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(54) **COMMUNICATION DEVICE, COMMUNICATION METHOD, COMMUNICATION SYSTEM, AND PROGRAM**

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(52) **U.S. Cl.**
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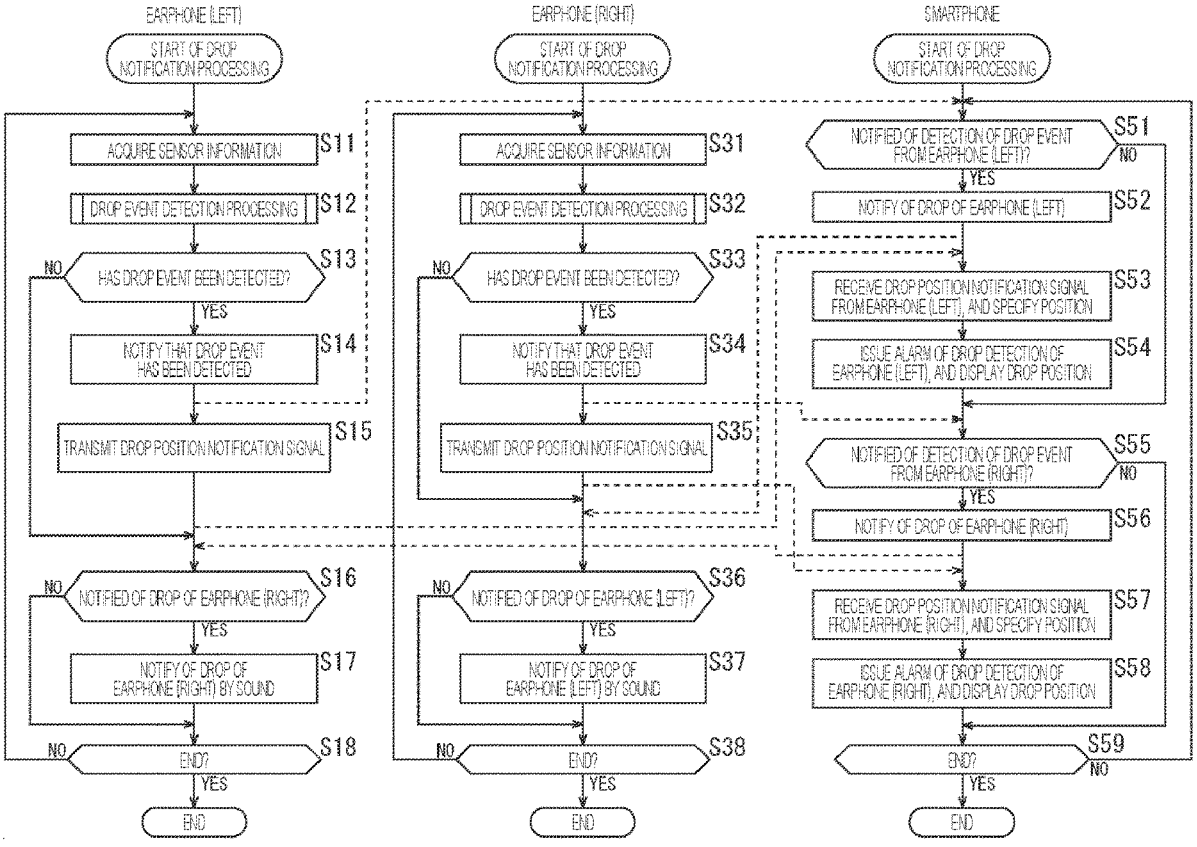
(57) **ABSTRACT**

The present disclosure relates to a communication device, a communication method, a communication system, and a program that enable recognition of a drop of the communication device. In a communication system including an earphone and a smartphone that perform Bluetooth (registered trademark) communication, when the earphone detects a drop, the earphone notifies the smartphone of the drop and transmits a drop position notification signal for providing a notification of its own position to the smartphone by the BLE communication. When notified of the drop of the smartphone, the smartphone vibrates a vibrator to notify the user that the earphone has dropped, and specifies and displays the position of the earphone on the basis of the drop position notification signal. The present disclosure can be applied to a communication system.



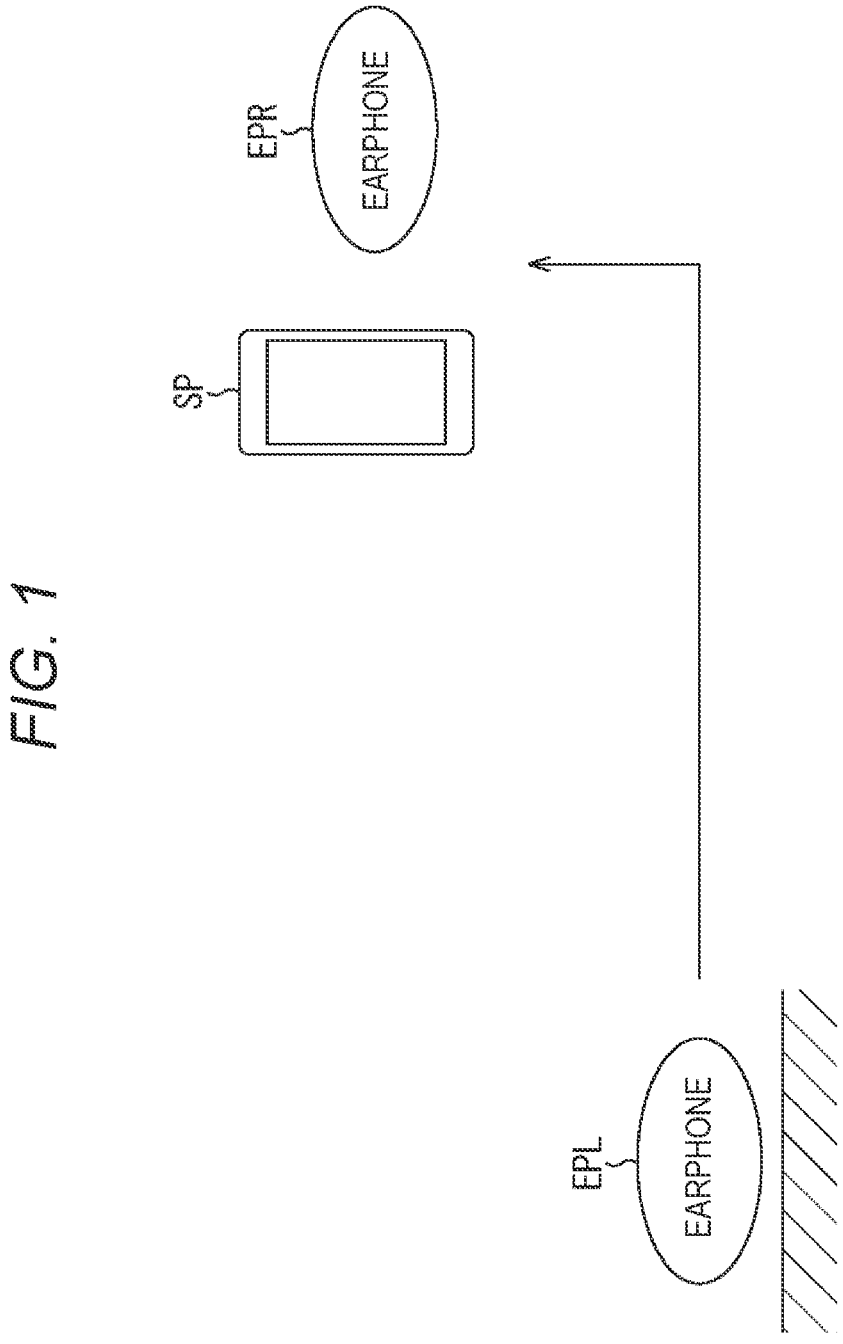


FIG. 1

FIG. 2

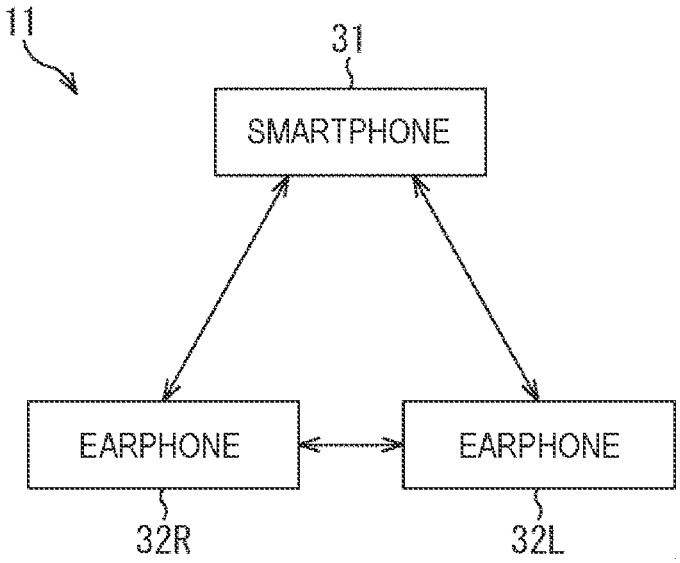


FIG. 3

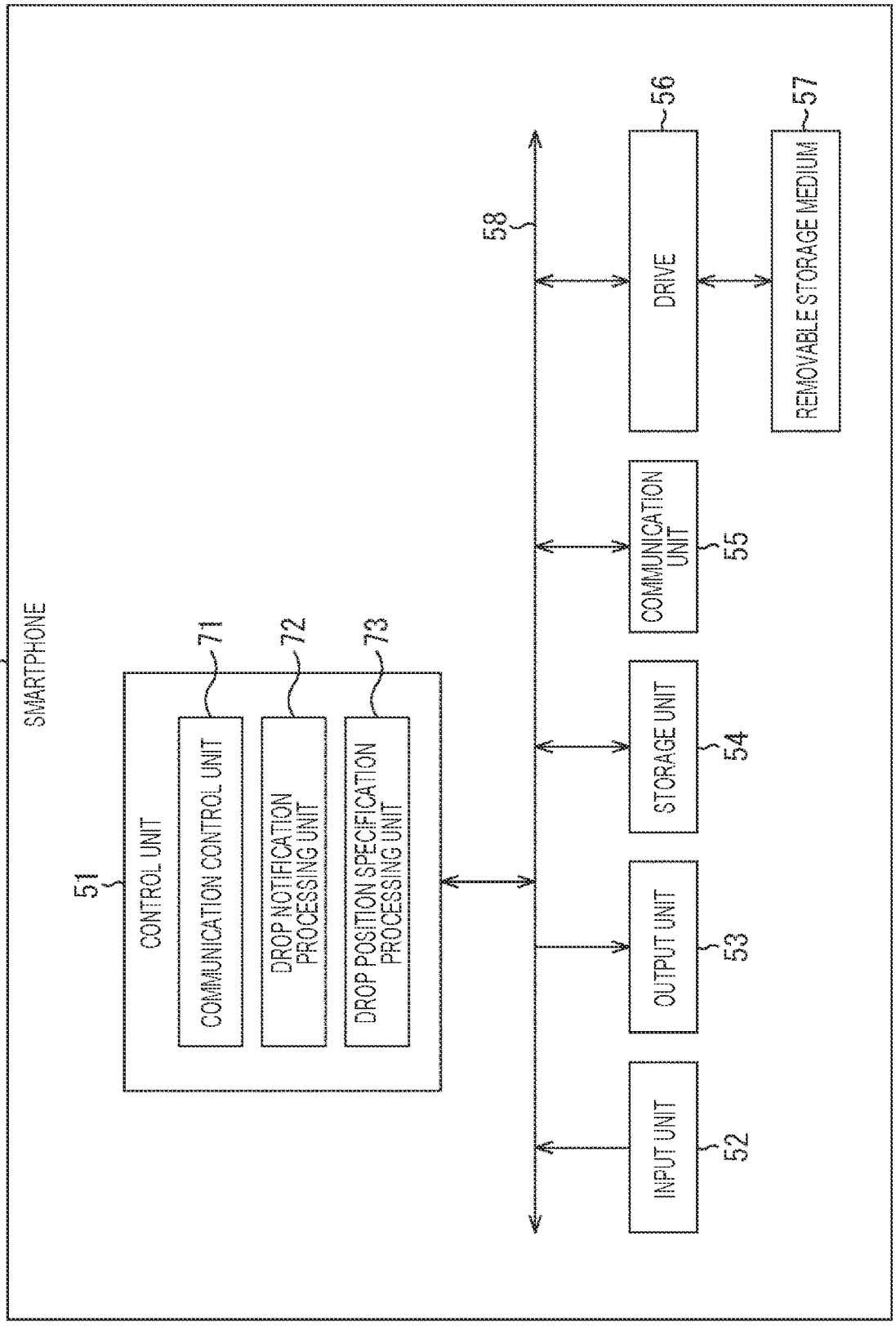

31
SMARTPHONE
51
CONTROL UNIT
71
COMMUNICATION CONTROL UNIT
72
DROP NOTIFICATION PROCESSING UNIT
73
DROP POSITION SPECIFICATION PROCESSING UNIT
58
INPUT UNIT
52
OUTPUT UNIT
53
STORAGE UNIT
54
COMMUNICATION UNIT
55
DRIVE
56
REMOVABLE STORAGE MEDIUM
57

FIG. 4

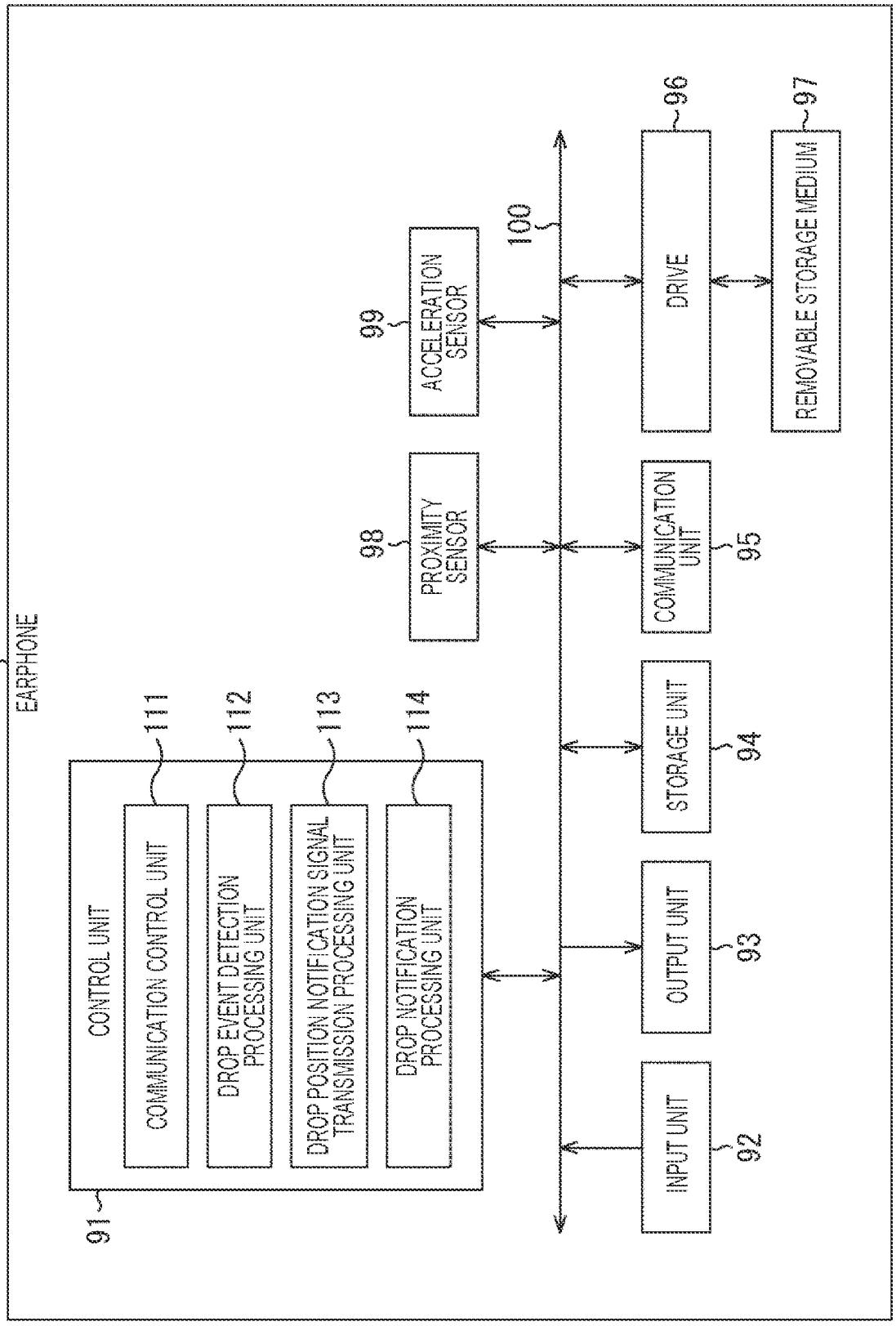

32
EARPHONE
91
CONTROL UNIT
111
COMMUNICATION CONTROL UNIT
112
DROP EVENT DETECTION PROCESSING UNIT
113
DROP POSITION NOTIFICATION SIGNAL TRANSMISSION PROCESSING UNIT
114
DROP NOTIFICATION PROCESSING UNIT
92
INPUT UNIT
93
OUTPUT UNIT
94
STORAGE UNIT
95
COMMUNICATION UNIT
96
DRIVE
97
REMOVABLE STORAGE MEDIUM
98
PROXIMITY SENSOR
99
ACCELERATION SENSOR
100

FIG. 5

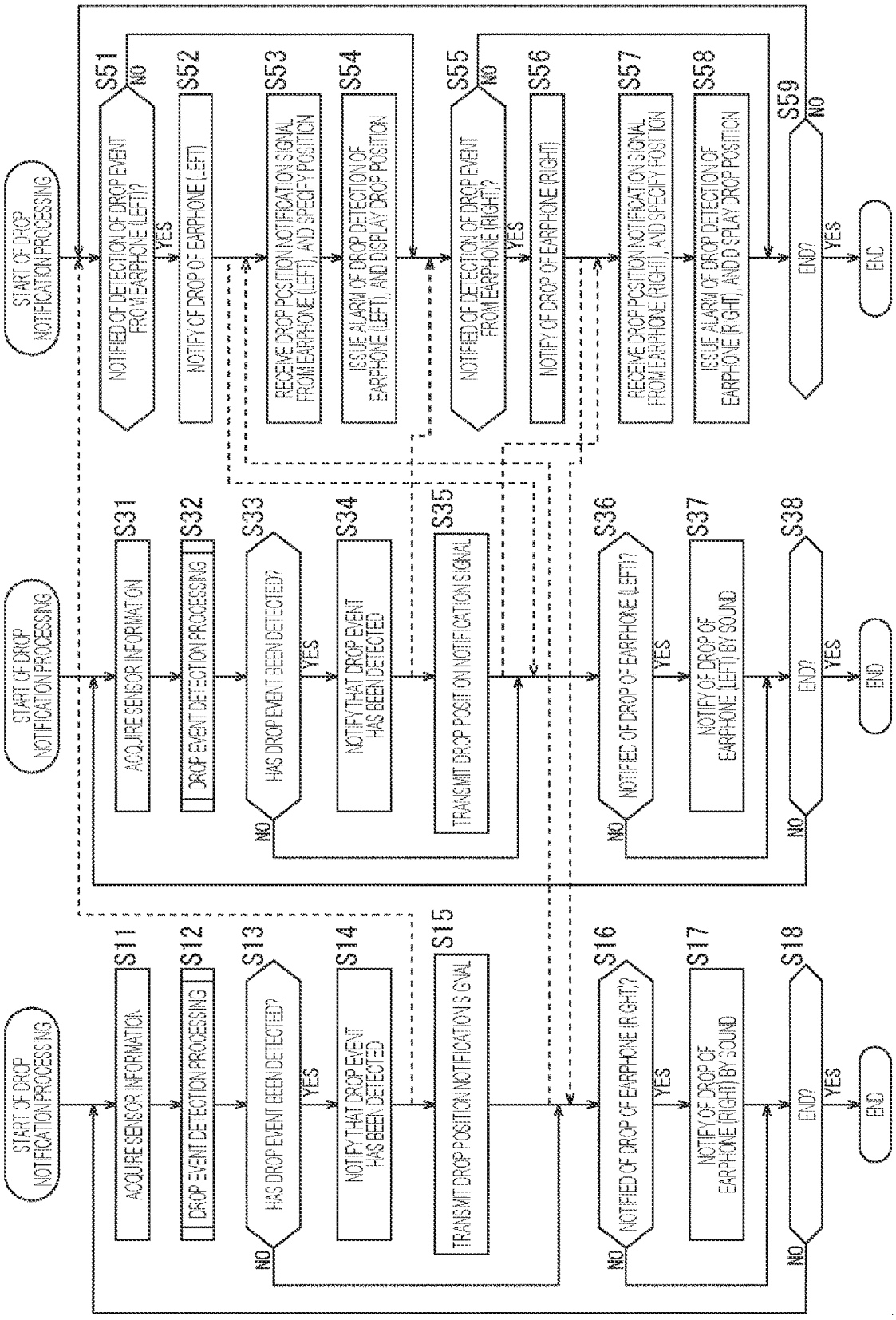

EARPHONE (LEFT)
START OF DROP NOTIFICATION PROCESSING
S11
ACQUIRE SENSOR INFORMATION
S12
DROP EVENT DETECTION PROCESSING
S13
HAS DROP EVENT BEEN DETECTED?
YES
NO
S14
NOTIFY THAT DROP EVENT HAS BEEN DETECTED
S15
TRANSMIT DROP POSITION NOTIFICATION SIGNAL
S16
NOTIFIED OF DROP OF EARPHONE (RIGHT)?
YES
NO
S17
NOTIFY OF DROP OF EARPHONE (RIGHT) BY SOUND
S18
END?
YES
NO
END
EARPHONE (RIGHT)
START OF DROP NOTIFICATION PROCESSING
S31
ACQUIRE SENSOR INFORMATION
S32
DROP EVENT DETECTION PROCESSING
S33
HAS DROP EVENT BEEN DETECTED?
YES
NO
S34
NOTIFY THAT DROP EVENT HAS BEEN DETECTED
S35
TRANSMIT DROP POSITION NOTIFICATION SIGNAL
S36
NOTIFIED OF DROP OF EARPHONE (LEFT)?
YES
NO
S37
NOTIFY OF DROP OF EARPHONE (LEFT) BY SOUND
S38
END?
YES
NO
END
SMARTPHONE
START OF DROP NOTIFICATION PROCESSING
S51
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (LEFT)?
YES
NO
S52
NOTIFY OF DROP OF EARPHONE (LEFT)
S53
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT), AND SPECIFY POSITION
S54
ISSUE ALARM OF DROP DETECTION OF EARPHONE (LEFT), AND DISPLAY DROP POSITION
S55
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (RIGHT)?
YES
NO
S56
NOTIFY OF DROP OF EARPHONE (RIGHT)
S57
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT), AND SPECIFY POSITION
S58
ISSUE ALARM OF DROP DETECTION OF EARPHONE (RIGHT), AND DISPLAY DROP POSITION
S59
END?
YES
NO
END

FIG. 6

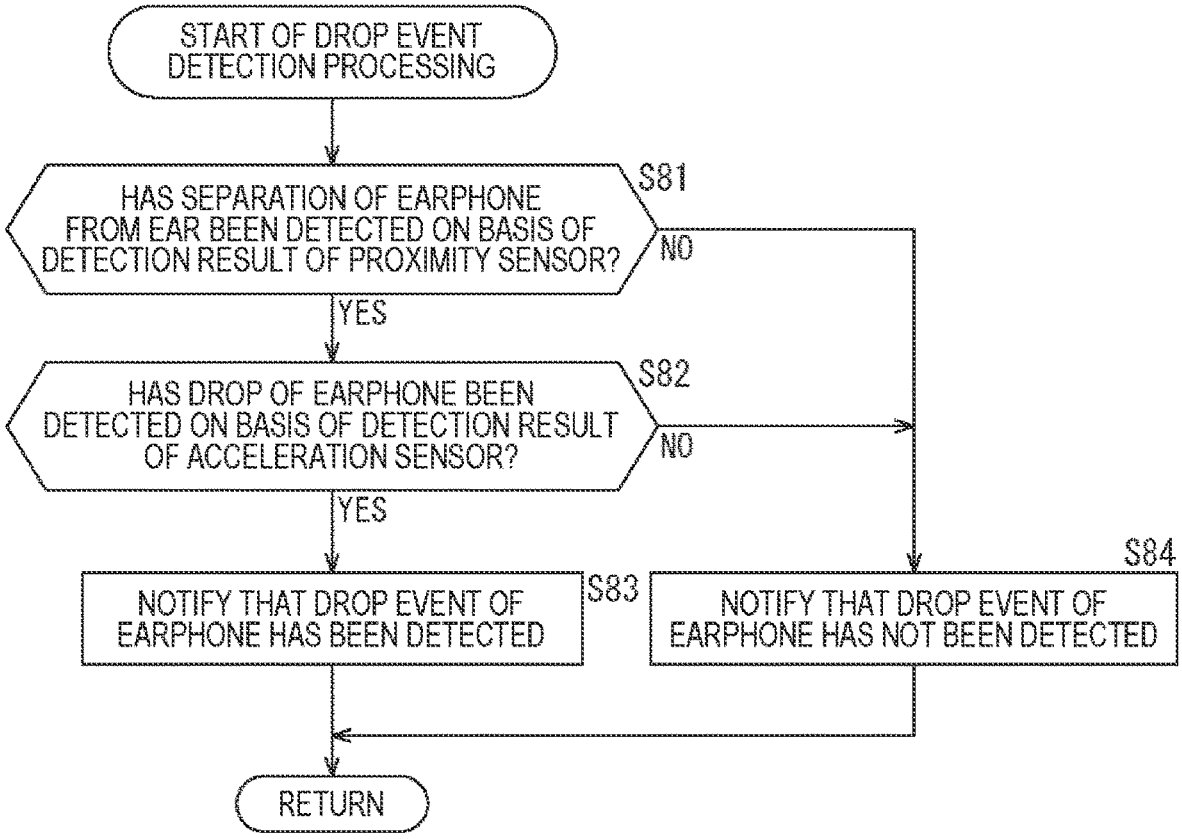

START OF DROP EVENT DETECTION PROCESSING
HAS SEPARATION OF EARPHONE FROM EAR BEEN DETECTED ON BASIS OF DETECTION RESULT OF PROXIMITY SENSOR?
S81
NO
YES
HAS DROP OF EARPHONE BEEN DETECTED ON BASIS OF DETECTION RESULT OF ACCELERATION SENSOR?
S82
NO
YES
NOTIFY THAT DROP EVENT OF EARPHONE HAS BEEN DETECTED
S83
NOTIFY THAT DROP EVENT OF EARPHONE HAS NOT BEEN DETECTED
S84
RETURN

FIG. 7

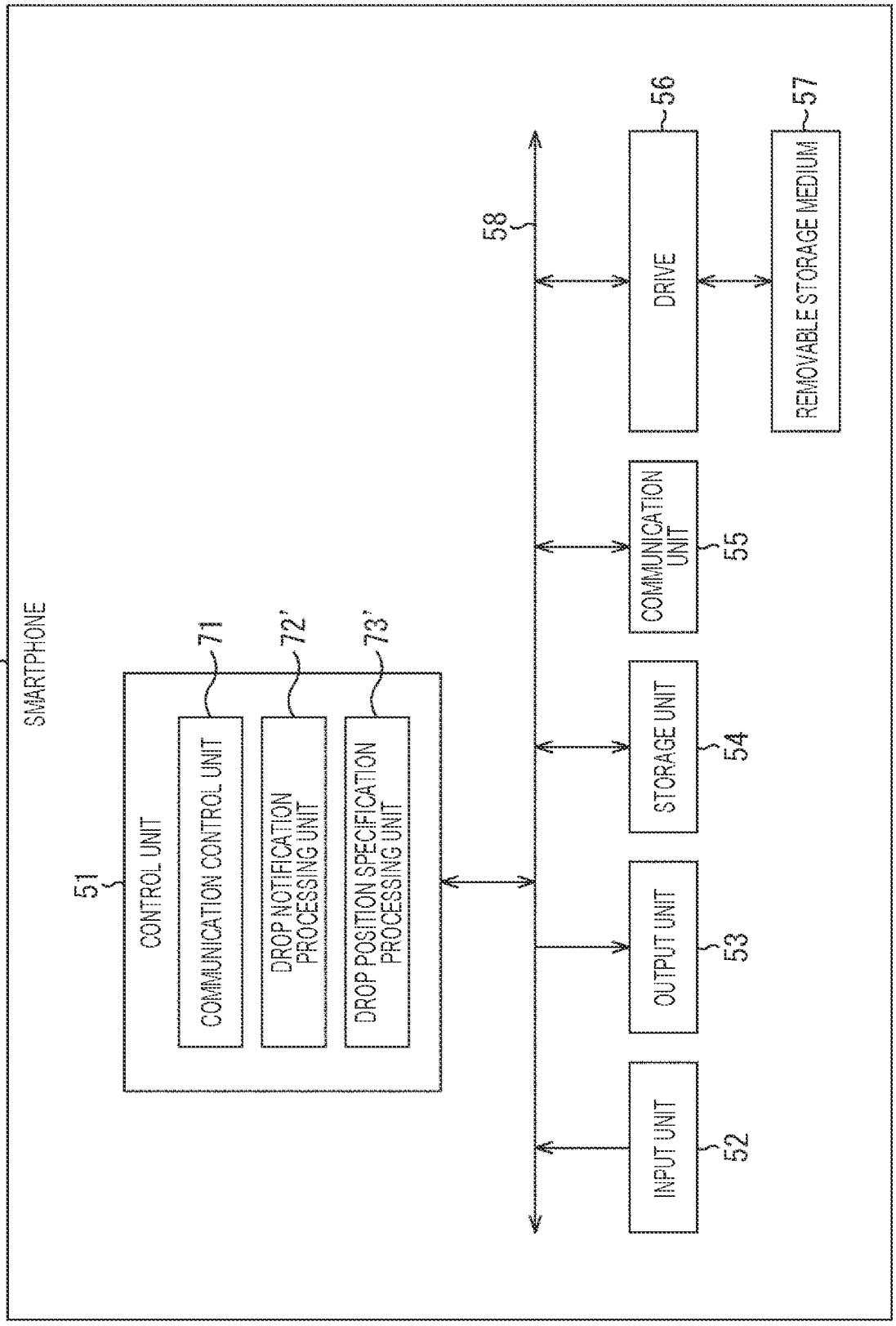

31
SMARTPHONE
51
CONTROL UNIT
71
COMMUNICATION CONTROL UNIT
72'
DROP NOTIFICATION PROCESSING UNIT
73'
DROP POSITION SPECIFICATION PROCESSING UNIT
58
52
INPUT UNIT
53
OUTPUT UNIT
54
STORAGE UNIT
55
COMMUNICATION UNIT
56
DRIVE
57
REMOVABLE STORAGE MEDIUM

FIG. 8

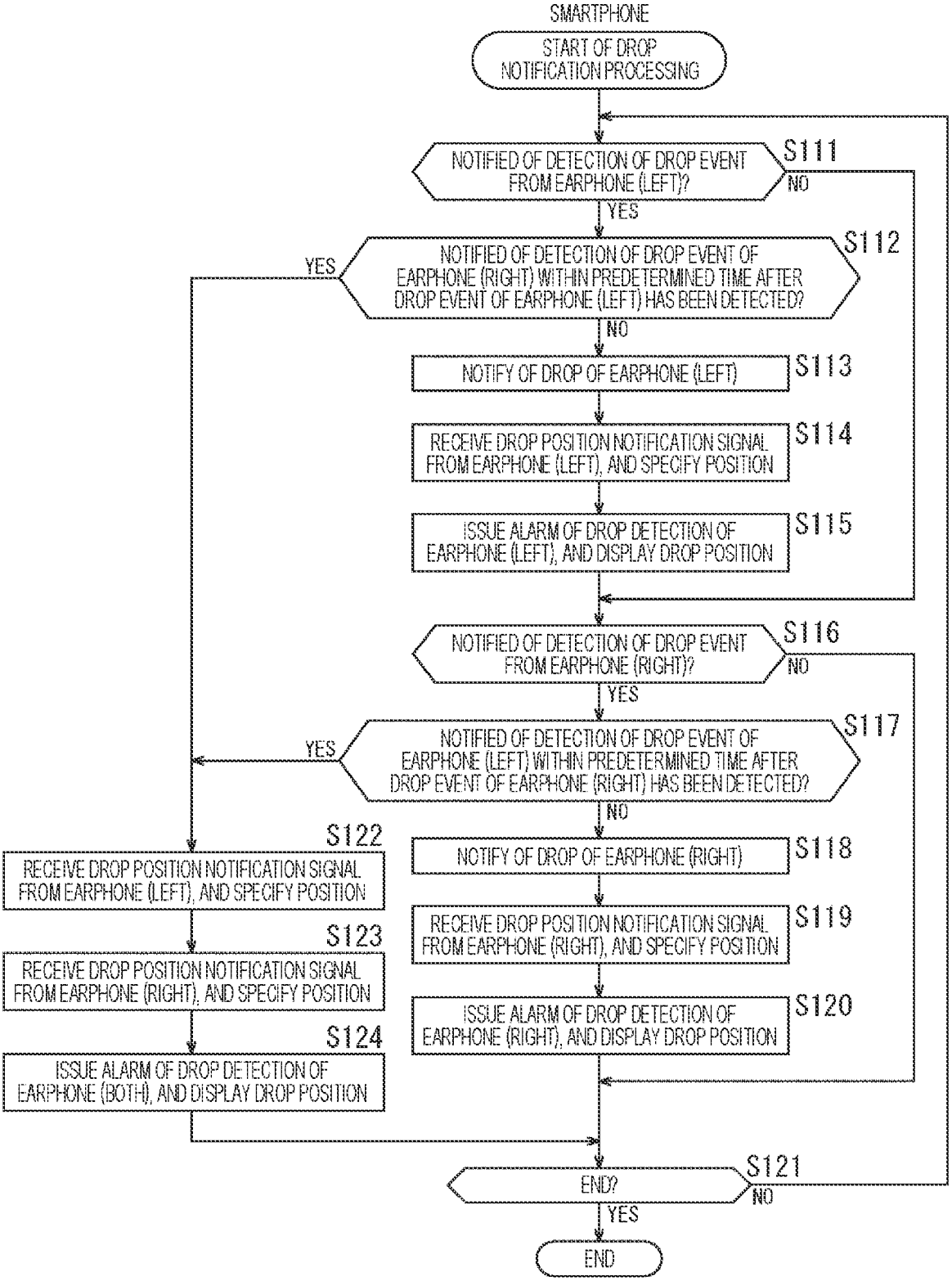

SMARTPHONE
START OF DROP NOTIFICATION PROCESSING
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (LEFT)?
S111
NO
YES
NOTIFIED OF DETECTION OF DROP EVENT OF EARPHONE (RIGHT) WITHIN PREDETERMINED TIME AFTER DROP EVENT OF EARPHONE (LEFT) HAS BEEN DETECTED?
S112
YES
NO
NOTIFY OF DROP OF EARPHONE (LEFT)
S113
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT), AND SPECIFY POSITION
S114
ISSUE ALARM OF DROP DETECTION OF EARPHONE (LEFT), AND DISPLAY DROP POSITION
S115
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (RIGHT)?
S116
NO
YES
NOTIFIED OF DETECTION OF DROP EVENT OF EARPHONE (LEFT) WITHIN PREDETERMINED TIME AFTER DROP EVENT OF EARPHONE (RIGHT) HAS BEEN DETECTED?
S117
YES
NO
NOTIFY OF DROP OF EARPHONE (RIGHT)
S118
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT), AND SPECIFY POSITION
S119
ISSUE ALARM OF DROP DETECTION OF EARPHONE (RIGHT), AND DISPLAY DROP POSITION
S120
S122
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT), AND SPECIFY POSITION
S123
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT), AND SPECIFY POSITION
S124
ISSUE ALARM OF DROP DETECTION OF EARPHONE (BOTH), AND DISPLAY DROP POSITION
END?
S121
NO
YES
END

FIG. 9

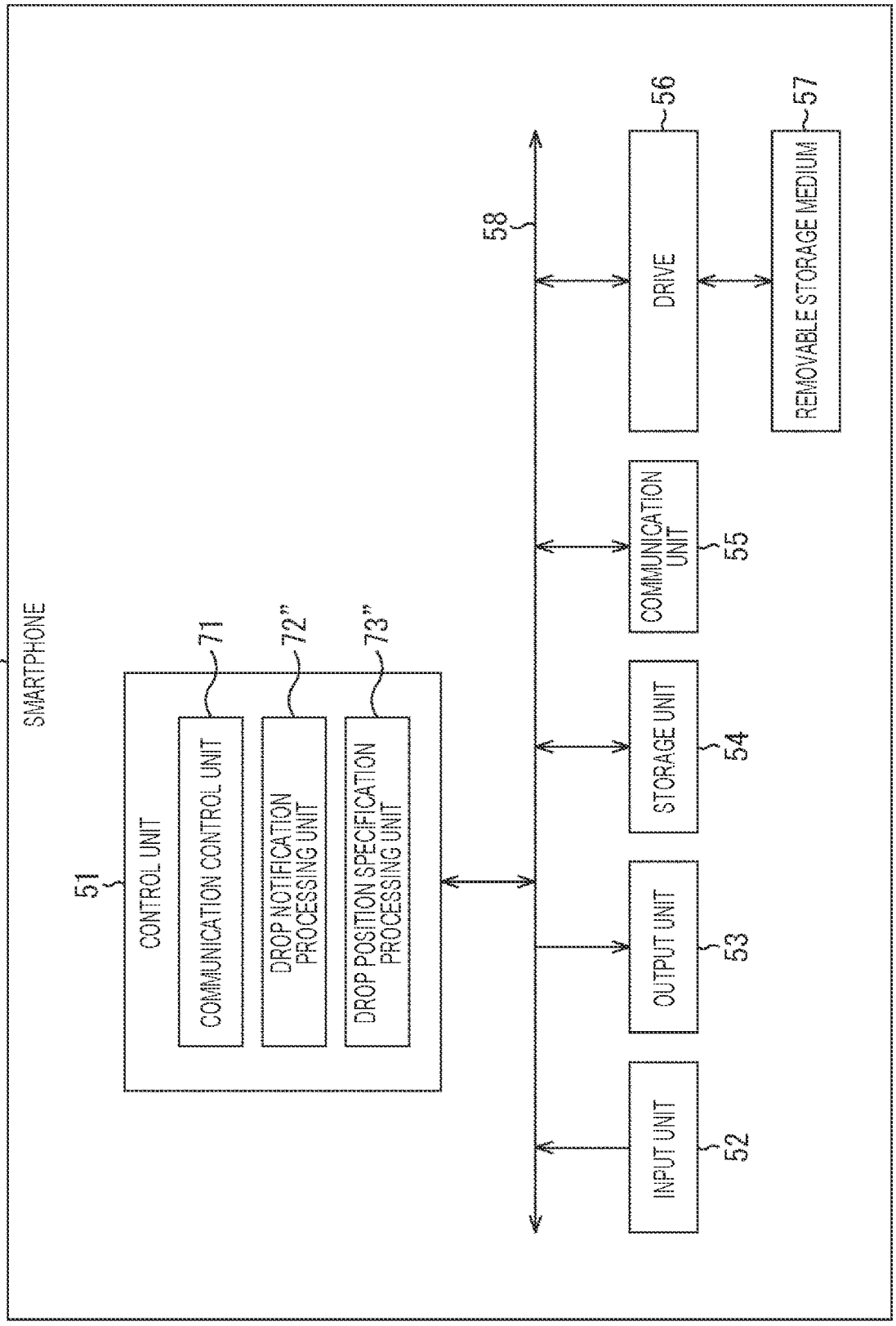

31
SMARTPHONE
51
CONTROL UNIT
71
COMMUNICATION CONTROL UNIT
72"
DROP NOTIFICATION PROCESSING UNIT
73"
DROP POSITION SPECIFICATION PROCESSING UNIT
58
52
INPUT UNIT
53
OUTPUT UNIT
54
STORAGE UNIT
55
COMMUNICATION UNIT
56
DRIVE
57
REMOVABLE STORAGE MEDIUM

FIG. 10

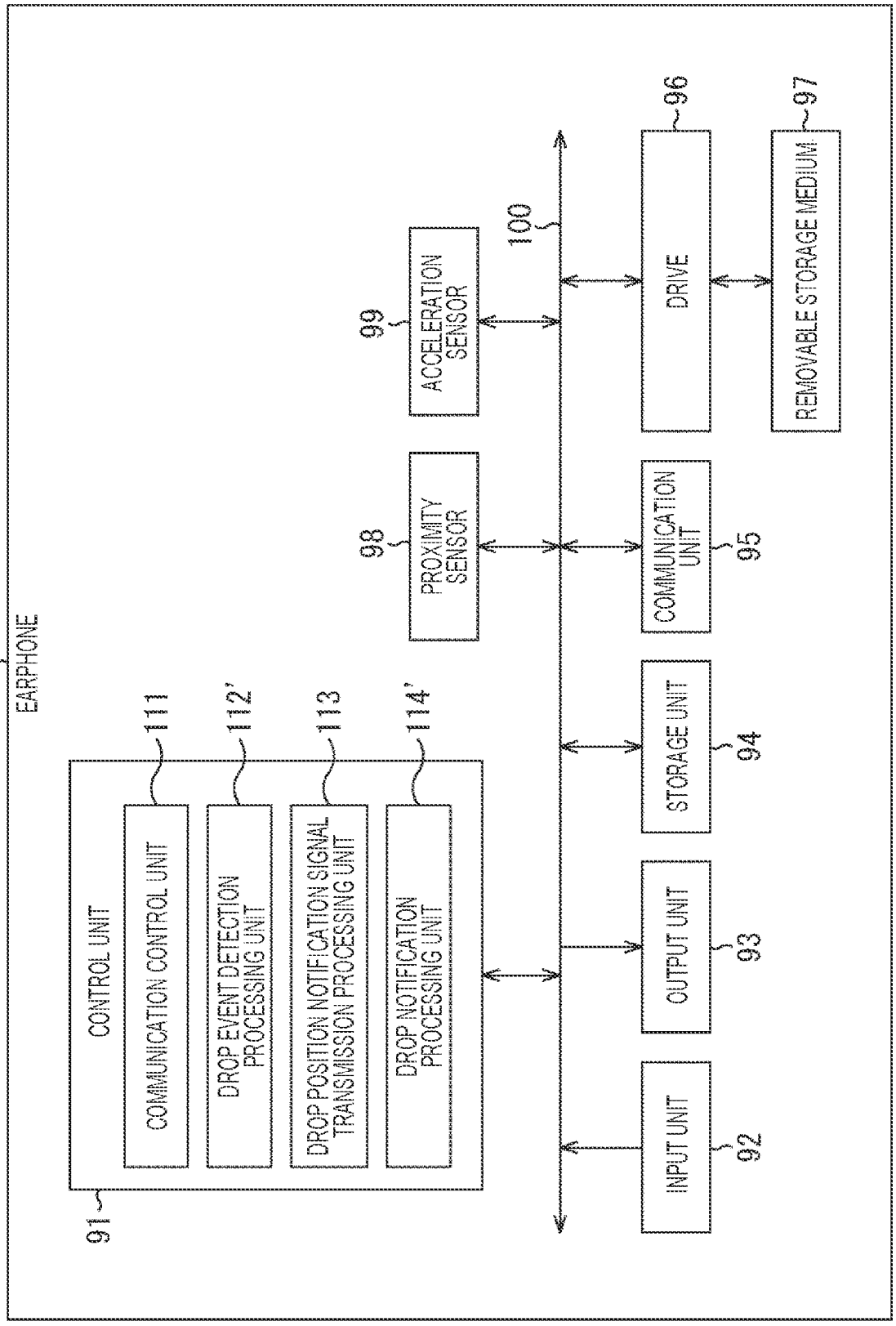

32
EARPHONE
91
CONTROL UNIT
111
COMMUNICATION CONTROL UNIT
112'
DROP EVENT DETECTION PROCESSING UNIT
113
DROP POSITION NOTIFICATION SIGNAL TRANSMISSION PROCESSING UNIT
114'
DROP NOTIFICATION PROCESSING UNIT
92
INPUT UNIT
93
OUTPUT UNIT
94
STORAGE UNIT
95
COMMUNICATION UNIT
96
DRIVE
97
REMOVABLE STORAGE MEDIUM
98
PROXIMITY SENSOR
99
ACCELERATION SENSOR
100

FIG. 11

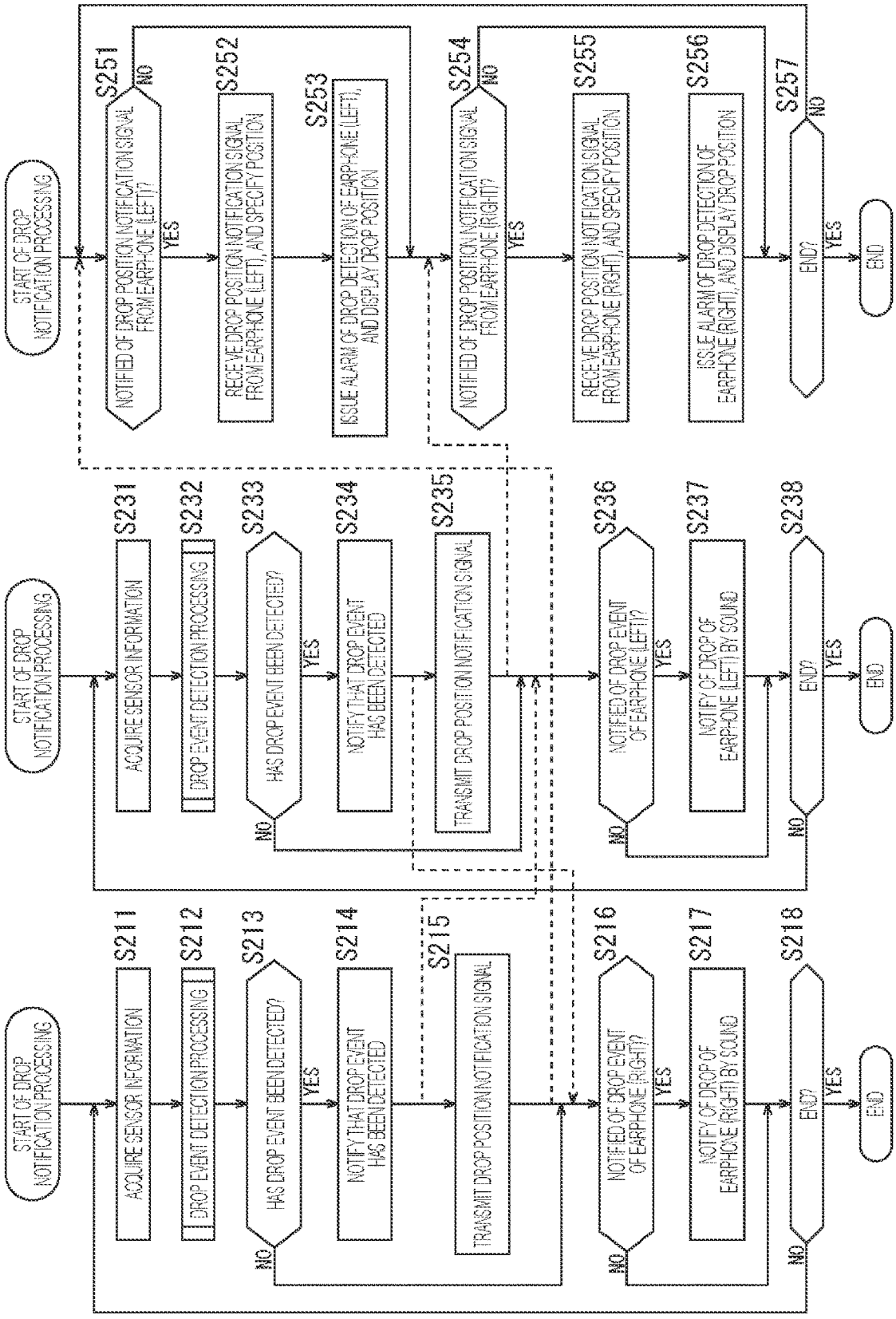

EARPHONE (LEFT)
START OF DROP NOTIFICATION PROCESSING
S211
ACQUIRE SENSOR INFORMATION
S212
DROP EVENT DETECTION PROCESSING
S213
HAS DROP EVENT BEEN DETECTED?
YES
NO
S214
NOTIFY THAT DROP EVENT HAS BEEN DETECTED
S215
TRANSMIT DROP POSITION NOTIFICATION SIGNAL
S216
NOTIFIED OF DROP EVENT OF EARPHONE (RIGHT)?
YES
NO
S217
NOTIFY OF DROP OF EARPHONE (RIGHT) BY SOUND
S218
END?
YES
NO
END
EARPHONE (RIGHT)
START OF DROP NOTIFICATION PROCESSING
S231
ACQUIRE SENSOR INFORMATION
S232
DROP EVENT DETECTION PROCESSING
S233
HAS DROP EVENT BEEN DETECTED?
YES
NO
S234
NOTIFY THAT DROP EVENT HAS BEEN DETECTED
S235
TRANSMIT DROP POSITION NOTIFICATION SIGNAL
S236
NOTIFIED OF DROP EVENT OF EARPHONE (LEFT)?
YES
NO
S237
NOTIFY OF DROP OF EARPHONE (LEFT) BY SOUND
S238
END?
YES
NO
END
SMARTPHONE
START OF DROP NOTIFICATION PROCESSING
S251
NOTIFIED OF DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT)?
YES
NO
S252
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT), AND SPECIFY POSITION
S253
ISSUE ALARM OF DROP DETECTION OF EARPHONE (LEFT), AND DISPLAY DROP POSITION
S254
NOTIFIED OF DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT)?
YES
NO
S255
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT), AND SPECIFY POSITION
S256
ISSUE ALARM OF DROP DETECTION OF EARPHONE (RIGHT), AND DISPLAY DROP POSITION
S257
END?
YES
NO
END

FIG. 12

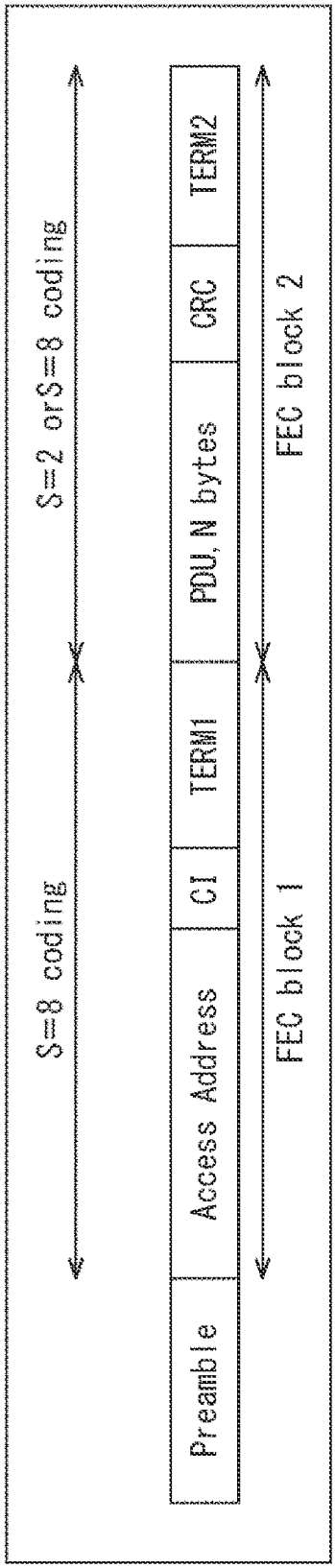

Preamble
Access Address
CI
TERM1
PDU, N bytes
CRC
TERM2
S=8 coding
S=2 orS=8 coding
FEC block 1
FEC block 2

FIG. 13

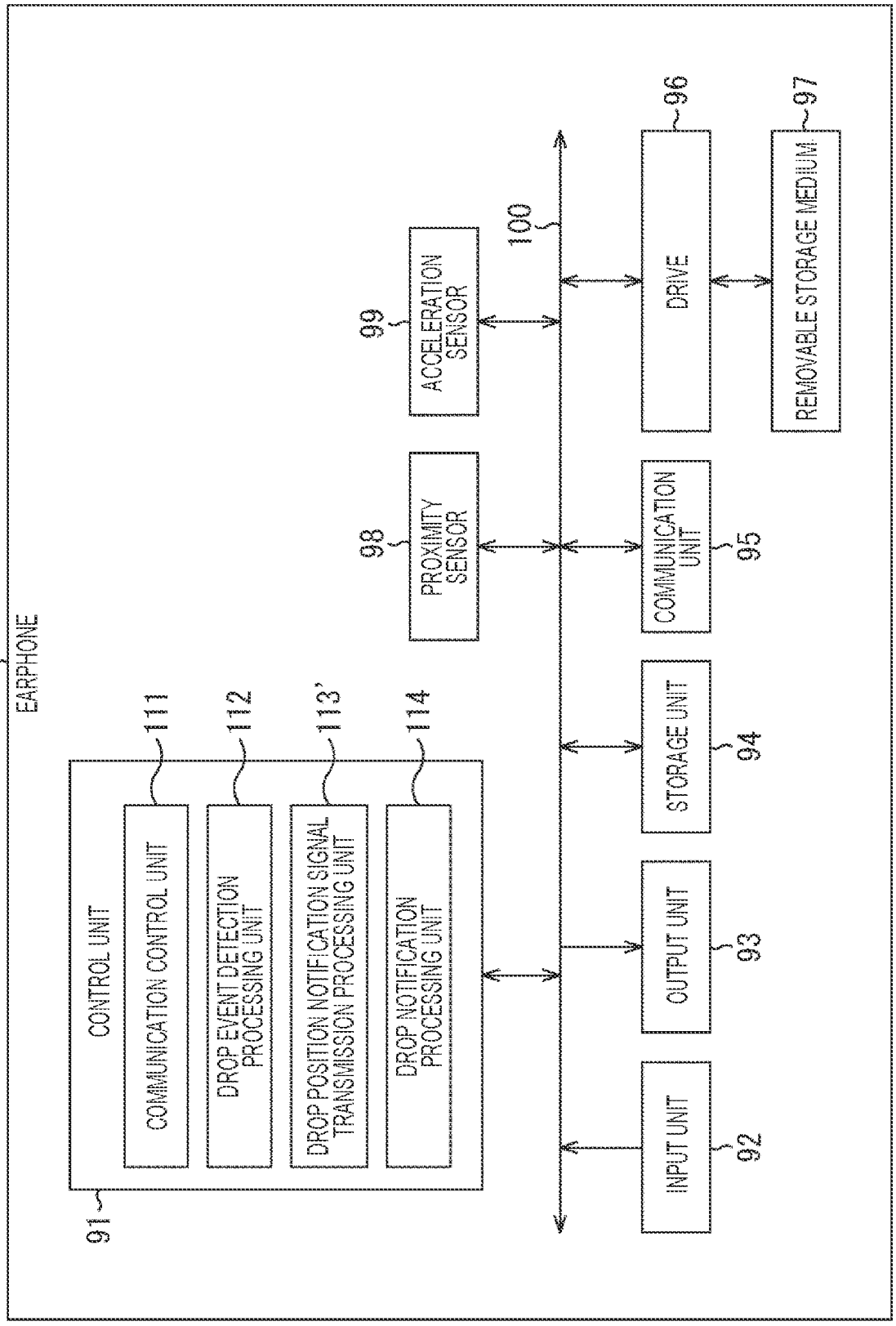

32
EARPHONE
91
CONTROL UNIT
111
COMMUNICATION CONTROL UNIT
112
DROP EVENT DETECTION PROCESSING UNIT
113'
DROP POSITION NOTIFICATION SIGNAL TRANSMISSION PROCESSING UNIT
114
DROP NOTIFICATION PROCESSING UNIT
92
INPUT UNIT
93
OUTPUT UNIT
94
STORAGE UNIT
95
COMMUNICATION UNIT
96
DRIVE
97
REMOVABLE STORAGE MEDIUM
98
PROXIMITY SENSOR
99
ACCELERATION SENSOR
100

FIG. 14

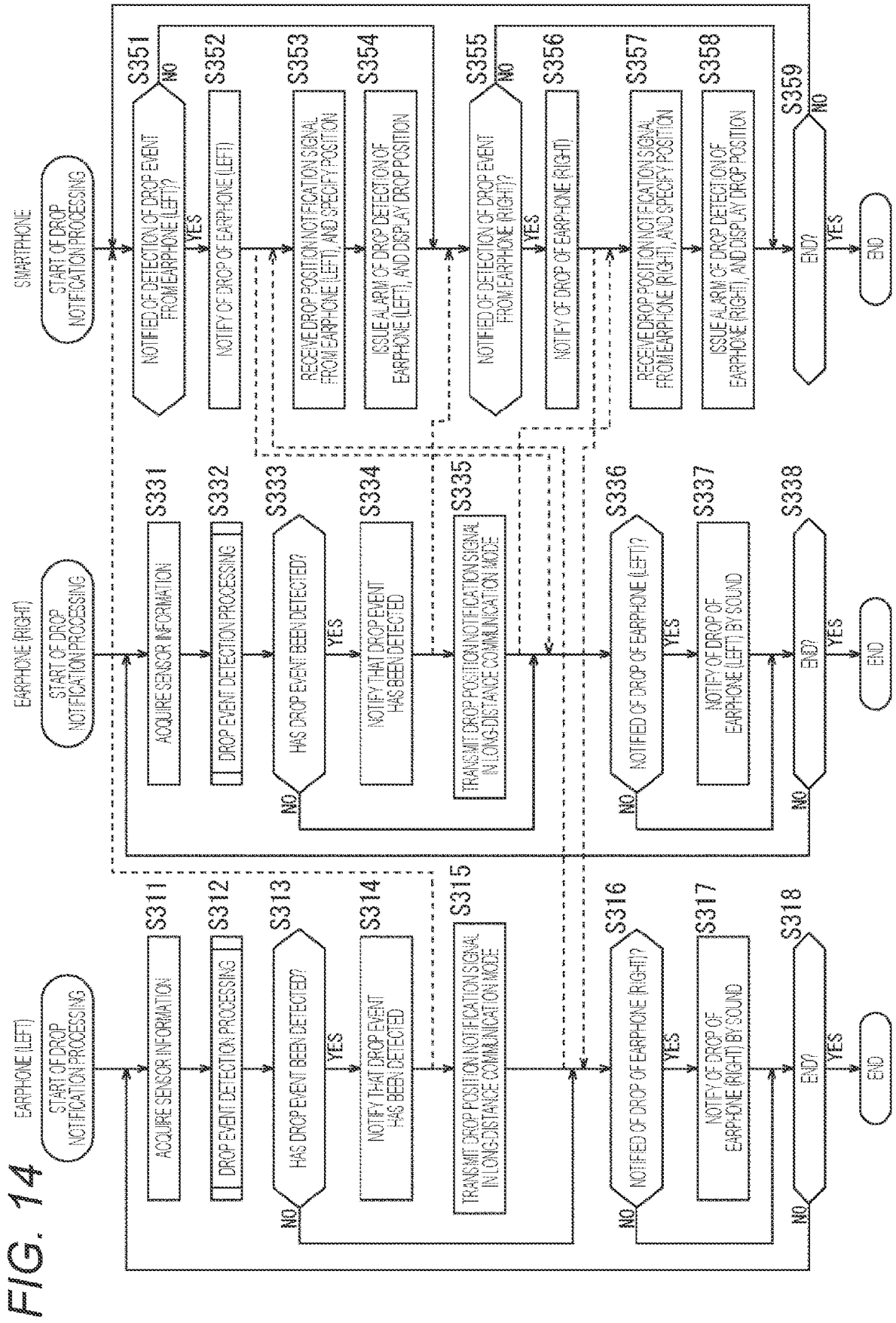

EARPHONE (LEFT)
START OF DROP NOTIFICATION PROCESSING
S311
ACQUIRE SENSOR INFORMATION
S312
DROP EVENT DETECTION PROCESSING
S313
HAS DROP EVENT BEEN DETECTED?
NO
YES
S314
NOTIFY THAT DROP EVENT HAS BEEN DETECTED
S315
TRANSMIT DROP POSITION NOTIFICATION SIGNAL IN LONG-DISTANCE COMMUNICATION MODE
S316
NOTIFIED OF DROP OF EARPHONE (RIGHT)?
NO
YES
S317
NOTIFY OF DROP OF EARPHONE (RIGHT) BY SOUND
S318
END?
NO
YES
END
EARPHONE (RIGHT)
START OF DROP NOTIFICATION PROCESSING
S331
ACQUIRE SENSOR INFORMATION
S332
DROP EVENT DETECTION PROCESSING
S333
HAS DROP EVENT BEEN DETECTED?
NO
YES
S334
NOTIFY THAT DROP EVENT HAS BEEN DETECTED
S335
TRANSMIT DROP POSITION NOTIFICATION SIGNAL IN LONG-DISTANCE COMMUNICATION MODE
S336
NOTIFIED OF DROP OF EARPHONE (LEFT)?
NO
YES
S337
NOTIFY OF DROP OF EARPHONE (LEFT) BY SOUND
S338
END?
NO
YES
END
SMARTPHONE
START OF DROP NOTIFICATION PROCESSING
S351
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (LEFT)?
NO
YES
S352
NOTIFY OF DROP OF EARPHONE (LEFT)
S353
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT), AND SPECIFY POSITION
S354
ISSUE ALARM OF DROP DETECTION OF EARPHONE (LEFT), AND DISPLAY DROP POSITION
S355
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (RIGHT)?
NO
YES
S356
NOTIFY OF DROP OF EARPHONE (RIGHT)
S357
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT), AND SPECIFY POSITION
S358
ISSUE ALARM OF DROP DETECTION OF EARPHONE (RIGHT), AND DISPLAY DROP POSITION
S359
END?
NO
YES
END

FIG. 15

Command	OCF	Command Parameters	Return Parameters
HCI_LE_Set_Extended_Advertising_Parameters	0x0036	Advertising_Handle, Advertising_Event_Properties, Primary_Advertising_Interval_Min, Primary_Advertising_Interval_Max, Primary_Advertising_Channel_Map, Own_Address_Type, Peer_Address_Type, Peer_Address, Advertising_Filter_Policy, Advertising_TX_Power, Primary_Advertising_PHY, Secondary_Advertising_Max_Skip, Secondary_Advertising_PHY, Advertising_SID, Scan_Request_Notification_Enable	Status, Selected_TX_Power

FIG. 16

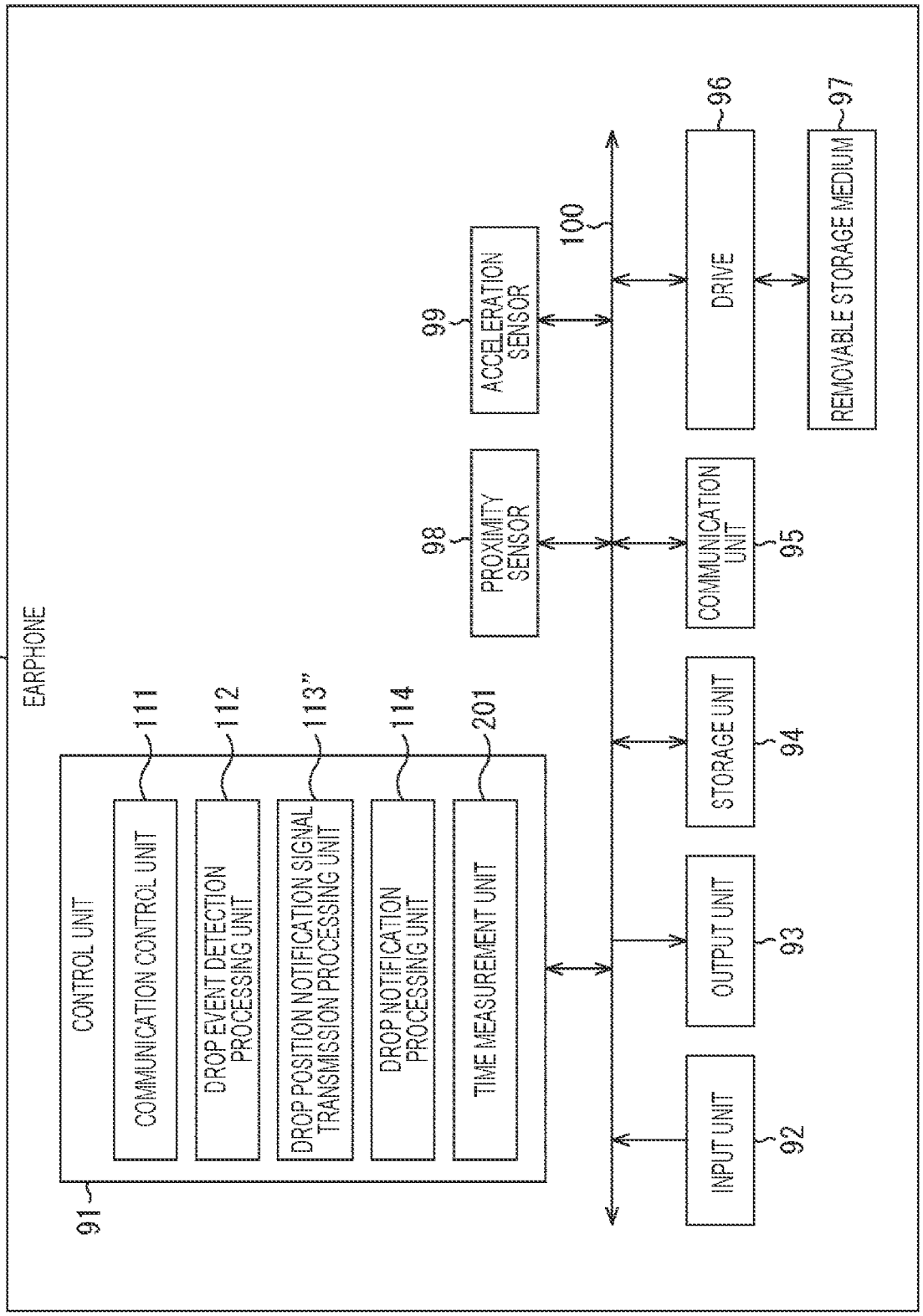

32
EARPHONE
91
CONTROL UNIT
111
COMMUNICATION CONTROL UNIT
112
DROP EVENT DETECTION PROCESSING UNIT
113"
DROP POSITION NOTIFICATION SIGNAL TRANSMISSION PROCESSING UNIT
114
DROP NOTIFICATION PROCESSING UNIT
201
TIME MEASUREMENT UNIT
92
INPUT UNIT
93
OUTPUT UNIT
94
STORAGE UNIT
95
COMMUNICATION UNIT
96
DRIVE
97
REMOVABLE STORAGE MEDIUM
98
PROXIMITY SENSOR
99
ACCELERATION SENSOR
100

FIG. 17

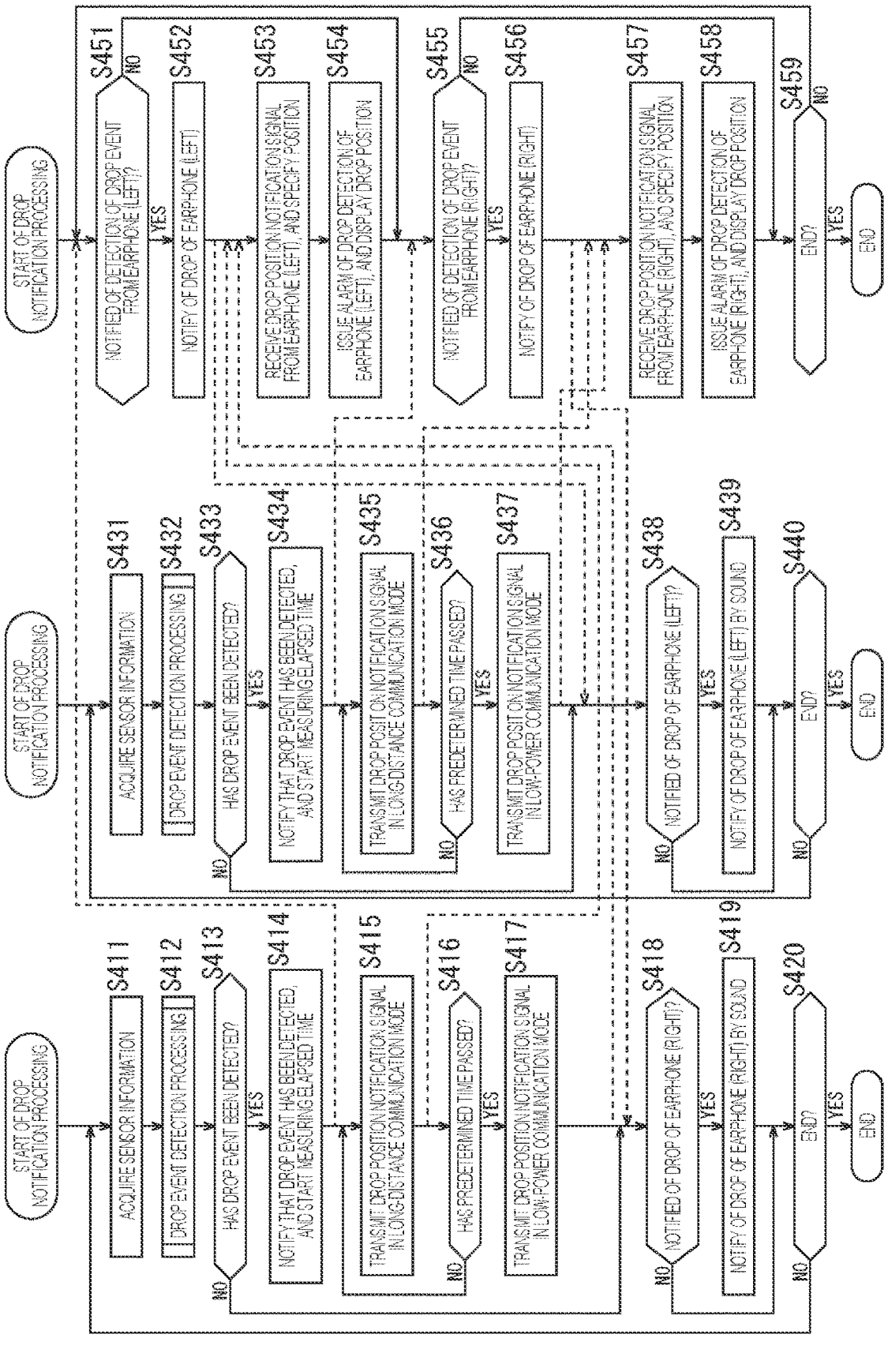
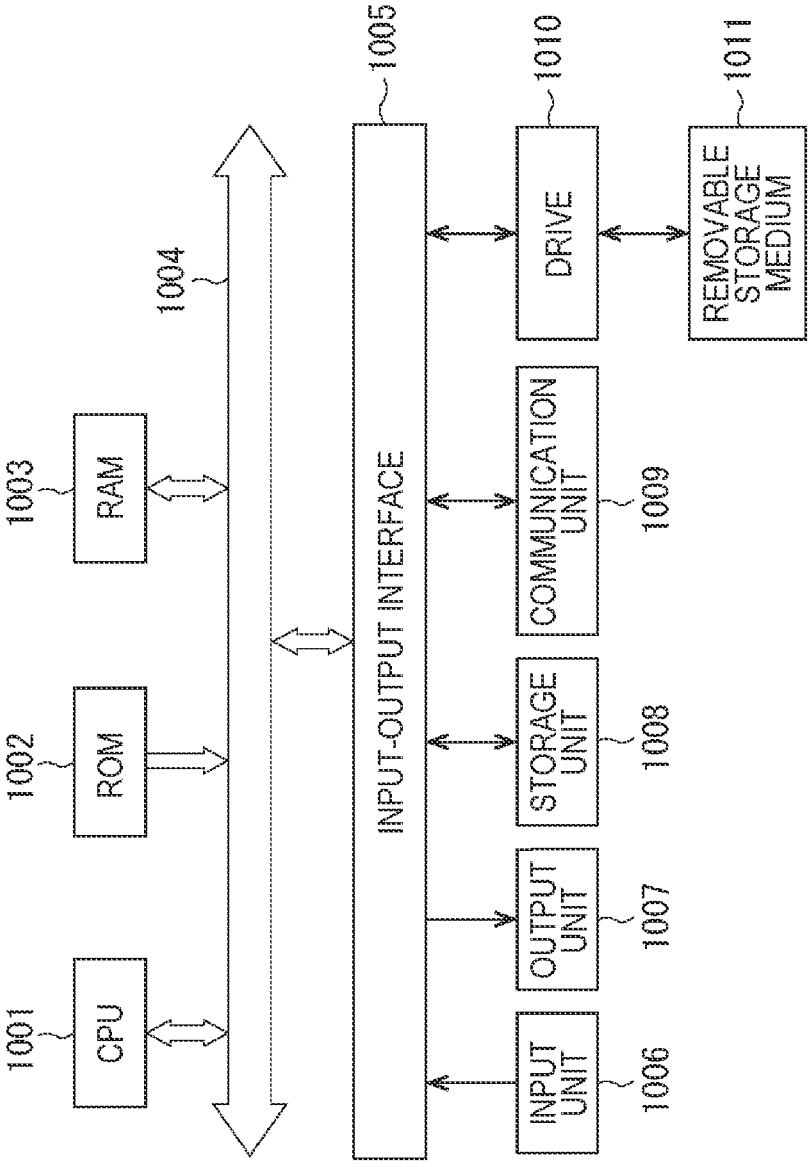

EARPHONE (LEFT)
START OF DROP NOTIFICATION PROCESSING
S411
ACQUIRE SENSOR INFORMATION
S412
DROP EVENT DETECTION PROCESSING
S413
HAS DROP EVENT BEEN DETECTED?
NO
YES
S414
NOTIFY THAT DROP EVENT HAS BEEN DETECTED, AND START MEASURING ELAPSED TIME
S415
TRANSMIT DROP POSITION NOTIFICATION SIGNAL IN LONG-DISTANCE COMMUNICATION MODE
S416
HAS PREDETERMINED TIME PASSED?
NO
YES
S417
TRANSMIT DROP POSITION NOTIFICATION SIGNAL IN LOW-POWER COMMUNICATION MODE
S418
NOTIFIED OF DROP OF EARPHONE (RIGHT)?
NO
YES
S419
NOTIFY OF DROP OF EARPHONE (RIGHT) BY SOUND
S420
END?
NO
YES
END
EARPHONE (RIGHT)
START OF DROP NOTIFICATION PROCESSING
S431
ACQUIRE SENSOR INFORMATION
S432
DROP EVENT DETECTION PROCESSING
S433
HAS DROP EVENT BEEN DETECTED?
NO
YES
S434
NOTIFY THAT DROP EVENT HAS BEEN DETECTED, AND START MEASURING ELAPSED TIME
S435
TRANSMIT DROP POSITION NOTIFICATION SIGNAL IN LONG-DISTANCE COMMUNICATION MODE
S436
HAS PREDETERMINED TIME PASSED?
NO
YES
S437
TRANSMIT DROP POSITION NOTIFICATION SIGNAL IN LOW-POWER COMMUNICATION MODE
S438
NOTIFIED OF DROP OF EARPHONE (LEFT)?
NO
YES
S439
NOTIFY OF DROP OF EARPHONE (LEFT) BY SOUND
S440
END?
NO
YES
END
SMARTPHONE
START OF DROP NOTIFICATION PROCESSING
S451
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (LEFT)?
NO
YES
S452
NOTIFY OF DROP OF EARPHONE (LEFT)
S453
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (LEFT), AND SPECIFY POSITION
S454
ISSUE ALARM OF DROP DETECTION OF EARPHONE (LEFT), AND DISPLAY DROP POSITION
S455
NOTIFIED OF DETECTION OF DROP EVENT FROM EARPHONE (RIGHT)?
NO
YES
S456
NOTIFY OF DROP OF EARPHONE (RIGHT)
S457
RECEIVE DROP POSITION NOTIFICATION SIGNAL FROM EARPHONE (RIGHT), AND SPECIFY POSITION
S458
ISSUE ALARM OF DROP DETECTION OF EARPHONE (RIGHT), AND DISPLAY DROP POSITION
S459
END?
NO
YES
END

FIG. 18


1001
CPU
1002
ROM
1003
RAM
1004
1005
INPUT-OUTPUT INTERFACE
1006
INPUT UNIT
1007
OUTPUT UNIT
1008
STORAGE UNIT
1009
COMMUNICATION UNIT
1010
DRIVE
1011
REMOVABLE STORAGE MEDIUM

COMMUNICATION DEVICE, COMMUNICATION METHOD, COMMUNICATION SYSTEM, AND PROGRAM

TECHNICAL FIELD

[0001] The present disclosure relates to a communication device, a communication method, a communication system, and a program, and more particularly relates to a communication device, a communication method, a communication system, and a program capable of recognizing a drop of the communication device.

BACKGROUND ART

[0002] Communication devices used for short-range communication typified by Bluetooth (registered trademark) are often small and lightweight devices such as earphones and headsets.

[0003] Since such a communication device is small and light, there has been a case where the communication device is lost due to dropping against the owner's will, or the like.

[0004] Accordingly, a technique has been proposed in which a tag is added to a communication device, communication for reading the tag is performed by a tag reader, and a drop of the communication device is notified by disconnection of the communication (see Patent Document 1).

CITATION LIST

Patent Document

[0005] Patent Document 1: Japanese Patent Application Laid-Open No. 2006-134242

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0006] However, in the technology of Patent Document 1, since the communication is not from the dropped communication device, the position cannot be specified on the basis of the communication from the communication device that is lost due to the dropping. For this reason, even if the user notices the drop of the communication device, the user cannot specify where the communication device has dropped and cannot find the dropped communication device in some cases.

[0007] The present disclosure has been made in view of such a situation, and makes it possible to recognize a drop by communication from a dropped communication device and to specify the position of the dropped communication device.

Solutions to Problems

[0008] A communication device and a program of a first aspect of the present disclosure are a communication device and a program including a drop detection unit that detects presence or absence of a drop of an own device and transmits a notification indicating the drop when the drop is detected.

[0009] A communication method of the first aspect of the present disclosure is a communication method including the step of detecting presence or absence of a drop of an own device, and transmitting, when the drop is detected, a notification indicating that the drop has been detected.

[0010] In the first aspect of the present disclosure, presence or absence of a drop of the own device is detected, and when the drop is detected, a notification indicating the drop is transmitted.

[0011] A communication device and a program of a second aspect of the present disclosure are a communication device and a program including a reception unit that receives a notification indicating that a drop has been detected from another communication device, and a presentation unit that presents, on the basis of the notification, information indicating that the drop of the other communication device has been detected.

[0012] A communication method of the second aspect of the present disclosure is a communication method including the steps of receiving a notification indicating that a drop has been detected from another communication device, and presenting, on the basis of the notification, information indicating that the drop of the other communication device has been detected.

[0013] In the second aspect of the present disclosure, a notification indicating that a drop has been detected from another communication device is received, and on the basis of the notification, information indicating that the drop of the other communication device has been detected is presented.

[0014] A communication system of a third aspect of the present disclosure is a communication system including a first communication device and a second communication device that communicate with each other, in which the first communication device includes a drop detection unit that detects presence or absence of a drop of an own device and transmits a notification indicating that the drop has been detected to the second communication device when the drop is detected, and the second communication device includes a reception unit that receives the notification indicating that the drop has been detected from the first communication device, and a presentation unit that presents, on the basis of the notification, information indicating that the drop of the first communication device has been detected.

[0015] In the third aspect of the present disclosure, the first communication device detects presence or absence of a drop of an own device and transmits a notification indicating that the drop has been detected to the second communication device when the drop is detected, and the second communication device receives the notification indicating that the drop has been detected from the first communication device, and presents, on the basis of the notification, information indicating that the drop of the first communication device has been detected.

BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. **1** is a diagram describing an outline of the present disclosure.

[0017] FIG. **2** is a diagram describing a configuration example of a communication system of the present disclosure.

[0018] FIG. **3** is a diagram describing a configuration example of a first embodiment of a smartphone of the present disclosure.

[0019] FIG. **4** is a diagram describing a configuration example of the first embodiment of an earphone of the present disclosure.

[0020] FIG. **5** is a flowchart describing drop notification processing according to the first embodiment of the present disclosure.

[0021] FIG. **6** is a flowchart describing drop event detection processing in FIG. **5**.

[0022] FIG. **7** is a diagram describing a configuration example of a second embodiment of the smartphone of the present disclosure.

[0023] FIG. **8** is a flowchart describing drop notification processing according to the second embodiment of the present disclosure.

[0024] FIG. **9** is a diagram describing a configuration example of a third embodiment of the smartphone of the present disclosure.

[0025] FIG. **10** is a diagram describing a configuration example of the third embodiment of the earphone of the present disclosure.

[0026] FIG. **11** is a flowchart describing drop notification processing according to the third embodiment of the present disclosure.

[0027] FIG. **12** is a diagram describing a packet format of LE Coded Phy.

[0028] FIG. **13** is a diagram describing a configuration example of a fourth embodiment of the earphone of the present disclosure.

[0029] FIG. **14** is a flowchart describing drop notification processing according to the fourth embodiment of the present disclosure.

[0030] FIG. **15** is a diagram describing an LE set Extended Advertising Parameters command.

[0031] FIG. **16** is a diagram describing a configuration example of a fifth embodiment of the earphone of the present disclosure.

[0032] FIG. **17** is a flowchart describing drop notification processing according to the fifth embodiment of the present disclosure.

[0033] FIG. **18** is a diagram describing a configuration example of a general-purpose computer.

MODE FOR CARRYING OUT THE INVENTION

[0034] Hereinafter, preferred embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. Note that in the description and the drawings, components having substantially the same functional configuration are denoted by the same reference numerals, and redundant descriptions are omitted.

[0035] Hereinafter, modes for carrying out the present technology will be described. The description will be made in the following order.

[0036] 1. Overview of present disclosure
[0037] 2. First Embodiment
[0038] 3. Second Embodiment
[0039] 4. Third Embodiment
[0040] 5. Fourth Embodiment
[0041] 6. Fifth Embodiment
[0042] 7. Example executed by software

1. Overview of Present Disclosure

[0043] The present disclosure enables recognition of a drop by communication from a dropped communication device, and enables specification of the position of the dropped communication device.

[0044] The technology of the present disclosure is implemented by, for example, a communication system including a smartphone SP as illustrated in FIG. **1** and earphones EPL and EPR (left ear earphone EPL and right ear earphone EPR) worn on the left and right ears.

[0045] Here, the smartphone SP reproduces the content and transmits the sound of reproduced content to the earphones EPL and EPR by, for example, short-range communication such as Bluetooth (registered trademark) communication. The earphones EPL and EPR receive audio data of the content reproduced and transmitted in the smartphone SP by short-range communication, and output the audio data as sound.

[0046] Each of the earphones EPL and EPR in FIG. **1** includes a proximity sensor, an acceleration sensor, and the like, and is capable of recognizing dropping from the ear, for example.

[0047] For example, as illustrated in the left part of FIG. **1**, in a case where the left ear earphone EPL drops, the earphone EPL itself detects the drop and notifies the smartphone SP or the right ear earphone EPR that has not dropped that the drop is detected. Furthermore, the earphone EPL performs smartphone SP communication of a drop position notification signal for specifying its own position.

[0048] Through this processing, the smartphone SP notifies that the drop has occurred on the basis of the communication from the left ear earphone EPL, and specifies the position of the left ear earphone EPL and displays it as an image.

[0049] Furthermore, the right ear earphone EPR outputs sound notifying that the drop of the left ear earphone EPL is detected.

[0050] With such processing, the user carrying the smartphone SP and wearing the right ear earphone EPR can recognize the drop of the left ear earphone EPL and specify the position of the dropping left ear earphone.

[0051] Consequently, it is possible to recognize the drop of the left ear earphone and specify the position where the left ear earphone has dropped.

2. First Embodiment

[0052] Next, a configuration example of a first embodiment of the communication system of the present disclosure will be described with reference to FIG. **2**.

[0053] The communication system **11** in FIG. **2** includes a smartphone **31** and earphones **32**L and **32**R carried by the same user.

[0054] The smartphone **31** is a mobile terminal, and can make a call or perform data communication with another smartphone via a public wireless communication line, and can reproduce content including an image and sound received by the data communication.

[0055] The smartphone **31** and the earphones **32**L and **32**R are capable of performing short-range communication such as Bluetooth (registered trademark) communication, and transmit sound of content reproduced by the smartphone **31** to the earphone **31**L for the left ear and the earphone **31**R for the right ear so that the sound is output.

[0056] The earphones **32**L and **32**R are in a paired configuration with each other, are worn on the left ear and the right ear of the user, respectively, receive audio data transmitted from the smartphone **31** via the short-range commu-

nication such as Bluetooth (registered trademark) communication, and output the audio data as monaural sound or stereo sound.

[0057] Each of the earphones **32**L and **32**R includes a sensor that detects a drop, and when detecting the drop, transmits a notification indicating that the drop is detected to the smartphone **31**.

[0058] When the notification indicating that the drop has been detected in at least one of the earphones **32**L and **32**R is transmitted, the smartphone **31** displays the notification as an image on a display unit including an organic EL (Electronic Luminescence), an LCD (Liquid Crystal Display), or the like to notify the user that the drop of the earphones **32**L and **32**R has been detected.

[0059] When the notification indicating that the drop has been detected in at least one of the earphones **32**L and **32**R is transmitted, the smartphone **31** transmits the notification indicating that the drop has been detected in the earphone **32**L or **32**R to one of the earphones **32**L and **32**R in which the drop has not been detected, and causes the earphone to notify the user of the detection of the drop by sound.

[0060] Furthermore, when detecting the drop, the earphones **32**L and **32**R transmit the drop position notification signal for specifying their own positions to the smartphone **31**.

[0061] When the drop position notification signal is transmitted from at least one of the earphones **32**L and **32**R in which the drop has been detected, the smartphone **31** specifies (estimates) a direction of the earphones **32**L and **32**R in which the drop has been detected on the basis of, for example, Bluetooth Low Energy (BLE) Angle of Arrival (AoA).

[0062] Alternatively, when the drop position notification signal is transmitted from at least one of the earphones **32**L and **32**R in which the drop has been detected, the smartphone **31** specifies (estimates) a direction and a distance (position of earphones **32**L and **32**R) of the earphones **32**L and **32**R in which the drop has been detected on the basis of, for example, BLE AoD (Angle of Departure).

[0063] Then, the smartphone **31** displays a direction or a direction and a distance of the earphones **32**L and **32**R in which the specified (estimated) drop is detected on the display unit.

[0064] Note that, hereinafter, in a case where it is not necessary to particularly distinguish the earphones **32**L and **32**R, the earphones are simply referred to as an earphone **32**, and other configurations are also referred to in a similar manner.

[0065] <Configuration Example of Smartphone>

[0066] Next, a configuration example of the smartphone **31** will be described with reference to FIG. **3**.

[0067] The smartphone **31** includes a control unit **51**, an input unit **52**, an output unit **53**, a storage unit **54**, a communication unit **55**, a drive **56**, and a removable storage medium **57**, and is connected to each other via a bus **58**, and can transmit and receive data and programs.

[0068] The control unit **51** includes a processor and a memory, and controls the entire operation of the smartphone **31**. Furthermore, the control unit **51** includes a communication control unit **71**, a drop notification processing unit **72**, and a drop position specification processing unit **73**.

[0069] The communication control unit **71** controls the communication unit **55** to execute communication processing with another communication device. The communication control unit **71** implements, for example, pairing processing for implementing Bluetooth (registered trademark) communication with the earphones **32**L and **32**R, and implements communication with the paired earphones **32**L and **32**R. Furthermore, the control unit **51** reproduces content and controls the communication control unit **71** to transmit audio data of the reproduced content to the earphones **32**L and **32**R.

[0070] The drop notification processing unit **72** controls the communication unit **55** to determine whether or not the earphones **32**L and **32**R have dropped according to whether or not information notifying that a drop event indicating an occurrence of a drop in any of the earphones **32**L and **32**R has been detected is transmitted in communication with the earphones **32**L and **32**R paired by the communication control unit **71**.

[0071] In a case where the drop of at least one of the earphones **32**L and **32**R is detected, the drop notification processing unit **72** causes a display constituting the output unit **53** to display information indicating that the drop is detected, or causes a vibrator constituting the output unit **53** to vibrate to notify that the drop of the earphones **32**L and **32**R is detected.

[0072] The drop position specification processing unit **73** specifies (estimates) the directions of the earphones **32**L and **32**R dropped by Bluetooth Low Energy (BLE) Angle of Arrival (AoA) using the drop position notification signal transmitted from the earphones **32**L and **32**R whose drop is detected by the drop notification processing unit **72**.

[0073] Alternatively, the drop position specification processing unit **73** specifies (estimates) the positions of the earphones **32**L and **32**R dropped by BLE AoD (Angle of Departure) using the drop position notification signal transmitted from the earphones **32**L and **32**R whose drop is detected by the drop notification processing unit **72**.

[0074] When the direction or the position of the earphones **32**L and **32**R that are dropped is specified, the drop position specification processing unit **73** outputs the direction or the position to the drop notification processing unit **72**. In response to this, the drop notification processing unit **72** presents information regarding the direction or position of the earphones **32**L and **32**R dropped on the display of the output unit **53**.

[0075] The input unit **52** includes an input device such as an operation button or a touch panel with which the user inputs an operation command, and supplies various input signals to the control unit **51**.

[0076] The output unit **53** is controlled by the control unit **51**, and includes a display unit (a display device (including a touch panel)) including a liquid crystal display (LCD), an organic electro luminescence (EL), or the like, and a vibrator that vibrates or the like for the supplied operation screen and image of the processing result, and presents various types of information by the image and the vibration. Note that the output unit **53** may have a configuration other than the display unit and the vibrator as long as various types of information can be presented, and may be, for example, a speaker, a light emitting unit, or the like.

[0077] The storage unit **54** includes a hard disk drive (HDD), a solid state drive (SSD), a semiconductor memory, or the like, is controlled by the control unit **51**, and writes or reads various data and programs.

[0078] The communication unit **55** is controlled by the control unit **51**, and transmits and receives various data and

programs to and from various devices including the earphone **32** by a local area network (LAN), Bluetooth (registered trademark), or the like.

[0079] The drive **56** reads and writes data from and to the removable storage medium **57** such as a magnetic disk (including a flexible disk), an optical disk (including a compact disc-read only memory (CD-ROM) and a digital versatile disc (DVD)), a magneto-optical disk (including a Mini Disc (MD)), or a semiconductor memory.

[0080] <Configuration Example of Earphone>

[0081] Next, a configuration example of the earphone **32** will be described with reference to FIG. **4**.

[0082] The earphone **32** includes a control unit **91**, an input unit **92**, an output unit **93**, a storage unit **94**, a communication unit **95**, a drive **96**, a removable storage medium **97**, a proximity sensor **98**, and an acceleration sensor **99**, and is connected to each other via a bus **100**, and can transmit and receive data and programs.

[0083] The control unit **91** includes a processor and a memory, and controls the entire operation of the earphone **32**. Furthermore, the control unit **91** includes a communication control unit **111**, a drop event detection processing unit **112**, a drop position notification signal transmission processing unit **113**, and a drop notification processing unit **114**.

[0084] The communication control unit **111** controls the communication unit **115** to execute communication processing with another communication device. The communication control unit **111** implements, for example, the pairing processing for implementing Bluetooth (registered trademark) communication with the smartphone **31**, and implements communication with the paired smartphone **31**. The control unit **91** controls the communication control unit **111** to receive audio data transmitted from the smartphone **31** and output the audio data as sound from the speaker constituting the output unit **93**.

[0085] The drop event detection processing unit **112** detects the presence or absence of a drop event indicating that the earphone **32** has dropped on the basis of detection results of the proximity sensor **98** and the acceleration sensor **99**.

[0086] The drop event detection processing unit **112** detects the presence or absence of occurrence of the drop event indicating that the earphone **32** has dropped from a pattern of a sensing result of the proximity sensor **98**, and a time-series detection pattern of acceleration detected by the acceleration sensor **99**.

[0087] The drop event detection processing unit **112** may be implemented by a deep neural network (DNN). In a case where the earphone **32** is provided with, for example, an audio analysis engine implemented by the DNN, the function of the drop event detection processing unit **112** may be implemented using the DNN used in the audio analysis engine to detect the drop event.

[0088] After the drop event is detected by the drop event detection processing unit **112** and the notification indicating that the drop event has been detected is transmitted to the smartphone **31**, the drop position notification signal transmission processing unit **113** transmits the drop position notification signal for specifying the direction and position of the earphone **32** to the smartphone **31** by Bluetooth low energy (BLE) communication.

[0089] When the notification indicating that the drop event of the other earphone **32** has been detected is transmitted from the smartphone **31**, the drop notification processing unit **114** outputs sound indicating that the drop event of one earphone **32** is detected from the speaker constituting the output unit **93**.

[0090] That is, in a case where the drop event indicating dropping is detected by the drop event detection processing unit **112** in the other earphone **32** of the left and right earphones **32**, the smartphone **31** transmits a notification indicating that the drop event of the other earphone **32** has been detected to the one earphone **32** in which the drop event has not been detected.

[0091] Accordingly, in response to this notification, the drop notification processing unit **114** outputs sound indicating that a drop event of the other earphone **32** is detected as sound from the speaker constituting the output unit **93**.

[0092] The input unit **92** includes an input device such as an operation button for the user to input an operation command, and supplies various input signals to the control unit **91**.

[0093] The output unit **93** is a speaker that is controlled by the control unit **91** and outputs sound.

[0094] The storage unit **94** includes a hard disk drive (HDD), a solid state drive (SSD), a semiconductor memory, or the like, is controlled by the control unit **91**, and writes or reads various data and programs.

[0095] The communication unit **95** is controlled by the control unit **91**, and transmits and receives various data and programs to and from the smartphone **31** by Bluetooth (registered trademark) communication.

[0096] The drive **96** reads and writes data from and to a removable storage medium **97** such as a magnetic disk (including a flexible disk), an optical disk (including a compact disc-read only memory (CD-ROM) and a digital versatile disc (DVD)), a magneto-optical disk (including a mini disc (MD)), or a semiconductor memory.

[0097] The proximity sensor **98** is an electromagnetic induction type, a magnetic type, an electrostatic type, or the like, detects whether or not the earphone **32** is in a state of being in close contact with the human body, that is, in a state of being worn on the ear, and outputs the detection result to the control unit **91**.

[0098] The acceleration sensor **99** is, for example, a micro electro mechanical systems (MEMS) type acceleration sensor, and detects acceleration of the earphone **32** and outputs the acceleration to the control unit **91**.

[0099] <Drop Notification Processing>

[0100] Next, drop notification processing by the communication system **11** of FIG. **2** will be described with reference to a flowchart of FIG. **5**. Note that, in the following description of processing, it is assumed that Bluetooth (registered trademark) communication (BLE communication) is established by pairing in advance through communication between the communication control unit **71** of the smartphone **31** and the communication control units **111** of the earphones **32**L and **32**R, and it is a state that communication can be performed with each other.

[0101] In step S**11**, the drop event detection processing unit **112** of the earphone **32**L acquires, as sensor information, a detection result indicating whether or not the earphone **32**L detected by the proximity sensor **98** is away from the user's ear, and a detection result including the acceleration of the earphone **32**L by the acceleration sensor **99**.

[0102] In step S**12**, the drop event detection processing unit **112** of the earphone **32**L executes drop event detection

processing of the earphone **32**L on the basis of the acquired sensor information, and detects the presence or absence of a drop event.

[0103] Note that details of the drop event detection processing will be described later with reference to the flowchart of FIG. **6**.

[0104] In step S**13**, the drop event detection processing unit **112** of the earphone **32**L determines whether or not a drop event of the earphone **32**L has been detected on the basis of a processing result of the drop event detection processing.

[0105] In a case where it is determined in step S**13** that the drop event of the earphone **32**L has been detected, that is, in a case where it is regarded that the earphone **32**L has fallen out and dropped from the ear, the processing proceeds to step S**14**.

[0106] In step S**14**, the drop event detection processing unit **112** of the earphone **32**L controls the communication unit **95** to notify the smartphone **31** that the drop event of the earphone **32**L has been detected.

[0107] At this time, in the smartphone **31**, in step S**51**, the drop notification processing unit **72** controls the communication unit **55** to determine whether or not a notification indicating that a drop event has been detected has been transmitted from the earphone **32**L.

[0108] In a case where it is determined in step S**51** that the notification indicating that a drop event has been detected has been transmitted from the earphone **32**L, the processing proceeds to step S**52**.

[0109] In step S**52**, the drop notification processing unit **72** controls the communication unit **55** to receive the notification indicating that a drop event has been detected, which has been transmitted from the earphone **32**L, and notify the earphone **32**R that the drop event has been detected in the earphone **32**L.

[0110] Furthermore, in the earphone **32**R, in step S**36**, the drop notification processing unit **114** controls the communication unit **95** to determine whether or not a notification indicating that a drop event has been detected in the earphone **32**L has been transmitted from the smartphone **31**.

[0111] In a case where it is determined in step S**36** that the notification indicating that a drop event has been detected in the earphone **32**L has been transmitted from the smartphone **31**, the processing proceeds to step S**37**.

[0112] In step S**37**, the drop notification processing unit **114** notifies by sound that a drop event has been detected in the earphone **32**L. The sound output here may be beep sound, buzzer sound, or announcement voice such as "the earphone of the left ear has dropped".

[0113] By the processing so far, when a drop event is detected in the earphone **32**L, the smartphone **31** is notified of the detection of the drop event, the earphone **32**R is notified of the detection of the drop event from the smartphone **31**, and the user is notified of the detection of the drop event in the earphone **32**L by sound.

[0114] Thus, when the earphone **32**L worn on the left ear of the user drops, the earphone **32**R worn on the right ear is notified via the smartphone **31**, and the user is notified by sound.

[0115] By the notification by sound of the worn earphone **32**R of the right ear, the user can recognize that the drop event has been detected in the earphone **32**L that has been worn on the left ear in which the drop event is detected.

[0116] Furthermore, in the earphone **32**L, in step S**15**, the drop position notification signal transmission processing unit **113** controls the communication unit **95** to start transmission of the drop position notification signal to the smartphone **31** by BLE communication.

[0117] Note that in a case where it is determined in step S**13** that no drop event has been detected, the processing in steps S**14** and S**15** is skipped.

[0118] Here, in the smartphone **31**, in step S**53**, the drop position specification processing unit **73** controls the communication unit **55** to receive the drop position notification signal transmitted from the earphone **32**L.

[0119] Then, on the basis of the received drop position notification signal, the drop position specification processing unit **73** specifies the direction and position of the earphone **32**L by Bluetooth Low Energy (BLE) Angle of Arrival (AoA) or BLE Angle of Departure (AoD), and outputs the direction and position to the drop notification processing unit **72**.

[0120] In step S**54**, the drop notification processing unit **72** controls the vibrator constituting the output unit **53** to generate vibration to issue an alarm, and notify the user that the earphone **32**L has dropped.

[0121] At the same time, the drop notification processing unit **72** causes the display constituting the output unit **53** to display the information regarding the direction and position of the earphone **32**L on the basis of the information regarding the specified direction and position of the earphone **32**L.

[0122] With this processing, the user carrying the smartphone **31** can recognize that the earphone **32**L has dropped due to vibration of the vibrator of the smartphone **31**. Furthermore, the user carrying the smartphone **31** can quickly find the dropped earphone **32**L since the information regarding the direction and position of the dropped earphone **32**L is displayed on the display constituting the output unit **53** of the smartphone **31**.

[0123] Note that in a case where it is determined in step S**51** that the notification indicating that a drop event has been detected has not been transmitted from the earphone **32**L, the processing of steps S**52** to S**54** is skipped.

[0124] In the above description, the processing in a case where the earphone **32**L worn on the left ear drops has been described, but basically, similar processing is performed in a case where the earphone **32**R worn on the right ear drops.

[0125] That is, in step S**31**, the drop event detection processing unit **112** of the earphone **32**R acquires, as the sensor information, a detection result indicating whether or not the earphone **32**R detected by the proximity sensor **98** is away from the user's ear, and a detection result including the acceleration of the earphone **32**R by the acceleration sensor **99**.

[0126] In step S**32**, the drop event detection processing unit **112** of the earphone **32**R executes the drop event detection processing on the basis of the acquired sensor information, and detects the presence or absence of a drop event of the earphone **32**R.

[0127] In step S**33**, the drop event detection processing unit **112** of the earphone **32**R determines whether or not a drop event of the earphone **32**R has been detected.

[0128] In a case where it is determined in step S**33** that the drop event of the earphone **32**R has been detected, that is, in a case where it is regarded that the earphone **32**R has fallen out and dropped from the ear, the processing proceeds to step S**34**.

[0129] In step S**34**, the drop event detection processing unit **112** of the earphone **32**R controls the communication unit **95** to notify the smartphone **31** that the drop event of the earphone **32**R has been detected by the BLE communication.

[0130] At this time, in the smartphone **31**, in step S**55**, the drop notification processing unit **72** controls the communication unit **55** to determine whether or not a notification indicating that a drop event has been detected has been transmitted from the earphone **32**R.

[0131] In a case where it is determined in step S**55** that the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R, the processing proceeds to step S**56**.

[0132] In step S**56**, the drop notification processing unit **72** controls the communication unit **55** to receive the notification indicating that a drop event has been detected, which has been transmitted from the earphone **32**R, and notify the earphone **32**L that the drop event has been detected in the earphone **32**R.

[0133] Furthermore, in the earphone **32**L, in step S**16**, the drop notification processing unit **114** controls the communication unit **95** to determine whether or not a notification indicating that a drop event has been detected in the earphone **32**R has been transmitted from the smartphone **31**.

[0134] In a case where it is determined in step S**16** that the notification indicating that a drop event has been detected in the earphone **32**R has been transmitted from the smartphone **31**, the processing proceeds to step S**17**.

[0135] In step S**17**, the drop notification processing unit **114** notifies by sound that a drop event has been detected in the earphone **32**R.

[0136] By the processing so far, when a drop event is detected in the earphone **32**R, the smartphone **31** is notified of the detection of the drop event, the earphone **32**L is notified of the detection of the drop event from the smartphone **31**, and the user is notified of the detection of the drop event in the earphone **32**R by sound.

[0137] Thus, when the earphone **32**R worn on the right ear of the user drops, the earphone **32**L worn on the left ear is notified via the smartphone **31**, and the user is notified by sound.

[0138] By the notification by sound of the worn earphone **32**L of the left ear, the user can recognize that the drop event has been detected in the earphone **32**R that has been worn on the right ear in which the drop event has been detected.

[0139] Furthermore, in the earphone **32**R, in step S**35**, the drop position notification signal transmission processing unit **113** controls the communication unit **95** to start transmission of the drop position notification signal to the smartphone **31** by the BLE communication.

[0140] Note that in a case where it is determined in step S**33** that no drop event has been detected, the processing in steps S**34** and S**35** is skipped.

[0141] Here, in the smartphone **31**, in step S**57**, the drop position specification processing unit **73** controls the communication unit **55** to receive the drop position notification signal transmitted from the earphone **32**R.

[0142] Then, on the basis of the received drop position notification signal, the drop position specification processing unit **73** specifies the direction and position of the earphone **32**R by Bluetooth Low Energy (BLE) Angle of Arrival (AoA) or BLE Angle of Departure (AoD), and outputs the direction and position to the drop notification processing unit **72**.

[0143] In step S**58**, the drop notification processing unit **72** controls the vibrator constituting the output unit **53** to generate vibration to issue an alarm, and notify the user that the earphone **32**R has dropped.

[0144] At the same time, the drop notification processing unit **72** causes the display constituting the output unit **53** to display the information regarding the direction and position of the earphone **32**R on the basis of the information regarding the specified direction and position of the earphone **32**R.

[0145] With this processing, the user carrying the smartphone **31** can recognize that the earphone **32**R has dropped due to vibration of the vibrator of the smartphone **31**. Furthermore, the user carrying the smartphone **31** can quickly find the dropped earphone **32**R since the information regarding the direction and position of the dropped earphone **32**R is displayed on the display constituting the output unit **53** of the smartphone **31**.

[0146] Note that, in a case where it is determined in step S**55** that the notification indicating that a drop event has been detected has not been transmitted from the earphone **32**R, the processing of steps S**56** to S**58** is skipped.

[0147] Furthermore, in steps S**18**, S**38**, and S**59**, it is determined whether or not an instruction to end the processing has been given, and in a case where the instruction to end the processing has not been given, the processing returns to the processing of S**11**, S**31**, and S**51**, respectively, and the subsequent processing is repeated.

[0148] Then, in a case where it is determined in steps S**18**, S**38**, and S**59** that the instruction to end the processing has been given, the processing ends.

[0149] Through the above series of processing, when a drop event is detected in any of the left and right earphones **32** (**32**L and **32**R), the smartphone **31** is notified of the drop event from the earphone **32** in which the drop event has been detected, and the earphone **32** in which the drop event has not been detected is notified of the detection of the drop event.

[0150] The earphone **32** notified of the detection of the drop event notifies the user of the detection of the drop event in the left-right inverted earphone **32** by sound.

[0151] The earphone **32** in which the drop event has been detected continues to transmit the drop position notification signal to the smartphone **31**. Upon receiving the drop position notification signal, the smartphone **31** specifies the direction and position of the earphone **32** in which the drop event has been detected by the AoD or the AoA on the basis of the drop position notification signal.

[0152] Then, the smartphone **31** vibrates the vibrator constituting the output unit **53** to notify the user that the drop event has been detected by any of the earphones **32**.

[0153] At the same time, the smartphone **31** displays the direction and position of the earphone **32** in which the specified drop event has been detected on the display constituting the output unit **53**.

[0154] Consequently, the user can recognize that the drop event has been detected in the earphone **32** by the notification of the sound from the earphone **32** in which the drop event has not been detected and the vibration of the vibrator of the smartphone **31**.

[0155] Furthermore, since the position of the earphone **32** in which the drop event has been detected, which is specified

on the basis of the drop position notification signal, is displayed, the user can quickly find the earphone **32** in which the drop event has been detected.

[0156] <Drop Event Detection Processing>

[0157] Next, the drop event detection processing will be described with reference to the flowchart of FIG. **6**.

[0158] In step S**81**, the drop event detection processing unit **112** determines whether or not the earphone **32** is away from the user's ear on the basis of the detection result of the proximity sensor **98**.

[0159] In a case where it is determined in step S**81** that the earphone **32** is away from the user's ear, the processing proceeds to step S**82**.

[0160] In step S**82**, the drop event detection processing unit **112** determines whether or not the earphone **32** has dropped on the basis of the detection result of the acceleration sensor **99**. More specifically, the drop event detection processing unit **112** determines whether or not the earphone **32** has dropped on the basis of whether or not a change is obtained such that, after time-series acceleration that is the detection result of the acceleration sensor **99**, for example, acceleration according to gravitational acceleration is obtained, and after the earphone drops by about the height of a human, the earphone suddenly stops.

[0161] In step S**82**, in a case where the drop of the earphone **32** is detected, the processing proceeds to step S**83**.

[0162] In step S**83**, the drop event detection processing unit **112** considers that a drop event of the earphone **32** has been detected, and the processing ends.

[0163] Furthermore, in a case where it is determined in step S**81** that the earphone **32** is not away from the user's ear, or in a case where it is determined in step S**82** that the drop of the earphone **32** has not been detected, the processing proceeds to step S**84**.

[0164] In step S**84**, the drop event detection processing unit **112** determines that no drop event of the earphone **32** has been detected, and the processing ends.

[0165] By the above processing, in a case where it is regarded that the earphone **32** is separated from the ear according to the detection result of the proximity sensor **98**, and it is regarded that the drop of the earphone **32** is detected according to the detection result of the acceleration sensor **99**, it is regarded that the drop event of the earphone **32** has been detected.

[0166] Note that the drop event detection processing in FIG. **6** is an example, and other processing may be performed. For example, the drop event of the earphone **32** may be regarded as being detected in only one of a case where it is regarded that the earphone **32** is separated from the ear according to the detection result of the proximity sensor **98** and a case where it is regarded that the drop of the earphone **32** is detected according to the detection result of the acceleration sensor **99**.

[0167] Furthermore, the sensor used for the drop event detection may be a sensor other than the proximity sensor **98** and the acceleration sensor **99**. For example, an impact detection sensor may be provided so that a drop event is detected in a case where an impact is detected. Furthermore, for example, an image sensor or a brightness/darkness sensor that images the inside of the ear may be provided, and when a black image is captured, it may be regarded as being worn on the ear, and when a bright image is captured, it may be recognized that the user is away from the ear and a drop event may be detected.

[0168] Note that, although the example in which the communication system **11** includes the smartphone **31** and the earphones **32**L and **32**R has been described above, the communication system is only required to be capable of short-range communication such as Bluetooth (registered trademark) communication, and thus may be implemented by other communication devices.

[0169] For example, instead of the earphone **32**, the communication system may include a hearing aid, a wearable terminal, or the like. Furthermore, a communication system may include a personal computer or the like instead of the smartphone **31**.

3. Second Embodiment

[0170] In the above, although the processing in a case where one of the left and right earphones **32**L and **32**R is worn on the ear without dropping has been described, in a case where both the left and right earphones **32**L and **32**R drop, detection of a drop event of the earphone **32** may be presented by vibration and display on the smartphone **31** without notification of detection of the drop event from the smartphone **31** to the earphone **32**.

[0171] <Configuration Example of Smartphone in Second Embodiment>

[0172] FIG. **7** illustrates a configuration example of the smartphone **31** in which, in a case where both the left and right earphones **32**L and **32**R drop, detection of a drop event of the earphone **32** is presented by vibration and display on the smartphone **31** without providing a notification of detection of the drop event from the smartphone **31** to the earphone **32**.

[0173] In the smartphone **31** in FIG. **7**, components having the same functions as those of the smartphone **31** in FIG. **3** are denoted by the same reference numerals, and the description thereof will be omitted as appropriate.

[0174] The smartphone **31** in FIG. **7** is different from the smartphone **31** in FIG. **3** in that a drop notification processing unit **72'** and a drop position specification processing unit **73'** are provided instead of the drop notification processing unit **72** and the drop position specification processing unit **73**.

[0175] The drop notification processing unit **72'** is similar in basic function to the drop notification processing unit **72**, but determines whether or not the other drop event has been detected within a predetermined time from a timing at which the drop event has been detected from one of the earphones **32**L and **32**R.

[0176] That is, the drop notification processing unit **72'** determines whether or not the earphones **32**L and **32**R have dropped simultaneously.

[0177] In a case where the drop notification processing unit **72'** determines that the earphones **32**L and **32**R have dropped simultaneously, the drop position specification processing unit **73'** receives the drop position notification signals transmitted from both the earphones **32**L and **32**R, and specifies the directions and positions of both the earphones **32**L and **32**R.

[0178] The drop notification processing unit **72'** causes the vibrator of the output unit **53** to vibrate to notify the user carrying the smartphone **31** of the drop of the earphones **32**L and **32**R, and causes the display unit to display an image indicating the directions and positions of the earphones **32**L and **32**R.

[0179] Note that the configurations of the earphones **32**L and **32**R are similar to the configuration of FIG. **4**, and thus the description thereof will be omitted.

[0180] <Dropping Notification Processing in Case of Using Smartphone of FIG. **7**>

[0181] Next, with reference to the flowchart of FIG. **8**, drop notification processing in a case of using the smartphone of FIG. **7** will be described.

[0182] Note that the processing of steps S**111**, S**113** to S**116**, and S**118** to S**121** in the flowchart of FIG. **8** is similar to the processing of steps S**51** to S**59** in the flowchart of FIG. **5**, and thus the description thereof will be omitted. In addition, the processing of the earphones **32**L and **32**R is the same as the flowchart of FIG. **5**, and thus the description thereof will be omitted.

[0183] That is, in a case where it is determined in step S**111** that a notification indicating that a drop event has been detected has been transmitted from the earphone **32**L, the processing proceeds to step S**112**.

[0184] In step S**112**, the drop notification processing unit **72'** controls the communication unit **55** to determine whether or not the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R within the predetermined time after the notification indicating that a drop event has been detected has been transmitted from the earphone **32**L.

[0185] That is, it is determined whether or not the earphone **32**R has dropped within the predetermined time after the earphone **32**L has dropped, that is, at substantially the same timing, and both the earphones **32**L and **32**R have dropped.

[0186] In a case where it is determined in step S**112** that the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R within the predetermined time after the notification indicating that a drop event has been detected has been transmitted from the earphone **32**L, the processing proceeds to step S**122**.

[0187] Note that, in a case where it is determined in step S**112** that the notification indicating that a drop event has been detected has not been transmitted from the earphone **32**R within the predetermined time after the notification indicating that a drop event has been detected has been transmitted from the earphone **32**L, the processing proceeds to step S**113**.

[0188] Furthermore, in a case where it is determined in step S**116** that the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R, the processing proceeds to step S**117**.

[0189] In step S**117**, the drop notification processing unit **72'** controls the communication unit **55** to determine whether or not the notification indicating that a drop event has been detected has been transmitted from the earphone **32**L within the predetermined time after the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R.

[0190] That is, it is determined whether or not the earphone **32**L has dropped within the predetermined time after the earphone **32**R has dropped, that is, at substantially the same timing, and both the earphones **32**L and **32**R have dropped.

[0191] In a case where it is determined in step S**117** that the notification indicating that a drop event has been detected has been transmitted from the earphone **32**L within the predetermined time after the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R, the processing proceeds to step S**122**.

[0192] Note that in a case where it is determined in step S**117** that the notification indicating that a drop event has been detected has not been transmitted from the earphone **32**L within the predetermined time after the notification indicating that a drop event has been detected has been transmitted from the earphone **32**R, the processing proceeds to step S**118**.

[0193] That is, in a case where it is determined in both steps S**112** and S**117** that both the earphones **32**L and **32**R have dropped, the processing proceeds to step S**122**.

[0194] In step S**122**, the drop position specification processing unit **73'** controls the communication unit **55** to receive the drop position notification signal transmitted from the earphone **32**L, specifies the direction and position of the earphone **32**L, and outputs the signal to the drop notification processing unit **72'**.

[0195] In step S**123**, the drop position specification processing unit **73'** controls the communication unit **55** to receive the drop position notification signal transmitted from the earphone **32**R, specifies the direction and position of the earphone **32**L, and outputs the signal to the drop notification processing unit **72'**.

[0196] In step S**124**, the drop notification processing unit **72'** controls the vibrator constituting the output unit **53** to generate vibration to issue an alarm, and notify the user that the earphones **32**L and **32**R have dropped.

[0197] At the same time, the drop notification processing unit **72'** causes the display constituting the output unit **53** to display an image indicating information regarding the directions and positions of the earphones **32**L and **32**R on the basis of the information regarding the specified directions and positions of the earphones **32**L and **32**R.

[0198] With this processing, the user carrying the smartphone **31** can recognize that earphones **32**L and **32**R have dropped due to vibration of the vibrator of the smartphone **31**.

[0199] Furthermore, the user carrying the smartphone **31** can quickly find the dropped earphones **32**L and **32**R since the images indicating the directions and positions of the dropped earphones **32**L and **32**R are displayed on the display constituting the output unit **53** of the smartphone **31**.

4. Third Embodiment

[0200] In the above, the example has been described in which the smartphone **31** is notified of a drop event from the earphone **32** in which the drop event has been detected.

[0201] However, one earphone **32** in which the drop event has been detected may notify the other earphone **32** that the drop event has been detected.

[0202] <Configuration Example of Smartphone in Third Embodiment>

[0203] FIG. **9** illustrates a configuration example of the smartphone **31** when a notification of the detection of the drop event is provided from the one earphone **32** in which the drop event has been detected to the other earphone **32**.

[0204] In the smartphone **31** in FIG. **9**, components having the same functions as those of the smartphone **31** in FIG. **3** are denoted by the same reference numerals, and the description thereof will be omitted as appropriate.

[0205] The smartphone **31** in FIG. **9** is different from the smartphone **31** in FIG. **3** in that a drop notification processing unit **72"** and a drop position specification processing unit

73" are provided instead of the drop notification processing unit 72 and the drop position specification processing unit 73.

[0206] The drop notification processing unit 72" has a basic function similar to that of the drop notification processing unit 72, but the drop notification processing unit 72" in FIG. 9 does not receive the notification indicating that a drop event from the earphone 32 has been detected.

[0207] The drop position specification processing unit 73" has a basic function similar to that of the drop position specification processing unit 73, but is different in that it recognizes that a drop event has occurred with reception of the drop position notification signal as a trigger.

[0208] That is, in the third embodiment, information indicating that a drop event has been detected, which is transmitted from the one earphone 32 in which the drop event has been detected, is transmitted to the other earphone 32, and the information indicating that the drop event has been detected is not transmitted to the smartphone 31.

[0209] However, since the drop position notification signal from the earphone 32 is transmitted to the smartphone 31, in the third embodiment, the smartphone 31 recognizes that the drop event has been detected on the basis of the presence or absence of the drop position notification signal.

[0210] <Configuration Example of Earphone in Third Embodiment>

[0211] Next, a configuration example of the earphone 32 according to the third embodiment will be described with reference to FIG. 10.

[0212] Note that, in the configuration of the earphone 32 in FIG. 10, components having the same functions as those of the earphone 32 in FIG. 4 are denoted by the same reference numerals, and the description thereof will be omitted as appropriate.

[0213] The earphone 32 of FIG. 10 is different from the earphone 32 of FIG. 4 in that a drop event detection processing unit 112' and a drop notification processing unit 114' are provided instead of the drop event detection processing unit 112 and the drop notification processing unit 114.

[0214] The drop event detection processing unit 112' is similar in basic function to the drop event detection processing unit 112, but is different in that, in a case where a drop event is detected, the drop event detection processing unit notifies the other earphone 32 instead of notifying the smartphone 31.

[0215] The drop notification processing unit 114' is similar in basic function to the drop notification processing unit 114, but is different in that the drop notification processing unit outputs sound notifying of the drop on the basis of the notification from the other earphone 32 instead of outputting sound providing a notification of the drop on the basis of the notification from the smartphone 31.

[0216] <Drop Notification Processing in Third Embodiment>

[0217] Next, drop notification processing in the third embodiment will be described with reference to FIG. 11.

[0218] Note that processing of steps S211 to S213, S215, S217, and S218, processing of steps S231 to S233, S235, S237, and S238, and processing of S252, S253, S255, and S256 in a flowchart of FIG. 11 are similar to the processing of steps S11 to S13, S15, S17, and S18, the processing of S31 to S33, S35, S37, and S38, and the processing of S53, S54, S57, and S58 in the flowchart of FIG. 5, and thus the description thereof is omitted.

[0219] That is, when the drop event of the earphone 32L is detected in step S213, the processing proceeds to step S214.

[0220] In step S214, the drop event detection processing unit 112' of the earphone 32L controls the communication unit 95 to notify the earphone 32R that the drop event of the earphone 32L has been detected.

[0221] Accordingly, in step S236, the drop notification processing unit 114' of the earphone 32R controls the communication unit 95 to determine whether or not a notification indicating that a drop event has been detected has been transmitted from the earphone 32L.

[0222] In a case where it is determined in step S236 that the notification indicating that a drop event has been detected has been transmitted from the earphone 32L, the processing proceeds to step S237, and a notification of the dropping of the earphone 32L is provided by sound.

[0223] Furthermore, in step S233, when a drop event of the earphone 32R is detected, the processing proceeds to step S234.

[0224] In step S234, the drop event detection processing unit 112' of the earphone 32R controls the communication unit 95 to notify the earphone 32L that the drop event of the earphone 32R has been detected.

[0225] Accordingly, in step S216, the drop notification processing unit 114' of the earphone 32L controls the communication unit 95 to determine whether or not a notification indicating that a drop event has been detected has been transmitted from the earphone 32R.

[0226] In a case where it is determined in step S216 that the notification indicating that a drop event has been detected has been transmitted from the earphone 32R, the processing proceeds to step S217, and a notification of the dropping of the earphone 32R is provided by sound.

[0227] At this time, in the smartphone 31, in step S251, the drop notification processing unit 72" controls the communication unit 55 to determine whether or not the drop position notification signal has been transmitted from the earphone 32L.

[0228] In a case where it is determined in step S251 that the drop position notification signal has been transmitted from the earphone 32L, the processing proceeds to step S252, and the drop position specification processing unit 73" specifies the direction and position of the earphone 32L on the basis of the drop position notification signal.

[0229] Then, in step S253, the drop notification processing unit 72" causes the vibrator to vibrate to issue an alarm regarding the drop of the earphone 32L and causes display of an image indicating the direction and position of the earphone 32L specified by the drop position specification processing unit 73".

[0230] Furthermore, in step S254, the drop notification processing unit 72" controls the communication unit 55 to determine whether or not the drop position notification signal has been transmitted from the earphone 32R.

[0231] In a case where it is determined in step S254 that the drop position notification signal has been transmitted from the earphone 32R, the processing proceeds to step S255, and the drop position specification processing unit 73" specifies the direction and position of the earphone 32R on the basis of the drop position notification signal.

[0232] Then, in step S**256**, the drop notification processing unit **72**" causes the vibrator to vibrate to issue an alarm regarding the drop of the earphone **32**R, and causes display of an image indicating the direction and position of the earphone **32**R specified by the drop position specification processing unit **73**".

[0233] By the above processing, when a drop event is detected in one of the left and right earphones **32**, the other earphone **32** is directly notified that the drop event is detected, so that it is possible to quickly notify the user of the drop by sound.

[0234] Furthermore, also at this time, in the smartphone **31**, it is recognized that the drop event has been detected by the drop position notification signal, an alarm regarding the drop of the earphone **32** is issued by vibration, and information regarding the direction and position of the dropping earphone **32** is displayed.

[0235] Consequently, the user can recognize the drop of the other earphone **32** by one earphone **32** in the worn state, and can quickly find the dropped earphone **32**.

5. Fourth Embodiment

[0236] In the above, the example has been described in which when a drop event is detected in the earphone **32**, the drop position notification signal is transmitted to the smartphone **31**, and the direction and position of the dropped earphone **32** are specified.

[0237] However, in general, the user who does not notice the drop of the earphone **32** moves away from the dropped earphone **32** as time elapses after the drop, and consequently, the distance between the earphone **32** and the smartphone **31** increases.

[0238] For this reason, it is expected that the smartphone **31** becomes difficult to receive the drop position notification signal transmitted from the earphone **32** as the time elapses after the earphone **32** drops, and it becomes difficult to specify the direction and the position.

[0239] Accordingly, even if the distance between the earphone **32** and the smartphone **31** becomes long, the drop position notification signal may be transmitted so that the smartphone **31** can receive the drop position notification signal.

[0240] For example, by using LE Coded Phy in the Bluetooth (registered trademark) communication standard, instead of decreasing the bit rate by increasing the redundant bits, the error correction capability is increased, so that highly accurate communication can be implemented even in a long distance.

[0241] <Packet Format of LE Coded Phy>

[0242] FIG. **12** illustrates an example of a packet format of LE Coded Phy.

[0243] The packet format of the LE Coded Phy of FIG. **12** includes a preamble, an FEC block **1**, and an FEC block **2**.

[0244] The preamble is an identifier for recognizing that it is the packet format of LE Coded Phy.

[0245] The forward error correction (FEC) block **1** is a block encoded by a scheme (S=8) having the highest redundancy among two types of encryption schemes related to forward error correction.

[0246] The FEC block **1** includes an access address (Access Address), a coding indicator (CI), and TERM**1**.

[0247] The access address includes information of an address to be accessed. The CI includes information specifying a scheme used for encoding the FEC block **2**. TERM**1** is termination information of the FEC block **1**.

[0248] The FEC block **2** is a block encoded by a scheme (S=2 or S=8) specified by CI of the FEC block **1** among two types of encryption schemes related to forward error correction.

[0249] The FEC block **2** includes a PDU (PDU, N bytes), a CRC, and a TERM **2**.

[0250] A protocol data unit (PDU) is information of a data area. A cyclic redundancy check (CRC) is a region of an error detection code. TERM**2** is termination information of the FEC block **2**.

[0251] That is, in a case where the LE Coded Phy illustrated in FIG. **12** is used, the data length of the PDU of the FEC block **2** is increased to enhance the redundancy of the error correction code, and the CRC is increased to enhance error tolerance as a whole, thereby enhancing communication accuracy in long-distance communication.

[0252] The transmission of the drop position notification signal from the earphone **32** can implement long-distance communication by enhancing the error tolerance using LE Coded Phy as illustrated in FIG. **12**, for example.

[0253] The communication mode in which the error tolerance is increased to enhance the reception accuracy in the long-distance communication using the LE Coded Phy as illustrated in FIG. **12** is hereinafter referred to as a long-distance communication mode.

[0254] <Configuration Example of Earphone in Fourth Embodiment>

[0255] Next, a configuration example of the earphone **32** according to the fourth embodiment will be described with reference to FIG. **13**.

[0256] In the earphone **32** in FIG. **13**, components having the same functions as those of the earphone **32** in FIG. **4** are denoted by the same reference numerals, and the description thereof will be omitted as appropriate.

[0257] The earphone **32** of FIG. **13** is different in configuration from the earphone **32** of FIG. **4** in that a drop position notification signal transmission processing unit **113'** is provided instead of the drop position notification signal transmission processing unit **113**.

[0258] The drop position notification signal transmission processing unit **113'** has the same basic function as the drop position notification signal transmission processing unit **113**, but is further different in that the drop position notification signal is transmitted in the long-distance communication mode described above.

[0259] That is, by transmitting the drop position notification signal in the long-distance communication mode, the drop position notification signal transmission processing unit **113'** can transmit the drop position notification signal with high accuracy even when the distance between the earphone **32** and the smartphone **31** becomes longer than a predetermined distance.

[0260] <Drop Notification Processing in Fourth Embodiment>

[0261] Next, drop notification processing in the fourth embodiment will be described with reference to a flowchart in FIG. **14**.

[0262] Note that processing of steps S**311** to S**314** and S**316** to S**318**, processing of steps S**331** to S**334** and S**336** to S**338**, and processing of steps S**351** to S**359** in the flowchart of FIG. **14** are similar to the processing of steps S**11** to S**14** and S**16** to S**18**, the processing of steps S**31** to S**34** and S**36**

to S38, and the processing of steps S51 to S59 in the flowchart of FIG. 5, and thus the description thereof is omitted.

[0263] That is, in step S315, the drop position notification signal transmission processing unit 113' of the earphone 32L controls the communication unit 95 to start transmission of the drop position notification signal to the smartphone 31 in the long-distance communication mode using LE Coded Phy in the BLE communication, for example.

[0264] Furthermore, in step S335, the drop position notification signal transmission processing unit 113' of the earphone 32R controls the communication unit 95 to start transmission of the drop position notification signal to the smartphone 31 in the long-distance communication mode using LE Coded Phy in the BLE communication, for example.

[0265] With this processing, in the smartphone 31, in each of steps S353 and S357, the drop position specification processing unit 73 controls the communication unit 55 to receive the drop position notification signal transmitted in the long-distance communication mode from the earphone 32L or 32R.

[0266] Then, the drop position specification processing unit 73 specifies the direction and position of the earphone 32L by Bluetooth Low Energy (BLE) Angle of Arrival (AoA) or Angle of Departure (BLE AoD) AoD on the basis of the received drop position notification signal.

[0267] By the above processing, when the drop event is detected in the earphones 32L and 32R, the drop position notification signal is transmitted to the smartphone 31 in the long-distance communication mode.

[0268] Consequently, even if the user carrying the smartphone 31 moves after the earphone 32 drops and the distance becomes longer than the predetermined distance, the drop position notification signal can be transmitted with high accuracy.

[0269] Consequently, even if the earphone 32 and the smartphone 31 are away from each other by more than the predetermined distance, the direction and position of the earphone 32 can be specified with high accuracy.

6. Fifth Embodiment

[0270] In the above, the example has been described in which the direction and position of the earphone 32 can be specified with high accuracy by transmitting the drop position notification signal in the long-distance communication mode even if the earphone 32 and the smartphone 31 are away from each other by more than the predetermined distance.

[0271] However, when a predetermined time or more elapses since the earphone 32 has dropped, the distance to the smartphone 31 may be longer than the distance by which the direction or position can be specified, and it is expected that the user carrying the smartphone 31 cannot receive the drop position notification signal unless the distance to the dropped earphone 32 returns to within the predetermined distance.

[0272] In this case, when the consumed electric power for transmitting the drop position notification signal is exhausted and the signal can no longer be transmitted, the user carrying the smartphone 31 cannot receive the drop position notification signal even if the user returns to within the predetermined distance from the dropped earphone 32, and thus it is difficult to specify the direction and position of the dropped earphone 32.

[0273] Accordingly, the drop position notification signal may be transmitted with a normal transmission output until the predetermined time elapses from the detection of a drop event, and the transmission output of the drop position notification signal may be reduced and transmitted after the predetermined time elapses from the detection of the drop event.

[0274] Regarding the reduction of the transmission output, the transmission output itself may be reduced, or the transmission output may be generally reduced by widening the transmission interval.

[0275] As described above, by reducing the transmission output of the drop position notification signal, the drop position notification signal can be transmitted for a long time, and even if the elapsed time after the drop becomes long, the direction and position of the earphone 32 can be easily specified, so that it can be easily found.

[0276] The adjustment of the transmission output can be implemented, for example, by using an LE set Extended Advertising Parameters command in Bluetooth (registered trademark) communication.

[0277] <LE Set Extended Advertising Parameters Command>

[0278] The LE set Extended Advertising Parameters command is expressed by, for example, an HCI_LE_set_Extended_-Advertising_Parameters command as illustrated in FIG. 15.

[0279] The HCI_LE_set_Extended_-Advertising_Parameters command includes, as command parameters, Advertising_Handle, Advertising_Event_Properties, Primary_Advertising_Interval_Min, Primary_Advertising_Interval_Max, Primary_Advertising_Channel_Map, Own_Address_Type, Peer_Address_Type, Peer_Address, Advertising_Filter_Policy, Advertising_TX_Power, Primary_Advertising_PHY, Seccondary_Advertising_Interval_Max_Skip, Seccondary_Advertising_PHY, Advertising_SID, and Scan_Request_Notification_Enable.

[0280] Among these, Advertising_TX_Power is a parameter for adjusting the transmission output. Accordingly, in the transmission of the drop position notification signal, when the elapsed time from the detection of the drop event exceeds a predetermined time, for example, the transmission output is reduced by adjusting the parameter set in Advertising_TX_Power.

[0281] Consequently, it is possible to extend the time during which the drop position notification signal can be transmitted, and thus, even if the elapsed time after the earphone 32 has dropped becomes long, it is possible to easily specify the direction and position of the dropped earphone 32 and to easily find it.

[0282] <Configuration Example of Earphone in Fifth Embodiment>

[0283] FIG. 16 illustrates a configuration example of the earphone 32 in which the drop position notification signal is transmitted with a normal transmission output until a predetermined time elapses from the detection of the drop event, and the transmission output of the drop position notification signal is reduced and transmitted after the predetermined time elapses from the detection of the drop event.

[0284] Note that the configuration of the earphone **32** in FIG. **16** is different from the earphone **32** in FIG. **4** in that a drop position notification signal transmission processing unit **113"** is provided instead of the drop position notification signal transmission processing unit **113**, and a time measurement unit **201** is newly provided.

[0285] The time measurement unit **201** measures an elapsed time from the detection of the drop event.

[0286] In a case where the time measured by the time measurement unit **201** exceeds a predetermined time, for example, the drop position notification signal transmission processing unit **113"** reduces the transmission output by adjusting Advertising_TX_Power described with reference to FIG. **15** and transmits the dropping position notification signal. Note that, hereinafter, a communication mode for reducing the transmission output and transmitting the drop position notification signal by adjusting Advertising_TX_Power is referred to as a low power communication mode.

[0287] <Drop Notification Processing in Fifth Embodiment>

[0288] Next, drop notification processing in the fifth embodiment will be described with reference to a flowchart in FIG. **17**.

[0289] Note that processing of steps S**411** to S**413** and S**418** to S**420**, processing of steps S**431** to S**433** and S**438** to S**440**, and processing of steps S**451** to S**459** in the flowchart of FIG. **17** are similar to the processing of steps S**11** to S**13** and S**18** to S**20**, the processing of steps S**31** to S**33** and S**38** to S**40**, and the processing of steps S**51** to S**59** in the flowchart of FIG. **5**, and thus the description thereof is omitted.

[0290] That is, in the earphone **32**L, in a case where it is determined in step S**413** that a drop event has been detected, the processing proceeds to step S**414**.

[0291] In step S**414**, the drop event detection processing unit **112** controls the communication unit **95** to notify the smartphone **31** that the drop event of the earphone **32**L has been detected. At this time, the time measurement unit **201** starts measuring time.

[0292] In step S**415**, the drop position notification signal transmission processing unit **113"** of the earphone **32**L controls the communication unit **95** to start transmission of the drop position notification signal to the smartphone **31** in the long-distance communication mode using LE Coded Phy in the BLE communication, for example.

[0293] In step S**416**, the drop position notification signal transmission processing unit **113"** determines whether or not the elapsed time from the detection of the drop event measured by the time measurement unit **201** has passed the predetermined time.

[0294] In a case where it is determined in step S**416** that the elapsed time from the detection of the drop event has not passed the predetermined time, the processing returns to step S**415**.

[0295] That is, until the elapsed time from the detection of the drop event passes the predetermined time, the drop position notification signal transmission processing unit **113"** transmits the drop position notification signal to the smartphone **31** in the long-distance communication mode with the normal transmission output.

[0296] Then, in a case where it is determined in step S**416** that the elapsed time from the detection of the drop event has passed the predetermined time, the processing proceeds to step S**417**.

[0297] In step S**417**, the drop position notification signal transmission processing unit **113"** starts transmitting the drop position notification signal in the low power communication mode for reducing the transmission output.

[0298] Furthermore, in the earphone **32**R, in a case where it is determined in step S**433** that a drop event has been detected, the processing proceeds to step S**434**.

[0299] In step S**434**, the drop event detection processing unit **112** controls the communication unit **95** to notify the smartphone **31** that the drop event of the earphone **32**R has been detected by the BLE communication. At this time, the time measurement unit **201** starts measuring time.

[0300] In step S**435**, the drop position notification signal transmission processing unit **113"** of the earphone **32**R controls the communication unit **95** to start transmission of the drop position notification signal to the smartphone **31** in the long-distance communication mode using LE Coded Phy in the BLE communication, for example.

[0301] In step S**436**, the drop position notification signal transmission processing unit **113"** determines whether or not the elapsed time from the detection of the drop event measured by the time measurement unit **201** has passed the predetermined time.

[0302] In a case where it is determined in step S**436** that the elapsed time from the detection of the drop event has not passed the predetermined time, the processing returns to step S**435**.

[0303] That is, until the elapsed time from the detection of the drop event passes the predetermined time, the drop position notification signal transmission processing unit **113"** transmits the drop position notification signal to the smartphone **31** in the long-distance communication mode with the normal transmission output.

[0304] Then, in a case where it is determined in step S**436** that the elapsed time from the detection of the drop event has passed the predetermined time, the processing proceeds to step S**437**.

[0305] In step S**437**, the drop position notification signal transmission processing unit **113"** starts transmitting the drop position notification signal in the low power communication mode for reducing the transmission output.

[0306] By the above processing, the drop position notification signal transmission processing unit **113"** transmits the drop position notification signal to the smartphone **31** in the long-distance communication mode with normal output until a predetermined elapsed time after the detection of the drop event.

[0307] Then, after a predetermined elapsed time has elapsed since the detection of the drop event, the drop position notification signal transmission processing unit **113"** transmits the drop position notification signal to the smartphone **31** in the low power communication mode for reducing the transmission output.

[0308] By this processing, until the predetermined time elapses after the detection of the drop event, the drop position notification signal is transmitted from the earphone **32** to the smartphone **31** with the normal transmission output.

[0309] Thus, immediately after the drop event is detected, there is a high possibility that the user carrying the smartphone **31** is present at a position close to the earphone **32** that has just dropped. Thus, it is possible to immediately specify the position of the earphone **32**, and it is possible to quickly find the earphone **32**.

[0310] Furthermore, after the predetermined time has elapsed since the detection of the drop event, a drop position notification signal is transmitted from the earphone **32** to the smartphone **31** in the low power communication mode in which the transmission output is reduced.

[0311] Generally, after the predetermined time has elapsed since the detection of the drop event, there is a high possibility that the user carrying the smartphone **31** has moved away from the earphone **32** to such an extent that the drop position notification signal cannot be received.

[0312] For this reason, there is a possibility that it takes time for the user carrying the smartphone **31** to return to the position of the earphone **32** while thinking about his/her behavior, and there is a possibility that the drop position notification signal cannot be transmitted due to battery exhaustion if the drop position notification signal is continuously transmitted with normal transmission output.

[0313] However, by the above-described processing, after the predetermined time has elapsed since the detection of the drop event, the drop position notification signal is transmitted from the earphone **32** to the smartphone **31** in the low power communication mode in which the transmission output is reduced.

[0314] Thus, the consumption of the battery can be reduced, and the drop position notification signal can be continuously transmitted for a longer time.

[0315] Consequently, even if it takes time for the user carrying the smartphone **31** to return to the position of the earphone **32** while thinking about his/her behavior, there is a high possibility that the direction and position of the earphone **32** can be specified, and thus it is possible to easily find the earphone **32**.

7. Example Executed by Software

[0316] Meanwhile, the above-described series of processing can be executed by hardware, but can also be executed by software. In a case where the series of processing are executed by software, a program constituting the software is installed from a recording medium into a computer built into dedicated hardware or, for example, a general-purpose computer that is capable of executing various functions by installing various programs, or the like.

[0317] FIG. **18** illustrates a configuration example of a general-purpose computer. This personal computer includes a central processing unit (CPU) **1001**. An input-output interface **1005** is connected to the CPU **1001** via a bus **1004**. A read only memory (ROM) **1002** and a random access memory (RAM) **1003** are connected to the bus **1004**.

[0318] To the input-output interface **1005**, an input unit **1006** including an input device such as a keyboard and a mouse by which a user inputs operation commands, an output unit **1007** that outputs a processing operation screen and an image of a processing result to a display device, a storage unit **1008** that includes a hard disk drive and the like and stores programs and various data, and a communication unit **1009** including a local area network (LAN) adapter or the like and executes a communication process via a network represented by the Internet are connected. Furthermore, a drive **1010** that reads and writes data from and to a removable storage medium **1011** such as a magnetic disk (including a flexible disk), an optical disk (including a compact disc-read only memory (CD-ROM), a digital versatile disc (DVD)), a magneto-optical disk (including a Mini Disc (MD)), or a semiconductor memory is connected.

[0319] The CPU **1001** executes various processes according to a program stored in the ROM **1002** or a program read from a removable storage medium **1011** such as a magnetic disk, an optical disk, a magneto-optical disk, or a semiconductor memory, installed in the storage unit **1008**, and loaded from the storage unit **1008** to the RAM **1003**. The RAM **1003** also appropriately stores data necessary for the CPU **1001** to execute various processes, and the like.

[0320] In the computer configured as described above, for example, the CPU **1001** loads the program stored in the storage unit **1008** into the RAM **1003** via the input-output interface **1005** and the bus **1004** and executes the program, to thereby perform the above-described series of processes.

[0321] The program executed by the computer (CPU **1001**) can be provided by being recorded in the removable storage medium **1011** as a package medium or the like, for example. Furthermore, the program can be provided via a wired or wireless transmission medium such as a local area network, the Internet, or digital satellite broadcasting.

[0322] In the computer, the program can be installed in the storage unit **1008** via the input-output interface **1005** by mounting the removable storage medium **1011** to the drive **1010**. Furthermore, the program can be received by the communication unit **1009** via a wired or wireless transmission medium and installed in the storage unit **1008**. In addition, the program can be installed in the ROM **1002** or the storage unit **1008** in advance.

[0323] Note that the program executed by the computer may be a program for processing in time series in the order described in the present description, or a program for processing in parallel or at a necessary timing such as when a call is made.

[0324] Note that the CPU **1001** in FIG. **18** implements the functions of the control unit **51** of the smartphone **31** in FIGS. **3**, **7**, and **9** and the control unit **91** of the earphone **32** in FIGS. **4**, **10**, **13**, and **16**.

[0325] Furthermore, in the present description, a system means a set of a plurality of components (devices, modules (parts), and the like), and it does not matter whether or not all components are in the same housing. Therefore, both of a plurality of devices housed in separate housings and connected via a network and a single device in which a plurality of modules is housed in one housing are systems.

[0326] Note that embodiments of the present disclosure are not limited to the above-described embodiments, and various modifications are possible without departing from the scope of the present disclosure.

[0327] For example, the present disclosure can have a configuration of cloud computing in which one function is shared by a plurality of devices via a network and processing is performed in cooperation.

[0328] Furthermore, each step described in the above-described flowcharts can be executed by one device, or can be executed in a shared manner by a plurality of devices.

[0329] Moreover, in a case where a plurality of processes is included in one step, the plurality of processes included in the one step can be executed in a shared manner by a plurality of devices in addition to being executed by one device.

[0330] Note that the present disclosure can also have the following configurations.

[0331] <1> A communication device, including:

[0332] a drop detection unit that detects presence or absence of a drop of an own device and transmits a notification indicating the drop when the drop is detected.

[0333] <2> The communication device according to <1>, further including:

[0334] a proximity sensor that detects whether or not the own device and a human body are in a proximity state; and

[0335] an acceleration sensor that detects acceleration of the own device, in which

[0336] the drop detection unit detects the drop in a case where the proximity sensor detects that the own device is not in proximity to the human body on the basis of a detection result of the proximity sensor and a detection result of the acceleration sensor, and the drop is detected from time-series information of acceleration detected by the acceleration sensor.

[0337] <3> The communication device according to <2>, in which

[0338] the drop detection unit detects the drop on the basis of an analysis result obtained by analyzing the detection result of the proximity sensor and the detection result of the acceleration sensor by a deep neural network (DNN).

[0339] <4> The communication device according to <3>, in which

[0340] the drop detection unit is an audio analysis engine including the DNN.

[0341] <5> The communication device according to <2>, in which

[0342] the drop detection unit transmits the notification indicating the drop to another communication device paired with the own device.

[0343] <6> The communication device according to any one of <1> to <5>, further including:

[0344] a communication unit that receives audio data transmitted from another communication device; and

[0345] an output unit that outputs sound on the basis of the audio data received by the communication unit, in which

[0346] the drop detection unit transmits the notification indicating the drop to the other communication device.

[0347] <7> The communication device according to <6>, in which

[0348] the communication unit receives the audio data transmitted from the other communication device by Bluetooth (registered trademark) communication.

[0349] <8> The communication device according to <6>, further including

[0350] a drop position notification signal transmission unit that transmits a drop position notification signal for estimating a position of the own device to the other communication device.

[0351] <9> The communication device according to <8>, in which

[0352] the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device by Bluetooth low energy (BLE) communication.

[0353] <10> The communication device according to <9>, in which

[0354] a direction indicating the position of the own device is estimated by BLE Angle of Arrival (AoA) using the drop position notification signal, or the position of the own device is estimated by BLE Angle of Departure (AoD) using the drop position notification signal.

[0355] <11> The communication device according to <8>, in which

[0356] the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device in a long-distance communication mode.

[0357] <12> The communication device according to <8>, in which

[0358] the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device in a low power communication mode.

[0359] <13> The communication device according to <12>, in which

[0360] the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device in the low power communication mode when an elapsed time from a timing at which the drop is detected by the drop detection unit becomes longer than a predetermined time.

[0361] <14> A communication method, including the step of detecting presence or absence of a drop of an own device, and transmitting, when the drop is detected, a notification indicating that the drop has been detected.

[0362] <15> A program for causing a computer to function as

[0363] a drop detection unit that detects presence or absence of a drop of an own device, and transmits, when the drop is detected, a notification indicating that the drop has been detected.

[0364] <16> A communication device, including:

[0365] a reception unit that receives a notification indicating that a drop has been detected from another communication device; and

[0366] a presentation unit that presents, on the basis of the notification, information indicating that the drop of the other communication device has been detected.

[0367] <17> The communication device according to <16>, further including

[0368] a specification unit that specifies a direction or a position of the other communication device on the basis of a drop position notification signal from the other communication device in which the drop has been detected, in which

[0369] the presentation unit presents information indicating that the drop of the other communication device has been detected, and presents the direction or the position of the other communication device specified by the specification unit.

[0370] <18> A communication method, including the steps of:

[0371] receiving a notification indicating that a drop has been detected from another communication device; and

[0372] presenting, on the basis of the notification, information indicating that the drop of the other communication device has been detected.

[0373] <19> A program for causing a computer to function as

[0374] a reception unit that receives a notification indicating that a drop has been detected from another communication device; and

[0375] a presentation unit that presents, on the basis of the notification, information indicating that the drop of the other communication device has been detected.

[0376] <20> A communication system, including a first communication device and a second communication device that communicate with each other, in which

[0377] the first communication device includes

[0378] a drop detection unit that detects presence or absence of a drop of an own device and transmits a notification indicating that the drop has been detected to the second communication device when the drop is detected, and

[0379] the second communication device includes

[0380] a reception unit that receives the notification indicating that the drop has been detected from the first communication device, and

[0381] a presentation unit that presents, on the basis of the notification, information indicating that the drop of the first communication device has been detected.

REFERENCE SIGNS LIST

[0382] **11** Communication system

[0383] **31** Smartphone

[0384] **32**, **32**L, **32**R Earphone

[0385] **51** Control unit

[0386] **71** Communication control unit

[0387] **72**, **72'**, **72"** Drop notification processing unit

[0388] **73**, **73'**, **73"** Drop position specification processing unit

[0389] **91** Control unit

[0390] **111** Communication processing unit

[0391] **112**, **112'** Drop event detection processing unit

[0392] **113**, **113'**, **113"** Drop position notification signal transmission processing unit

[0393] **113**, **114'** Drop notification processing unit

1. A communication device, comprising

a drop detection unit that detects presence or absence of a drop of an own device and transmits a notification indicating the drop when the drop is detected.

2. The communication device according to claim **1**, further comprising:

a proximity sensor that detects whether or not the own device and a human body are in a proximity state; and

an acceleration sensor that detects acceleration of the own device, wherein

the drop detection unit detects the drop in a case where the proximity sensor detects that the own device is not in proximity to the human body on a basis of a detection result of the proximity sensor and a detection result of the acceleration sensor, and the drop is detected from time-series information of acceleration detected by the acceleration sensor.

3. The communication device according to claim **2**, wherein

the drop detection unit detects the drop on a basis of an analysis result obtained by analyzing the detection result of the proximity sensor and the detection result of the acceleration sensor by a deep neural network (DNN).

4. The communication device according to claim **3**, wherein

the drop detection unit is an audio analysis engine including the DNN.

5. The communication device according to claim **2**, wherein

the drop detection unit transmits the notification indicating the drop to another communication device paired with the own device.

6. The communication device according to claim **1**, further comprising:

a communication unit that receives audio data transmitted from another communication device; and

an output unit that outputs sound on a basis of the audio data received by the communication unit, wherein

the drop detection unit transmits the notification indicating the drop to the other communication device.

7. The communication device according to claim **6**, wherein

the communication unit receives the audio data transmitted from the other communication device by Bluetooth (registered trademark) communication.

8. The communication device according to claim **6**, further comprising

a drop position notification signal transmission unit that transmits a drop position notification signal for estimating a position of the own device to the other communication device.

9. The communication device according to claim **8**, wherein

the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device by Bluetooth low energy (BLE) communication.

10. The communication device according to claim **9**, wherein

a direction indicating the position of the own device is estimated by BLE Angle of Arrival (AoA) using the drop position notification signal, or the position of the own device is estimated by BLE Angle of Departure (AoD) using the drop position notification signal.

11. The communication device according to claim **8**, wherein

the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device in a long-distance communication mode.

12. The communication device according to claim **8**, wherein

the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device in a low power communication mode.

13. The communication device according to claim **12**, wherein

the drop position notification signal transmission unit transmits the drop position notification signal to the other communication device in the low power communication mode when an elapsed time from a timing at which the drop is detected by the drop detection unit becomes longer than a predetermined time.

14. A communication method, comprising the step of detecting presence or absence of a drop of an own device, and transmitting, when the drop is detected, a notification indicating that the drop has been detected.

15. A program for causing a computer to function as

a drop detection unit that detects presence or absence of a drop of an own device, and transmits, when the drop is detected, a notification indicating that the drop has been detected.

16. A communication device, comprising:

a reception unit that receives a notification indicating that a drop has been detected from another communication device; and

a presentation unit that presents, on a basis of the notification, information indicating that the drop of the other communication device has been detected.

17. The communication device according to claim **16**, further comprising

a specification unit that specifies a direction or a position of the other communication device on a basis of a drop position notification signal from the other communication device in which the drop has been detected, wherein

the presentation unit presents information indicating that the drop of the other communication device has been detected, and presents the direction or the position of the other communication device specified by the specification unit.

18. A communication method, comprising the steps of:

receiving a notification indicating that a drop has been detected from another communication device; and

presenting, on a basis of the notification, information indicating that the drop of the other communication device has been detected.

19. A program for causing a computer to function as:

a reception unit that receives a notification indicating that a drop has been detected from another communication device; and

a presentation unit that presents, on a basis of the notification, information indicating that the drop of the other communication device has been detected.

20. A communication system comprising a first communication device and a second communication device that communicate with each other, wherein

the first communication device includes

a drop detection unit that detects presence or absence of a drop of an own device and transmits a notification indicating that the drop has been detected to the second communication device when the drop is detected, and

the second communication device includes

a reception unit that receives the notification indicating that the drop has been detected from the first communication device, and

a presentation unit that presents, on a basis of the notification, information indicating that the drop of the first communication device has been detected.

* * * * *