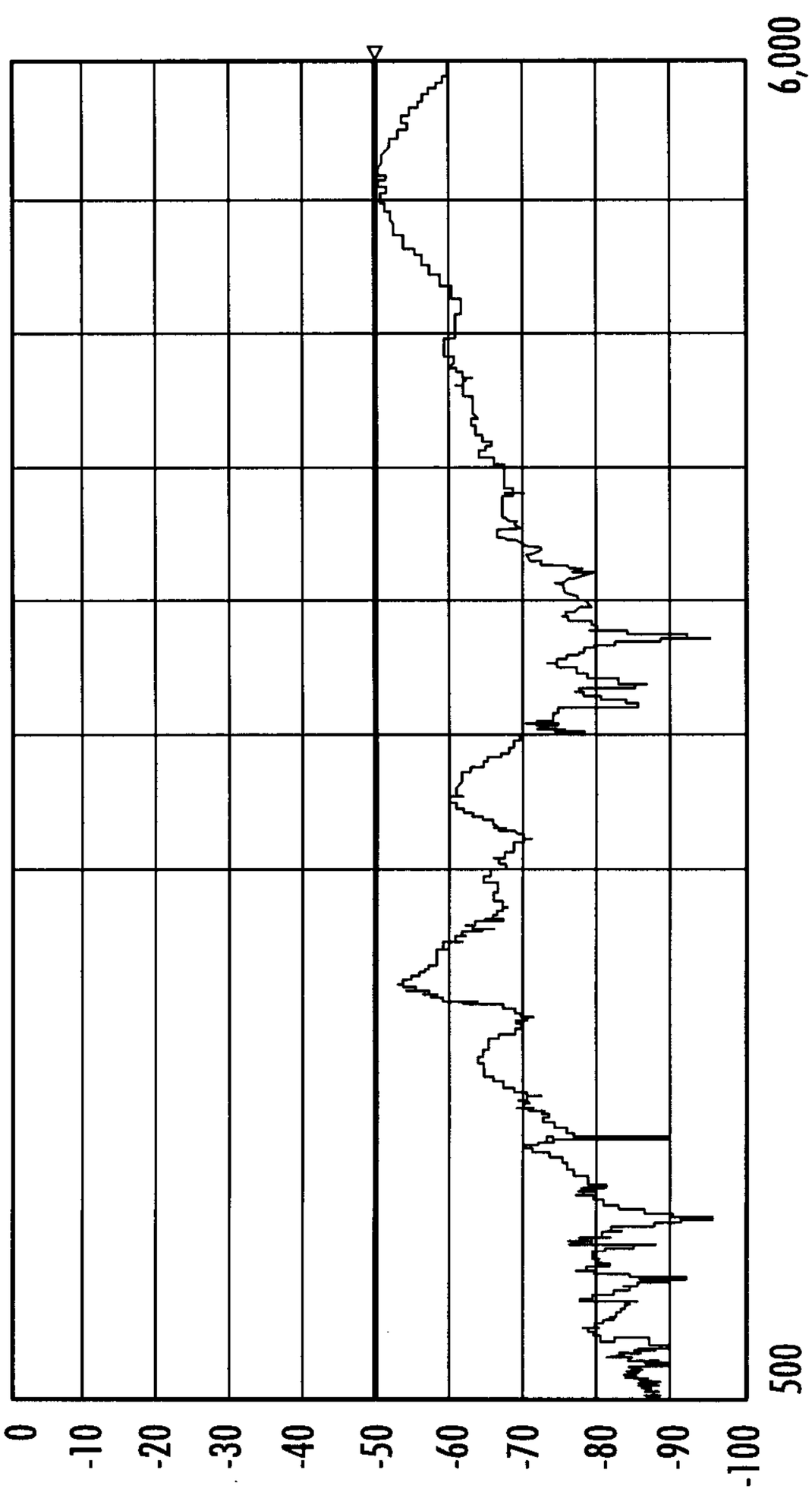


FIG. 10

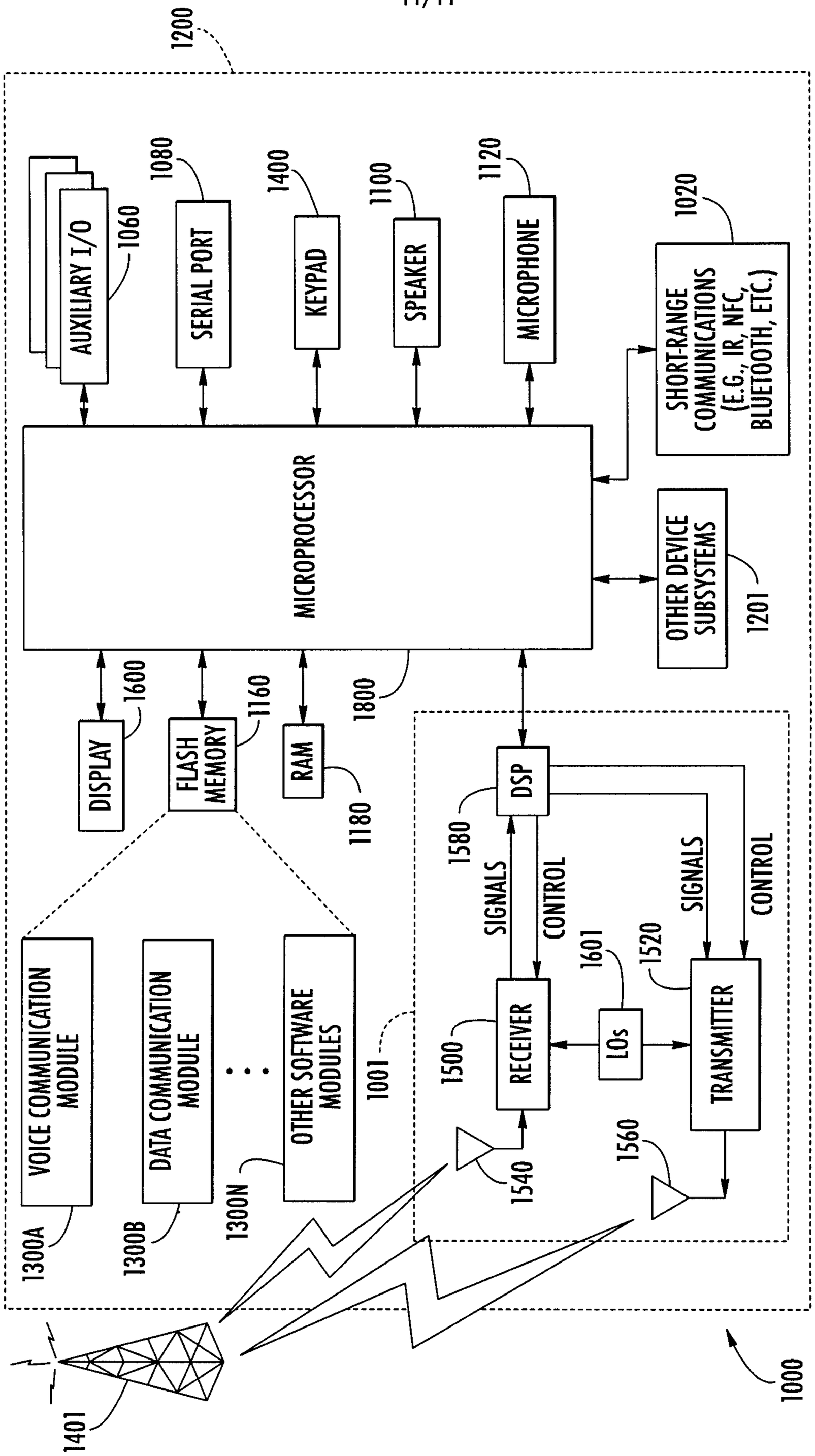
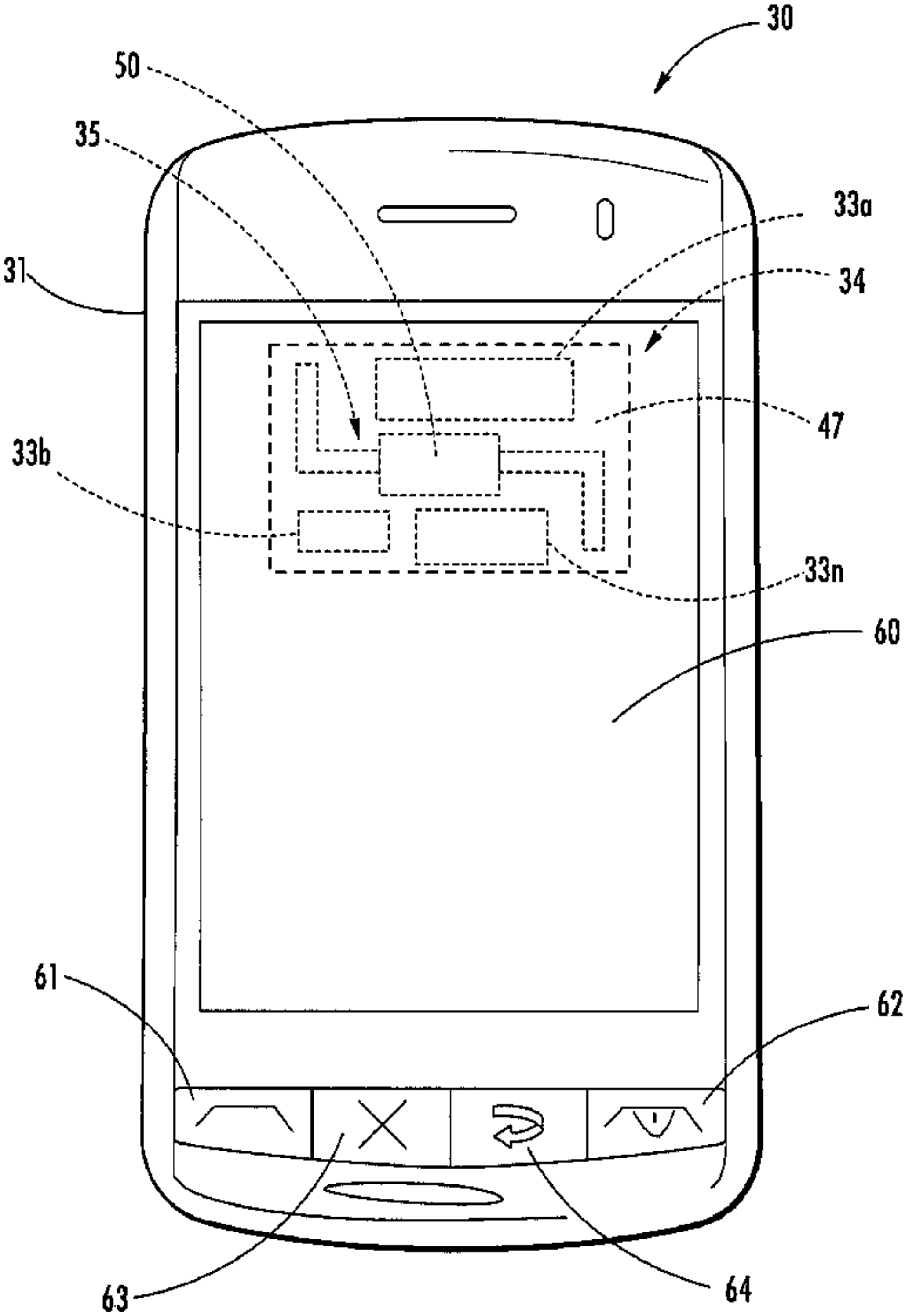

1200
1080
1400
1100
1120
1020
AUXILIARY I/O
1060
SERIAL PORT
KEYPAD
SPEAKER
MICROPHONE
SHORT-RANGE COMMUNICATIONS (E.G., IR, NFC, BLUETOOTH, ETC.)
MICROPROCESSOR
OTHER DEVICE SUBSYSTEMS
1201
1600
1160
1800
DISPLAY
FLASH MEMORY
RAM
1180
DSP
1580
SIGNALS
CONTROL
1601
1520
1500
RECEIVER
LOs
TRANSMITTER
1540
1560
VOICE COMMUNICATION MODULE
DATA COMMUNICATION MODULE
OTHER SOFTWARE MODULES
1001
1300A
1300B
1300N
1401
1000

FIG. 11


30
50
35
33a
31
34
47
33b
33n
60
61
62
63
64