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(54) **CONTROLLING EAR STIMULATION IN RESPONSE TO IMAGE ANALYSIS**

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(57) **ABSTRACT**

Systems and related methods for controlling an ear stimulation device with a personal computing device, based on analysis of an image of a user of the personal computing device captured with a camera associated with the personal computing device, are described. One or more parameter is determined from the processed image, including, but not limited, to user identity, emotion, physiological condition, or

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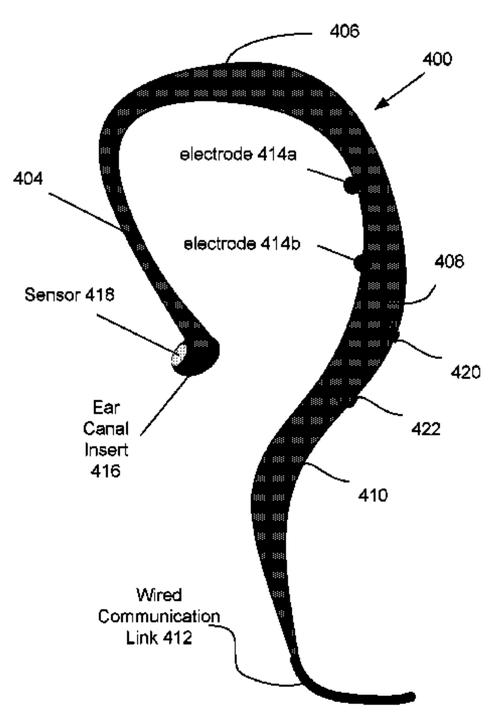

placement of a stimulator earpiece, and control of the ear stimulation device is based thereon. If the earpiece is located incorrectly, in an aspect, delivery of a stimulus is prevented. In another aspect, the user is notified of the need to reposition an incorrectly located earpiece.

44 Claims, 47 Drawing Sheets

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See application file for complete search history.

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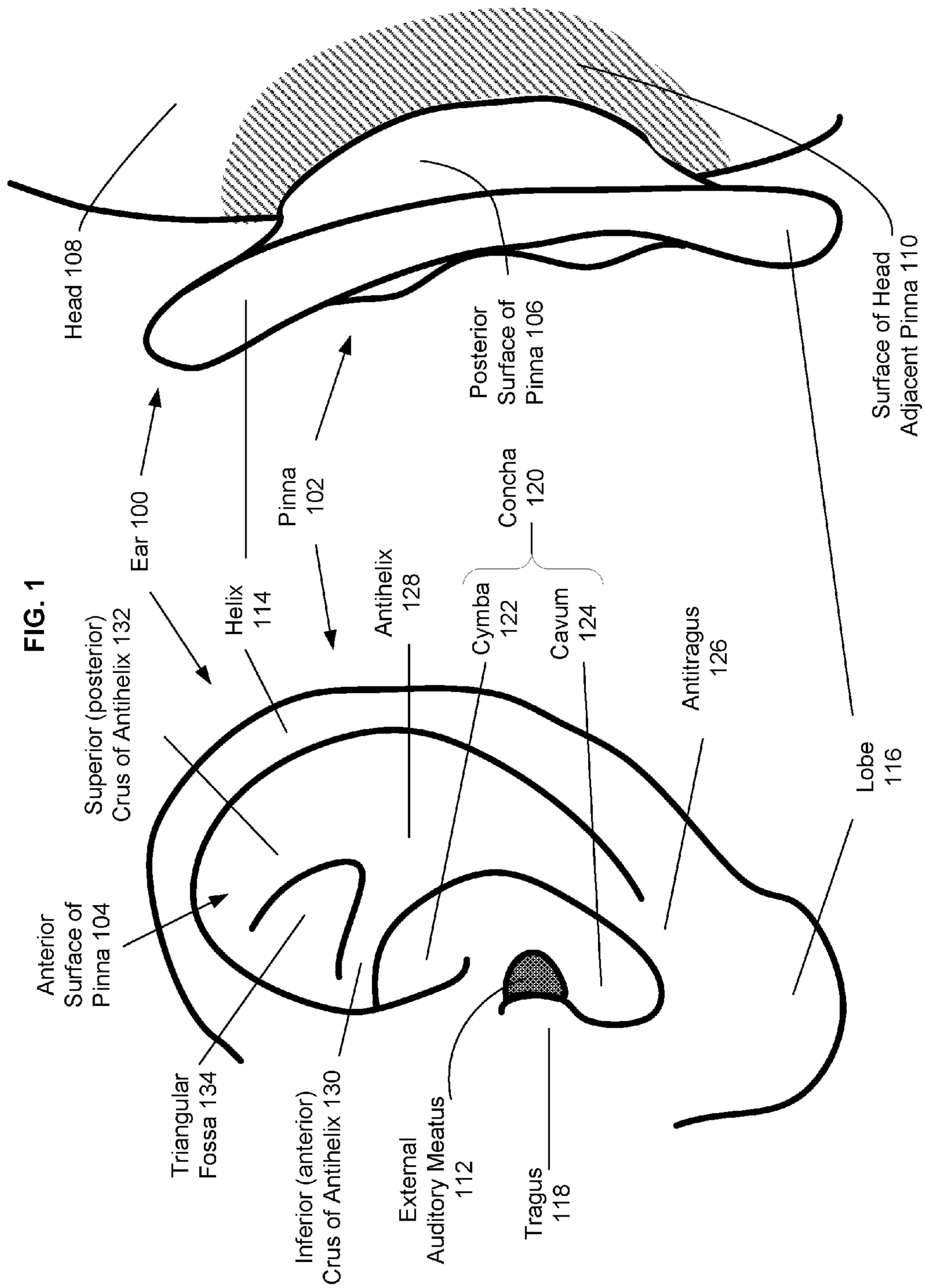
FIG. 1


Head 108
Ear 100
Pinna 102
Posterior Surface of Pinna 106
Surface of Head Adjacent Pinna 110
Concha 120
Superior (posterior) Crus of Antihelix 132
Helix 114
Antihelix 128
Cymba 122
Cavum 124
Antitragus 126
Lobe 116
Anterior Surface of Pinna 104
Triangular Fossa 134
Inferior (anterior) Crus of Antihelix 130
External Auditory Meatus 112
Tragus 118

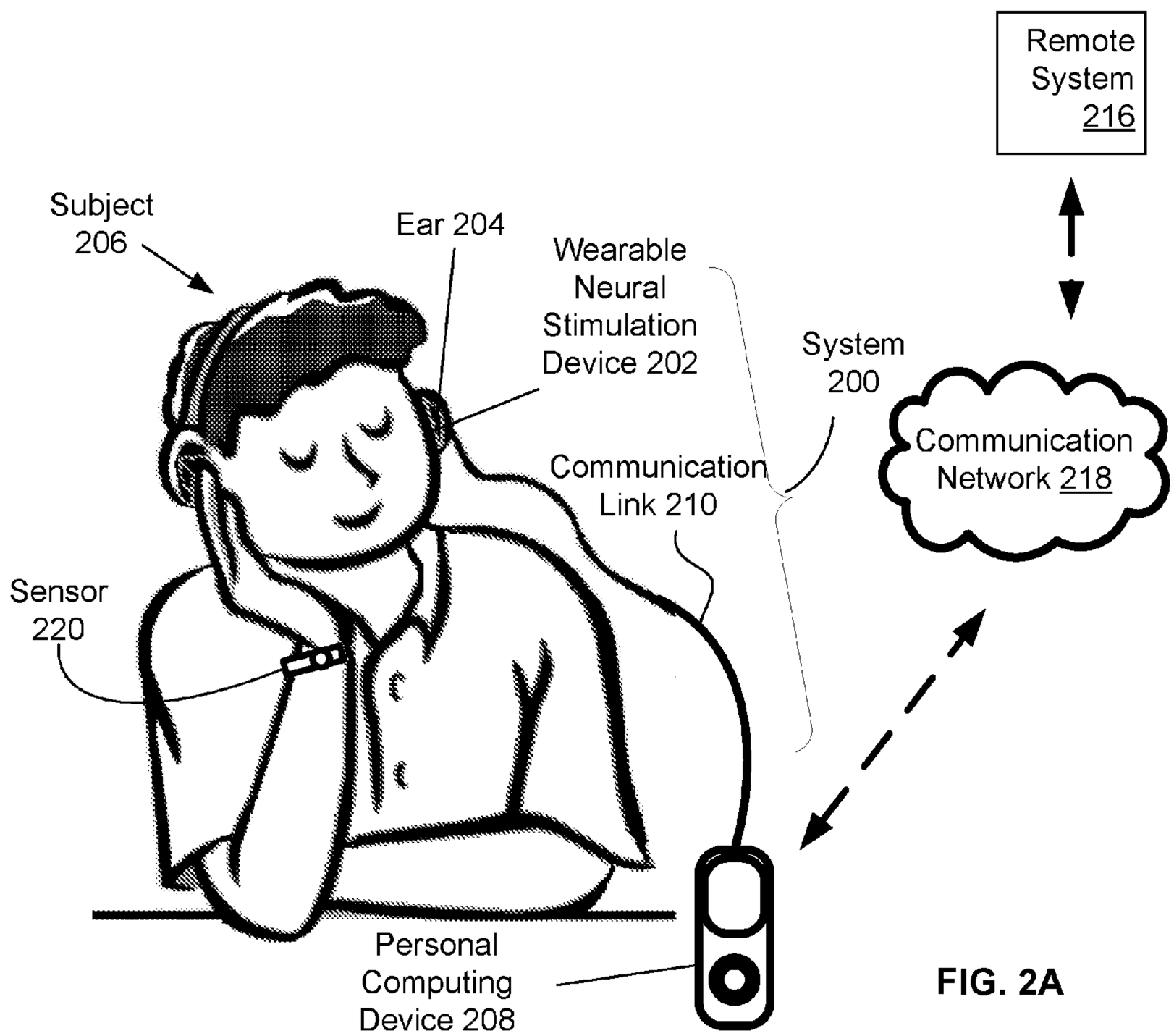

Remote System 216
Subject 206
Ear 204
Wearable Neural Stimulation Device 202
System 200
Communication Network 218
Communication Link 210
Sensor 220
Personal Computing Device 208

FIG. 2A

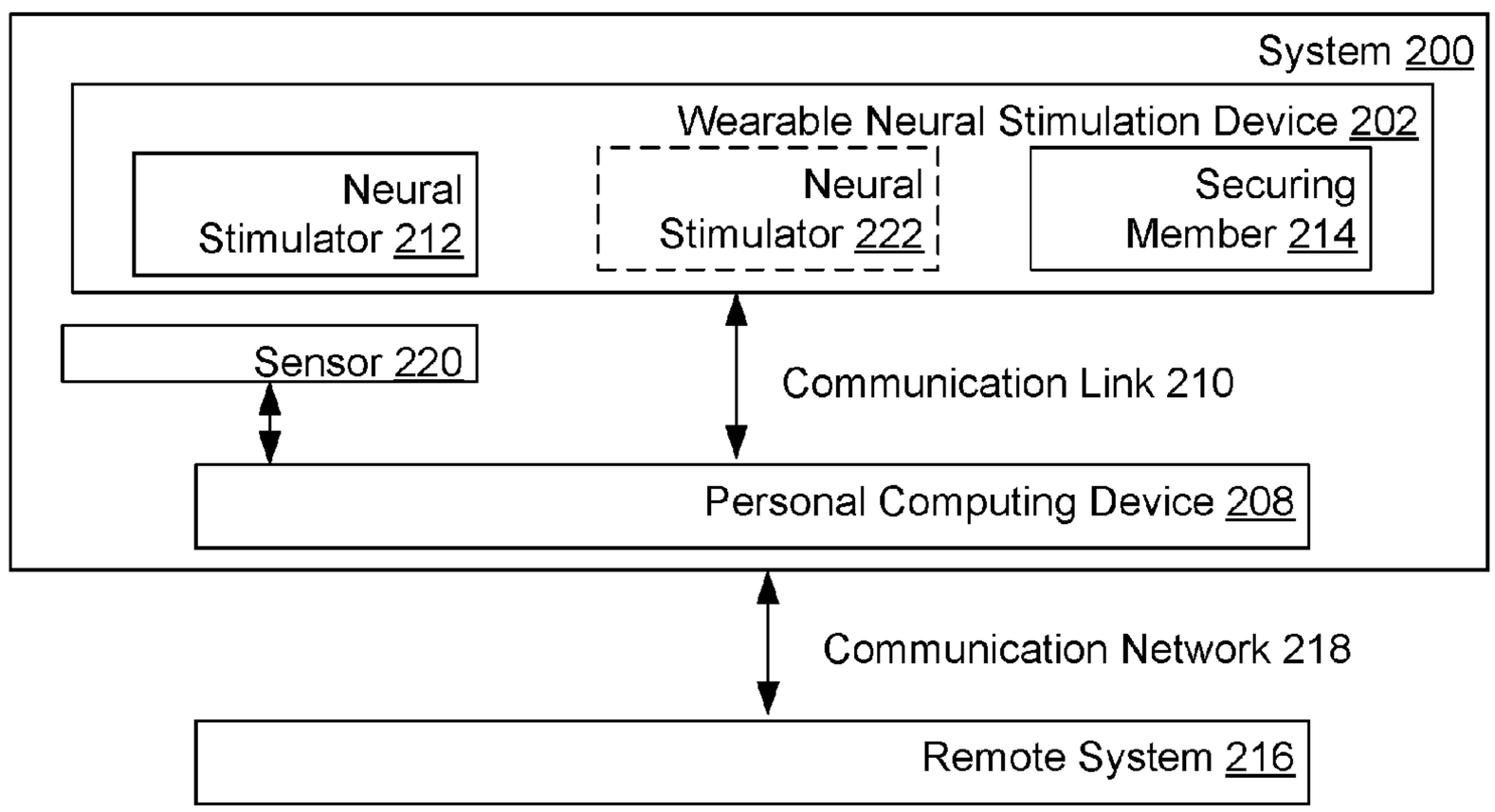
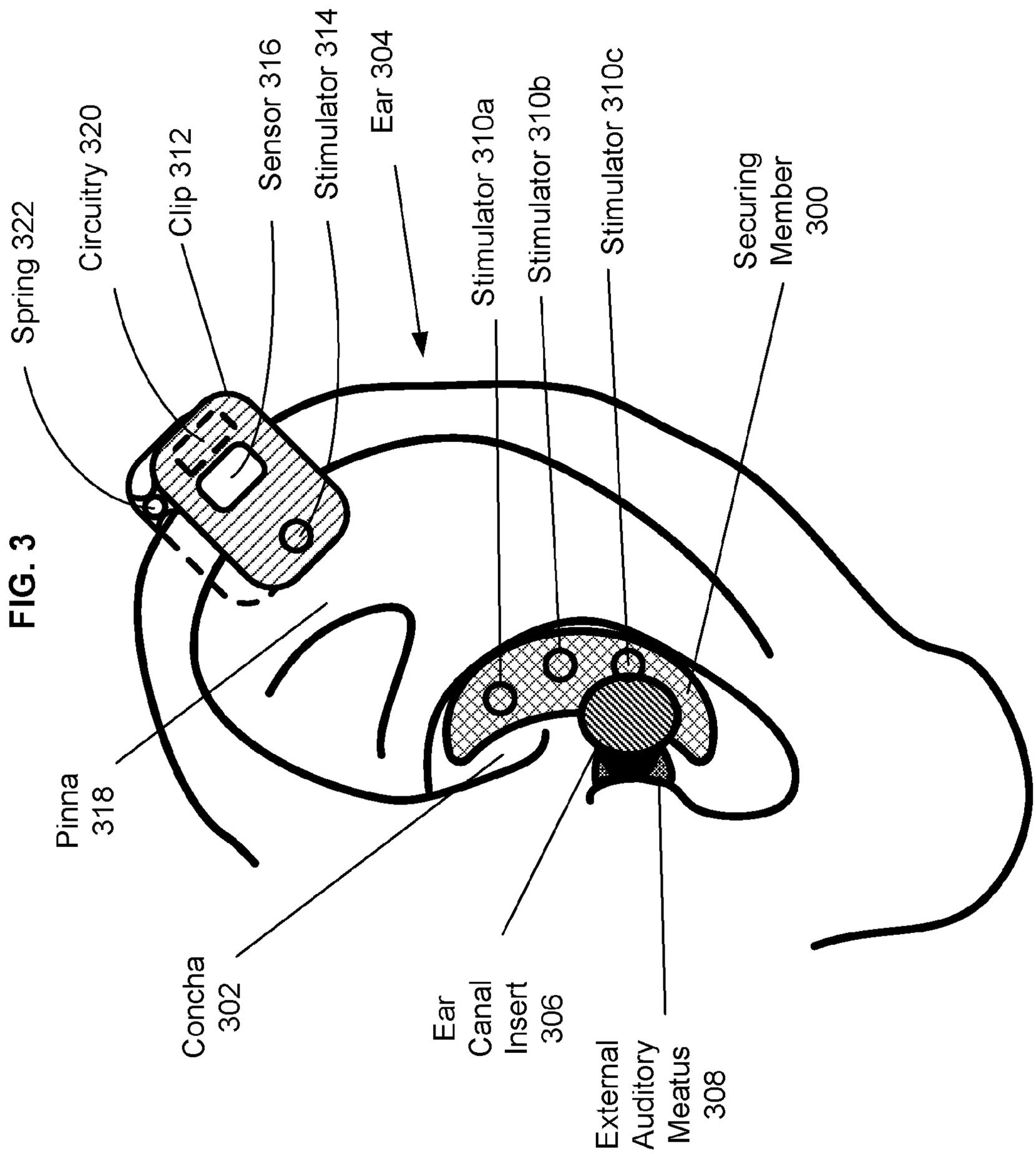

System 200
Wearable Neural Stimulation Device 202
Neural Stimulator 212
Neural Stimulator 222
Securing Member 214
Sensor 220
Communication Link 210
Personal Computing Device 208
Communication Network 218
Remote System 216

FIG. 2B

FIG. 3


Spring 322
Circuitry 320
Clip 312
Sensor 316
Stimulator 314
Ear 304
Stimulator 310a
Stimulator 310b
Stimulator 310c
Securing Member 300
Pinna 318
Concha 302
Ear Canal Insert 306
External Auditory Meatus 308

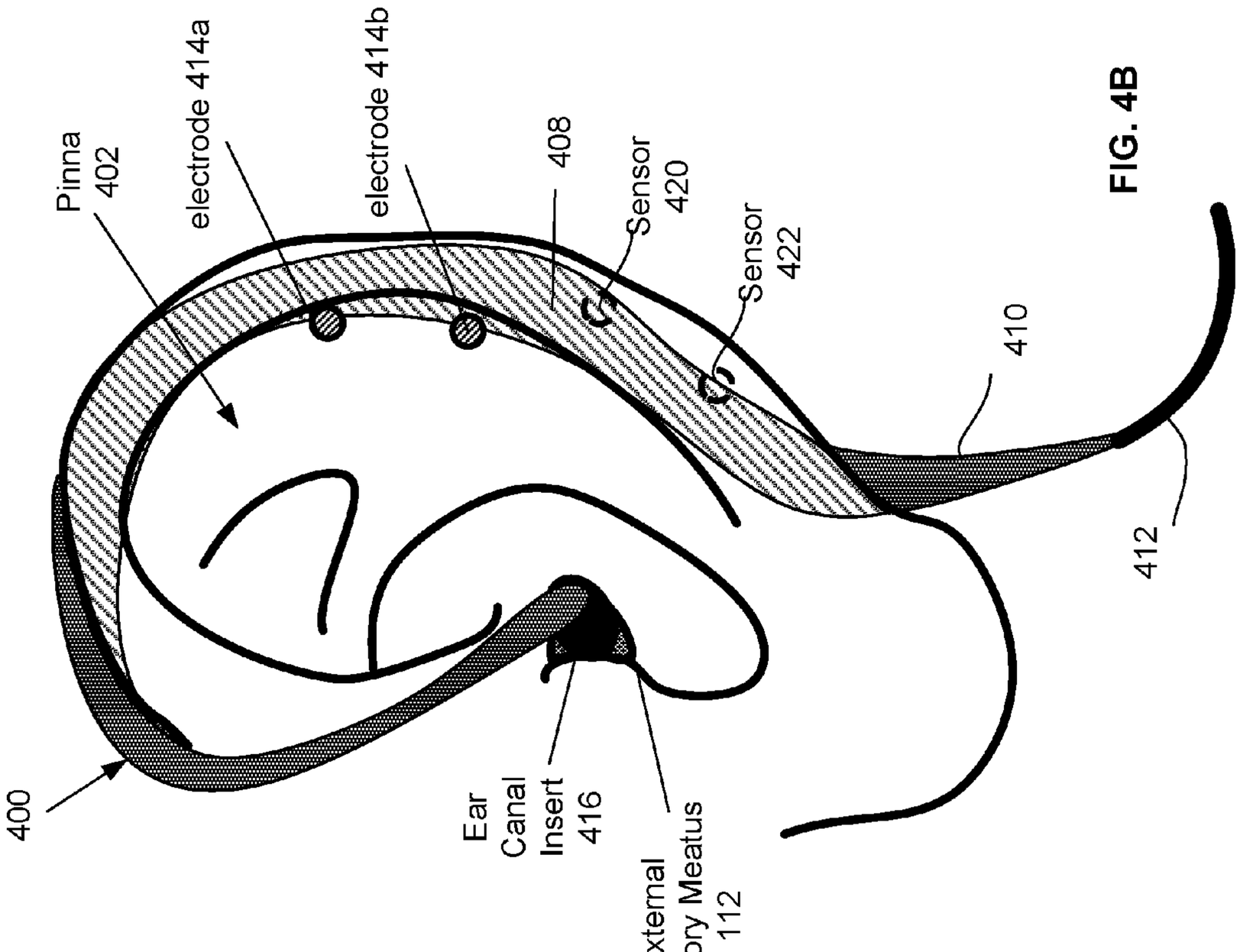

Pinna
402
electrode 414a
electrode 414b
408
Sensor
420
Sensor
422
410
412
400
Ear
Canal
Insert
416
External
Auditory Meatus
112

FIG. 4B

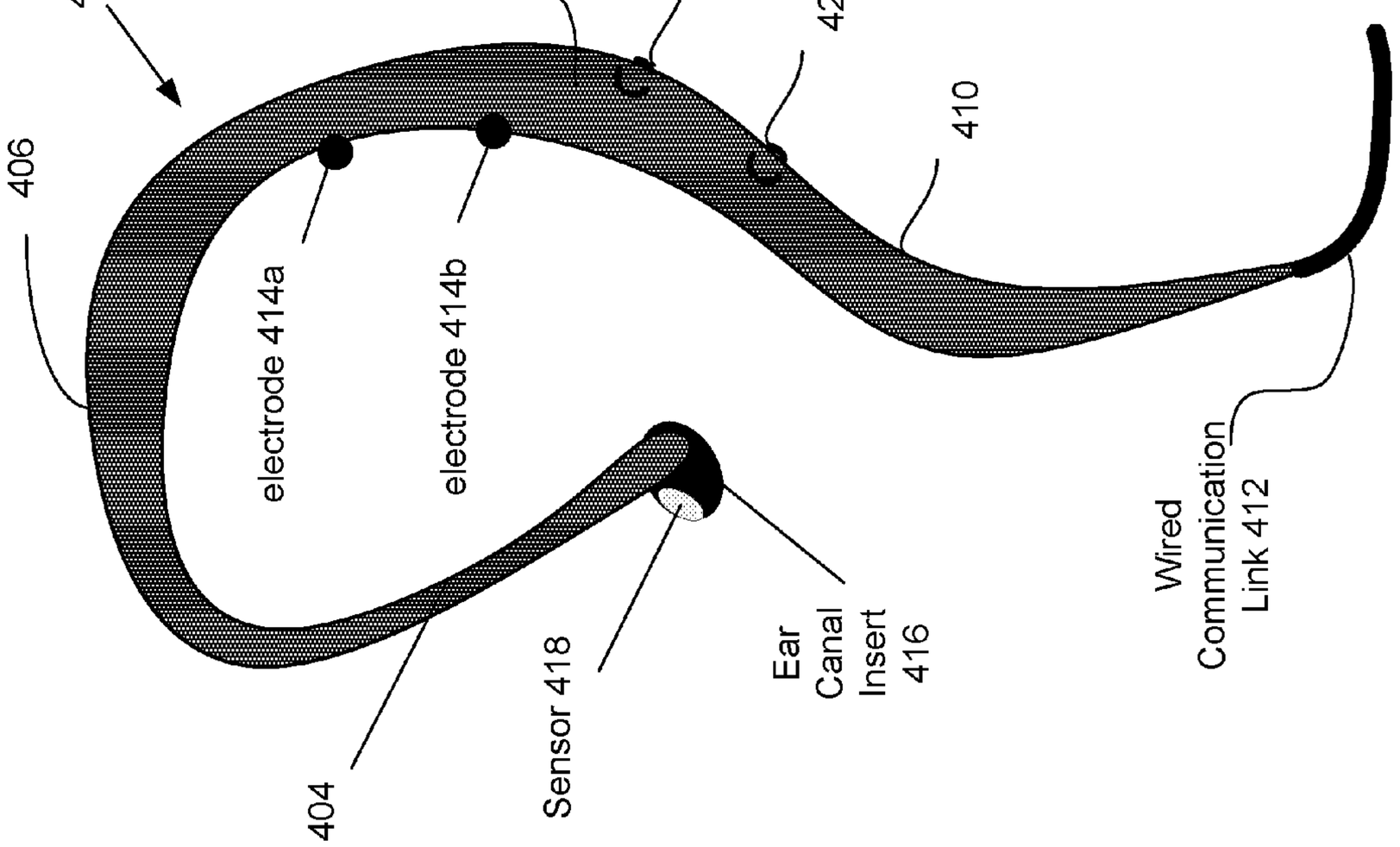

400
408
420
422
410
406
electrode 414a
electrode 414b
Wired
Communication
Link 412
Ear
Canal
Insert
416
Sensor 418
404

FIG. 4A

FIG. 5

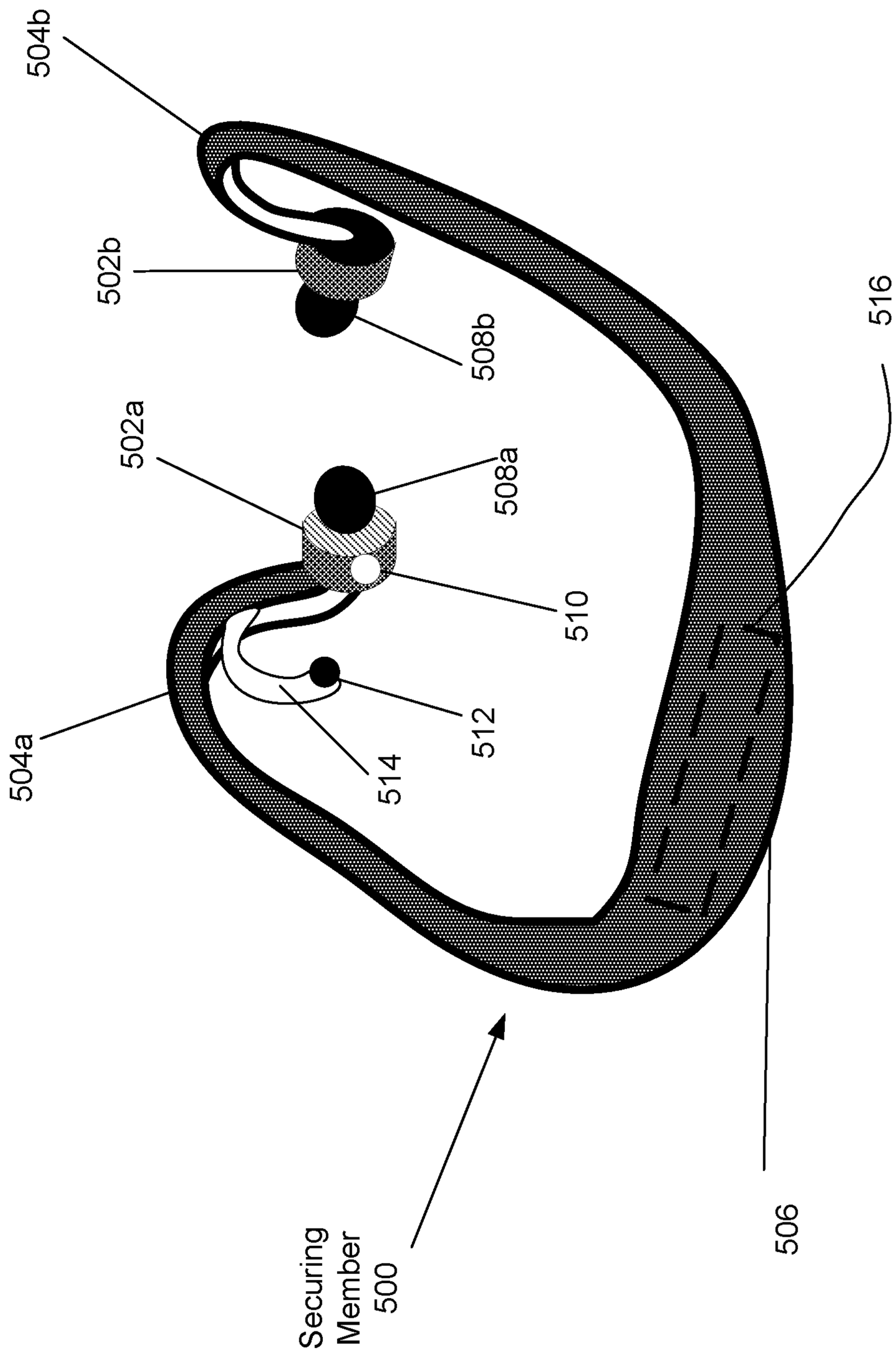
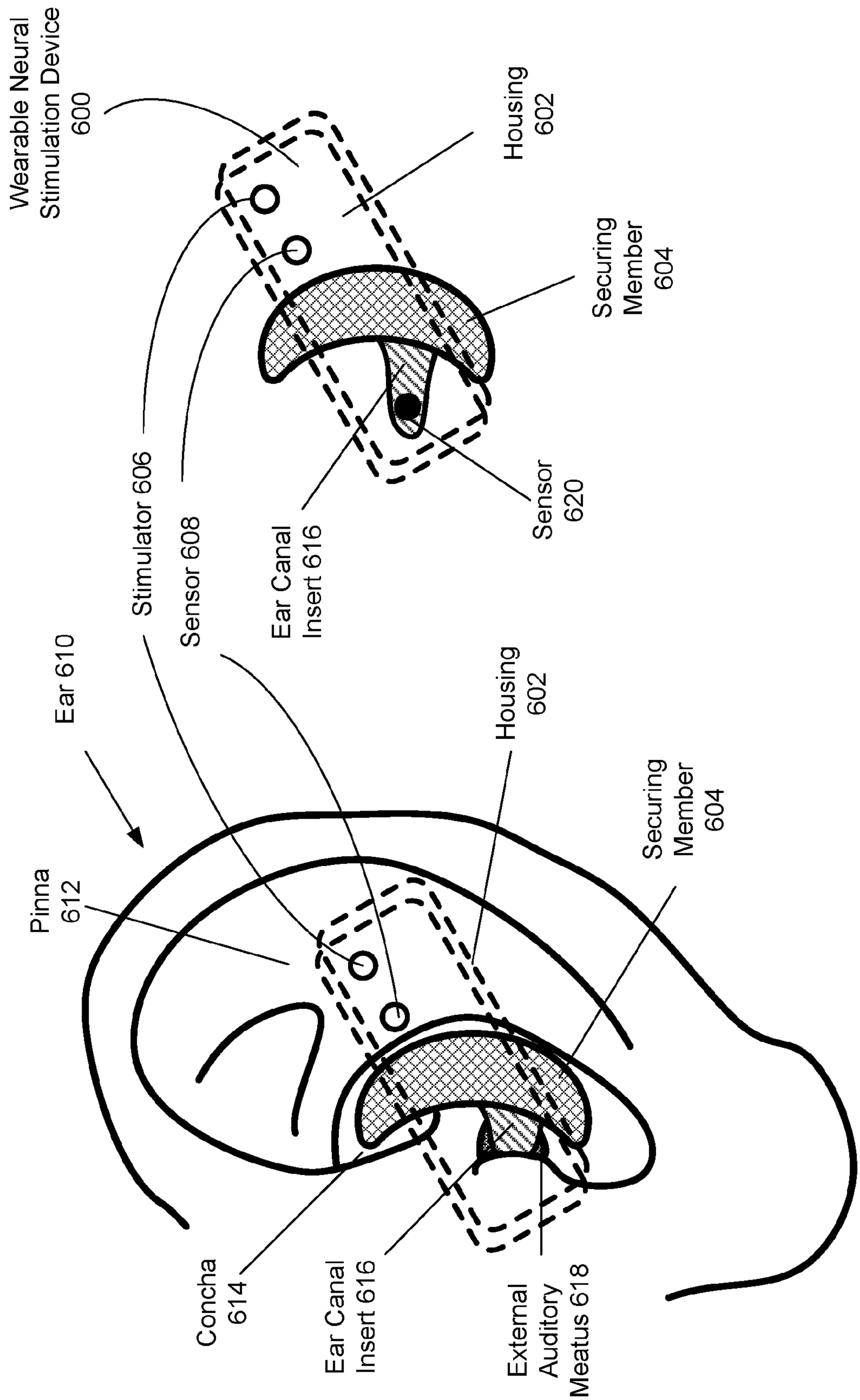

504b
502b
508b
502a
508a
510
516
504a
514
512
Securing
Member
500
506

FIG. 6


Wearable Neural Stimulation Device 600
Housing 602
Securing Member 604
Stimulator 606
Sensor 608
Ear Canal Insert 616
Sensor 620
Ear 610
Pinna 612
Concha 614
Ear Canal Insert 616
External Auditory Meatus 618
Housing 602
Securing Member 604

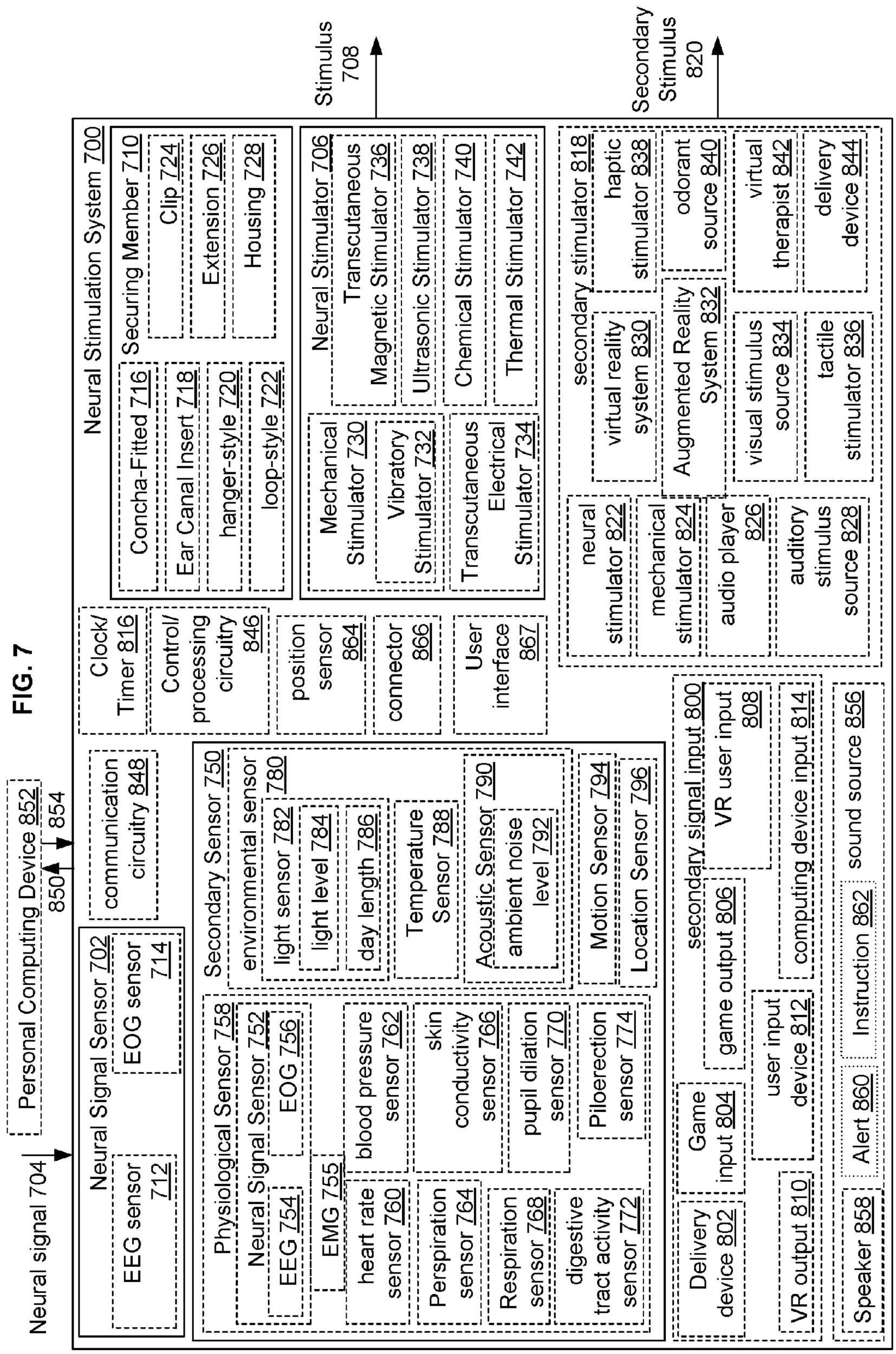

Neural signal 704
Personal Computing Device 852
850
854
Neural Signal Sensor 702
EEG sensor 712
EOG sensor 714
communication circuitry 848
Neural Stimulation System 700
Securing Member 710
Concha-Fitted 716
Ear Canal Insert 718
hanger-style 720
loop-style 722
Clip 724
Extension 726
Housing 728
Stimulus 708
Neural Stimulator 706
Mechanical Stimulator 730
Vibratory Stimulator 732
Transcutaneous Electrical Stimulator 734
Transcutaneous Magnetic Stimulator 736
Ultrasonic Stimulator 738
Chemical Stimulator 740
Thermal Stimulator 742
Secondary Stimulus 820
secondary stimulator 818
neural stimulator 822
mechanical stimulator 824
audio player 826
auditory stimulus source 828
virtual reality system 830
Augmented Reality System 832
visual stimulus source 834
tactile stimulator 836
haptic stimulator 838
odorant source 840
virtual therapist 842
delivery device 844
Clock/ Timer 816
Control/ processing circuitry 846
position sensor 864
connector 866
User interface 867
Secondary Sensor 750
environmental sensor 780
light sensor 782
light level 784
day length 786
Temperature Sensor 788
Acoustic Sensor 790
ambient noise level 792
Motion Sensor 794
Location Sensor 796
Physiological Sensor 758
Neural Signal Sensor 752
EEG 754
EOG 756
EMG 755
heart rate sensor 760
blood pressure sensor 762
Perspiration sensor 764
skin conductivity sensor 766
Respiration sensor 768
pupil dilation sensor 770
digestive tract activity sensor 772
Piloerection sensor 774
secondary signal input 800
Delivery device 802
Game input 804
VR output 810
VR user input 808
game output 806
user input device 812
computing device input 814
Speaker 858
Alert 860
Instruction 862
sound source 856

FIG. 7

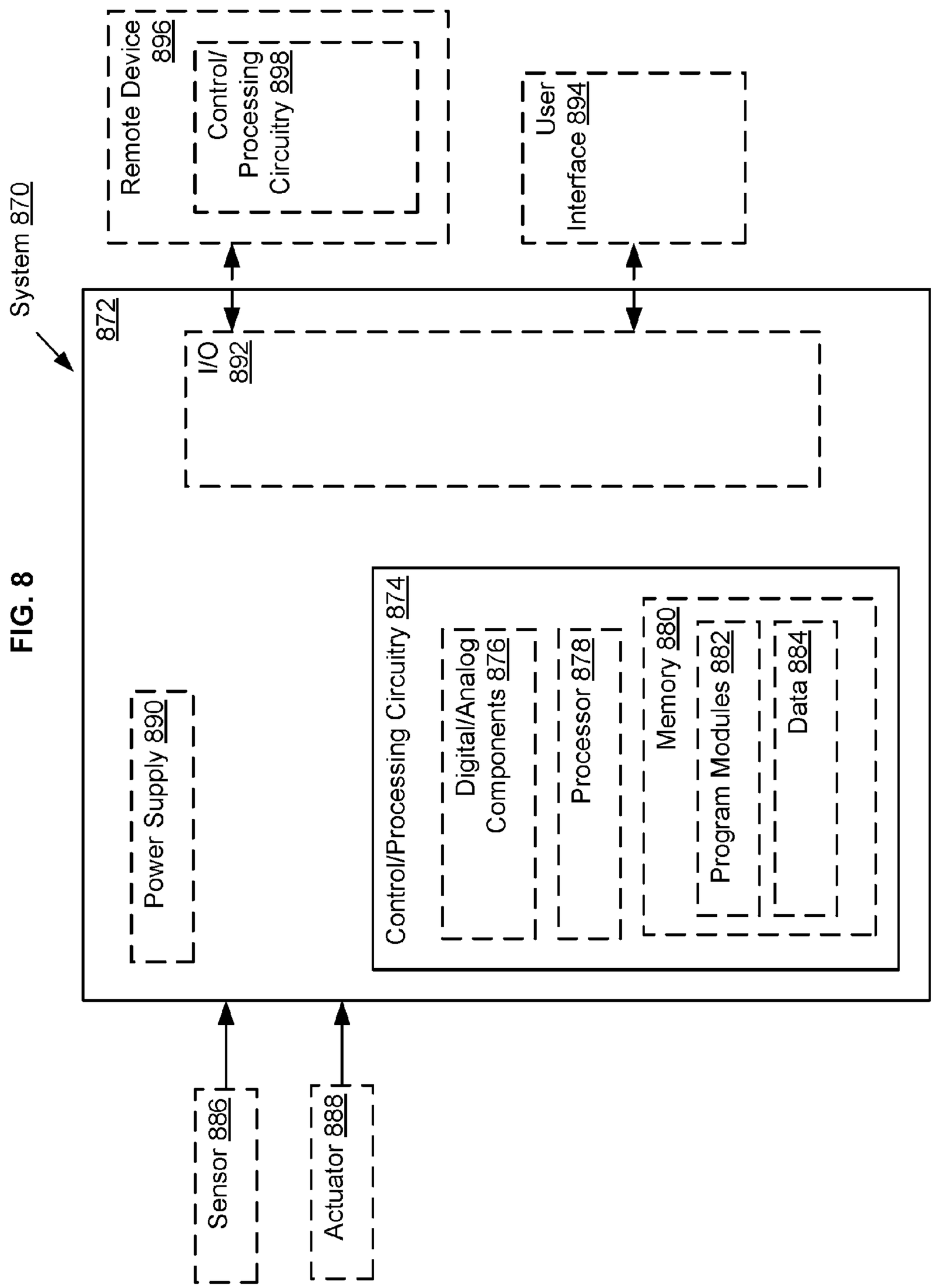

System 870
872
Remote Device 896
Control/ Processing Circuitry 898
User Interface 894
I/O 892
Power Supply 890
Control/Processing Circuitry 874
Digital/Analog Components 876
Processor 878
Memory 880
Program Modules 882
Data 884
Sensor 886
Actuator 888

FIG. 8

FIG. 9

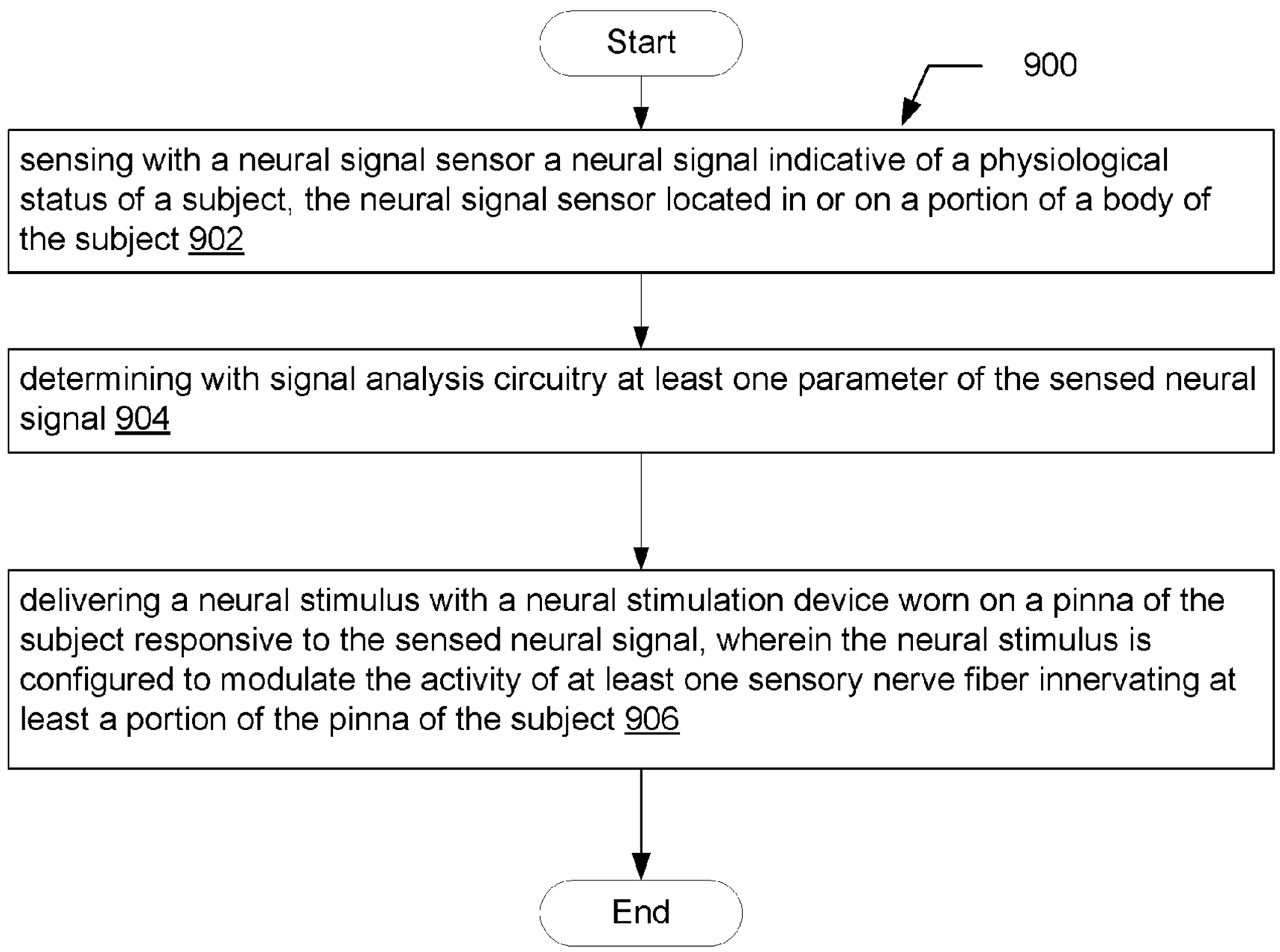

Start
900
sensing with a neural signal sensor a neural signal indicative of a physiological status of a subject, the neural signal sensor located in or on a portion of a body of the subject 902
determining with signal analysis circuitry at least one parameter of the sensed neural signal 904
delivering a neural stimulus with a neural stimulation device worn on a pinna of the subject responsive to the sensed neural signal, wherein the neural stimulus is configured to modulate the activity of at least one sensory nerve fiber innervating at least a portion of the pinna of the subject 906
End

FIG. 10

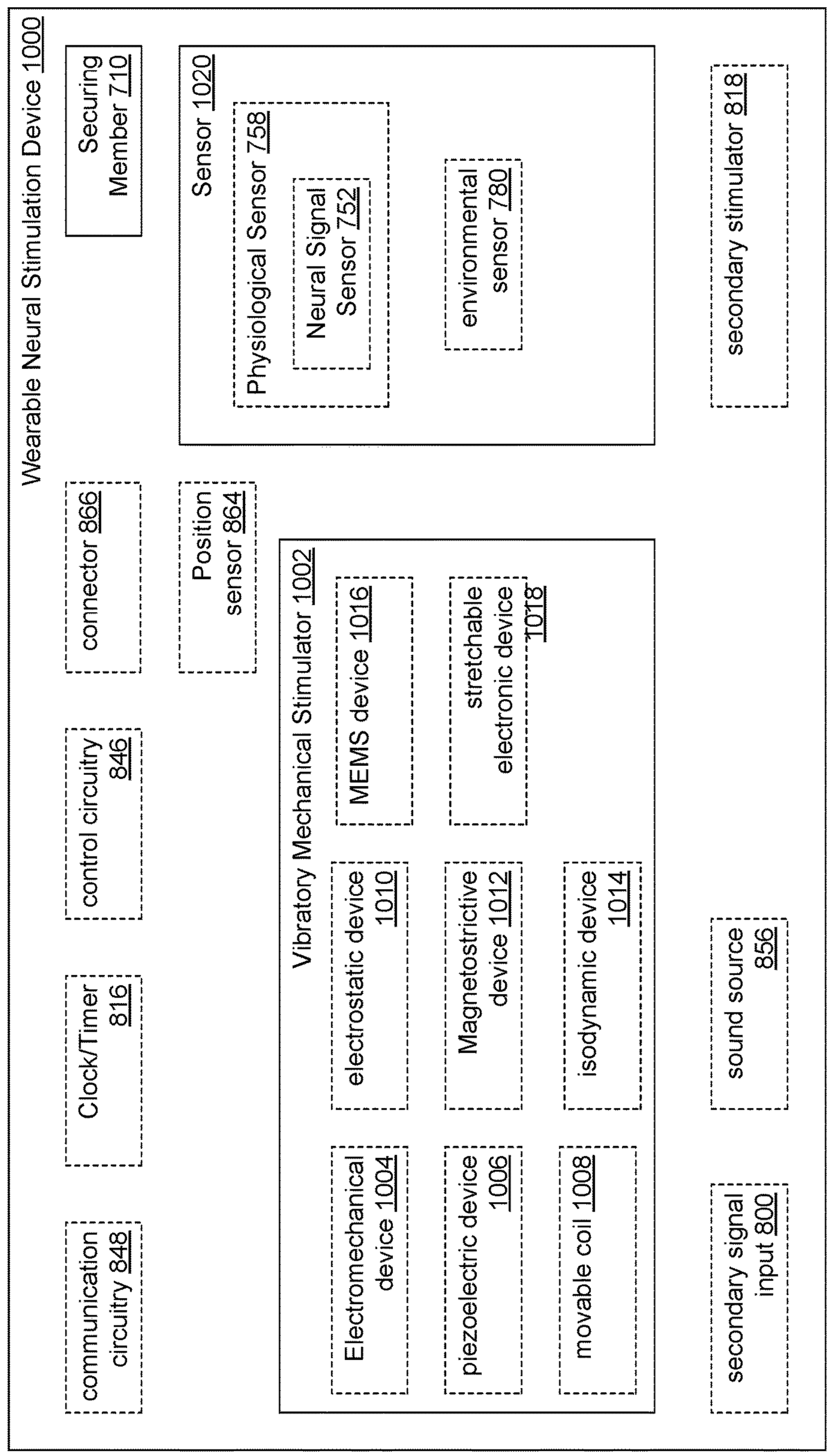

Wearable Neural Stimulation Device 1000
Securing Member 710
Sensor 1020
Physiological Sensor 758
Neural Signal Sensor 752
environmental sensor 780
secondary stimulator 818
connector 866
Position sensor 864
control circuitry 846
Vibratory Mechanical Stimulator 1002
MEMS device 1016
stretchable electronic device 1018
Clock/Timer 816
electrostatic device 1010
Magnetostrictive device 1012
isodynamic device 1014
sound source 856
communication circuitry 848
Electromechanical device 1004
piezoelectric device 1006
movable coil 1008
secondary signal input 800

FIG. 11

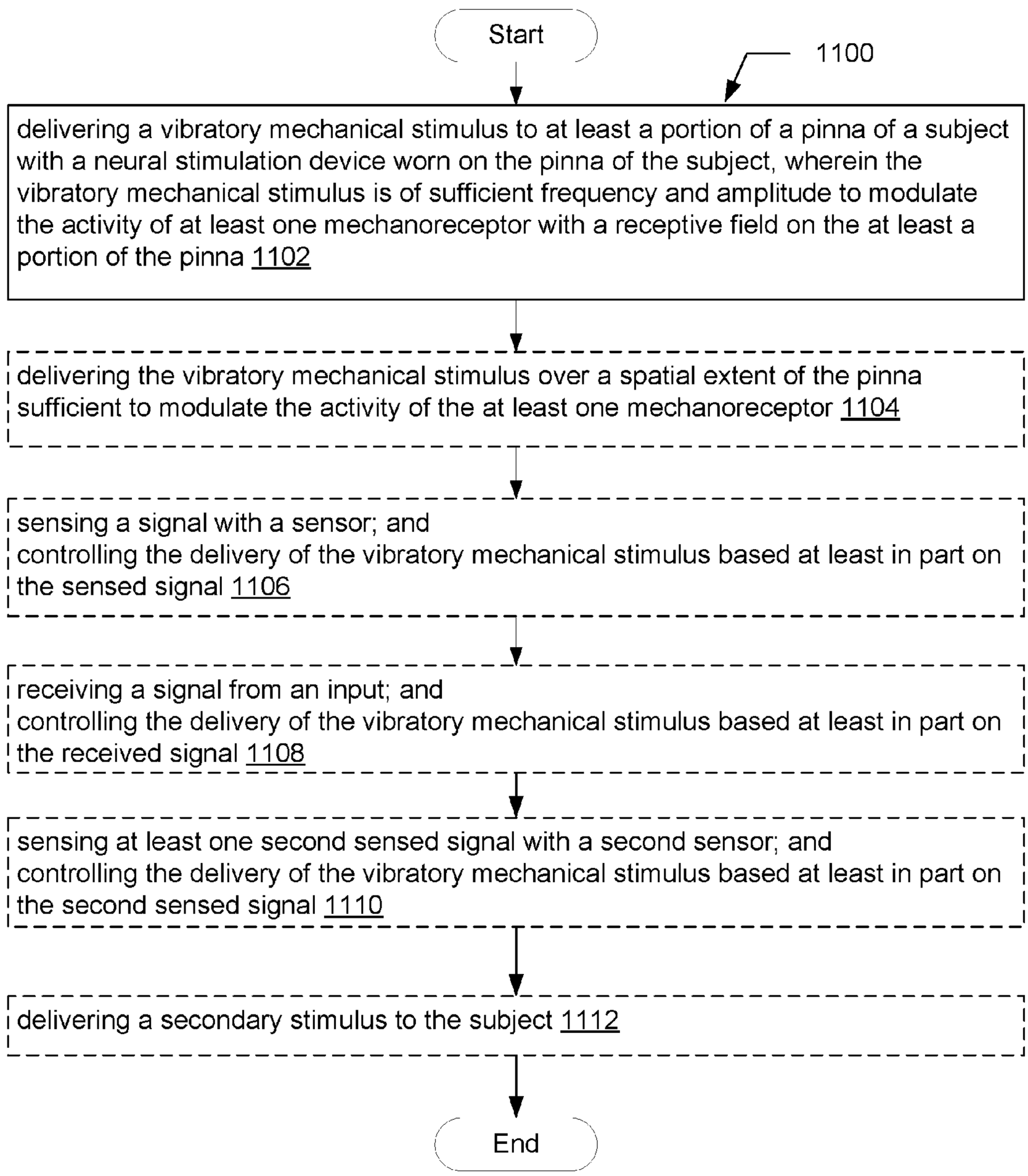

Start
1100
delivering a vibratory mechanical stimulus to at least a portion of a pinna of a subject with a neural stimulation device worn on the pinna of the subject, wherein the vibratory mechanical stimulus is of sufficient frequency and amplitude to modulate the activity of at least one mechanoreceptor with a receptive field on the at least a portion of the pinna 1102
delivering the vibratory mechanical stimulus over a spatial extent of the pinna sufficient to modulate the activity of the at least one mechanoreceptor 1104
sensing a signal with a sensor; and
controlling the delivery of the vibratory mechanical stimulus based at least in part on the sensed signal 1106
receiving a signal from an input; and
controlling the delivery of the vibratory mechanical stimulus based at least in part on the received signal 1108
sensing at least one second sensed signal with a second sensor; and
controlling the delivery of the vibratory mechanical stimulus based at least in part on the second sensed signal 1110
delivering a secondary stimulus to the subject 1112
End

FIG. 12

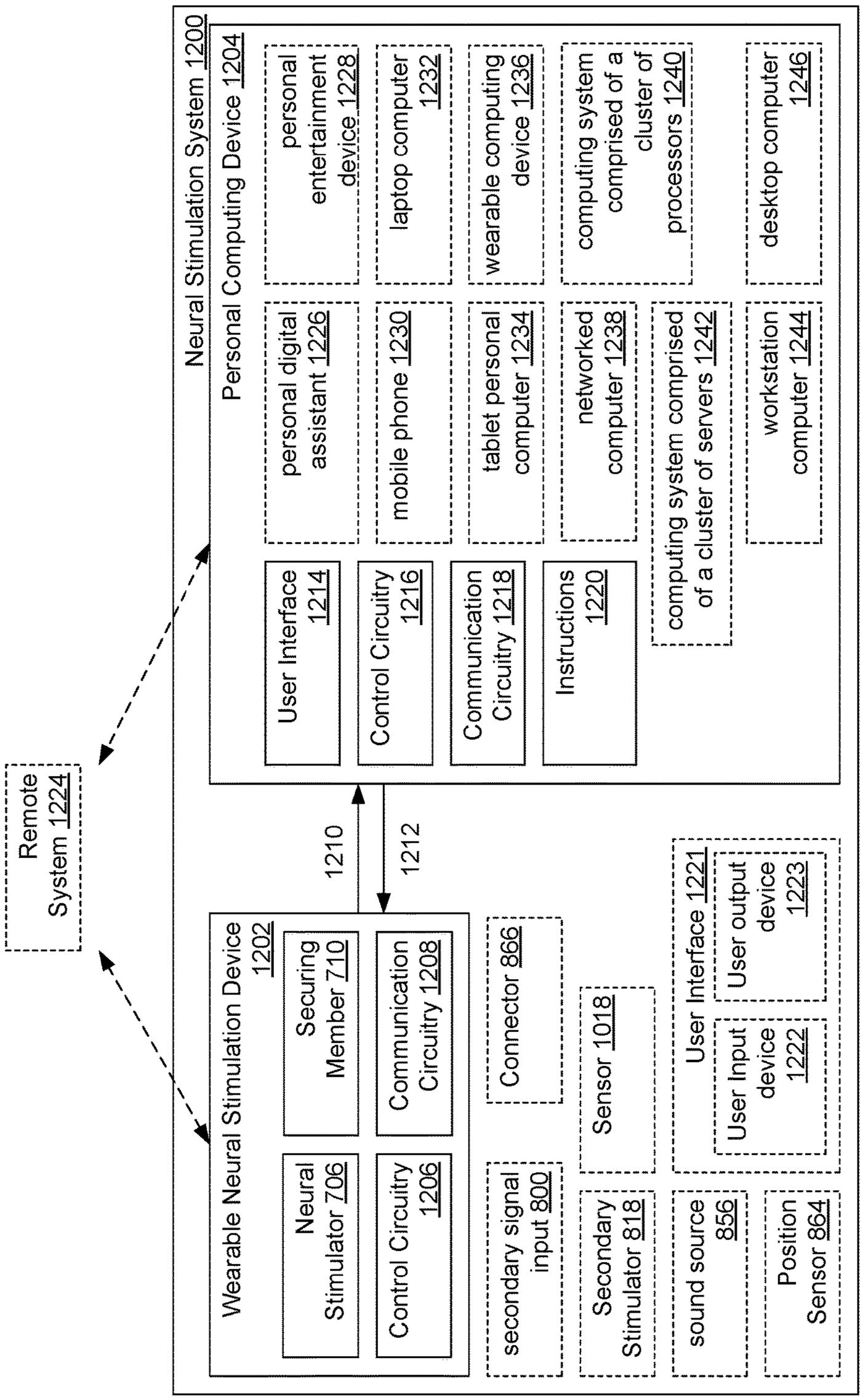

Remote System 1224
Neural Stimulation System 1200
Personal Computing Device 1204
User Interface 1214
Control Circuitry 1216
Communication Circuitry 1218
Instructions 1220
personal digital assistant 1226
mobile phone 1230
tablet personal computer 1234
networked computer 1238
computing system comprised of a cluster of servers 1242
workstation computer 1244
personal entertainment device 1228
laptop computer 1232
wearable computing device 1236
computing system comprised of a cluster of processors 1240
desktop computer 1246
1210
1212
Wearable Neural Stimulation Device 1202
Neural Stimulator 706
Control Circuitry 1206
Securing Member 710
Communication Circuitry 1208
Connector 866
secondary signal input 800
Sensor 1018
Secondary Stimulator 818
User Interface 1221
User Input device 1222
User output device 1223
sound source 856
Position Sensor 864

FIG. 13

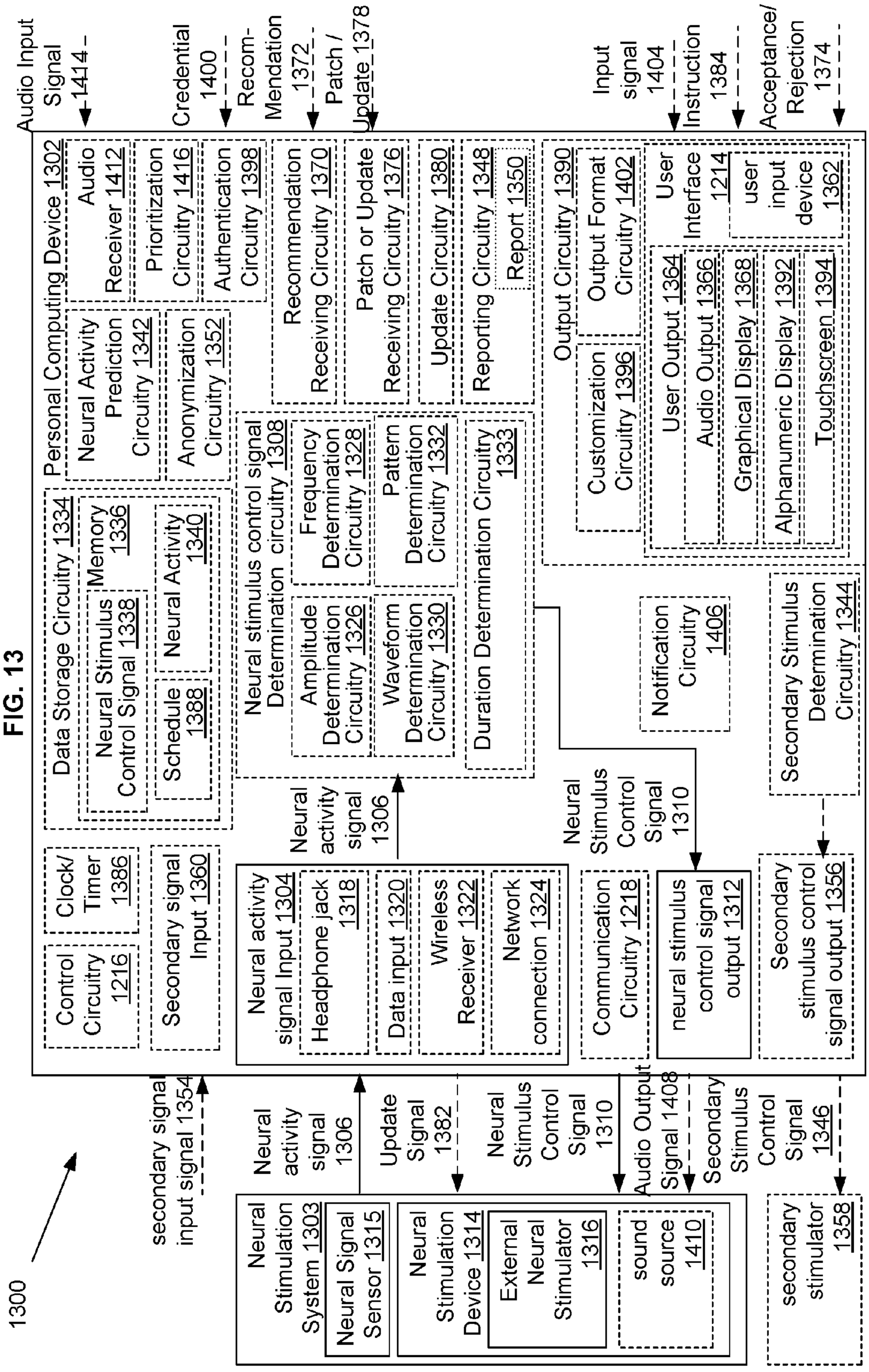

1300
Audio Input Signal 1414
Credential 1400
Recom-Mendation 1372
Patch / Update 1378
Input signal 1404
Instruction 1384
Acceptance/ Rejection 1374
Personal Computing Device 1302
Audio Receiver 1412
Prioritization Circuitry 1416
Authentication Circuitry 1398
Neural Activity Prediction Circuitry 1342
Anonymization Circuitry 1352
Recommendation Receiving Circuitry 1370
Patch or Update Receiving Circuitry 1376
Update Circuitry 1380
Reporting Circuitry 1348
Report 1350
Output Circuitry 1390
Output Format Circuitry 1402
Customization Circuitry 1396
User Interface 1214
user input device 1362
User Output 1364
Audio Output 1366
Graphical Display 1368
Alphanumeric Display 1392
Touchscreen 1394
Data Storage Circuitry 1334
Memory 1336
Neural Stimulus Control Signal 1338
Neural Activity 1340
Schedule 1388
Neural stimulus control signal Determination circuitry 1308
Frequency Determination Circuitry 1328
Pattern Determination Circuitry 1332
Amplitude Determination Circuitry 1326
Waveform Determination Circuitry 1330
Duration Determination Circuitry 1333
Notification Circuitry 1406
Secondary Stimulus Determination Circuitry 1344
Control Circuitry 1216
Clock/ Timer 1386
Secondary signal Input 1360
Neural activity signal Input 1304
Headphone jack 1318
Data input 1320
Wireless Receiver 1322
Network connection 1324
Communication Circuitry 1218
neural stimulus control signal output 1312
Secondary stimulus control signal output 1356
Neural activity signal 1306
Neural Stimulus Control Signal 1310
secondary signal input signal 1354
Neural activity signal 1306
Update Signal 1382
Neural Stimulus Control Signal 1310
Audio Output Signal 1408
Secondary Stimulus Control Signal 1346
Neural Stimulation System 1303
Neural Signal Sensor 1315
Neural Stimulation Device 1314
External Neural Stimulator 1316
sound source 1410
secondary stimulator 1358

FIG. 14

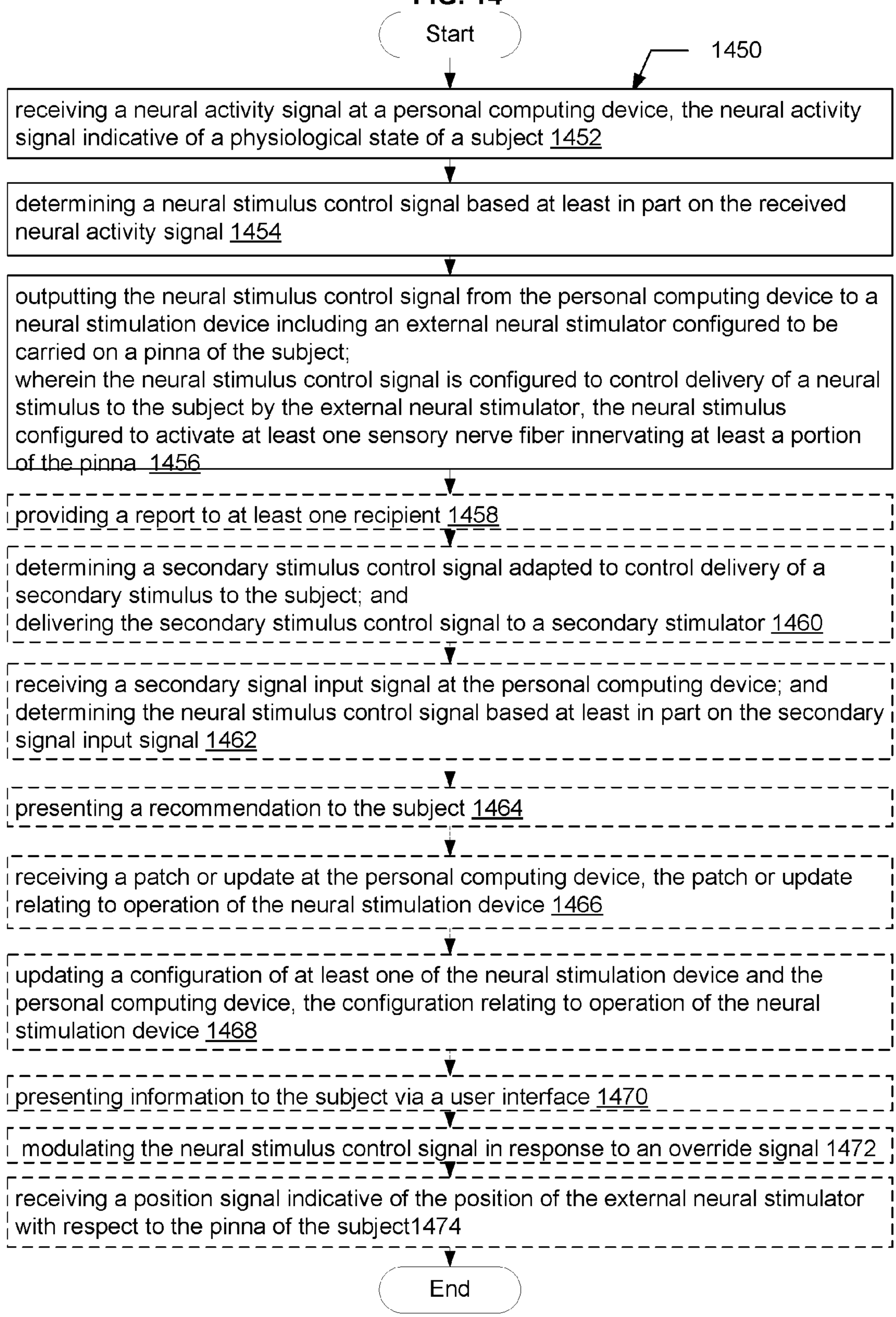
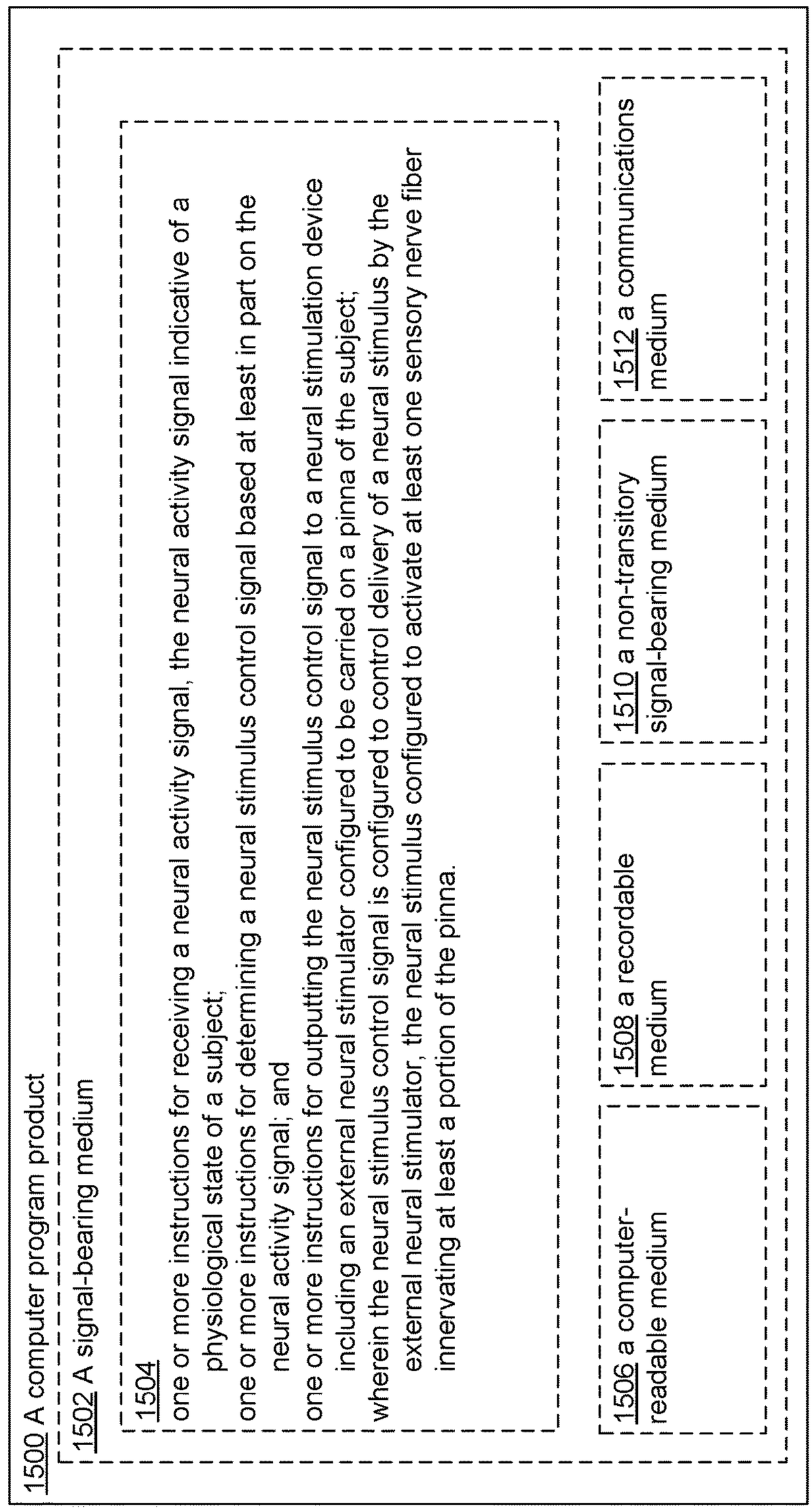

Start
1450
receiving a neural activity signal at a personal computing device, the neural activity signal indicative of a physiological state of a subject 1452
determining a neural stimulus control signal based at least in part on the received neural activity signal 1454
outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject;
wherein the neural stimulus control signal is configured to control delivery of a neural stimulus to the subject by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna 1456
providing a report to at least one recipient 1458
determining a secondary stimulus control signal adapted to control delivery of a secondary stimulus to the subject; and
delivering the secondary stimulus control signal to a secondary stimulator 1460
receiving a secondary signal input signal at the personal computing device; and
determining the neural stimulus control signal based at least in part on the secondary signal input signal 1462
presenting a recommendation to the subject 1464
receiving a patch or update at the personal computing device, the patch or update relating to operation of the neural stimulation device 1466
updating a configuration of at least one of the neural stimulation device and the personal computing device, the configuration relating to operation of the neural stimulation device 1468
presenting information to the subject via a user interface 1470
modulating the neural stimulus control signal in response to an override signal 1472
receiving a position signal indicative of the position of the external neural stimulator with respect to the pinna of the subject1474
End

FIG. 15


1500 A computer program product
1502 A signal-bearing medium
1504
one or more instructions for receiving a neural activity signal, the neural activity signal indicative of a physiological state of a subject;
one or more instructions for determining a neural stimulus control signal based at least in part on the neural activity signal; and
one or more instructions for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject;
wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna.
1506 a computer-readable medium
1508 a recordable medium
1510 a non-transitory signal-bearing medium
1512 a communications medium

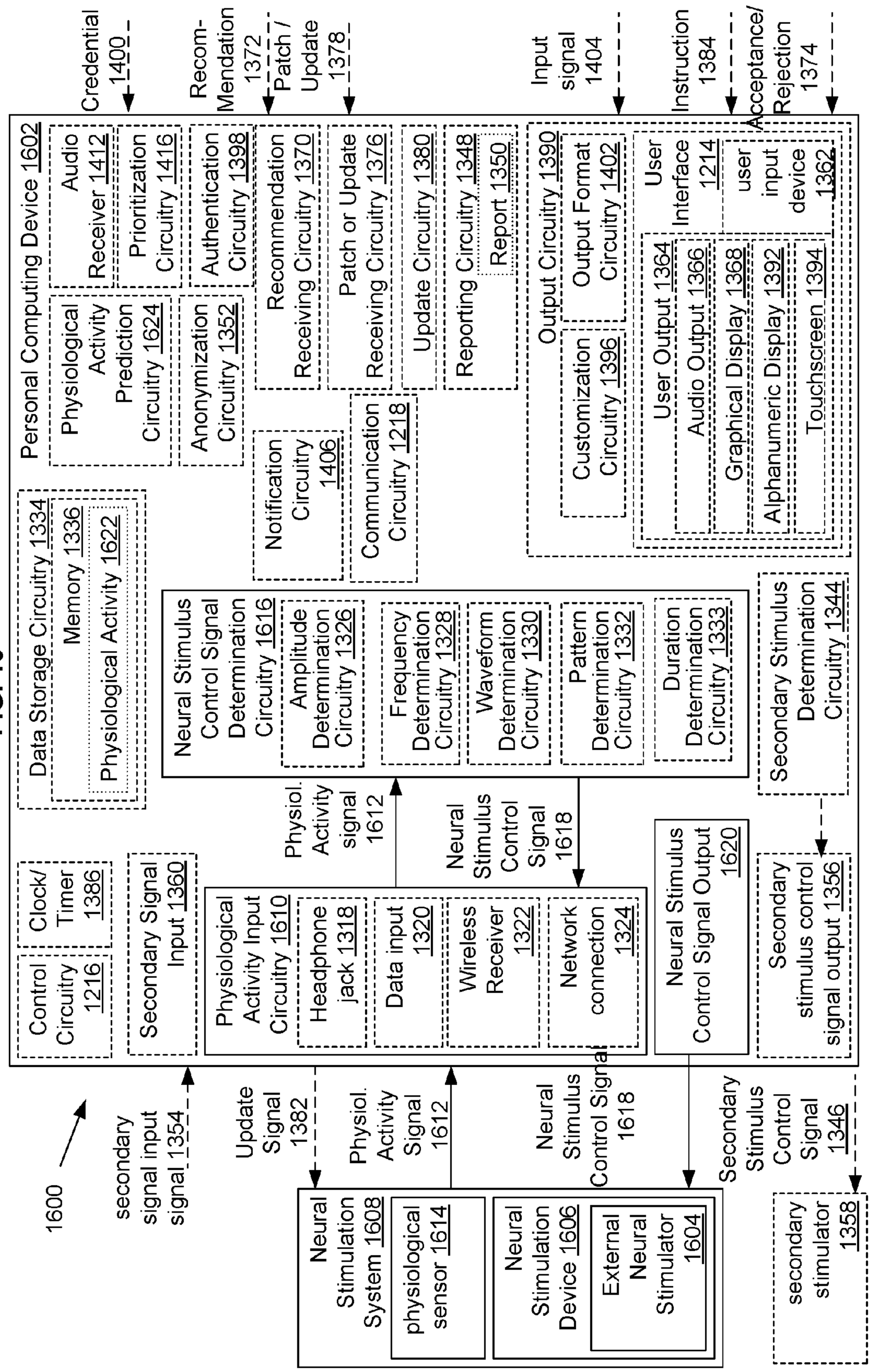

1600
Personal Computing Device 1602
Audio Receiver 1412
Prioritization Circuitry 1416
Authentication Circuitry 1398
Recommendation Receiving Circuitry 1370
Patch or Update Receiving Circuitry 1376
Update Circuitry 1380
Reporting Circuitry 1348
Report 1350
Output Circuitry 1390
Output Format Circuitry 1402
Customization Circuitry 1396
User Interface 1214
user input device 1362
User Output 1364
Audio Output 1366
Graphical Display 1368
Alphanumeric Display 1392
Touchscreen 1394
Physiological Activity Prediction Circuitry 1624
Anonymization Circuitry 1352
Notification Circuitry 1406
Communication Circuitry 1218
Data Storage Circuitry 1334
Memory 1336
Physiological Activity 1622
Neural Stimulus Control Signal Determination Circuitry 1616
Amplitude Determination Circuitry 1326
Frequency Determination Circuitry 1328
Waveform Determination Circuitry 1330
Pattern Determination Circuitry 1332
Duration Determination Circuitry 1333
Secondary Stimulus Determination Circuitry 1344
Control Circuitry 1216
Clock/ Timer 1386
Secondary Signal Input 1360
Physiological Activity Input Circuitry 1610
Headphone jack 1318
Data input 1320
Wireless Receiver 1322
Network connection 1324
Neural Stimulus Control Signal Output 1620
Secondary stimulus control signal output 1356
Credential 1400
Recom-Mendation 1372
Patch / Update 1378
Input signal 1404
Instruction 1384
Acceptance/ Rejection 1374
Physiol. Activity signal 1612
Neural Stimulus Control Signal 1618
secondary signal input signal 1354
Update Signal 1382
Physiol. Activity Signal 1612
Neural Stimulus Control Signal 1618
Secondary Stimulus Control Signal 1346
Neural Stimulation System 1608
physiological sensor 1614
Neural Stimulation Device 1606
External Neural Stimulator 1604
secondary stimulator 1358

FIG. 16

FIG. 17

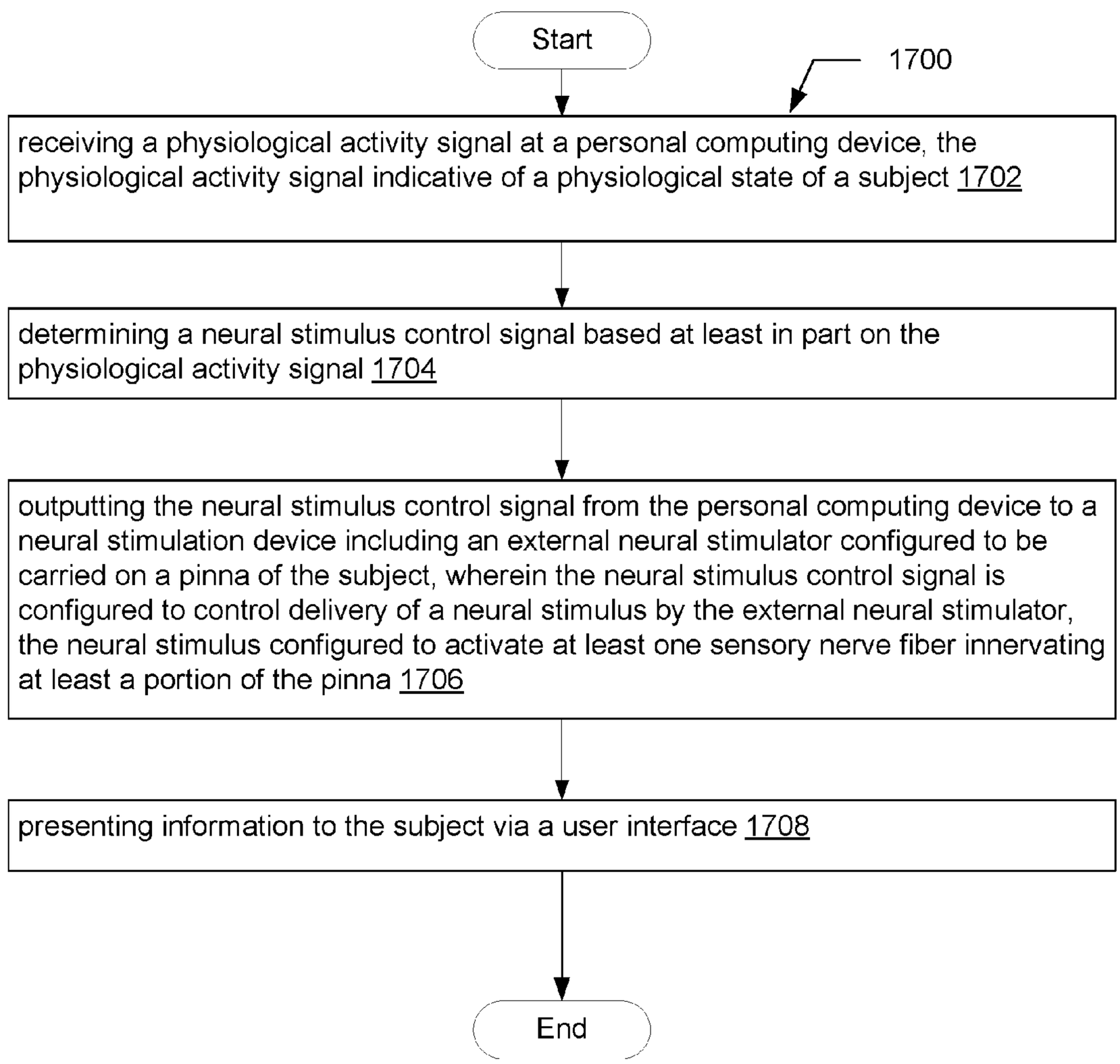

Start
1700
receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological state of a subject 1702
determining a neural stimulus control signal based at least in part on the physiological activity signal 1704
outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna 1706
presenting information to the subject via a user interface 1708
End

FIG. 18

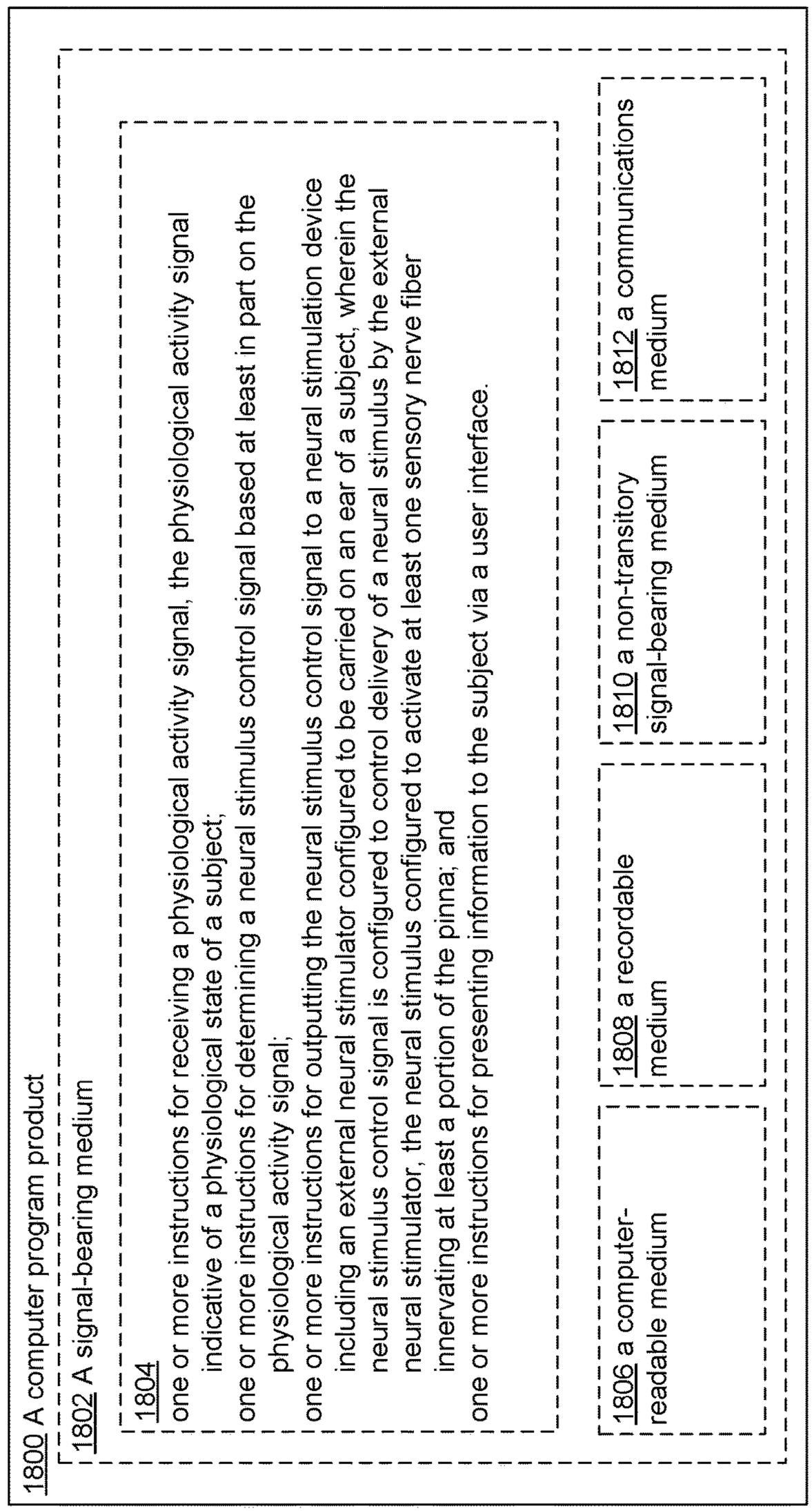

1800 A computer program product
1802 A signal-bearing medium
1804
one or more instructions for receiving a physiological activity signal, the physiological activity signal indicative of a physiological state of a subject;
one or more instructions for determining a neural stimulus control signal based at least in part on the physiological activity signal;
one or more instructions for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on an ear of a subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna; and
one or more instructions for presenting information to the subject via a user interface.
1806 a computer-readable medium
1808 a recordable medium
1810 a non-transitory signal-bearing medium
1812 a communications medium

FIG. 19

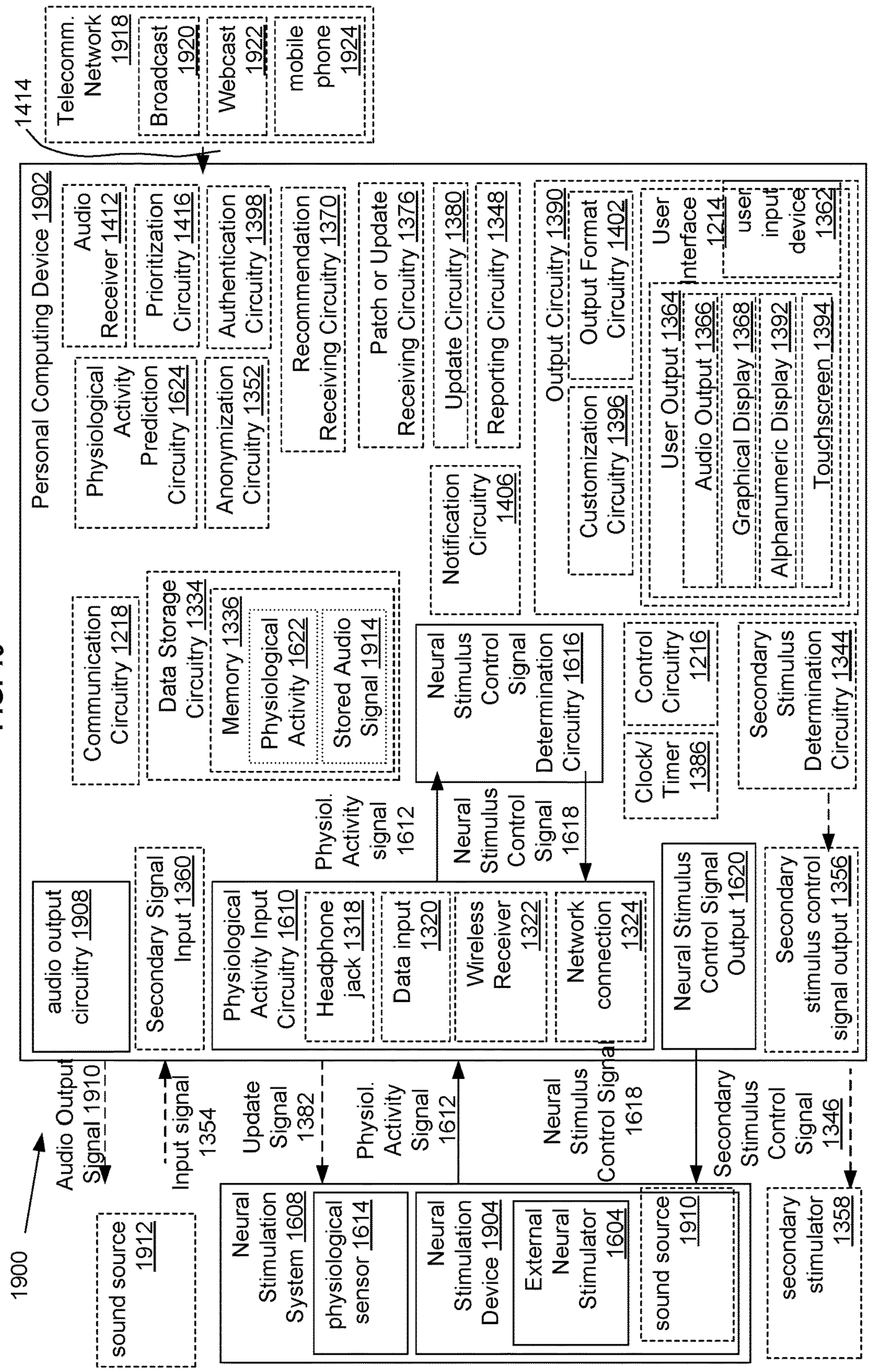

1900
1414
Telecomm. Network 1918
Broadcast 1920
Webcast 1922
mobile phone 1924
Personal Computing Device 1902
Audio Receiver 1412
Prioritization Circuitry 1416
Authentication Circuitry 1398
Physiological Activity Prediction Circuitry 1624
Anonymization Circuitry 1352
Recommendation Receiving Circuitry 1370
Patch or Update Receiving Circuitry 1376
Update Circuitry 1380
Reporting Circuitry 1348
Output Circuitry 1390
Output Format Circuitry 1402
Customization Circuitry 1396
User Interface 1214
User Output 1364
Audio Output 1366
Graphical Display 1368
Alphanumeric Display 1392
Touchscreen 1394
user input device 1362
Notification Circuitry 1406
Communication Circuitry 1218
Data Storage Circuitry 1334
Memory 1336
Physiological Activity 1622
Stored Audio Signal 1914
Neural Stimulus Control Signal Determination Circuitry 1616
Control Circuitry 1216
Clock/ Timer 1386
Secondary Stimulus Determination Circuitry 1344
Physiol. Activity signal 1612
Neural Stimulus Control Signal 1618
audio output circuitry 1908
Secondary Signal Input 1360
Physiological Activity Input Circuitry 1610
Headphone jack 1318
Data input 1320
Wireless Receiver 1322
Network connection 1324
Neural Stimulus Control Signal Output 1620
Secondary stimulus control signal output 1356
Audio Output Signal 1910
Input signal 1354
Update Signal 1382
Physiol. Activity Signal 1612
Neural Stimulus Control Signal 1618
Secondary Stimulus Control Signal 1346
sound source 1912
Neural Stimulation System 1608
physiological sensor 1614
Neural Stimulation Device 1904
External Neural Stimulator 1604
sound source 1910
secondary stimulator 1358

FIG. 20

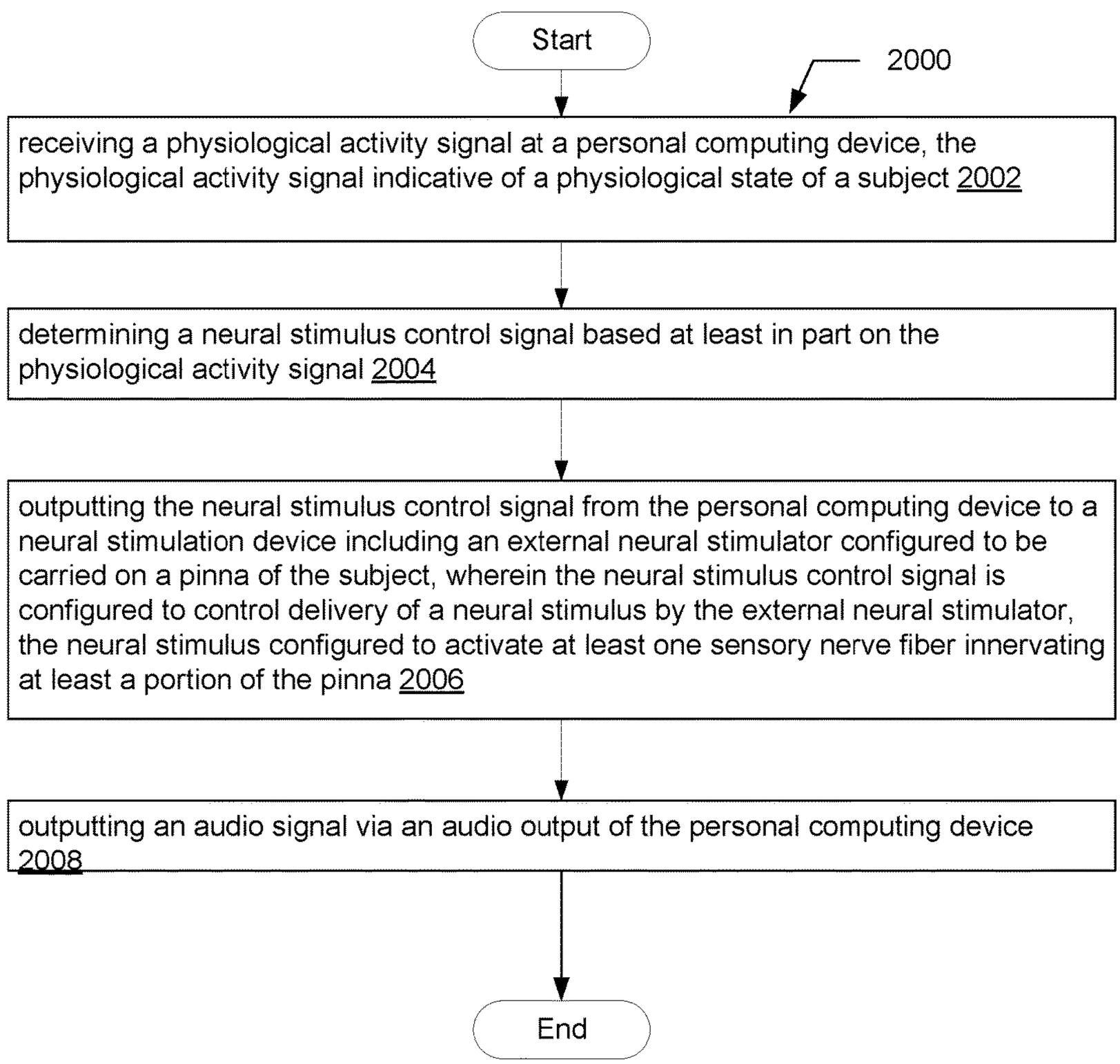
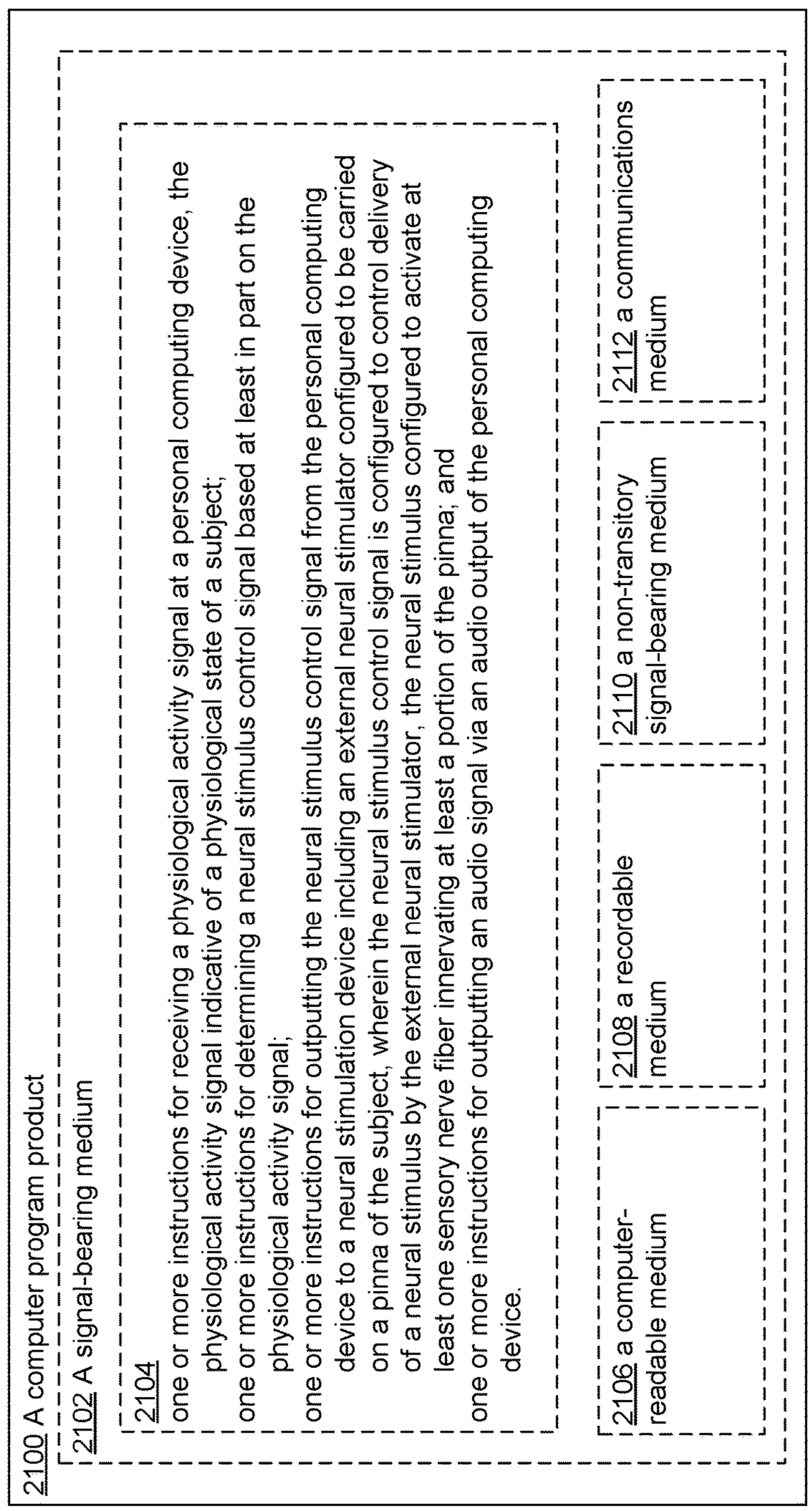

Start
2000
receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological state of a subject 2002
determining a neural stimulus control signal based at least in part on the physiological activity signal 2004
outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna 2006
outputting an audio signal via an audio output of the personal computing device 2008
End

FIG. 21


2100 A computer program product
2102 A signal-bearing medium
2104
one or more instructions for receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological state of a subject;
one or more instructions for determining a neural stimulus control signal based at least in part on the physiological activity signal;
one or more instructions for outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna; and
one or more instructions for outputting an audio signal via an audio output of the personal computing device.
2106 a computer-readable medium
2108 a recordable medium
2110 a non-transitory signal-bearing medium
2112 a communications medium

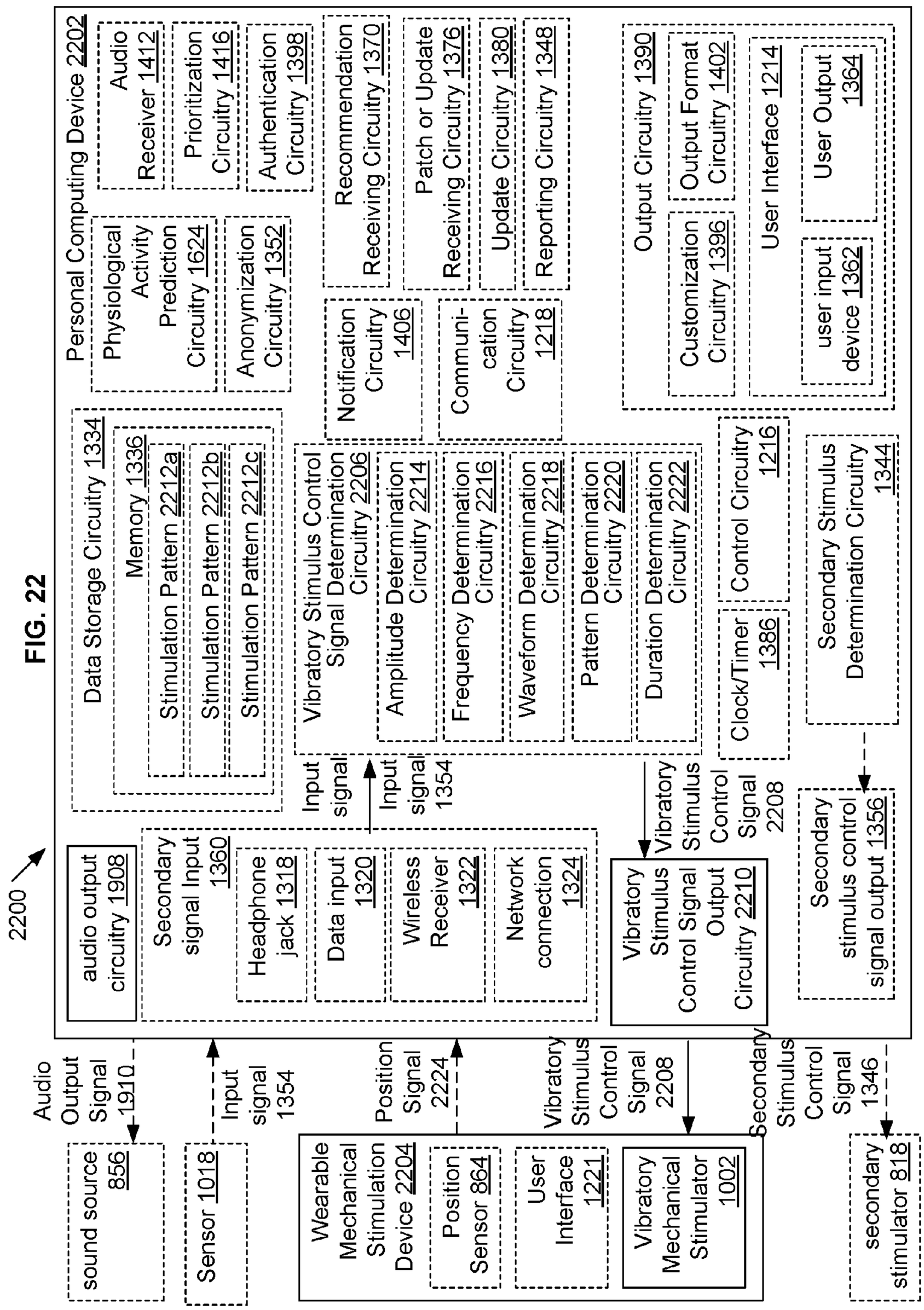

2200
Personal Computing Device 2202
Audio Receiver 1412
Prioritization Circuitry 1416
Authentication Circuitry 1398
Physiological Activity Prediction Circuitry 1624
Anonymization Circuitry 1352
Recommendation Receiving Circuitry 1370
Patch or Update Receiving Circuitry 1376
Update Circuitry 1380
Reporting Circuitry 1348
Notification Circuitry 1406
Communi-cation Circuitry 1218
Output Circuitry 1390
Output Format Circuitry 1402
Customization Circuitry 1396
User Interface 1214
User Output 1364
user input device 1362
Data Storage Circuitry 1334
Memory 1336
Stimulation Pattern 2212a
Stimulation Pattern 2212b
Stimulation Pattern 2212c
Vibratory Stimulus Control Signal Determination Circuitry 2206
Amplitude Determination Circuitry 2214
Frequency Determination Circuitry 2216
Waveform Determination Circuitry 2218
Pattern Determination Circuitry 2220
Duration Determination Circuitry 2222
Control Circuitry 1216
Clock/Timer 1386
Secondary Stimulus Determination Circuitry 1344
Input signal
Input signal 1354
audio output circuitry 1908
Secondary signal Input 1360
Headphone jack 1318
Data input 1320
Wireless Receiver 1322
Network connection 1324
Vibratory Stimulus Control Signal Output Circuitry 2210
Vibratory Stimulus Control Signal 2208
Secondary stimulus control signal output 1356
Audio Output Signal 1910
Input signal 1354
Position Signal 2224
Vibratory Stimulus Control Signal 2208
Secondary Stimulus Control Signal 1346
sound source 856
Sensor 1018
Wearable Mechanical Stimulation Device 2204
Position Sensor 864
User Interface 1221
Vibratory Mechanical Stimulator 1002
secondary stimulator 818

FIG. 22

FIG. 23

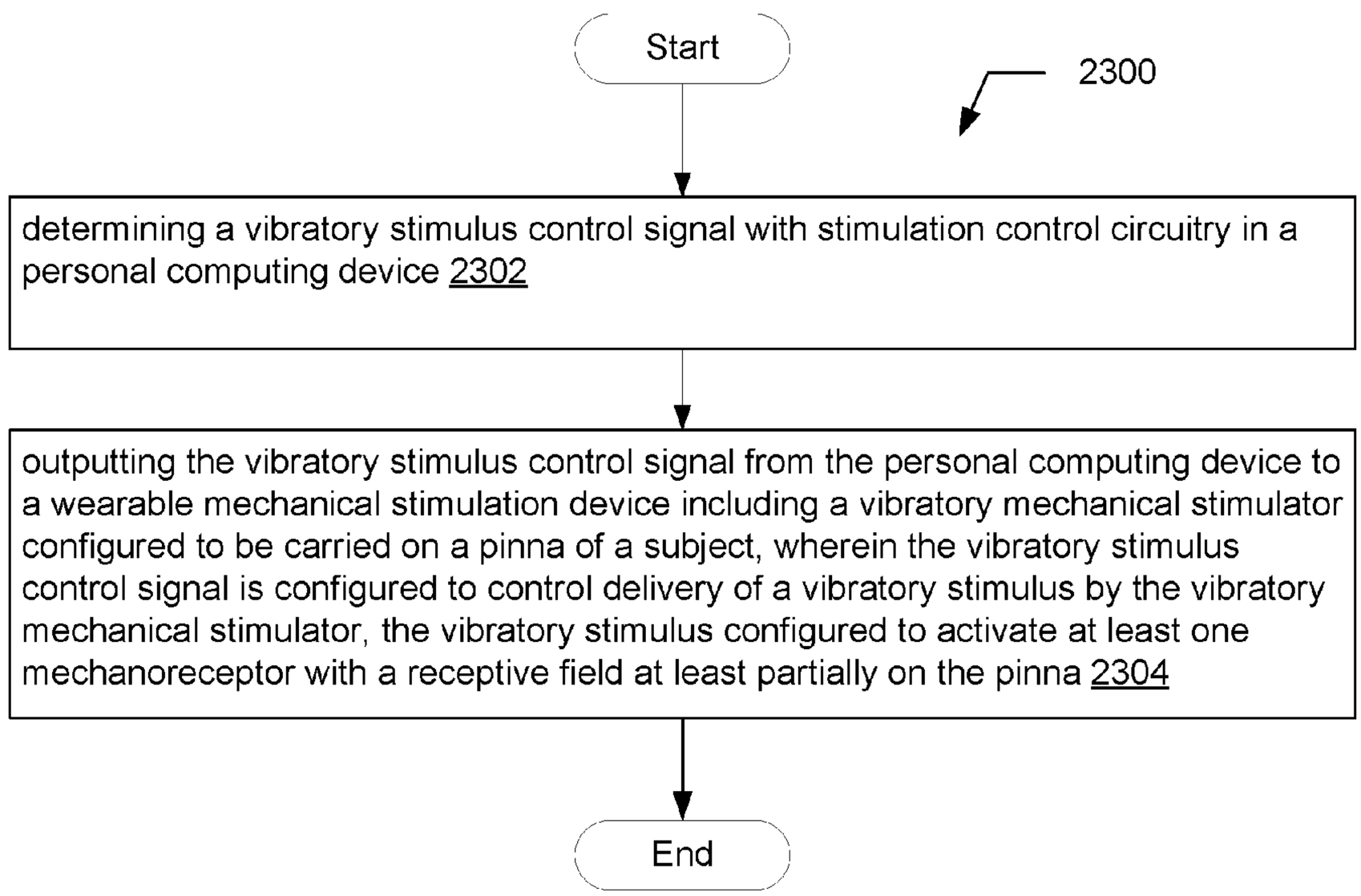
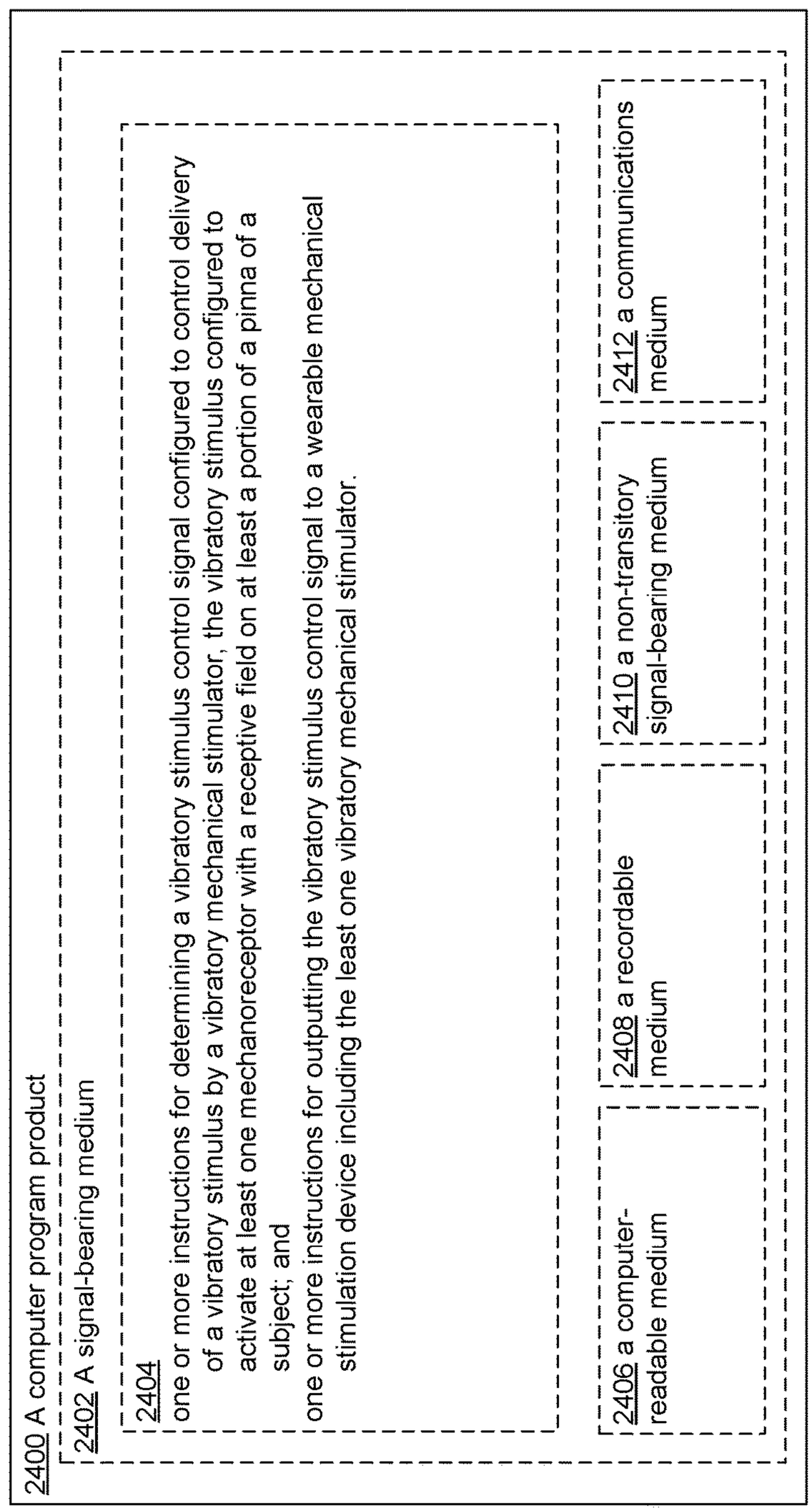

Start
2300
determining a vibratory stimulus control signal with stimulation control circuitry in a personal computing device 2302
outputting the vibratory stimulus control signal from the personal computing device to a wearable mechanical stimulation device including a vibratory mechanical stimulator configured to be carried on a pinna of a subject, wherein the vibratory stimulus control signal is configured to control delivery of a vibratory stimulus by the vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field at least partially on the pinna 2304
End

FIG. 24


2400 A computer program product
2402 A signal-bearing medium
2404
one or more instructions for determining a vibratory stimulus control signal configured to control delivery of a vibratory stimulus by a vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field on at least a portion of a pinna of a subject; and
one or more instructions for outputting the vibratory stimulus control signal to a wearable mechanical stimulation device including the least one vibratory mechanical stimulator.
2406 a computer-readable medium
2408 a recordable medium
2410 a non-transitory signal-bearing medium
2412 a communications medium

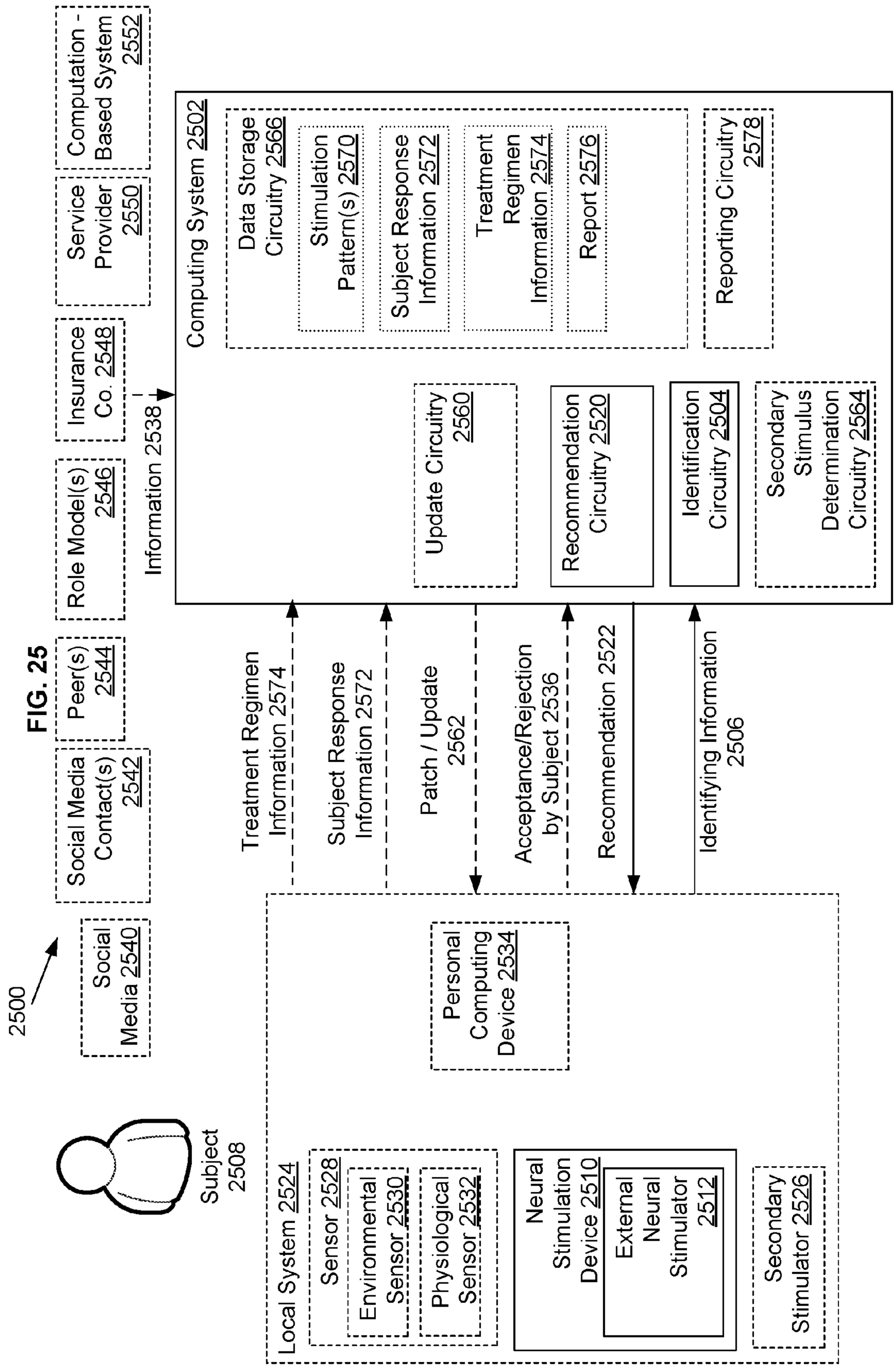

2500
Social Media 2540
Social Media Contact(s) 2542
Peer(s) 2544
Role Model(s) 2546
Insurance Co. 2548
Service Provider 2550
Computation - Based System 2552
Information 2538
Computing System 2502
Data Storage Circuitry 2566
Stimulation Pattern(s) 2570
Subject Response Information 2572
Treatment Regimen Information 2574
Report 2576
Reporting Circuitry 2578
Update Circuitry 2560
Recommendation Circuitry 2520
Identification Circuitry 2504
Secondary Stimulus Determination Circuitry 2564
Treatment Regimen Information 2574
Subject Response Information 2572
Patch / Update 2562
Acceptance/Rejection by Subject 2536
Recommendation 2522
Identifying Information 2506
Subject 2508
Personal Computing Device 2534
Local System 2524
Sensor 2528
Environmental Sensor 2530
Physiological Sensor 2532
Neural Stimulation Device 2510
External Neural Stimulator 2512
Secondary Stimulator 2526

FIG. 25

FIG. 26

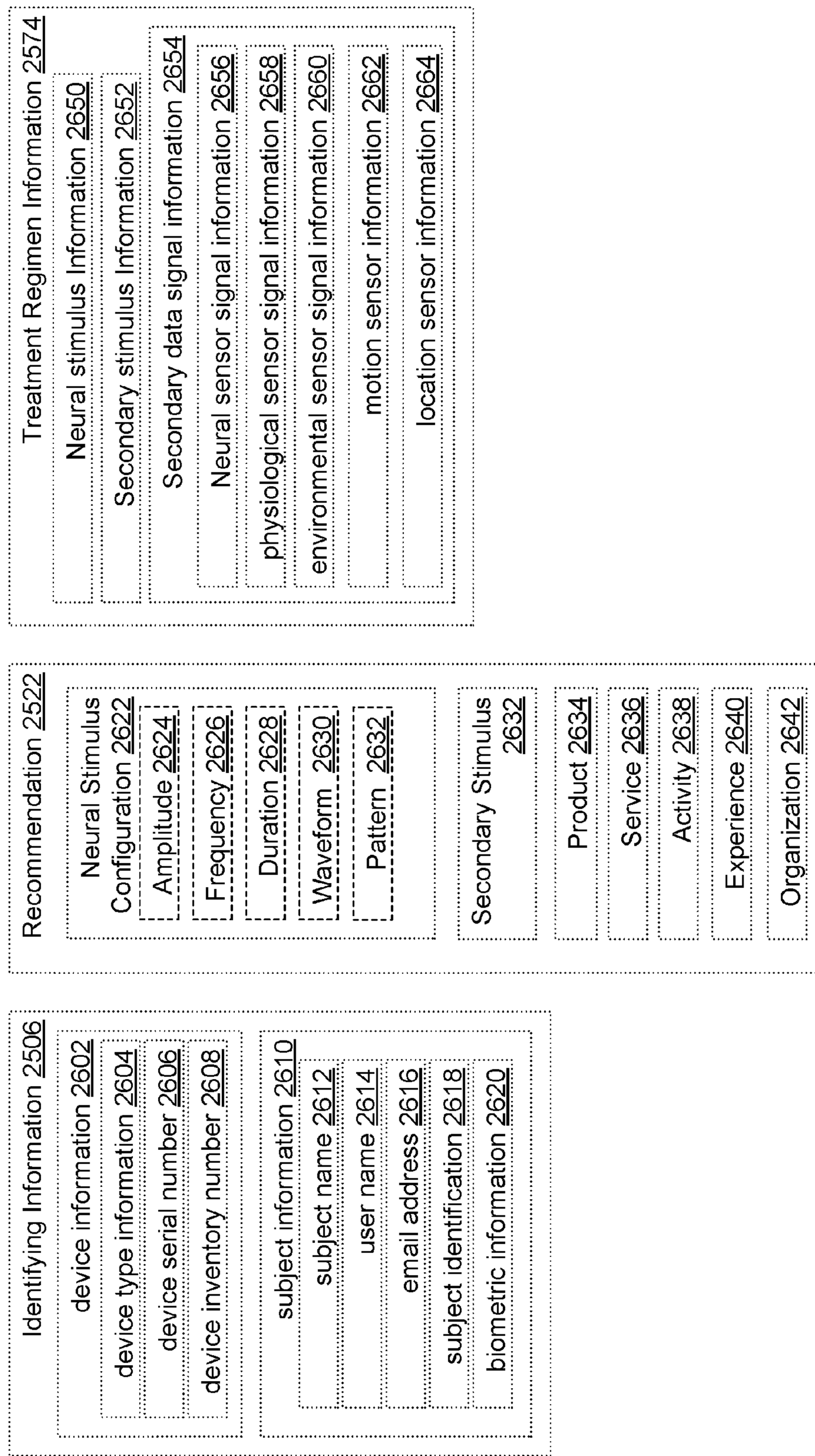

Treatment Regimen Information 2574
Neural stimulus Information 2650
Secondary stimulus Information 2652
Secondary data signal information 2654
Neural sensor signal information 2656
physiological sensor signal information 2658
environmental sensor signal information 2660
motion sensor information 2662
location sensor information 2664
Recommendation 2522
Neural Stimulus Configuration 2622
Amplitude 2624
Frequency 2626
Duration 2628
Waveform 2630
Pattern 2632
Secondary Stimulus 2632
Product 2634
Service 2636
Activity 2638
Experience 2640
Organization 2642
Identifying Information 2506
device information 2602
device type information 2604
device serial number 2606
device inventory number 2608
subject information 2610
subject name 2612
user name 2614
email address 2616
subject identification 2618
biometric information 2620

FIG. 27

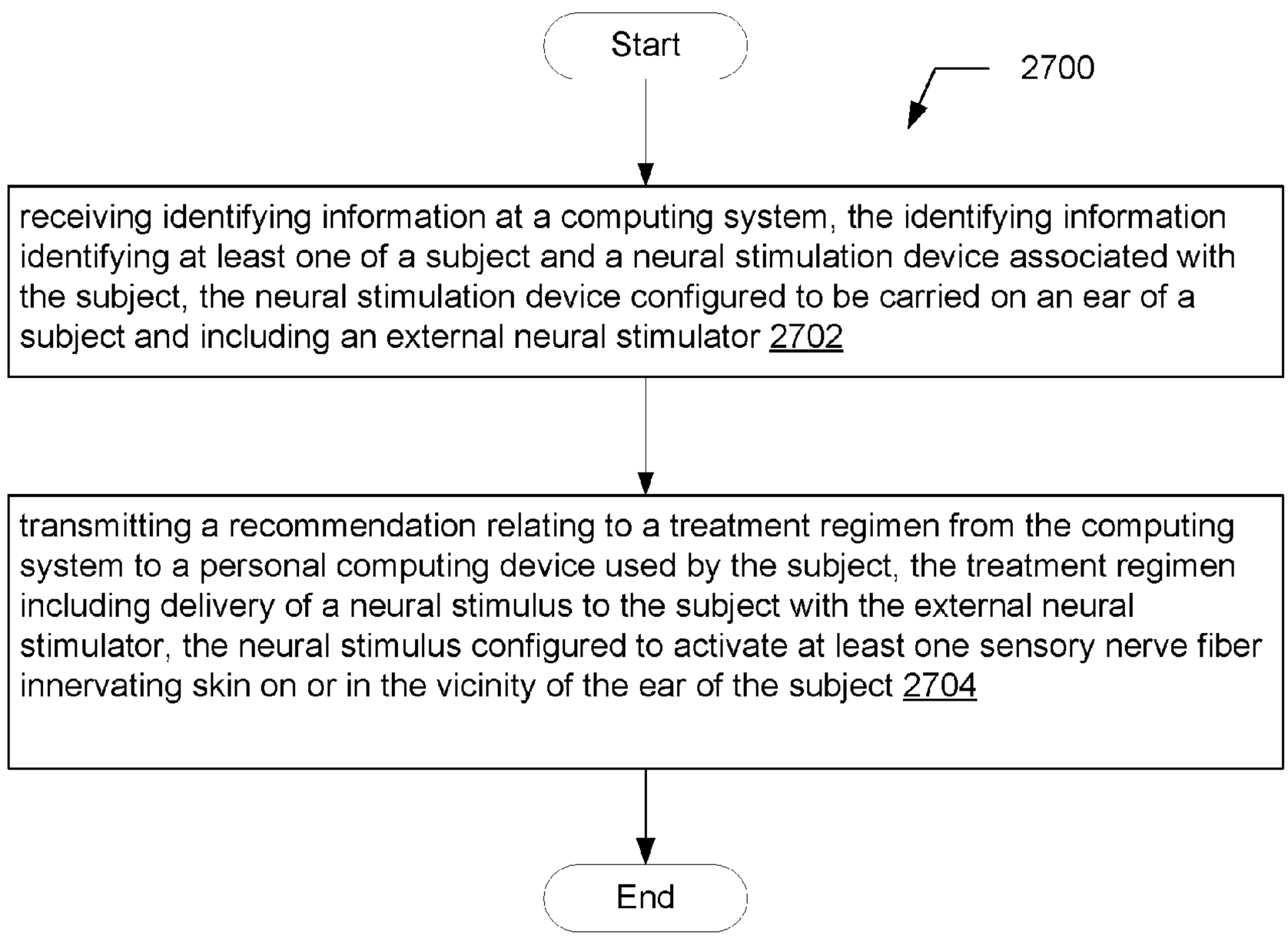
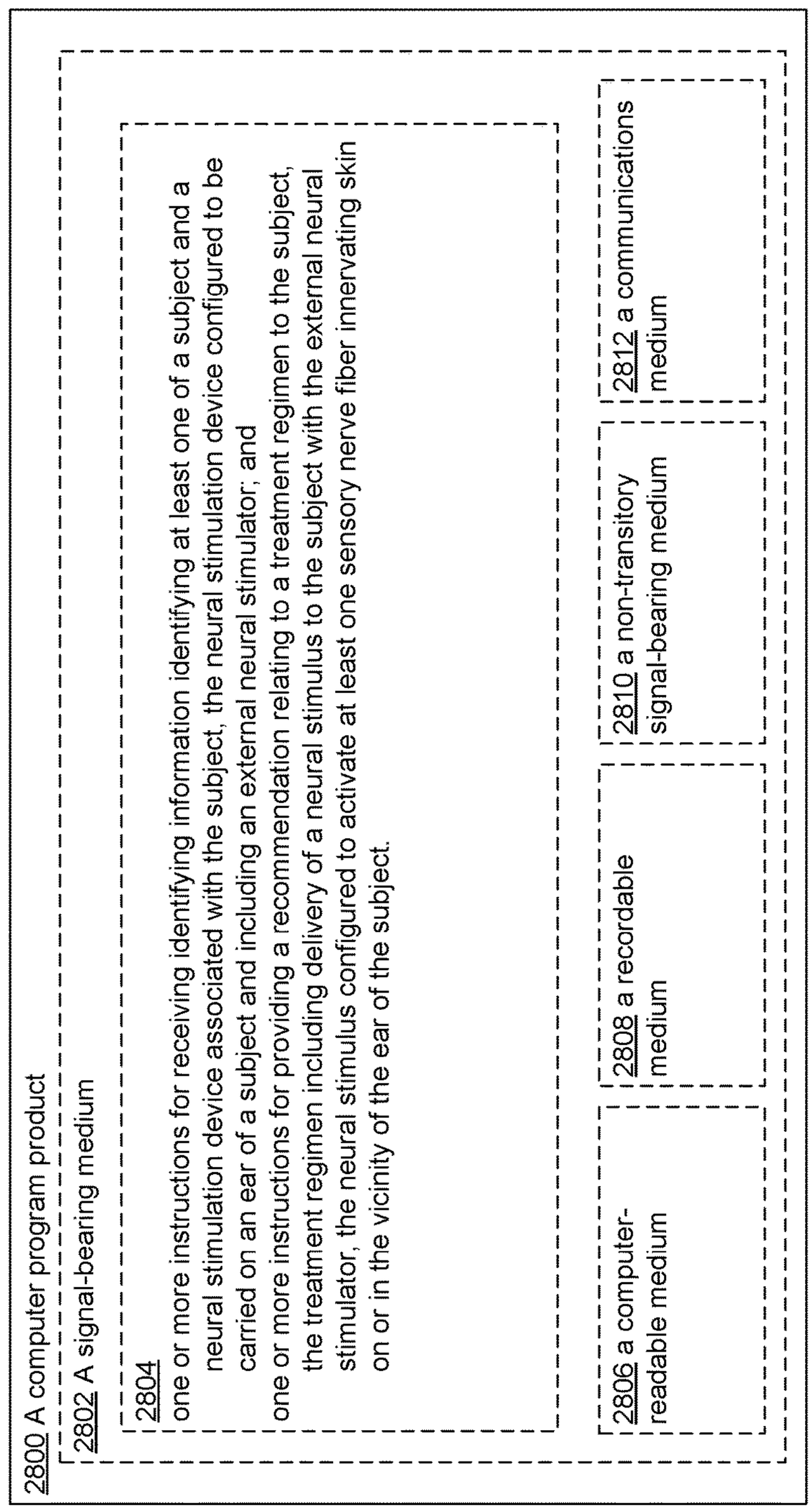

Start
2700
receiving identifying information at a computing system, the identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator 2702
transmitting a recommendation relating to a treatment regimen from the computing system to a personal computing device used by the subject, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject 2704
End

FIG. 28


2800 A computer program product
2802 A signal-bearing medium
2804
one or more instructions for receiving identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator; and
one or more instructions for providing a recommendation relating to a treatment regimen to the subject, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject.
2806 a computer-readable medium
2808 a recordable medium
2810 a non-transitory signal-bearing medium
2812 a communications medium

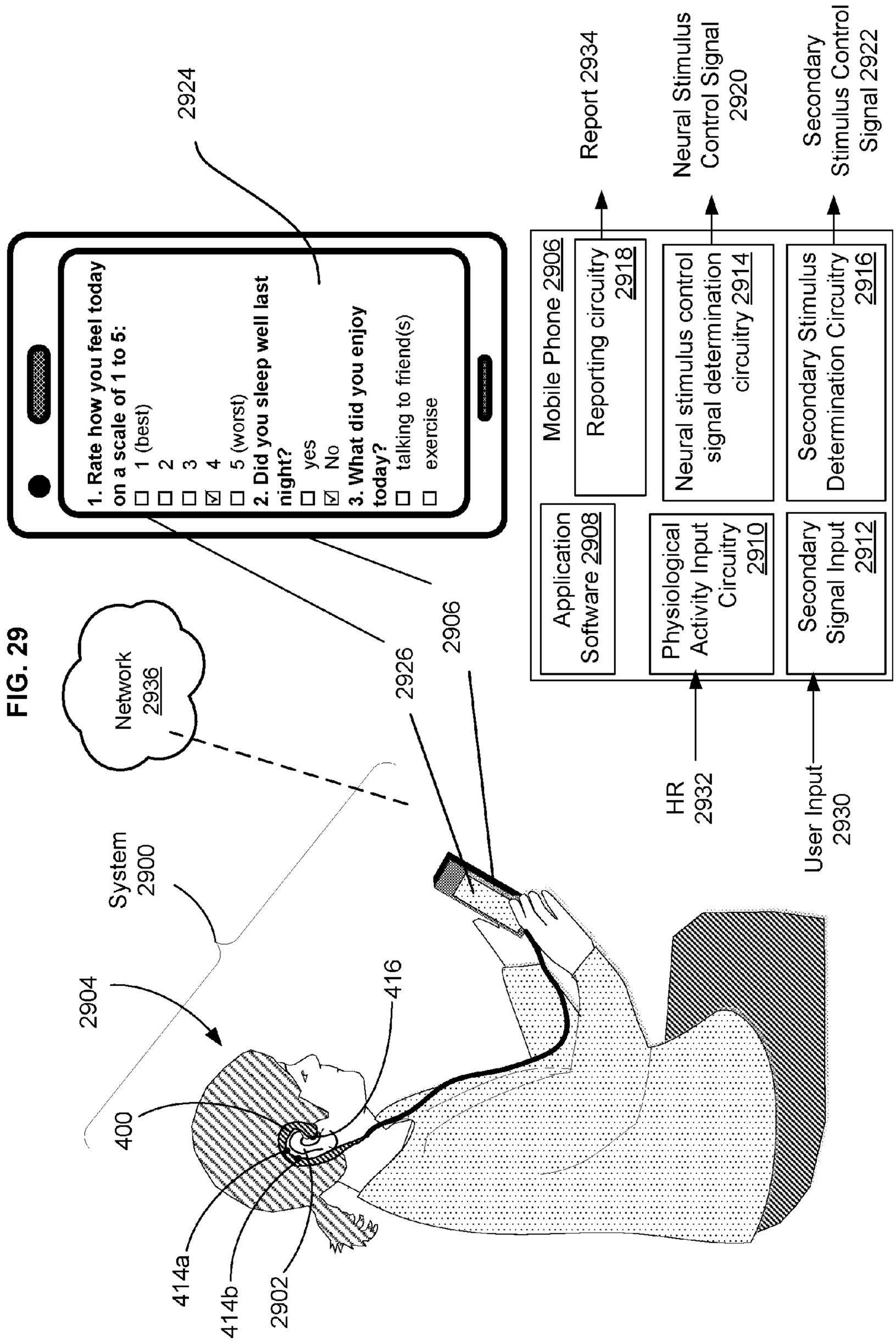

2924
1. Rate how you feel today on a scale of 1 to 5:
1 (best)
2
3
4
5 (worst)
2. Did you sleep well last night?
yes
No
3. What did you enjoy today?
talking to friend(s)
exercise
Report 2934
Neural Stimulus Control Signal 2920
Secondary Stimulus Control Signal 2922
Mobile Phone 2906
Reporting circuitry 2918
Neural stimulus control signal determination circuitry 2914
Secondary Stimulus Determination Circuitry 2916
Application Software 2908
Physiological Activity Input Circuitry 2910
Secondary Signal Input 2912
Network 2936
2926
2906
HR 2932
User Input 2930
System 2900
2904
416
400
414a
414b
2902

FIG. 29

FIG. 30

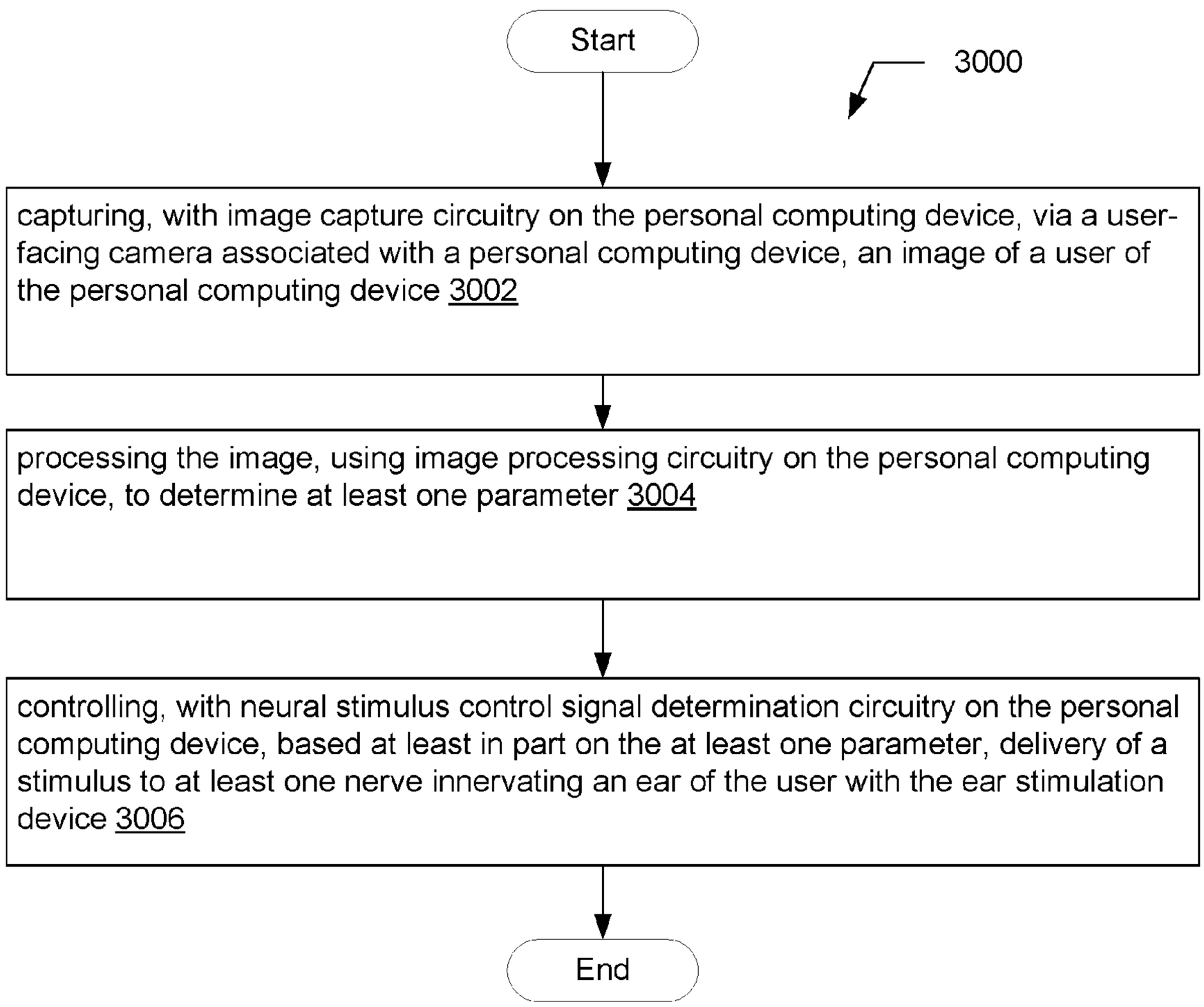

Start
3000
capturing, with image capture circuitry on the personal computing device, via a user-facing camera associated with a personal computing device, an image of a user of the personal computing device 3002
processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter 3004
controlling, with neural stimulus control signal determination circuitry on the personal computing device, based at least in part on the at least one parameter, delivery of a stimulus to at least one nerve innervating an ear of the user with the ear stimulation device 3006
End

FIG. 31

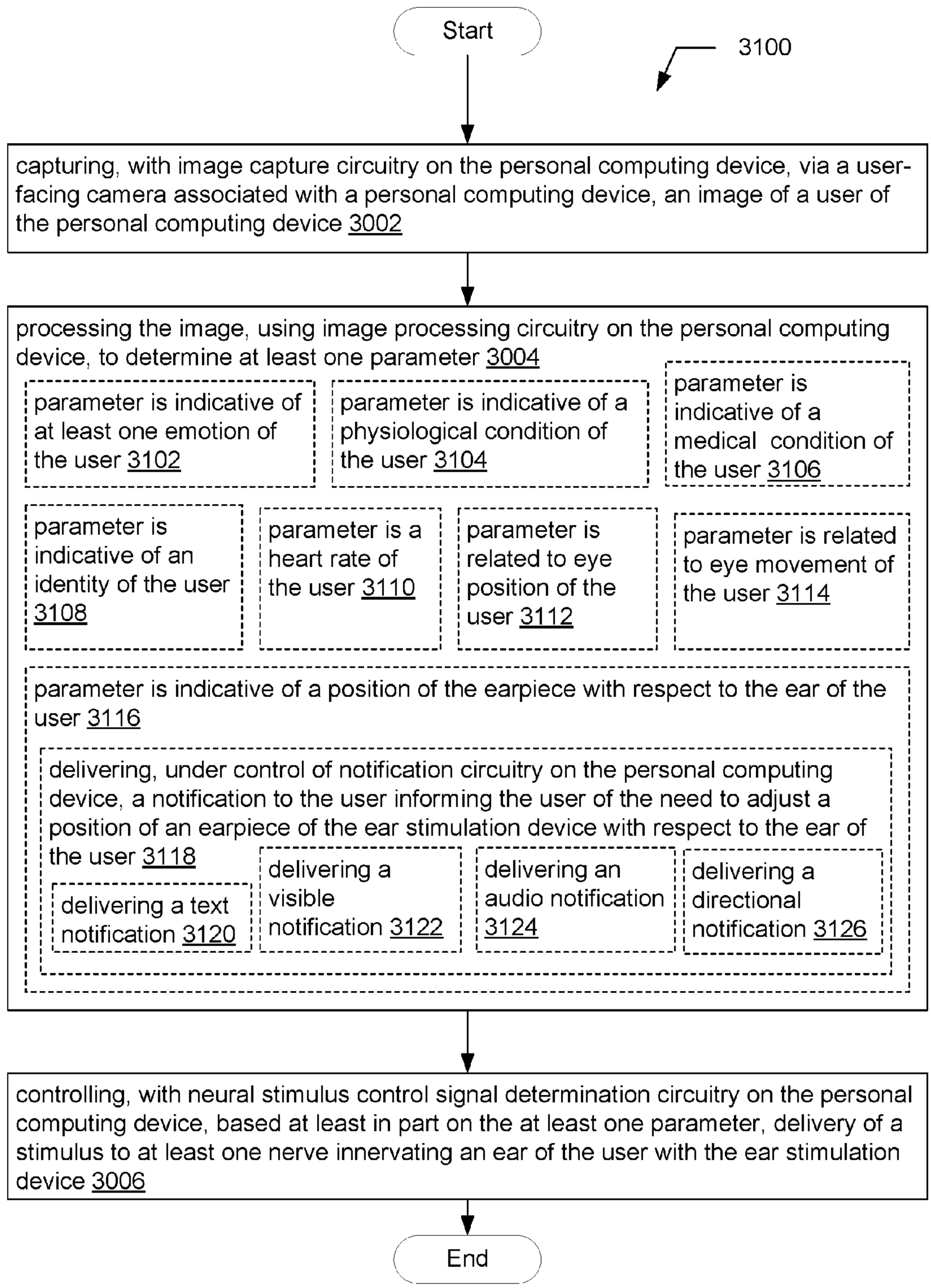

Start
3100
capturing, with image capture circuitry on the personal computing device, via a user-facing camera associated with a personal computing device, an image of a user of the personal computing device 3002
processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter 3004
parameter is indicative of at least one emotion of the user 3102
parameter is indicative of a physiological condition of the user 3104
parameter is indicative of a medical condition of the user 3106
parameter is indicative of an identity of the user 3108
parameter is a heart rate of the user 3110
parameter is related to eye position of the user 3112
parameter is related to eye movement of the user 3114
parameter is indicative of a position of the earpiece with respect to the ear of the user 3116
delivering, under control of notification circuitry on the personal computing device, a notification to the user informing the user of the need to adjust a position of an earpiece of the ear stimulation device with respect to the ear of the user 3118
delivering a text notification 3120
delivering a visible notification 3122
delivering an audio notification 3124
delivering a directional notification 3126
controlling, with neural stimulus control signal determination circuitry on the personal computing device, based at least in part on the at least one parameter, delivery of a stimulus to at least one nerve innervating an ear of the user with the ear stimulation device 3006
End

FIG. 32

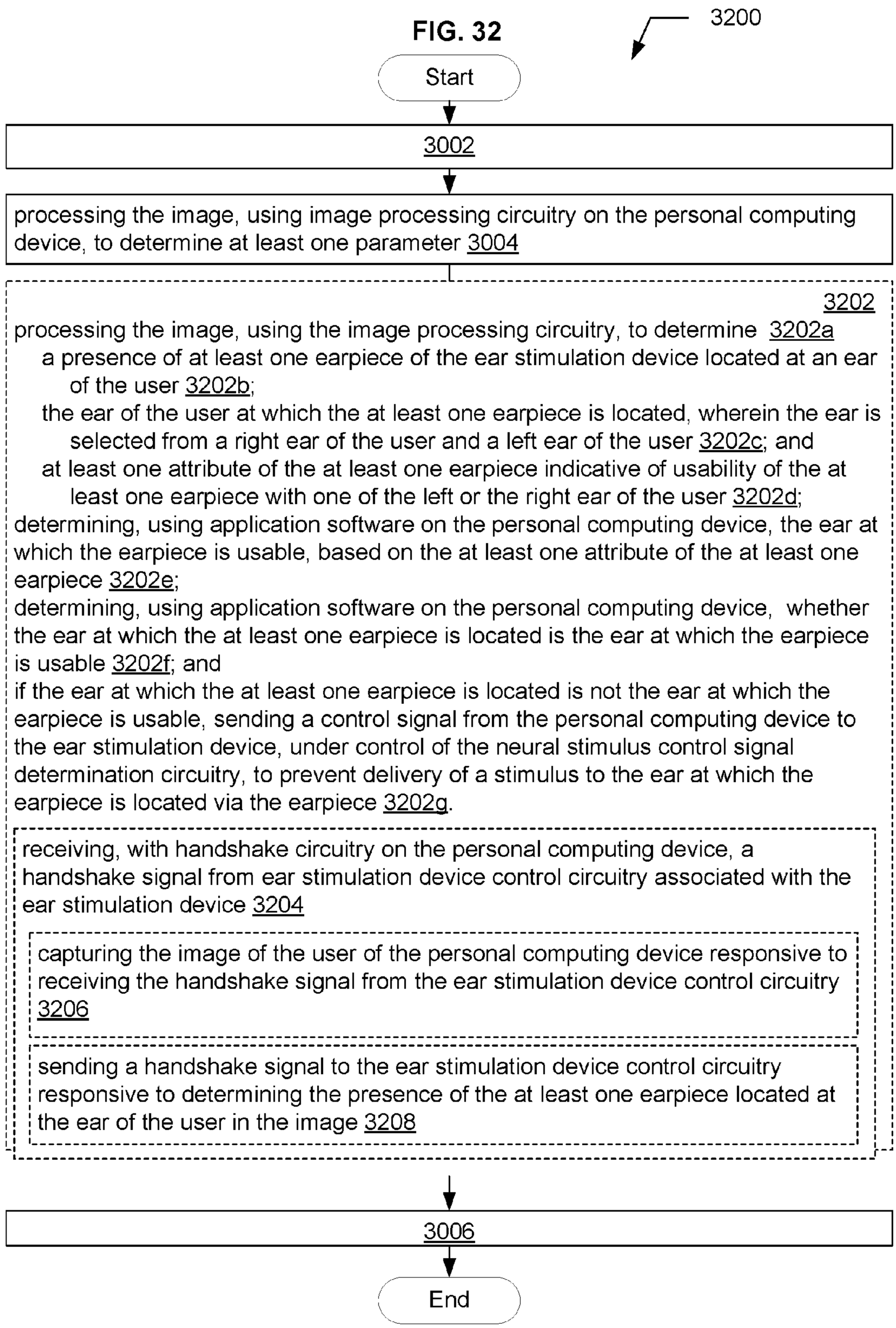

3200
Start
3002
processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter 3004
3202
processing the image, using the image processing circuitry, to determine 3202a
a presence of at least one earpiece of the ear stimulation device located at an ear of the user 3202b;
the ear of the user at which the at least one earpiece is located, wherein the ear is selected from a right ear of the user and a left ear of the user 3202c; and
at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with one of the left or the right ear of the user 3202d;
determining, using application software on the personal computing device, the ear at which the earpiece is usable, based on the at least one attribute of the at least one earpiece 3202e;
determining, using application software on the personal computing device, whether the ear at which the at least one earpiece is located is the ear at which the earpiece is usable 3202f; and
if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable, sending a control signal from the personal computing device to the ear stimulation device, under control of the neural stimulus control signal determination circuitry, to prevent delivery of a stimulus to the ear at which the earpiece is located via the earpiece 3202g.
receiving, with handshake circuitry on the personal computing device, a handshake signal from ear stimulation device control circuitry associated with the ear stimulation device 3204
capturing the image of the user of the personal computing device responsive to receiving the handshake signal from the ear stimulation device control circuitry 3206
sending a handshake signal to the ear stimulation device control circuitry responsive to determining the presence of the at least one earpiece located at the ear of the user in the image 3208
3006
End

FIG. 33

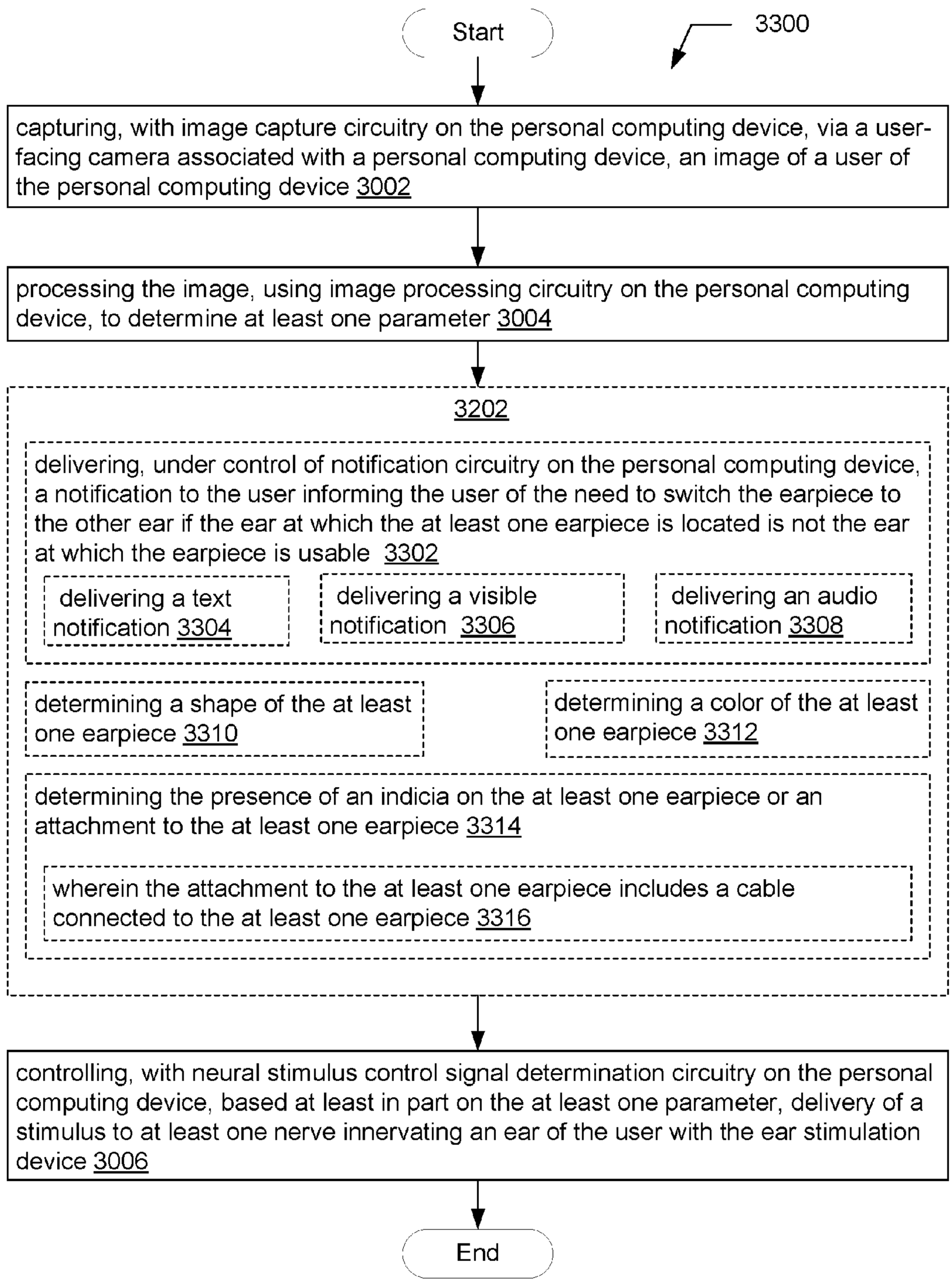
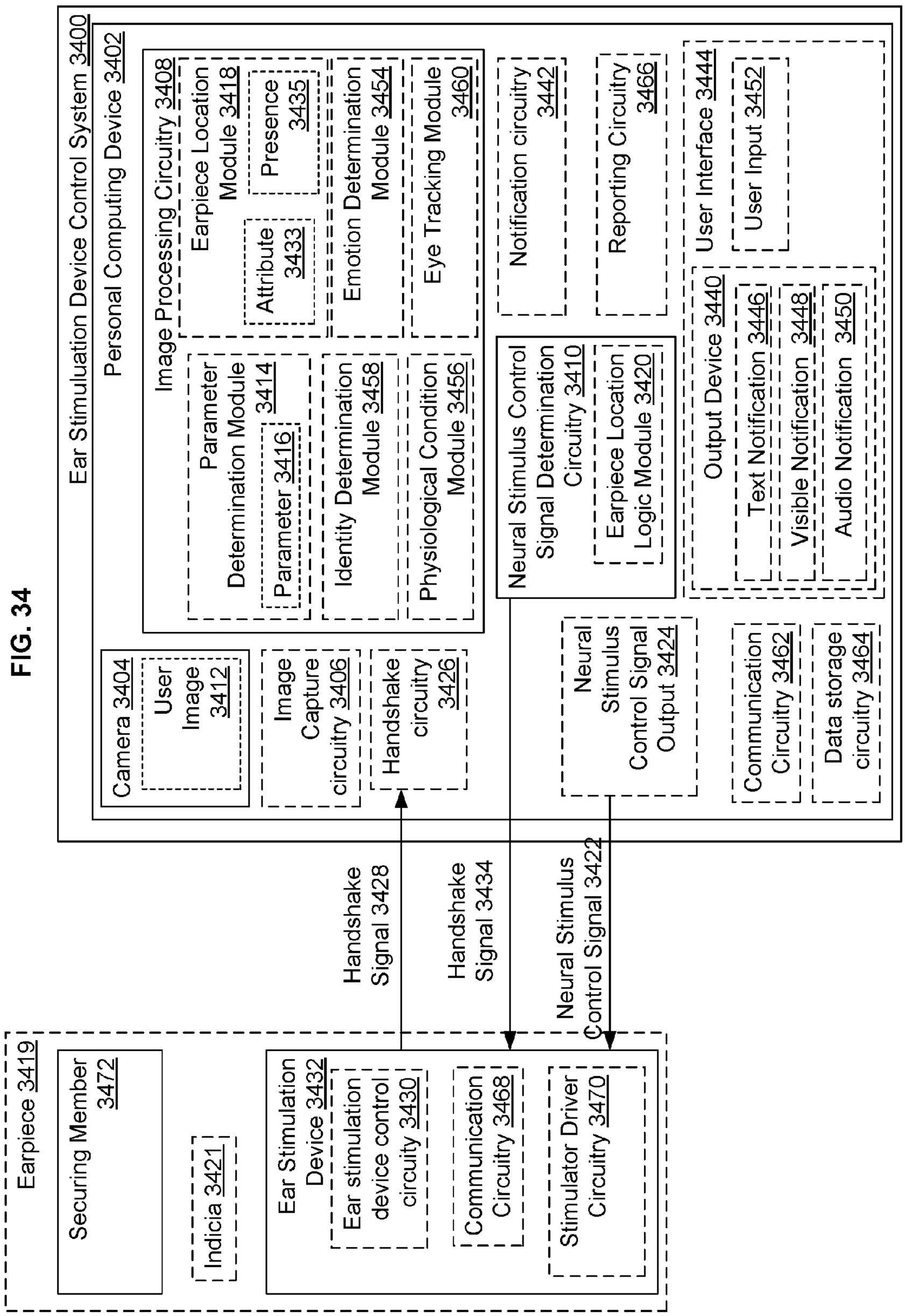

Start
3300
capturing, with image capture circuitry on the personal computing device, via a user-facing camera associated with a personal computing device, an image of a user of the personal computing device 3002
processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter 3004
3202
delivering, under control of notification circuitry on the personal computing device, a notification to the user informing the user of the need to switch the earpiece to the other ear if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable 3302
delivering a text notification 3304
delivering a visible notification 3306
delivering an audio notification 3308
determining a shape of the at least one earpiece 3310
determining a color of the at least one earpiece 3312
determining the presence of an indicia on the at least one earpiece or an attachment to the at least one earpiece 3314
wherein the attachment to the at least one earpiece includes a cable connected to the at least one earpiece 3316
controlling, with neural stimulus control signal determination circuitry on the personal computing device, based at least in part on the at least one parameter, delivery of a stimulus to at least one nerve innervating an ear of the user with the ear stimulation device 3006
End

FIG. 34


Ear Stimulation Device Control System 3400
Personal Computing Device 3402
Camera 3404
User Image 3412
Image Capture circuitry 3406
Handshake circuitry 3426
Image Processing Circuitry 3408
Parameter Determination Module 3414
Parameter 3416
Earpiece Location Module 3418
Attribute 3433
Presence 3435
Identity Determination Module 3458
Emotion Determination Module 3454
Physiological Condition Module 3456
Eye Tracking Module 3460
Neural Stimulus Control Signal Determination Circuitry 3410
Earpiece Location Logic Module 3420
Notification circuitry 3442
Reporting Circuitry 3466
Neural Stimulus Control Signal Output 3424
Output Device 3440
Text Notification 3446
Visible Notification 3448
Audio Notification 3450
User Interface 3444
User Input 3452
Communication Circuitry 3462
Data storage circuitry 3464
Handshake Signal 3428
Handshake Signal 3434
Neural Stimulus Control Signal 3422
Earpiece 3419
Securing Member 3472
Indicia 3421
Ear Stimulation Device 3432
Ear stimulation device control circuity 3430
Communication Circuitry 3468
Stimulator Driver Circuitry 3470

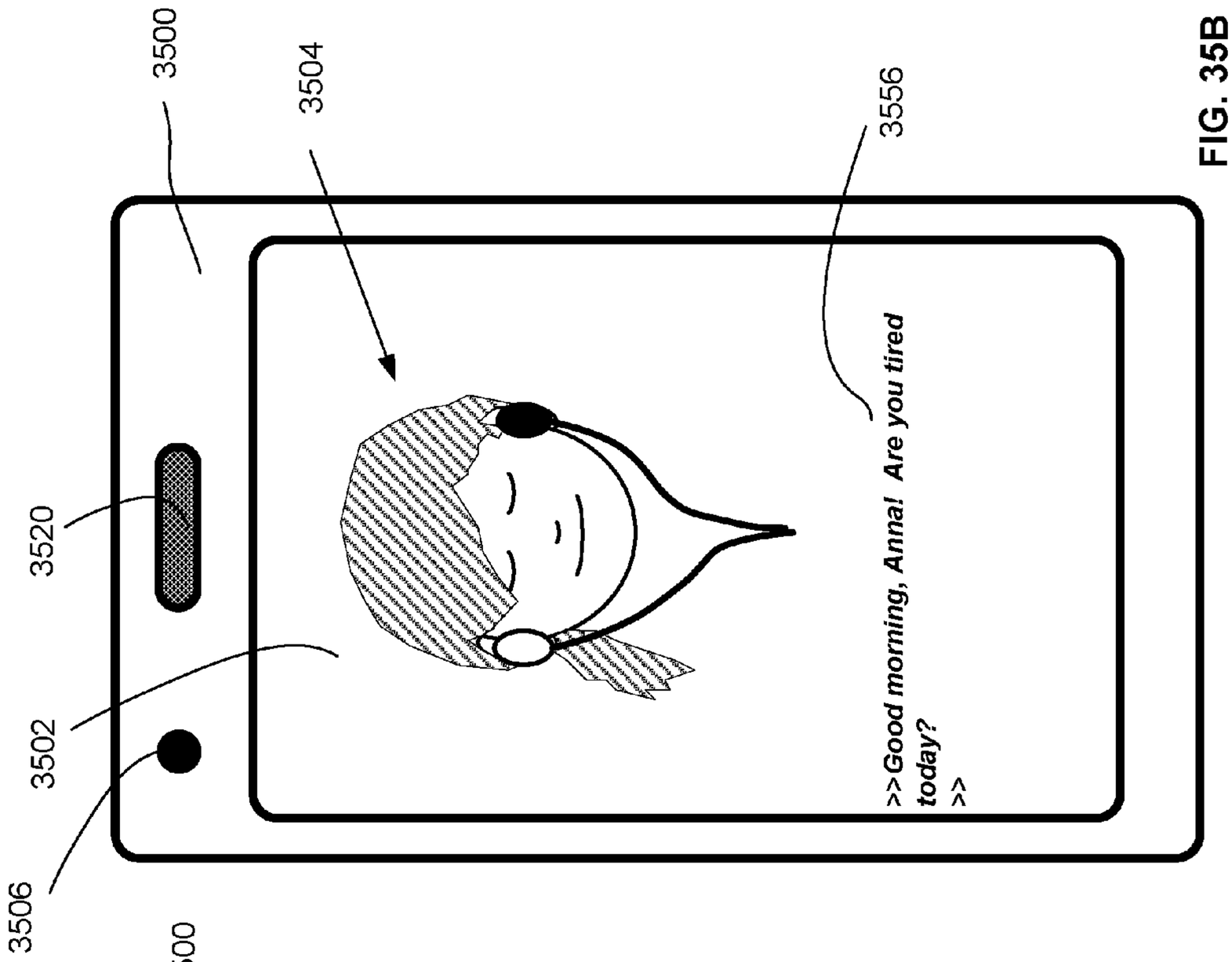


FIG. 35B

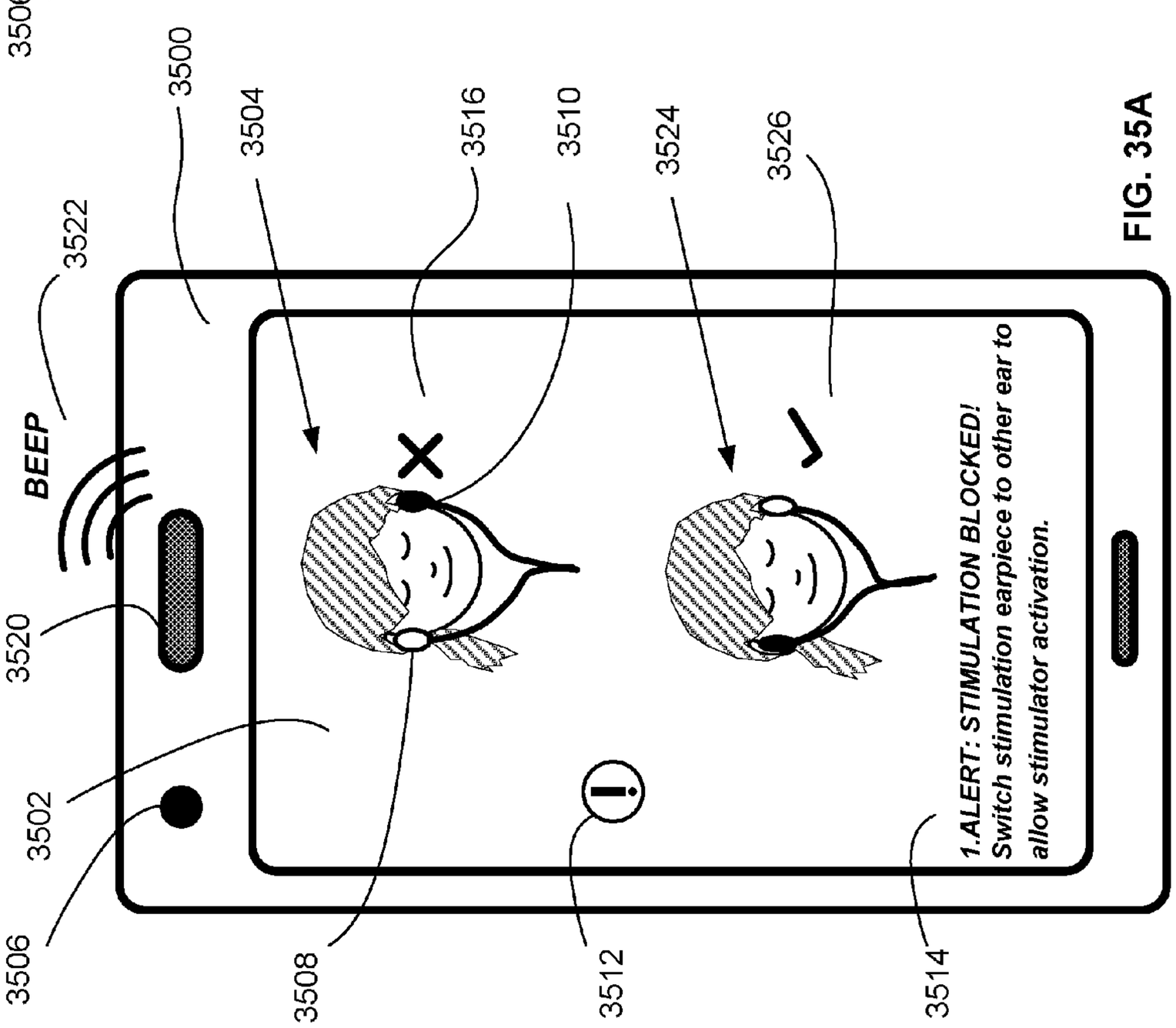


FIG. 35A

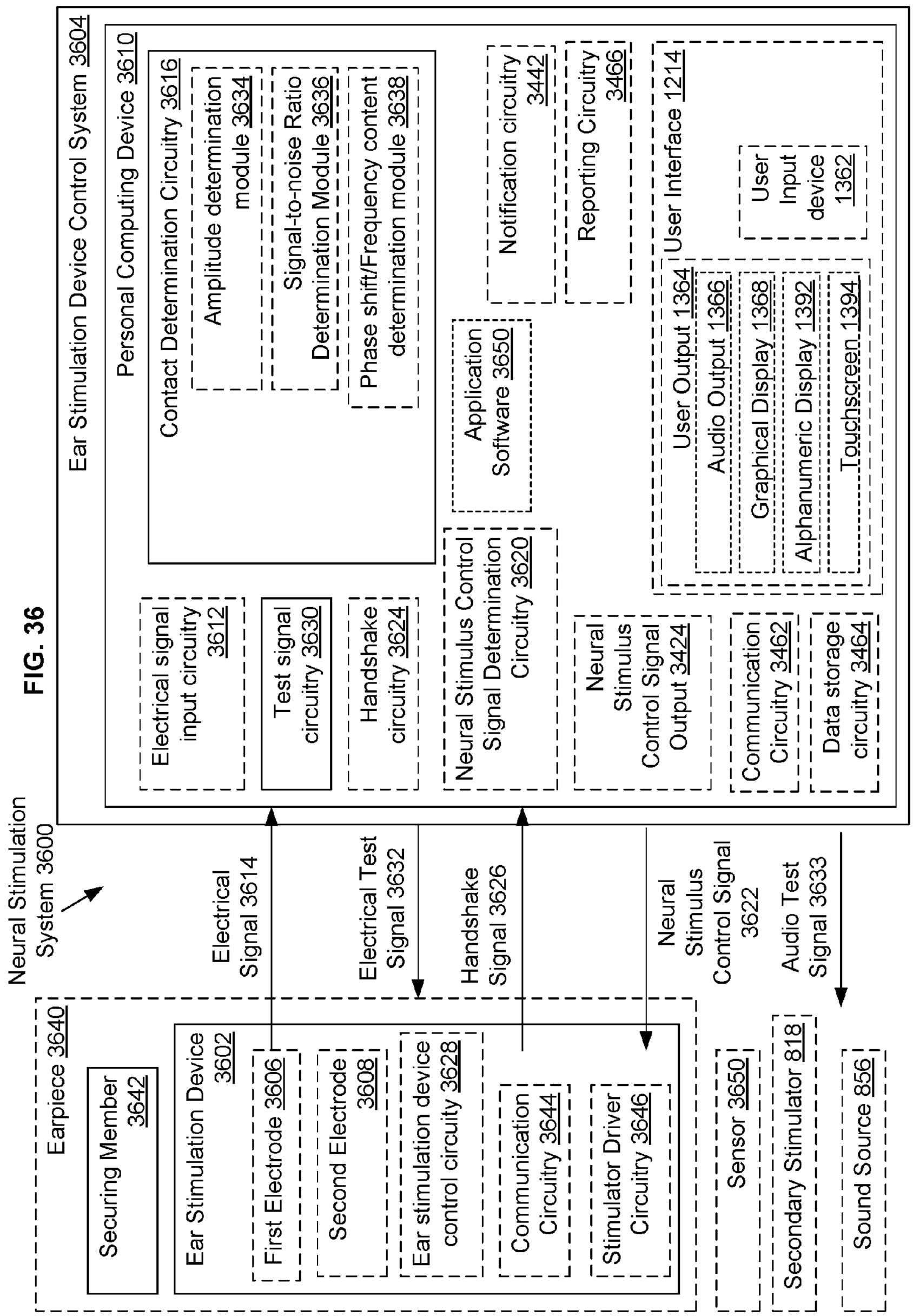

Neural Stimulation System 3600
Ear Stimulation Device Control System 3604
Personal Computing Device 3610
Contact Determination Circuitry 3616
Amplitude determination module 3634
Signal-to-noise Ratio Determination Module 3636
Phase shift/Frequency content determination module 3638
Electrical signal input circuitry 3612
Test signal circuitry 3630
Handshake circuitry 3624
Neural Stimulus Control Signal Determination Circuitry 3620
Application Software 3650
Notification circuitry 3442
Reporting Circuitry 3466
Neural Stimulus Control Signal Output 3424
Communication Circuitry 3462
Data storage circuitry 3464
User Interface 1214
User Output 1364
Audio Output 1366
Graphical Display 1368
Alphanumeric Display 1392
Touchscreen 1394
User Input device 1362
Electrical Signal 3614
Electrical Test Signal 3632
Handshake Signal 3626
Neural Stimulus Control Signal 3622
Audio Test Signal 3633
Earpiece 3640
Securing Member 3642
Ear Stimulation Device 3602
First Electrode 3606
Second Electrode 3608
Ear stimulation device control circuity 3628
Communication Circuitry 3644
Stimulator Driver Circuitry 3646
Sensor 3650
Secondary Stimulator 818
Sound Source 856

FIG. 36

FIG. 37

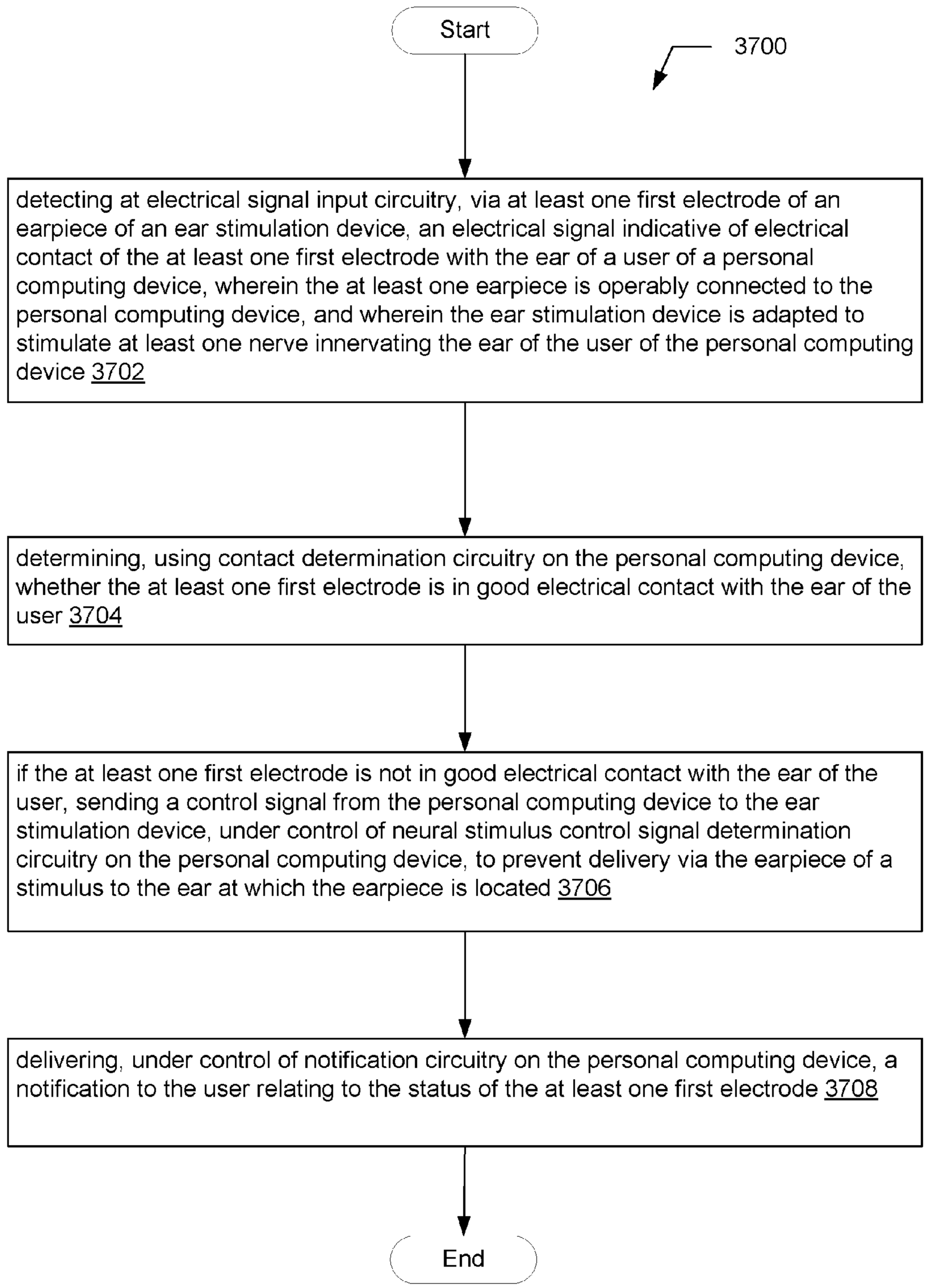

Start
3700
detecting at electrical signal input circuitry, via at least one first electrode of an earpiece of an ear stimulation device, an electrical signal indicative of electrical contact of the at least one first electrode with the ear of a user of a personal computing device, wherein the at least one earpiece is operably connected to the personal computing device, and wherein the ear stimulation device is adapted to stimulate at least one nerve innervating the ear of the user of the personal computing device 3702
determining, using contact determination circuitry on the personal computing device, whether the at least one first electrode is in good electrical contact with the ear of the user 3704
if the at least one first electrode is not in good electrical contact with the ear of the user, sending a control signal from the personal computing device to the ear stimulation device, under control of neural stimulus control signal determination circuitry on the personal computing device, to prevent delivery via the earpiece of a stimulus to the ear at which the earpiece is located 3706
delivering, under control of notification circuitry on the personal computing device, a notification to the user relating to the status of the at least one first electrode 3708
End

FIG. 38

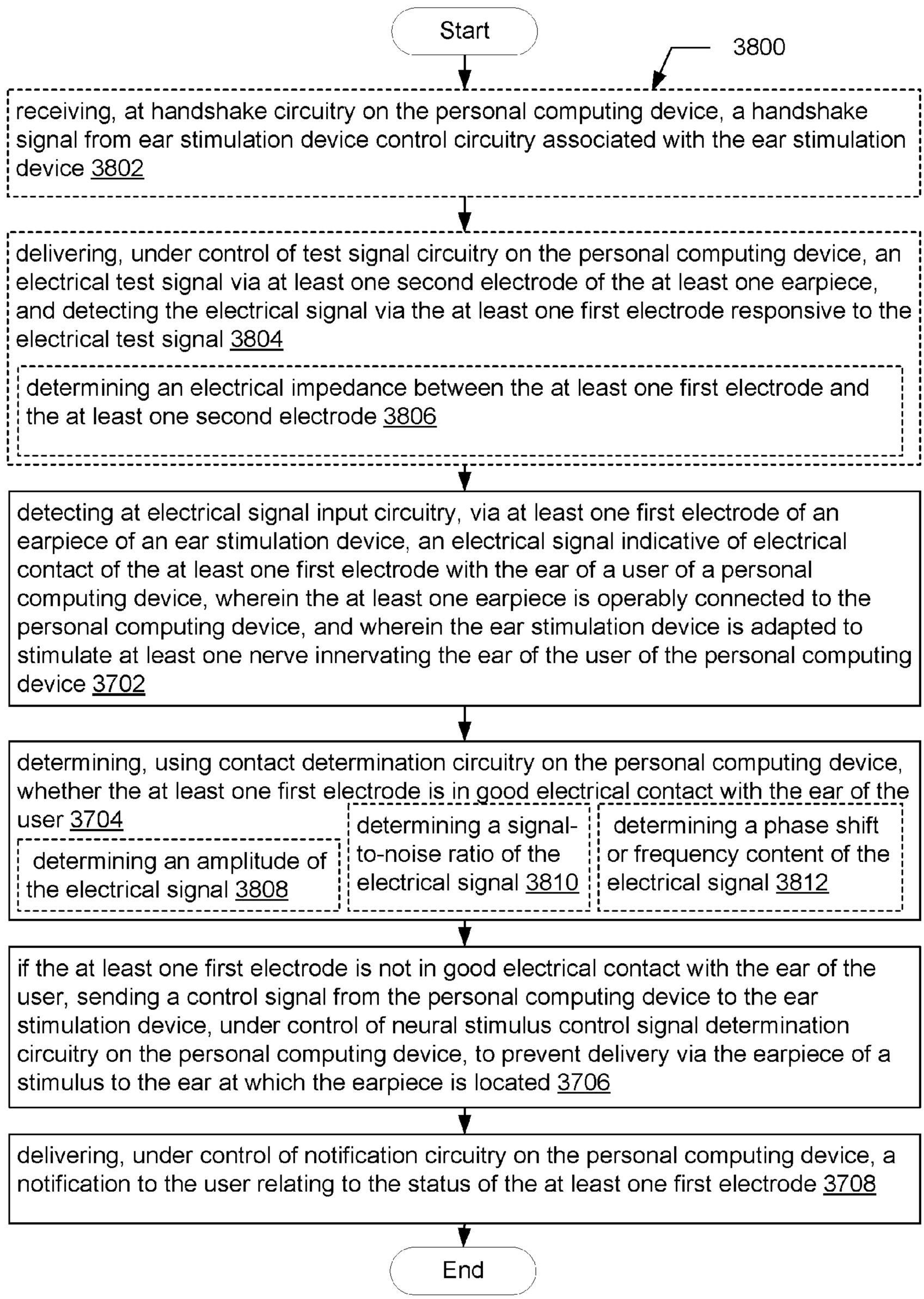

Start
3800
receiving, at handshake circuitry on the personal computing device, a handshake signal from ear stimulation device control circuitry associated with the ear stimulation device 3802
delivering, under control of test signal circuitry on the personal computing device, an electrical test signal via at least one second electrode of the at least one earpiece, and detecting the electrical signal via the at least one first electrode responsive to the electrical test signal 3804
determining an electrical impedance between the at least one first electrode and the at least one second electrode 3806
detecting at electrical signal input circuitry, via at least one first electrode of an earpiece of an ear stimulation device, an electrical signal indicative of electrical contact of the at least one first electrode with the ear of a user of a personal computing device, wherein the at least one earpiece is operably connected to the personal computing device, and wherein the ear stimulation device is adapted to stimulate at least one nerve innervating the ear of the user of the personal computing device 3702
determining, using contact determination circuitry on the personal computing device, whether the at least one first electrode is in good electrical contact with the ear of the user 3704
determining an amplitude of the electrical signal 3808
determining a signal-to-noise ratio of the electrical signal 3810
determining a phase shift or frequency content of the electrical signal 3812
if the at least one first electrode is not in good electrical contact with the ear of the user, sending a control signal from the personal computing device to the ear stimulation device, under control of neural stimulus control signal determination circuitry on the personal computing device, to prevent delivery via the earpiece of a stimulus to the ear at which the earpiece is located 3706
delivering, under control of notification circuitry on the personal computing device, a notification to the user relating to the status of the at least one first electrode 3708
End

FIG. 39

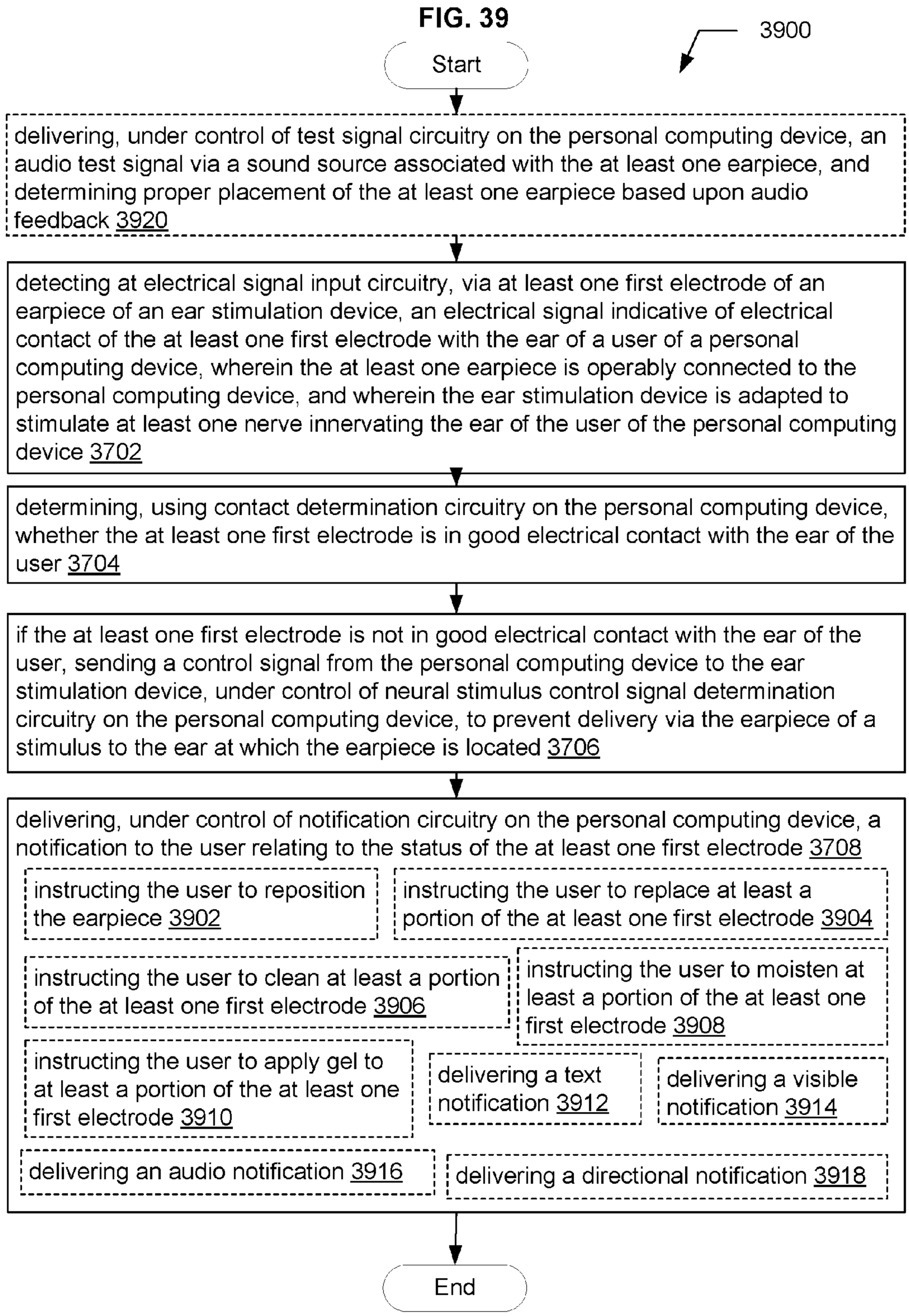

3900
Start
delivering, under control of test signal circuitry on the personal computing device, an audio test signal via a sound source associated with the at least one earpiece, and determining proper placement of the at least one earpiece based upon audio feedback 3920
detecting at electrical signal input circuitry, via at least one first electrode of an earpiece of an ear stimulation device, an electrical signal indicative of electrical contact of the at least one first electrode with the ear of a user of a personal computing device, wherein the at least one earpiece is operably connected to the personal computing device, and wherein the ear stimulation device is adapted to stimulate at least one nerve innervating the ear of the user of the personal computing device 3702
determining, using contact determination circuitry on the personal computing device, whether the at least one first electrode is in good electrical contact with the ear of the user 3704
if the at least one first electrode is not in good electrical contact with the ear of the user, sending a control signal from the personal computing device to the ear stimulation device, under control of neural stimulus control signal determination circuitry on the personal computing device, to prevent delivery via the earpiece of a stimulus to the ear at which the earpiece is located 3706
delivering, under control of notification circuitry on the personal computing device, a notification to the user relating to the status of the at least one first electrode 3708
instructing the user to reposition the earpiece 3902
instructing the user to replace at least a portion of the at least one first electrode 3904
instructing the user to clean at least a portion of the at least one first electrode 3906
instructing the user to moisten at least a portion of the at least one first electrode 3908
instructing the user to apply gel to at least a portion of the at least one first electrode 3910
delivering a text notification 3912
delivering a visible notification 3914
delivering an audio notification 3916
delivering a directional notification 3918
End

FIG. 40

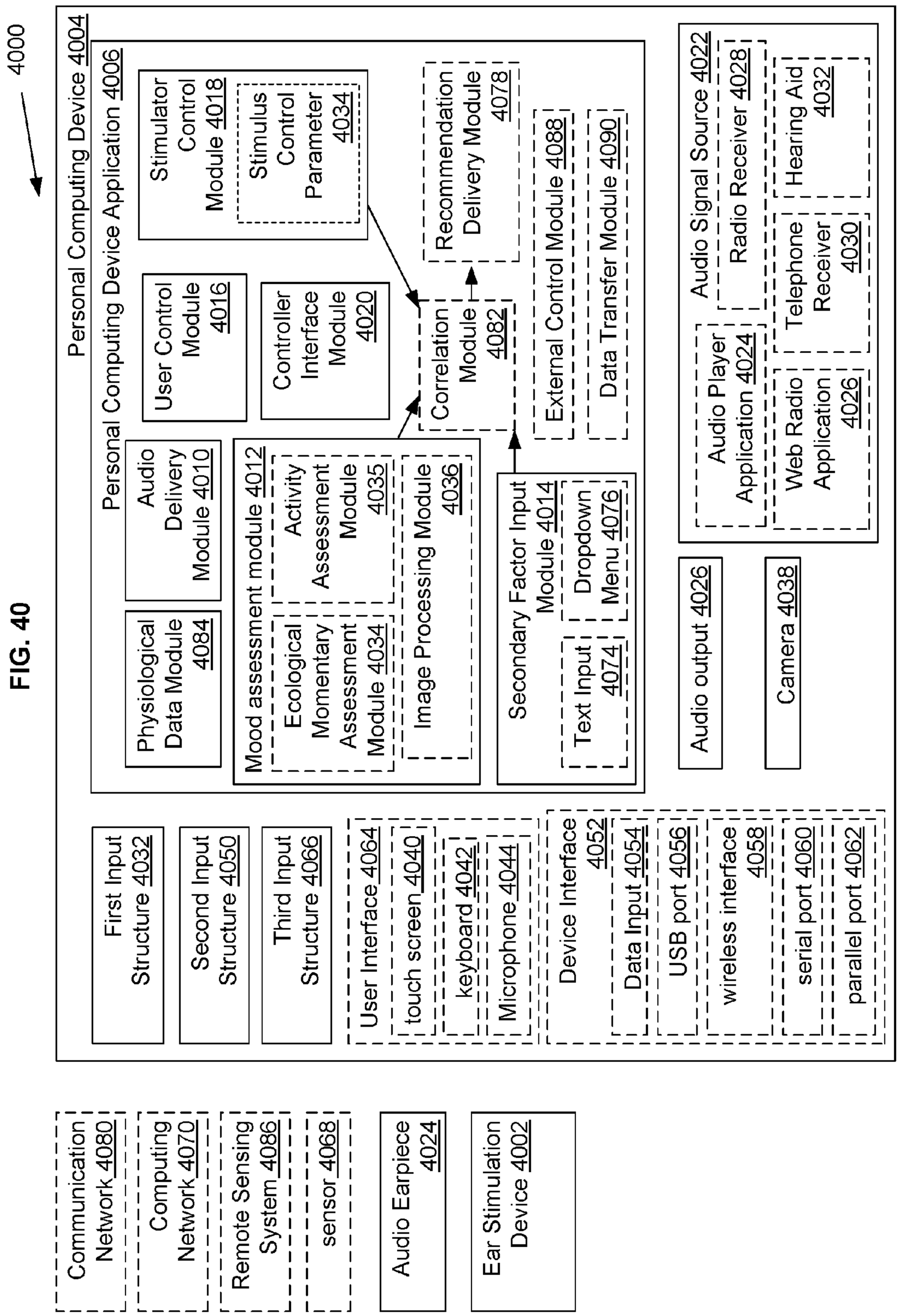

4000
Personal Computing Device 4004
Personal Computing Device Application 4006
Physiological Data Module 4084
Audio Delivery Module 4010
Mood assessment module 4012
Ecological Momentary Assessment Module 4034
Activity Assessment Module 4035
Image Processing Module 4036
User Control Module 4016
Stimulator Control Module 4018
Stimulus Control Parameter 4034
Controller Interface Module 4020
Correlation Module 4082
Recommendation Delivery Module 4078
Secondary Factor Input Module 4014
Text Input 4074
Dropdown Menu 4076
External Control Module 4088
Data Transfer Module 4090
Audio output 4026
Camera 4038
Audio Signal Source 4022
Audio Player Application 4024
Radio Receiver 4028
Web Radio Application 4026
Telephone Receiver 4030
Hearing Aid 4032
First Input Structure 4032
Second Input Structure 4050
Third Input Structure 4066
User Interface 4064
touch screen 4040
keyboard 4042
Microphone 4044
Device Interface 4052
Data Input 4054
USB port 4056
wireless interface 4058
serial port 4060
parallel port 4062
Communication Network 4080
Computing Network 4070
Remote Sensing System 4086
sensor 4068
Audio Earpiece 4024
Ear Stimulation Device 4002

FIG. 41

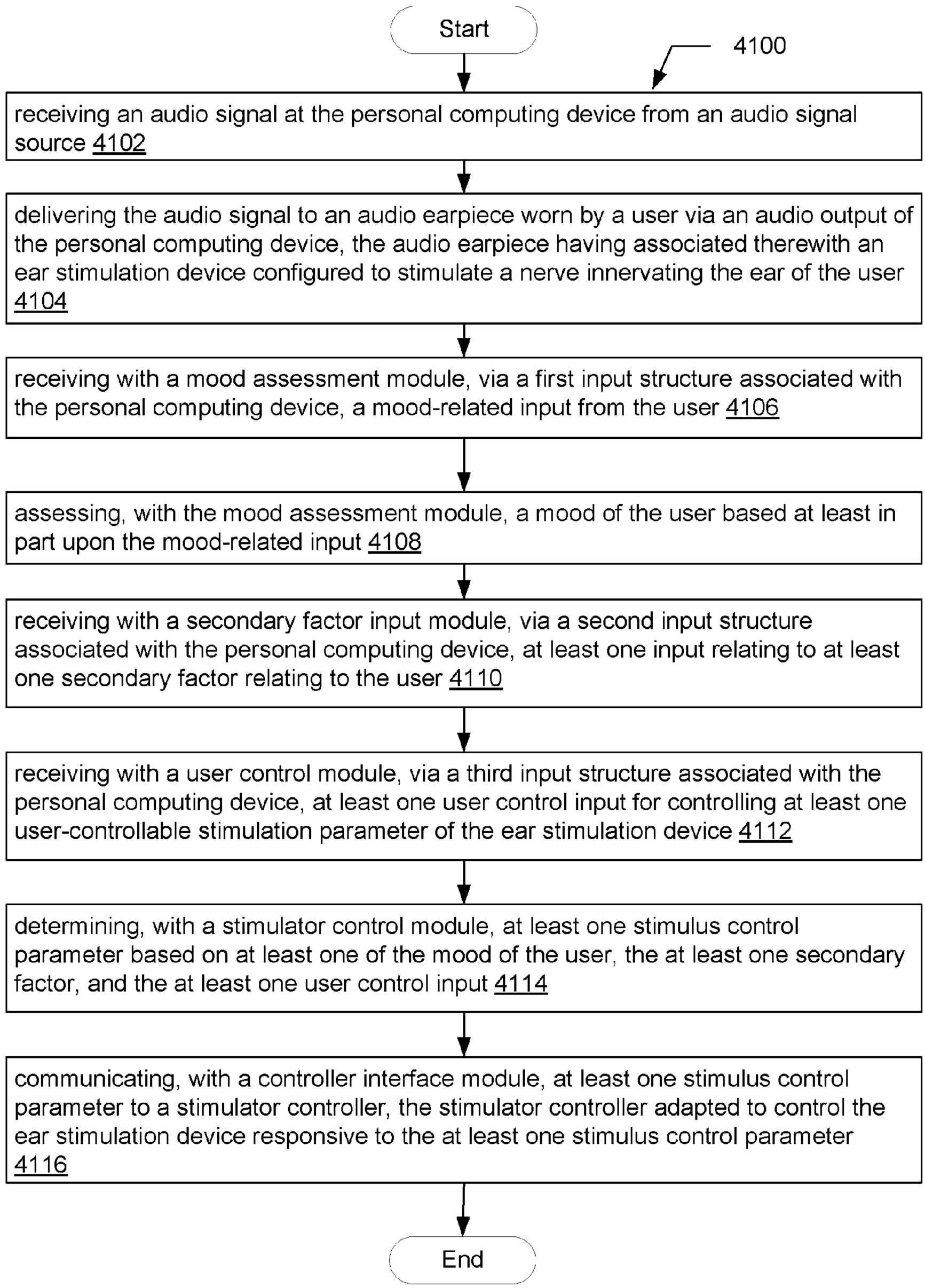

Start
4100
receiving an audio signal at the personal computing device from an audio signal source 4102
delivering the audio signal to an audio earpiece worn by a user via an audio output of the personal computing device, the audio earpiece having associated therewith an ear stimulation device configured to stimulate a nerve innervating the ear of the user 4104
receiving with a mood assessment module, via a first input structure associated with the personal computing device, a mood-related input from the user 4106
assessing, with the mood assessment module, a mood of the user based at least in part upon the mood-related input 4108
receiving with a secondary factor input module, via a second input structure associated with the personal computing device, at least one input relating to at least one secondary factor relating to the user 4110
receiving with a user control module, via a third input structure associated with the personal computing device, at least one user control input for controlling at least one user-controllable stimulation parameter of the ear stimulation device 4112
determining, with a stimulator control module, at least one stimulus control parameter based on at least one of the mood of the user, the at least one secondary factor, and the at least one user control input 4114
communicating, with a controller interface module, at least one stimulus control parameter to a stimulator controller, the stimulator controller adapted to control the ear stimulation device responsive to the at least one stimulus control parameter 4116
End

FIG. 42

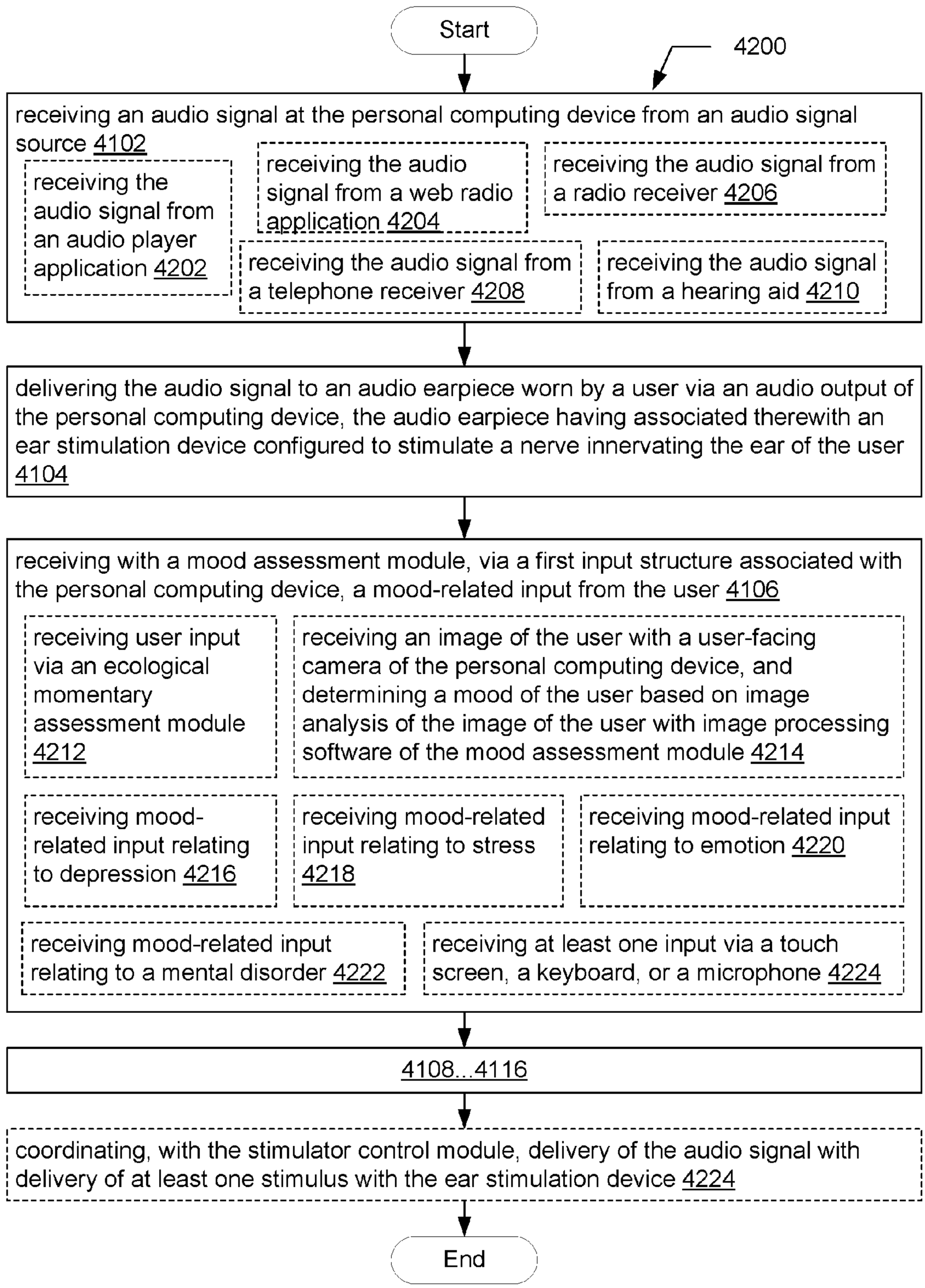

Start
4200
receiving an audio signal at the personal computing device from an audio signal source 4102
receiving the audio signal from an audio player application 4202
receiving the audio signal from a web radio application 4204
receiving the audio signal from a radio receiver 4206
receiving the audio signal from a telephone receiver 4208
receiving the audio signal from a hearing aid 4210
delivering the audio signal to an audio earpiece worn by a user via an audio output of the personal computing device, the audio earpiece having associated therewith an ear stimulation device configured to stimulate a nerve innervating the ear of the user 4104
receiving with a mood assessment module, via a first input structure associated with the personal computing device, a mood-related input from the user 4106
receiving user input via an ecological momentary assessment module 4212
receiving an image of the user with a user-facing camera of the personal computing device, and determining a mood of the user based on image analysis of the image of the user with image processing software of the mood assessment module 4214
receiving mood-related input relating to depression 4216
receiving mood-related input relating to stress 4218
receiving mood-related input relating to emotion 4220
receiving mood-related input relating to a mental disorder 4222
receiving at least one input via a touch screen, a keyboard, or a microphone 4224
4108...4116
coordinating, with the stimulator control module, delivery of the audio signal with delivery of at least one stimulus with the ear stimulation device 4224
End

FIG. 43

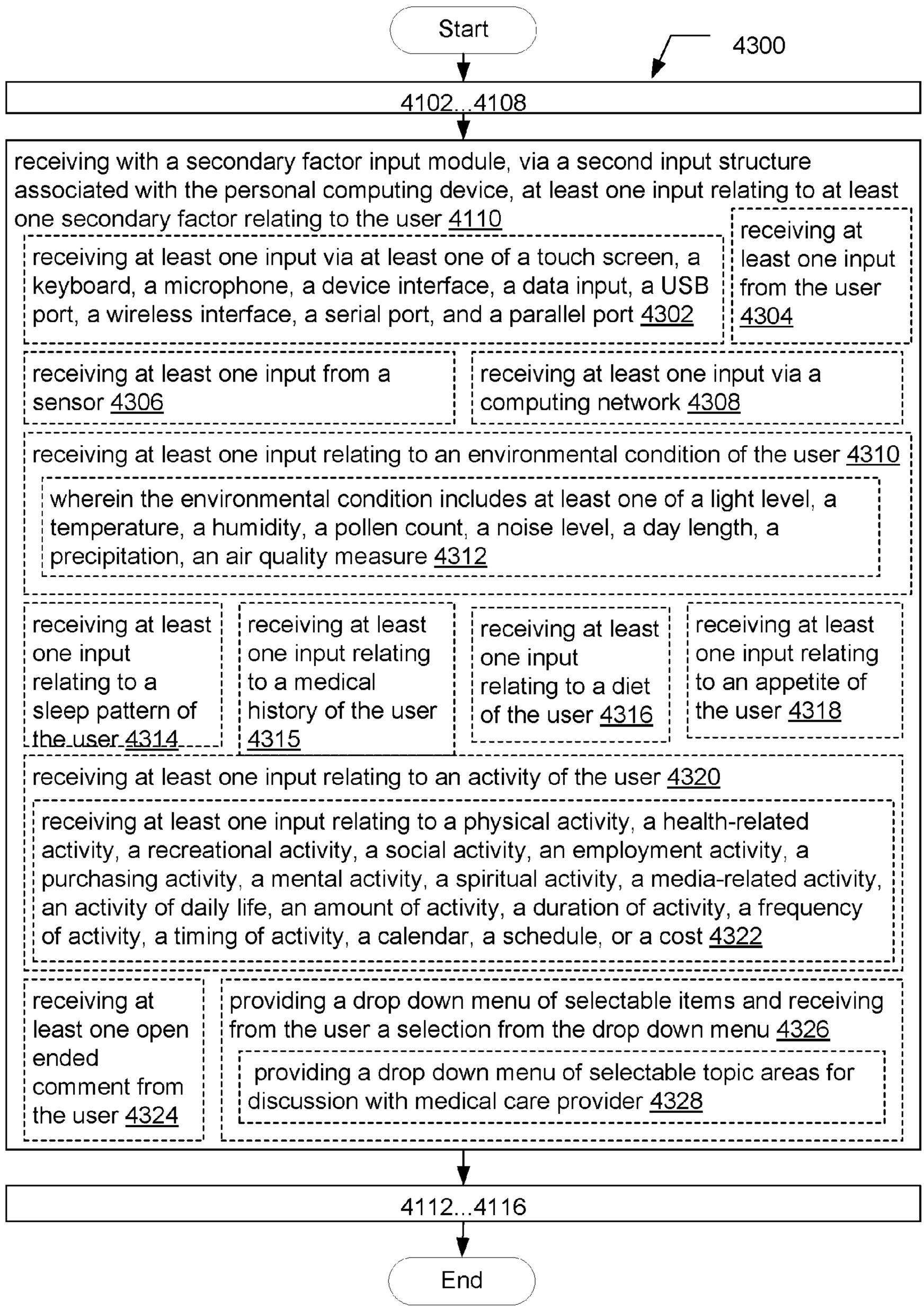

Start
4300
4102...4108
receiving with a secondary factor input module, via a second input structure associated with the personal computing device, at least one input relating to at least one secondary factor relating to the user 4110
receiving at least one input via at least one of a touch screen, a keyboard, a microphone, a device interface, a data input, a USB port, a wireless interface, a serial port, and a parallel port 4302
receiving at least one input from the user 4304
receiving at least one input from a sensor 4306
receiving at least one input via a computing network 4308
receiving at least one input relating to an environmental condition of the user 4310
wherein the environmental condition includes at least one of a light level, a temperature, a humidity, a pollen count, a noise level, a day length, a precipitation, an air quality measure 4312
receiving at least one input relating to a sleep pattern of the user 4314
receiving at least one input relating to a medical history of the user 4315
receiving at least one input relating to a diet of the user 4316
receiving at least one input relating to an appetite of the user 4318
receiving at least one input relating to an activity of the user 4320
receiving at least one input relating to a physical activity, a health-related activity, a recreational activity, a social activity, an employment activity, a purchasing activity, a mental activity, a spiritual activity, a media-related activity, an activity of daily life, an amount of activity, a duration of activity, a frequency of activity, a timing of activity, a calendar, a schedule, or a cost 4322
receiving at least one open ended comment from the user 4324
providing a drop down menu of selectable items and receiving from the user a selection from the drop down menu 4326
providing a drop down menu of selectable topic areas for discussion with medical care provider 4328
4112...4116
End

FIG. 44

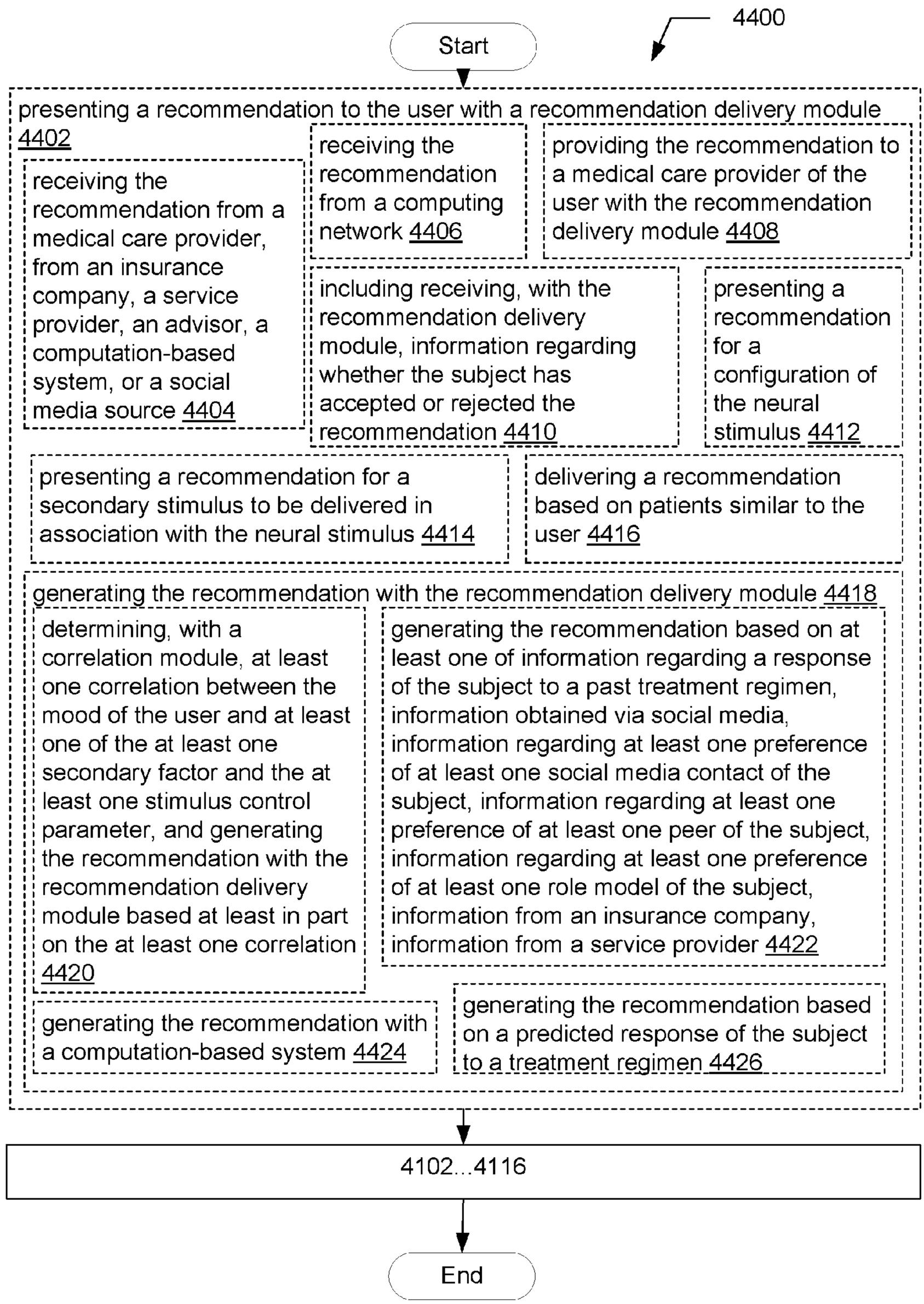

4400
Start
presenting a recommendation to the user with a recommendation delivery module 4402
receiving the recommendation from a medical care provider, from an insurance company, a service provider, an advisor, a computation-based system, or a social media source 4404
receiving the recommendation from a computing network 4406
providing the recommendation to a medical care provider of the user with the recommendation delivery module 4408
including receiving, with the recommendation delivery module, information regarding whether the subject has accepted or rejected the recommendation 4410
presenting a recommendation for a configuration of the neural stimulus 4412
presenting a recommendation for a secondary stimulus to be delivered in association with the neural stimulus 4414
delivering a recommendation based on patients similar to the user 4416
generating the recommendation with the recommendation delivery module 4418
determining, with a correlation module, at least one correlation between the mood of the user and at least one of the at least one secondary factor and the at least one stimulus control parameter, and generating the recommendation with the recommendation delivery module based at least in part on the at least one correlation 4420
generating the recommendation based on at least one of information regarding a response of the subject to a past treatment regimen, information obtained via social media, information regarding at least one preference of at least one social media contact of the subject, information regarding at least one preference of at least one peer of the subject, information regarding at least one preference of at least one role model of the subject, information from an insurance company, information from a service provider 4422
generating the recommendation with a computation-based system 4424
generating the recommendation based on a predicted response of the subject to a treatment regimen 4426
4102...4116
End

FIG. 45

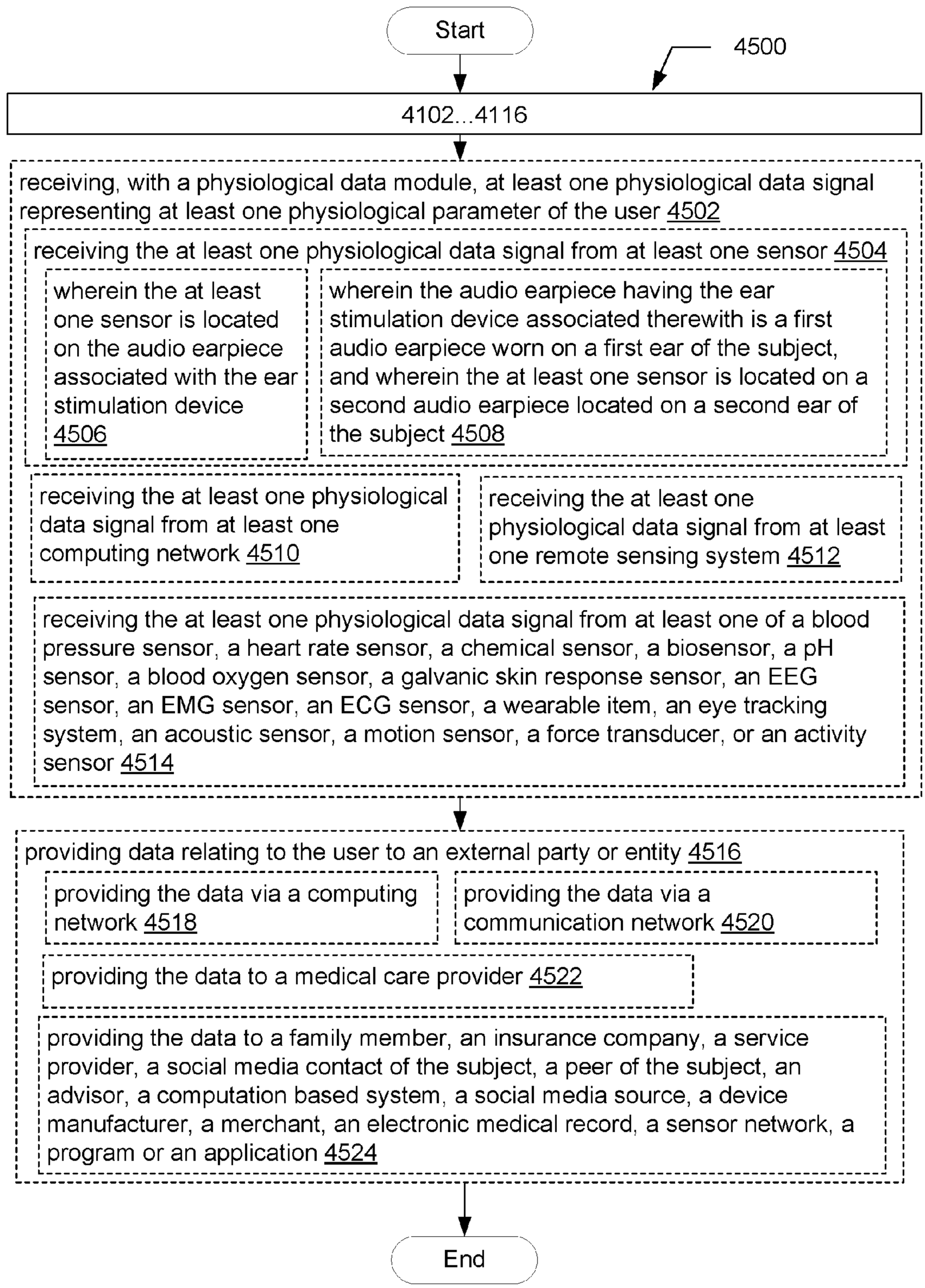

Start
4500
4102...4116
receiving, with a physiological data module, at least one physiological data signal representing at least one physiological parameter of the user 4502
receiving the at least one physiological data signal from at least one sensor 4504
wherein the at least one sensor is located on the audio earpiece associated with the ear stimulation device 4506
wherein the audio earpiece having the ear stimulation device associated therewith is a first audio earpiece worn on a first ear of the subject, and wherein the at least one sensor is located on a second audio earpiece located on a second ear of the subject 4508
receiving the at least one physiological data signal from at least one computing network 4510
receiving the at least one physiological data signal from at least one remote sensing system 4512
receiving the at least one physiological data signal from at least one of a blood pressure sensor, a heart rate sensor, a chemical sensor, a biosensor, a pH sensor, a blood oxygen sensor, a galvanic skin response sensor, an EEG sensor, an EMG sensor, an ECG sensor, a wearable item, an eye tracking system, an acoustic sensor, a motion sensor, a force transducer, or an activity sensor 4514
providing data relating to the user to an external party or entity 4516
providing the data via a computing network 4518
providing the data via a communication network 4520
providing the data to a medical care provider 4522
providing the data to a family member, an insurance company, a service provider, a social media contact of the subject, a peer of the subject, an advisor, a computation based system, a social media source, a device manufacturer, a merchant, an electronic medical record, a sensor network, a program or an application 4524
End

FIG. 46

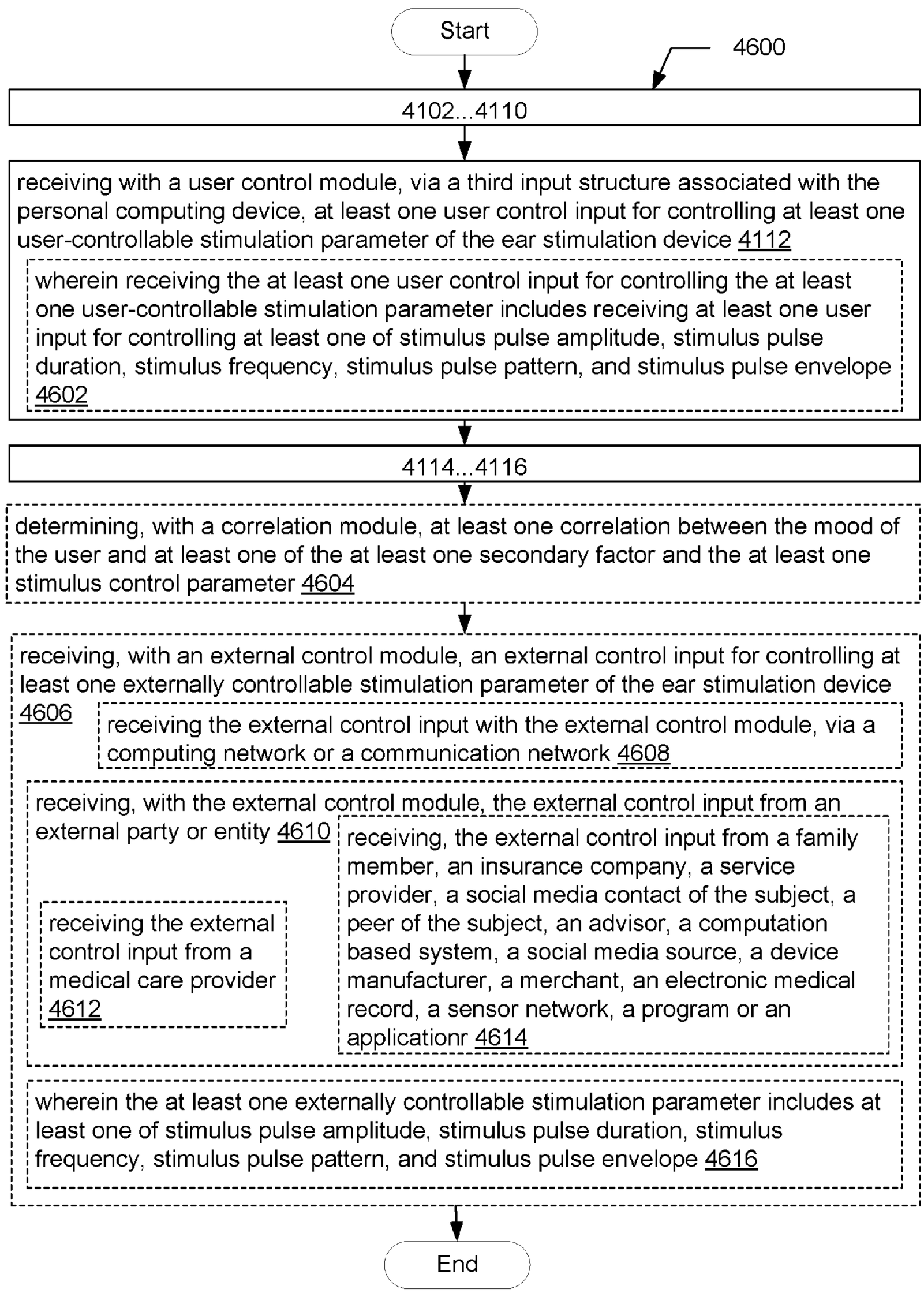
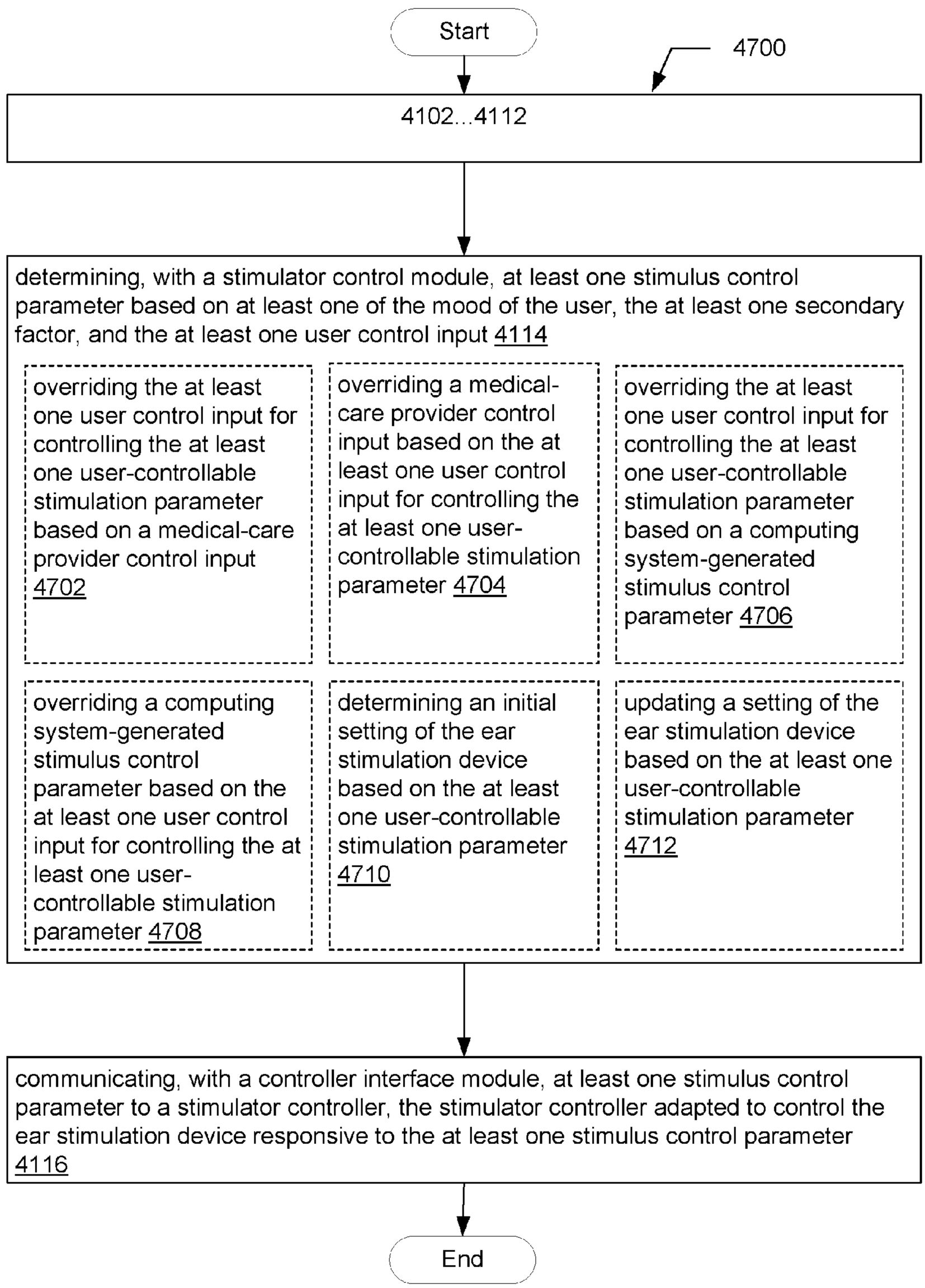

Start
4600
4102...4110
receiving with a user control module, via a third input structure associated with the personal computing device, at least one user control input for controlling at least one user-controllable stimulation parameter of the ear stimulation device 4112
wherein receiving the at least one user control input for controlling the at least one user-controllable stimulation parameter includes receiving at least one user input for controlling at least one of stimulus pulse amplitude, stimulus pulse duration, stimulus frequency, stimulus pulse pattern, and stimulus pulse envelope 4602
4114...4116
determining, with a correlation module, at least one correlation between the mood of the user and at least one of the at least one secondary factor and the at least one stimulus control parameter 4604
receiving, with an external control module, an external control input for controlling at least one externally controllable stimulation parameter of the ear stimulation device 4606
receiving the external control input with the external control module, via a computing network or a communication network 4608
receiving, with the external control module, the external control input from an external party or entity 4610
receiving the external control input from a medical care provider 4612
receiving, the external control input from a family member, an insurance company, a service provider, a social media contact of the subject, a peer of the subject, an advisor, a computation based system, a social media source, a device manufacturer, a merchant, an electronic medical record, a sensor network, a program or an applicationr 4614
wherein the at least one externally controllable stimulation parameter includes at least one of stimulus pulse amplitude, stimulus pulse duration, stimulus frequency, stimulus pulse pattern, and stimulus pulse envelope 4616
End

FIG. 47


Start
4700
4102...4112
determining, with a stimulator control module, at least one stimulus control parameter based on at least one of the mood of the user, the at least one secondary factor, and the at least one user control input 4114
overriding the at least one user control input for controlling the at least one user-controllable stimulation parameter based on a medical-care provider control input 4702
overriding a medical-care provider control input based on the at least one user control input for controlling the at least one user-controllable stimulation parameter 4704
overriding the at least one user control input for controlling the at least one user-controllable stimulation parameter based on a computing system-generated stimulus control parameter 4706
overriding a computing system-generated stimulus control parameter based on the at least one user control input for controlling the at least one user-controllable stimulation parameter 4708
determining an initial setting of the ear stimulation device based on the at least one user-controllable stimulation parameter 4710
updating a setting of the ear stimulation device based on the at least one user-controllable stimulation parameter 4712
communicating, with a controller interface module, at least one stimulus control parameter to a stimulator controller, the stimulator controller adapted to control the ear stimulation device responsive to the at least one stimulus control parameter 4116
End

CONTROLLING EAR STIMULATION IN RESPONSE TO IMAGE ANALYSIS

If an Application Data Sheet (ADS) has been filed on the filing date of this application, it is incorporated by reference herein. Any applications claimed on the ADS for priority under 35 U.S.C. §§ 119, 120, 121, or 365(c), and any and all parent, grandparent, great-grandparent, etc. applications of such applications, are also incorporated by reference, including any priority claims made in those applications and any material incorporated by reference, to the extent such subject matter is not inconsistent herewith.

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of the earliest available effective filing date(s) from the following listed application(s) (the "Priority Applications"), if any, listed below (e.g., claims earliest available priority dates for other than provisional patent applications or claims benefits under 35 USC § 119(e) for provisional patent applications, for any and all parent, grandparent, great-grandparent, etc. applications of the Priority Application(s)).

PRIORITY APPLICATIONS

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 14/670,504, entitled EAR STIMULATION WITH NEURAL FEEDBACK SENSING, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 27 Mar. 2015, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 14/670,537, entitled VIBRATORY EAR STIMULATION SYSTEM AND METHOD, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 27 Mar. 2015, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 14/670,560, entitled METHOD AND SYSTEM FOR CONTROLLING EAR STIMULATION, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 27 Mar. 2015, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 14/670,582, entitled USER INTERFACE METHOD AND SYSTEM FOR EAR STIMULATION, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 27 Mar. 2015, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 14/670,620, entitled NEURAL STIMULATION METHOD AND SYSTEM WITH AUDIO OUTPUT, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 27 Mar. 2015, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 14/670,656, entitled RECOMMENDATION METHOD AND SYSTEM FOR TREATMENTS INCLUDING EAR STIMULATION, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 27 Mar. 2015, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

The present application constitutes a continuation-in-part of U.S. patent application Ser. No. 15/291,358, entitled NERVE STIMULATION SYSTEM AND RELATED CONTROLLER, naming RODERICK A. HYDE, MURIEL Y. ISHIKAWA, JORDIN T. KARE, ERIC C. LEUTHARDT, MARK A. MALAMUD, STEPHEN L. MALASKA, NATHAN P. MYHRVOLD, BRITTANY SCHEID, ELIZABETH A. SWEENEY, CLARENCE T. TEGREENE, CHARLES WHITMER, LOWELL L. WOOD, JR., AND VICTORIA Y. H. WOOD, as inventors, filed 12 Oct. 2016, which is currently co-pending or is an application of which a currently co-pending application is entitled to the benefit of the filing date.

If the listings of applications provided above are inconsistent with the listings provided via an ADS, it is the intent of the Applicant to claim priority to each application that appears in the Domestic Benefit/National Stage Information section of the ADS and to each application that appears in the Priority Applications section of this application.

All subject matter of the Priority Applications and of any and all applications related to the Priority Applications by priority claims (directly or indirectly), including any priority claims made and subject matter incorporated by reference therein as of the filing date of the instant application, is incorporated herein by reference to the extent such subject matter is not inconsistent herewith.

SUMMARY

In an aspect, a neural stimulation system includes, but is not limited to, a neural signal sensor adapted to sense a

neural signal from a subject, the neural signal indicative of a physiological status of the subject, a neural stimulator adapted to produce a stimulus responsive to the sensed neural signal, the stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of a pinna of the subject, and a securing member configured to secure the neural stimulator to the pinna. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to, sensing with a neural signal sensor a neural signal indicative of a physiological status of a subject, the neural signal sensor located in or on a portion of a body of the subject, determining with signal analysis circuitry at least one parameter of the sensed neural signal, and delivering a neural stimulus with a neural stimulation device worn on a pinna of the subject responsive to the sensed neural signal, wherein the neural stimulus is configured to modulate the activity of at least one sensory nerve fiber innervating at least a portion of the pinna of the subject. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

A wearable neural stimulation device includes, but is not limited to, a vibratory mechanical stimulator adapted to produce a vibratory stimulus of sufficient frequency and amplitude to modulate the activity of at least one mechanoreceptor with a receptive field on at least a portion of a pinna of a subject, and a securing member configured to secure the vibratory mechanical stimulator to the pinna. In addition to the foregoing, other device aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to, delivering a vibratory mechanical stimulus to at least a portion of a pinna of a subject with a neural stimulation device worn on the pinna of the subject, wherein the vibratory mechanical stimulus is of sufficient frequency and amplitude to modulate the activity of at least one mechanoreceptor with a receptive field on the at least a portion of the pinna. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a neural stimulation system includes, but is not limited to, a wearable neural stimulation device and a personal computing device, the wearable neural stimulation device including a neural stimulator adapted to produce a stimulus for activating at least one sensory nerve fiber innervating at least a portion of a pinna of a subject, a securing member configured to secure the neural stimulator to the pinna, control circuitry incorporated into the wearable neural stimulation device for controlling operation of the neural stimulator, and first communication circuitry incorporated into the wearable neural stimulation device and operatively connected to the control circuitry, the first communication circuitry configured for at least one of sending a signal to and receiving a signal from a personal computing device; and the personal computing device including a user interface for at least one of presenting information to and receiving information from a user, control circuitry operatively connected to the user interface, second communication circuitry configured for at least one of sending a signal to and receiving a signal from the first communication circuitry, and instructions that when executed on the personal computing device cause the personal computing device to perform at least one of sending a signal to and receiving a signal from the wearable neural stimulation device via the second communication circuitry. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a system includes, but is not limited to, a personal computing device comprising circuitry for receiving a neural activity signal, the neural activity signal indicative of a physiological status of a subject, circuitry for determining a neural stimulus control signal based at least in part on the neural activity signal, and circuitry for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to, receiving a neural activity signal at a personal computing device, the neural activity signal indicative of a physiological status of a subject, determining a neural stimulus control signal based at least in part on the neural activity signal, and outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a computer program product includes, but is not limited to, a non-transitory signal-bearing medium bearing one or more instructions for receiving a neural activity signal, the neural activity signal indicative of a physiological status of a subject, one or more instructions for determining a neural stimulus control signal based at least in part on the neural activity signal, and one or more instructions for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna. In addition to the foregoing, other aspects of a computer program product are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, determining a neural stimulus control signal based at least in part on the physiological activity signal, outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the

pinna, and presenting information to the subject via a user interface. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a system includes, but is not limited to a personal computing device including circuitry for receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, circuitry for determining a neural stimulus control signal based at least in part on the physiological activity signal, the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, circuitry for outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, and circuitry for presenting information to the subject via a user interface. In addition to the foregoing, other personal computing device aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a computer program product includes, but is not limited to, a non-transitory signal-bearing medium bearing one or more instructions for receiving a physiological activity signal, the physiological activity signal indicative of a physiological status of a subject, one or more instructions for determining a neural stimulus control signal based at least in part on the physiological activity signal, one or more instructions for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on an ear of a subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, and one or more instructions for presenting information to the subject via a user interface. In addition to the foregoing, other computer program product aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a system includes, but is not limited to a personal computing device including circuitry for receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, circuitry for determining a neural stimulus control signal based at least in part on the physiological activity signal, circuitry for outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, and circuitry for outputting an audio output signal via an audio output of the personal computing device. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to, receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, determining a neural stimulus control signal based at least in part on the physiological activity signal, outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, and outputting an audio output signal via an audio output of the personal computing device. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a computer program product includes, but is not limited to, a non-transitory signal-bearing medium bearing one or more instructions for receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, one or more instructions for determining a neural stimulus control signal based at least in part on the physiological activity signal, one or more instructions for outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, and one or more instructions for outputting an audio output signal via an audio output of the personal computing device. In addition to the foregoing, other computer program product aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to, determining a vibratory stimulus control signal with stimulation control circuitry in a personal computing device, and outputting the vibratory stimulus control signal from the personal computing device to a wearable mechanical stimulation device including a vibratory mechanical stimulator configured to be carried on a pinna of a subject, wherein the vibratory stimulus control signal is configured to control delivery of a vibratory stimulus by the vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field on at least a portion of the pinna. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a system includes, but is not limited to, a personal computing device including circuitry for determining a vibratory stimulus control signal, and circuitry for outputting the vibratory stimulus control signal to a wearable mechanical stimulation device including a vibratory mechanical stimulator configured to be carried on a pinna of a subject, wherein the vibratory stimulus control signal is configured to control delivery of a vibratory stimulus by the vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field on at least a portion of the pinna. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a computer program product includes, but is not limited to, a non-transitory signal-bearing medium bearing one or more instructions for determining a vibratory stimulus control signal configured to control delivery of a vibratory stimulus by a vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mecha-

noreceptor with a receptive field on at least a portion of a pinna of a subject, and one or more instructions for outputting the vibratory stimulus control signal to a wearable mechanical stimulation device including the least one vibratory mechanical stimulator. In addition to the foregoing, other computer program product aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method includes, but is not limited to, receiving identifying information at a computing system, the identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator, and transmitting a recommendation relating to a treatment regimen from the computing system to a personal computing device used by the subject, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a system includes, but is not limited to, circuitry for receiving identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator, and circuitry for providing a recommendation relating to a treatment regimen to the subject, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a computer program product includes, but is not limited to, a non-transitory signal-bearing medium bearing one or more instructions for receiving identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator, and one or more instructions for providing a recommendation relating to a treatment regimen to the subject, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject. In addition to the foregoing, other computer program product aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method of controlling an ear stimulation device with a personal computing device includes, but is not limited to, capturing, with image capture circuitry on the personal computing device, via a user-facing camera associated with the personal computing device, an image of a user of the personal computing device; processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter; and controlling, with neural stimulus control signal determination circuitry on the personal computing device, based at least in part on the at least one parameter, delivery of a stimulus to at least one nerve innervating an ear of the user with the ear stimulation device. In a further aspect, the method includes processing the image, using the image processing circuitry, to determine the presence of at least one earpiece of the ear stimulation device located at an ear of the user; the ear of the user at which the at least one earpiece is located, the ear selected from a right ear of the user and a left ear of the user; and at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with one of the left or the right ear of the user; determining, using application software on the personal computing device, the ear at which the earpiece is usable, based on the at least one attribute of the at least one earpiece; determining, using application software on the personal computing device, whether the ear at which the at least one earpiece is located is the ear at which the earpiece is usable; and if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable, sending a control signal from the personal computing device to the ear stimulation device, under control of the neural stimulus control signal determination circuitry, to prevent delivery of a stimulus to the ear at which the earpiece is located via the earpiece. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, an ear stimulation device control system includes, but is not limited to, a personal computing device; a user-facing camera associated with the personal computing device; image capture circuitry adapted to capture an image of a user of the personal computing device from the user-facing camera; image processing circuitry configured to process the image to determine at least one parameter; and neural stimulus control signal determination circuitry configured to control delivery of a stimulus to at least one nerve innervating an ear of the user with an ear stimulation device, based at least in part on the at least one parameter. In a further aspect, image processing circuitry includes an earpiece location module configured to process the image to determine the presence of at least one earpiece of the ear stimulation device located at an ear of the user; the ear of the user at which the at least one earpiece is located, the ear selected from a right ear of the user and a left ear of the user; and at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with one of the left or the right ear of the user; and the neural stimulus control signal determination circuitry is configured to determine the ear at which the earpiece is usable, based on the at least one attribute of the at least one earpiece; determine whether the ear at which the at least one earpiece is located is the ear at which the earpiece is usable; and if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable, send a control signal from the personal computing device to the ear stimulation device to prevent delivery of the stimulus to the a least one nerve innervating the ear of the user. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method of controlling an ear stimulation device with a personal computing device includes, but is not limited, to detecting at electrical signal input circuitry, via at least one first electrode of an earpiece of an ear stimulation device, an electrical signal indicative of electrical contact of the at least one first electrode with the ear of a user of a personal computing device, wherein the at least one earpiece is operably connected to the personal computing device, and wherein the ear stimulation device is adapted to stimulate at least one nerve innervating the ear of the user of the personal computing device; determining, using contact determination circuitry on the personal computing device, whether the at least one first electrode is in good electrical contact with the

ear of the user; if the at least one first electrode is not in good electrical contact with the ear of the user, sending a control signal from the personal computing device to the ear stimulation device, under control of neural stimulus control signal determination circuitry on the personal computing device, to prevent delivery via the earpiece of a stimulus to the ear at which the earpiece is located; and delivering, under control of notification circuitry on the personal computing device, a notification to the user relating to the status of the at least one first electrode. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, an ear stimulation device control system includes, but is not limited to, a personal computing device configured to control delivery via an ear stimulation device of a stimulus to at least one nerve innervating an ear of a user of the personal computing device, the ear stimulation device including at least one first electrode, and the personal computing device including electrical signal circuitry adapted to receive an electrical signal indicative of electrical contact of the at least one first electrode with the ear of a user of the personal computing device; contact determination circuitry configured to determine whether the at least one first electrode is in good electrical contact with the ear of the user; neural stimulus control signal determination circuitry configured to send a control signal from the personal computing device to the ear stimulation device to prevent delivery of the stimulus if the at least one first electrode is not in good electrical contact with the ear of the user; and notification circuitry configured to deliver a notification to the user relating to the status of the at least one first electrode. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a personal computing device application for monitoring use of a nerve stimulation system by a user includes, but is not limited to, an audio delivery module adapted to control delivery of an audio signal from an audio signal source to an audio earpiece via an audio output of the personal computing device, the audio earpiece having associated therewith an ear stimulation device configured to stimulate a nerve innervating the ear of the user; a mood assessment module adapted to receive mood-related input from the user via a first input structure associated with the personal computing device; and assess a mood of the user based at least in part upon the mood-related input; a secondary factor input module adapted to receive at least one input relating to at least one secondary factor relating to the user via a second input structure associated with the personal computing device; user control module adapted to receive at least one user control input via a third input structure of the personal computing device, the user control input for controlling user-controllable stimulation parameters of the ear stimulation device; a stimulator control module adapted to determine at least one stimulus control parameter based on at least one of the mood of the user, the at least one secondary factor, and the at least one user control input; and a controller interface module for communicating the at least one stimulus control parameter to a stimulator controller adapted to control the ear stimulation device responsive to the at least one stimulus control parameter. In addition to the foregoing, other system aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

In an aspect, a method of controlling an ear stimulation device with a personal computing device includes, but is not limited to, receiving an audio signal at the personal computing device from an audio signal source; delivering the audio signal to an audio earpiece worn by a user via an audio output of the personal computing device, the audio earpiece having associated therewith an ear stimulation device configured to stimulate a nerve innervating the ear of the user; receiving with a mood assessment module, via a first input structure associated with the personal computing device, a mood-related input from the user; assessing, with the mood assessment module, a mood of the user based at least in part upon the mood-related input; receiving with a secondary factor input module, via a second input structure associated with the personal computing device, at least one input relating to at least one secondary factor relating to the user; receiving with a user control module, via a third input structure associated with the personal computing device, at least one user control input for controlling at least one user-controllable stimulation parameter of the ear stimulation device; determining, with a stimulator control module, at least one stimulus control parameter based on at least one of the mood of the user, the at least one secondary factor, and the at least one user control input; and communicating, with a controller interface module, at least one stimulus control parameter to a stimulator controller, the stimulator controller adapted to control the ear stimulation device responsive to the at least one stimulus control parameter. In addition to the foregoing, other method aspects are described in the claims, drawings, and text forming a part of the disclosure set forth herein.

The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is an illustration of the external anatomy of the ear of a human.

FIG. **2**A is an illustration of a system including a neural stimulation device worn on the ear of a subject.

FIG. **2**B is a block diagram of the system of FIG. **2**A.

FIG. **3** depicts a stimulation device including a securing member configured to fit in the concha, and a clip securing member.

FIG. **4**A depicts a stimulation device including a hanger-style securing member.

FIG. **4**B depicts the stimulation device of FIG. **4**A positioned on an ear.

FIG. **5** depicts an embodiment of a stimulation device.

FIG. **6** depicts an embodiment of a stimulation device.

FIG. **7** is a block diagram of a neural stimulation system.

FIG. **8** is a block diagram of a computing system.

FIG. **9** is a flow diagram of a method.

FIG. **10** is a block diagram of a neural stimulation device.

FIG. **11** is a flow diagram of a method.

FIG. **12** is a block diagram of a neural stimulation system.

FIG. **13** is a block diagram of a system including a personal computing device.

FIG. **14** is a flow diagram of a method.

FIG. **15** is a block diagram of a computer program product relating to the method of FIG. **14**.

FIG. **16** is a block diagram of a system including a personal computing device.

FIG. **17** is a flow diagram of a method.

FIG. **18** is a block diagram of a computer program product relating to the method of FIG. **17**.

FIG. **19** is a block diagram of a system including a personal computing device.

FIG. **20** is a flow diagram of a method.

FIG. **21** is a block diagram of a computer program product relating to the method of FIG. **20**.

FIG. **22** is a block diagram of a system including a personal computing device.

FIG. **23** is a flow diagram of a method.

FIG. **24** is a block diagram of a computer program product relating to the method of FIG. **23**.

FIG. **25** is a block diagram of a system relating to operation of a neural stimulation device.

FIG. **26** depicts data aspects relating to FIG. **25**.

FIG. **27** is a flow diagram of a method.

FIG. **28** is block diagram of a computer program product relating to the method of FIG. **27**.

FIG. **29** is an illustration of an embodiment of a system for delivering neural stimulation in combination with a secondary stimulus.

FIG. **30** is a flow diagram of a method.

FIG. **31** is a flow diagram of a method.

FIG. **32** is a flow diagram of a method.

FIG. **33** is a flow diagram of a method.

FIG. **34** is a block diagram of a neural stimulation system.

FIG. **35**A depicts a user interface for a neural stimulation system.

FIG. **35**B depicts a user interface for a neural stimulation system.

FIG. **36** is a block diagram of an embodiment of a neural stimulation system.

FIG. **37** is a flow diagram of a method.

FIG. **38** is a flow diagram of a method.

FIG. **39** is a flow diagram of a method.

FIG. **40** is a block diagram of a system including a personal computing device.

FIG. **41** is a flow diagram of a method.

FIG. **42** is a flow diagram of a method.

FIG. **43** is a flow diagram of a method.

FIG. **44** is a flow diagram of a method.

FIG. **45** is a flow diagram of a method.

FIG. **46** is a flow diagram of a method.

FIG. **47** is a flow diagram of a method.

DETAILED DESCRIPTION

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

Various studies indicate that stimulation of the ear can have beneficial effects on the health of a subject. For example, Rong et al., "Transcutaneous vagus nerve stimulation for the treatment of depression: a study protocol for a double blinded randomized clinical trial," BMC Complementary and Alternative Medicine 2012, 12:255, which is incorporated herein by reference, describes the possibility of using transcutaneous stimulation of the vagus nerve via portions of the ear to treat major depressive disorder (MDD) and other disorders, including epilepsy, bipolar disorder, and morbid obesity. Ellrich, "Transcutaneous Vagus Nerve Stimulations," European Neurological Review, 2011; 6(4): 254-256, which is incorporated herein by reference, describes transcutaneous vagus nerve stimulation via the ear for treating epilepsy and depression.

Nerves innervating the skin on or in the vicinity of the ear of the subject include, e.g., the facial nerve (cranial nerve VII), the glossopharyngeal nerve (cranial nerve IX), the auricular branch of the vagus nerve (cranial nerve X), the auriculotemporal branch of trigeminal nerve (cranial nerve V), the lesser occipital nerve (spinal nerve C3), and the greater auricular nerve (spinal nerves C2, C3). These nerves contain various nerve fibers including sensory nerve fibers, including, for example, nerve fibers from skin mechanoreceptors. Various types of skin mechanoreceptors are well characterized and are innervated by fibers having diameters in the range of approximately 5 to 12 μm (also known as Aβ fibers). Skin mechanoreceptors include, for example, slowly adapting mechanoreceptors, which are more sensitive to continuous stimulation, and rapidly adapting mechanoreceptors, which are more sensitive to transient stimuli. Rapidly adapting mechanoreceptors include Pacinian corpuscles and Meissner's corpuscles, for example.

Mechanoreceptors are activated well by cyclical or vibratory (e.g., sinusoidal) mechanical stimuli having frequencies in the range of 1 Hz to 1000 Hz. In some aspects, such mechanical stimuli may include indentation of the skin by a few micrometers to a few millimeters. Pacinian corpuscles are thought to be most responsive to vibratory mechanical stimuli with frequencies in the range of 200 Hz-300 Hz, while Meissner's Corpuscles are thought to be most responsive to vibratory mechanical stimuli with frequencies in the range of 30-40 Hz.

Electrical stimuli having sinusoidal or other waveforms are also effective for activating sensory fibers. Stimuli may be applied cyclically, for example. See e.g., Ellrich, "Transcutaneous Vagus Nerve Stimulations," European Neurological Review, 2011; 6(4):254-256, which is incorporated herein by reference.

For reference, FIG. **1** depicts an ear **100** of a human subject, showing anatomical structures which may be referred to herein. The external portion of ear **100** is referred to as the pinna **102**. FIG. **1** depicts a front/side view of ear **100**, showing anterior surface of pinna **104**, and a back view of ear **100**, showing posterior surface of pinna **106** as well as head **108** of the subject. The surface of the head **108** adjacent the pinna **102** is indicated by shading and reference number **110**. Anatomical features of the ear include external auditory meatus **112** (the external ear canal), helix **114**, lobe **116**, and tragus **118**. Concha **120**, the indented region in the vicinity of external auditory meatus **112**, is comprised of cymba **122** and cavum **124**, and bounded by antitragus **126** and antihelix **128**. Antihelix **128** includes inferior (anterior) crus of antihelix **130** and superior (posterior) crus of antihelix **132**, which bound triangular fossa **134**.

FIGS. **2**A and **2**B depict a generalized system **200** including a wearable neural stimulation device **202** for delivering a stimulus to an ear **204** of a subject **206**. System **200** includes a personal computing device **208** in communication with wearable neural stimulation device **202** via communication link **210**. Personal computing device **208** can be an audio player, a mobile phone, a computer, or any of various other devices having computing capability (e.g., microprocessor based devices) and including application software and/or suitable hardware for controlling operation of wearable neural stimulation device **202**. In an aspect, personal computing device **208** is a wearable computing device. In an aspect, wearable neural stimulation device **202** is used to deliver a stimulus sufficient to activate one or more nerves or nerve branches innervating the skin on or in the vicinity

of ear **204** of subject **206**. In an aspect, personal computing device **208** is used to control delivery of the stimulus to ear **204** of subject **206**. As illustrated in the block diagram of FIG. **2**B, and described in greater detail herein below, wearable neural stimulation device **202** includes neural stimulator **212** and securing member **214** for securing neural stimulator **212** to ear **204**. In an aspect, personal computing device **208** is configured to send, or receive, information relating to operation of the wearable neural stimulation device **202** to, or from, one or more remote system **216** via a communications network **218**. Control of stimulation may be based on data from one or more sensor **220**, including, but not limited to, physiological sensors, neural activity sensors, motion sensors, location sensors, or environmental sensors, for example. In some aspects, sensor **220** is worn by the subject at a location distinct from wearable neural stimulation system **202** (e.g., on an armband as depicted in FIG. **2**A). In other aspects, one or more sensors are located on a wearable neural stimulation device that can be implanted in the subject, located on the personal computing device, or located elsewhere in the environment of the subject, as depicted and described in the following text and accompanying figures.

In the embodiment of FIGS. **2**A and **2**B, and in other embodiments described herein, neural stimulator **212** can be any of various types of neural stimulators, including but not limited to mechanical, electrical, magnetic, ultrasonic, optical, or chemical stimulators, as will be discussed in greater detail herein below. In an aspect, neural stimulation devices as described herein can include multiple (two or more) neural stimulators (see e.g., optional additional neural stimulator **222** in FIG. **2**B). If multiple neural stimulators are used, they may all be of the same type, or may be of several different types.

In an aspect, neural stimulator **212** is a mechanical stimulator. In an aspect, a mechanical stimulator includes, for example, a vibratory mechanical stimulator that delivers a cyclical or vibrating mechanical stimulus to the skin of the ear of the subject. Vibratory mechanical stimulators can include, for example, various types of vibrating mechanical devices, e.g., electromechanical, piezoelectric, movable coil, electrostatic, magnetostrictive, isodynamic, and/or MEMS devices, for example as used for manufacturing small-scale speakers and microphones.

In an aspect, neural stimulator **212** includes a transcutaneous electrical stimulator for delivering a transcutaneous electrical stimulus. For example, neural stimulator **212** may include an electrode or electrical contact designed for contacting the skin surface, for example as described in Rong et al., "Transcutaneous vagus nerve stimulation for the treatment of depression: a study protocol for a double blinded randomized clinical trial," BMC Complementary and Alternative Medicine 2012, 12:255, which is incorporated herein by reference. In an aspect, neural stimulator **212** includes a magnetic stimulator for delivering a transcutaneous magnetic stimulus. For example, such a magnetic stimulator may include one or more coil through which electrical current is passed to generate a magnetic field. The magnetic field induces electrical currents within the tissue in/around the ear of the subject to activate neural structures. In an aspect, neural stimulator **212** includes an ultrasonic stimulator, for example as described in Legon et al., "Pulsed Ultrasound Differentially Stimulates Somatosensory Circuits in Humans as Indicated by EEG and fMRI," PLOS ONE 7(12): e5177. Doi:10.01371/journal.pone.0051177, December 2012, which is incorporated herein by reference. In some aspects, other types of neural stimulators, such as optical or chemical stimulators are used. See, for example, stimulators described in U.S. Pat. No. 8,170,658 to Dacey, Jr. et al., which is incorporated herein by reference.

In some aspects, circuitry for driving delivery of the neural stimulus is included fully or partially in wearable neural stimulation device **202**. In some aspects, some or all of the circuitry for driving delivery of the neural stimulus are housed separately from wearable neural stimulation device **202**, and a control signal for driving delivery of the neural stimulus by neural stimulator **212** is provided by personal computing device **208**, or from remote system **216** via communication network **218**.

Various examples and embodiments of neural stimulation devices are described herein. In various aspects of neural stimulation systems described herein, neural stimulation devices are wearable, i.e. the device can be carried by or worn on the ear of a subject, secured by a securing member, in order to position one or more neural stimulator with respect to a portion of the ear of the subject, or in some cases, in the vicinity of the ear of the subject. Various types of securing members may be used, without limitation. A securing member may also serve to position one or more sensors on or in the vicinity of the ear of the subject and may also include or support other system components, such as electrical circuitry components. Examples of neural stimulation devices including different types of securing members are shown in FIGS. **3**-**6**.

FIG. **3** depicts securing member **300**, which is a concha-fitted member configured to fit into concha **302** of ear **304**. In this example, securing member **300** has a size and shape sufficient to be retained in concha **302** by friction and/or tensioning of securing member **300** with respect to concha **302**. Other system components may be attached to securing member **300**, e.g., ear canal insert **306**, which extends into external auditory meatus (ear canal) **308** and stimulators **310***a*, **310***b*, and **310***c*. In addition, system components may be built into or contained within securing member **300**, e.g., control and/or communication circuitry (not shown) used to drive stimulators **310***a*, **310***b*, and **310***c* and/or provide for communication with e.g., a personal computing device (not shown). A battery can be provided in securing member **300** to power the device for wireless operation. FIG. **3** also depicts a second type of securing member, clip **312**, for attaching stimulator **314** and/or sensor **316** to the pinna **318** of the subject. Circuitry **320** provides for wireless communication between stimulator **314**/sensor **316** and circuitry on securing member **300** or a personal computing device or remote system. Spring **322** provides spring force to secure clip **312** onto pinna **318**. Clip **312** may be formed of a resilient material or formed from two sections of rigid material, joined at a hinge.

FIGS. **4**A and **4**B depict securing member **400** having a hanger-style configuration designed to hang on pinna **402**. The hanger-style configuration is similar to the configuration used in certain types of headsets for listening to music. Securing member **400** includes anterior portion **404**, which in use (shown in FIG. **4**B) is positioned anterior to the ear of the subject (i.e. in front of pinna **402**); over-ear portion **406**, which arcs over and behind pinna **402**; and posterior portion **408**, which fits behind pinna **402**. In an aspect, securing member **400** includes downward extension **410**. In an aspect, wired communication link **412** (e.g., a cable) provides for connection of electrical components on securing member **400** to a remote computing device. For example, electrodes **414***a* and **414***b* on posterior portion **408** of securing member **400** are used to deliver electrical stimulation under control of a control signal delivered via

wired communication link **412**. Securing member **400** also includes ear canal insert **416**, which fits into the external auditory meatus **112**. A sensor **418** on ear canal insert **416** can be used to sense a physiological signal, which in some aspects is used to determine the stimulation delivered with electrodes **414***a* and **414***b*. Physiological sensor **418** may include, for example, an electrode for sensing a heart rate, or other physiological sensor as described in greater detail elsewhere herein. Additional sensors **420** and **422** are located on the aspect of posterior portion **408**, facing and adapted to contact the surface of the head adjacent the pinna **402**. In an aspect, sensors **420** and **422** are electrodes configured to detect an electroencephalographic (EEG) signal.

FIG. **5** depicts securing member **500** having a loop configuration of a type used for wireless headsets. Securing member **500** includes earpieces **502***a* and **502***b*, which fit into the left and right ears of a subject, respectively (e.g., fitting into one or both of the concha and external auditory meatus). Securing member **500** also includes arcs **504***a* and **504***b*, which fit over and behind the two ears of the subject, and connecting loop **506** which fits behind the head of the subject and connects earpieces **502***a* and **502***b*. In an aspect, securing member **500** is sufficiently rigid to maintain earpieces **502***a* and **502***b* in position in the ears of the subject while the subject moves about (e.g., walking or running). In an aspect, ear canal inserts **508***a* and **508***b* fit into the ear canals of the subject. A neural stimulator **510** may be positioned on earpiece **502***a*, as shown, or alternatively (or in addition) on ear canal extension **508***a*. A secondary neural stimulator **512** may be located on pinna extension **514**. Extension **514** serves to position secondary neural stimulator **512** on the pinna of the subject at a desired location. In an aspect, extension **514** can be adjusted by elastic or plastic deformation to change the positioning of neural stimulator **512** on the pinna. In some aspects, extension **514** can include an adjustable linkage that provides for positioning of neural stimulator **512** with respect to the pinna.

FIG. **5** depicts a system in which neural stimulators **510** and **512** are positioned on securing member **500** so as to deliver stimulation to the left ear of the subject. Depending upon the desired application, neural stimulators can be positioned on one or both ears of the subject. In some aspects, stimulation is delivered to only one ear, while in other aspects, stimulation is delivered to both ears.

In some aspects, stimulator **512** located on pinna extension **514** can be used as the only, or primary neural stimulator, and stimulator **510** on earpiece **502***a* can be omitted. Earpieces **502***a* and **502***b* can function to hold securing member **500** in place with respect to the head of the subject, and, optionally, to deliver sound (such as a voice signal from a phone or music from an audio player) to the ears of the subject, independent of carrying stimulator **510**. Circuitry **516** in securing member **506** includes communication circuitry for wirelessly communicating with other system components, for example a personal computing device (e.g., an audio player, a mobile phone, or a laptop computer). In addition, circuitry **516** may provide for wireless communication with a sensor located at a distance from securing member **500**. For example, the wireless headset device depicted in FIG. **5** can be used in combination with sensors in one or more locations, not limited to sensors on securing member **500**. Sensors include any type of physiological sensor located in, on or adjacent to the body of the subject (e.g., implanted sensors, sensors secured to the body, sensors in wearable items such as clothing, wristbands); remote sensors, environmental sensors, motion sensors, location sensors, and/or other types of sensors, without limitation.

FIG. **6** depicts a further example of a wearable neural stimulation device **600** including a housing **602** attached to a securing member **604**. Housing **602** is shown only in a dashed outline so that the position of stimulator **606** and sensor **608** with respect to ear **610** can be seen. Housing **602** is a thin, flat box-like structure, with stimulator **606** and sensor **608** mounted on the exterior of housing **602** on the side facing pinna **612**. Housing **602** is fastened to or formed integrally with securing member **604**. Securing member **604** fits into concha **614** to secure device **600** to ear **610**. Ear canal insert **616** fits into external auditory meatus **618**. Sensor **620** on ear canal insert **616** senses a physiological signal from external auditory meatus **618**. Sensor **608** is an environmental sensor that senses light from the environment of the subject, e.g., to determine whether it is day or night.

FIG. **7** is a block diagram of a neural stimulation system **700**. Neural stimulation **700** system includes neural signal sensor **702**, which is adapted to sense a neural signal **704** from a subject. Neural signal **704** may be an electroencephalographic (EEG) signal or electrooculographic (EOG) signal, and in an aspect is indicative of a physiological status of the subject. Neural stimulation system **700** also includes neural stimulator **706**, which is adapted to produce a stimulus **708** responsive to sensed neural signal **704**, stimulus **708** configured to activate at least one sensory nerve fiber innervating at least a portion of a pinna of the subject. Neural stimulation system **700** also includes securing member **710** configured to secure neural stimulator **706** to the pinna of the subject.

In various aspects, neural signal sensor **702** can be an electroencephalographic signal sensor **712** or electrooculographic signal sensor **714**. Electroencephalographic signal sensor **712** can be configured to fit within an ear canal of a subject, e.g., on an ear canal insert as depicted in FIG. **4**A (for example as described in U.S. Patent Publication 2003/0195588 to Fischell et al., or U.S. Patent Publication 2006/0094974 to Cain, both of which are incorporated herein by reference). EOG sensor **714** can be located on an extension (e.g., similar to extension **514** shown in FIG. **5**) to position EOG sensor **714** on the subject's temple or side of the subject's head. An electromyographic signal sensor could be similarly placed. Physiological status of the subject, as indicated by neural signal **704**, may include indications or symptoms of various types of physiological status, including various brain-related disorders or statuses, or other physiological statuses. Brain-related disorders include, for example, mental health disorders (e.g., psychological or psychiatric disorder), depression, post-traumatic stress disorder, seasonal affective disorder, anxiety, headache (e.g., primary headache, cluster headache, or migraine headache), or epilepsy). Neural signal sensor **704** may include other types of neural signal sensors, including external or implantable sensors, located in or on the ear or other part of the body. One or more neural signal sensors may be used.

In various aspects, securing member **710** is configured to secure neural stimulator **706** to different portions of the pinna of the subject. For example, in an aspect, securing member **710** includes a concha-fitted portion **716**, configured to fit into the concha of the subject (e.g., as depicted in FIG. **3**). In an aspect, securing member **710** includes an ear canal insert **718** configured to fit in the ear canal of the subject (e.g., as depicted in FIGS. **4**A, **4**B, and **5**). In another aspect, securing member **710** is a hanger-style securing member **720**, as depicted in FIGS. **4**A and **4**B. Hanger-style securing member **720** can be used to secure the neural

stimulator to the back of the pinna, or to the surface of the head adjacent the pinna. In another aspect, securing member **710** is a loop-style securing member **722**, (e.g., of the type depicted in FIG. **5**). In another aspect, securing member **710** includes a clip **724** (e.g., of the type depicted in FIG. **3**). A clip may be used to secure neural stimulator **706** to various parts of the front or back of the pinna, including the front or back of the ear lobe. In another aspect, securing member **720** includes an extension **726** (e.g., such as extension **514** depicted in FIG. **5**). Such an extension can be used to position the neural stimulator in virtually any desired position on the pinna, or on the head adjacent to and above, below, in front of, or behind the ear. In an aspect, securing member **710** includes a housing **728**. It should be noted that housing **710** may in some cases function as an extension. For example, housing **602** depicted in FIG. **6** also functions as an extension extending from securing member **604** to provide for placement and securing of stimulator **606** and sensor **608** on a portion of the pinna **612** not immediately adjacent securing member **604**. Securing member **710** can be configured to secure the neural stimulator to the concha, tragus, front or back of the pinna, the helix, or various other parts of the pinna, e.g., the triangular fossa, antihelix, superior or inferior crus of the antihelix, antitragus, or tragus of the subject. In some aspects securing member **710** is permanently configured to position neural stimulator **706** in a particular position with respect to the ear of the subject, wherein in some aspects securing member **710** is adjustable such that the positioning of neural stimulator **706** can be selected by the subject. For example, a sensor or stimulator may be secured to a particular portion of the pinna by being pressed sufficiently firmly against the pinna by the securing member or extension to form a reliable mechanical or electrical contact with the pinna. In an aspect, securing member **710** includes a shape memory material. Various materials may be suitable for the construction of securing member **710**, including but not limited to hard or soft, elastically or plastically deformable polymers, metals, ceramics, glasses, and composites formed therefrom. Flexible or stretchable electronic circuitry, formed from flexible materials or structures (e.g. conductors having, e.g., a serpentine design) or resilient conductive materials such as conductive polymers can be used in sensors and stimulators that conform to the pinna. While discussion herein has focused on positioning of the neural stimulator by securing member **710**, it will be appreciated that securing member **710** can also be configured to position sensors with respect to the ear in a similar fashion. Several such examples are provided in FIGS. **3**-**6**.

In an aspect, the neural stimulator **706** is positioned with respect to securing member **710** such that when securing member **710** is worn on the pinna, neural stimulator **706** is positioned (secured) over a specific region of the pinna, e.g., a region of the pinna innervated by a cranial nerve, e.g., the vagus nerve, the facial nerve, the trigeminal nerve, or the glossopharyngeal nerve. Such positioning may be selected based upon knowledge of the innervation of the pinna, for example, as provided in references texts such as Cranial Nerves in Health and Disease, by Linda Wilson-Pauwels, Elizabeth J. Akesson, Patricia A. Stewart, and Sian D. Spacey; BC Decker Inc.; 2 edition (Jan. 1, 2002); ISBN-10: 1550091646/ISBN-13: 978-1550091649, which is incorporated herein by reference.

As noted above, neural stimulator **706** may be, for example, a mechanical stimulator **730** (e.g., a vibratory mechanical stimulator **732**), a transcutaneous electrical stimulator **734**, a transcutaneous magnetic stimulator **736**, an ultrasonic stimulator **738**, a chemical stimulator **740**, a thermal stimulator **742**, or other type of stimulator.

As shown in FIG. **7**, in an aspect, neural stimulation system **700** includes at least one secondary sensor **750**. In an aspect, neural signal sensor **702** is a primary neural signal sensor, and secondary sensor **750** is a secondary neural signal sensor **752**, which may be, for example, an electroencephalographic (EEG) sensor **754**, or electrooculographic (EOG) sensor **756**. The secondary neural signal sensor **752** may be of the same or different type as primary neural signal sensor **702**, and may be located at the same or different location on the body as primary neural signal sensor **702**. In an aspect, secondary sensor **750** is a physiological sensor **758**, for example, an electromyographic (EMG) sensor **755**, a heart rate sensor **760** (which may be used to heart rhythm variability, as well as heart rate, and may include, but is not limited to, and EKG or pulse-oximeter based heart rate sensor), blood pressure sensor **762**, perspiration sensor **764**, skin conductivity sensor **766**, respiration sensor **768**, pupil dilation sensor **770**, digestive tract activity sensor **772**, or piloerection sensor **774**. In another aspect, secondary sensor **750** is an environmental sensor, for example a light sensor **782**, which may be configured to sense light level **784** and or day length **786**. Environmental sensor **750** may include a temperature sensor **788**, or an acoustic sensor **790**, e.g., configured to sense ambient noise level **792**. Other types of sensors for providing information regarding the state of the subject and his or her environment may be used, without limitation, including motion sensor **794** or location sensor **796**, for example. A variety of physiological and environmental sensors are described in U.S. Pat. No. 8,204,786 to LeBoueuf et al., which is incorporated herein by reference. Digestive tract activity may be sensed with external acoustical sensors, for example as described in "New disposable biosensor may help physicians determine which patients can safely be fed following surgery," MedicalXpress, Aug. 7, 2014, which is incorporated herein by reference.

In an aspect, neural stimulation system **700** includes a secondary signal input **800**. In various aspects, the signal received at secondary signal input **800** includes a signal from a delivery device **802** (indicative of delivery of a drug or nutraceutical to the subject), an input to a game **804** (e.g., a signal corresponding to the subjects input to a video game played by the subject), an output from a game **806** (e.g., a signal output by a game system indicative of a state of or an event in a game played by the subject), a user input to a virtual reality system **808**, an output from a virtual reality system **810** (e.g., a signal output by the VR system indicative of an state of or an event in the VR system), a user input device **812** (e.g., a user input device of a computing device or a user input to the neural stimulation system), or a computing device input **814** (e.g., a data input). Inputs received via a user input device or computing device input may be indicative of intake of a food item, beverage, nutraceutical, or pharmaceutical by the subject, for example. Inputs received via a user input device may be provided by the subject, or by another user, e.g. a medical caregiver. Inputs may be provided spontaneously by the user, or in response to a prompt or query. In an aspect, inputs may be provided by the user in response to queries or prompts that form a part of a quiz, questionnaire, or survey, including, e.g. questions presented in yes/no or multiple choice response format. User responses provided in response to such prompts or queries may indicate the subject's mental or emotional state. Inputs received via a data input may include, for example, health-related information of the subject, including genome information or microbiome informa-

tion of the subject, information from medical-records of the subject, or other information pertaining to the health of the subject.

In an aspect, neural stimulation system **700** includes a clock or timer **816**. In various aspects, neural stimulator **706** is adapted to produce stimulus **708** based at least in part on a time of day indicated by clock/timer **816**, and/or based at least in part on a date indicated by clock/timer **816**.

Data drawn from one or more neural signals, physiological signals, environmental signals, or other secondary signals (e.g. obtained with secondary sensor **750** in FIG. **7**) or secondary inputs (e.g. secondary signal input **800** in FIG. **7**), as well as clock or timer information, can be correlated with a mental or emotional state of the subject, reported to a medical care provider or other party, and/or stored in the subject's medical or health records. In particular, values of any such parameters that are indicative of worsening mental or physical/physiological status of the subject can be reported to a medical care provider so that an appropriate intervention can be made, and/or used as a basis for modulating the delivery of neural stimulation.

In various aspects, neural stimulation system **700** includes at least one secondary stimulator **818** for delivery a secondary stimulus **820** to the subject. In an aspect, secondary stimulator **818** is a secondary neural stimulator **822**, which may be any of the various types of neural stimulators described in connection with neural stimulator **706**, and which may be of the same or different type as neural stimulator **706**. Alternatively, secondary stimulator **818** may include a mechanical stimulator **824**, an audio player **826**, an auditory stimulus source **828**, a virtual reality system **830**, an augmented reality system **832**, a visual stimulus source **834**, a tactile stimulator **836**, a haptic stimulator **838**, an odorant source **840**, a virtual therapist, or a delivery device **844**, for delivering a drug or nutraceutical, for example.

In various aspects, neural stimulation system **700** includes control circuitry **846** carried by securing member **710** (either directly on securing member **710**, or on an extension or housing connected to securing member **710**, e.g., as depicted in FIGS. **3-6**), the control circuitry **846** configured to control neural stimulator **706**.

In an aspect, neural stimulation system **700** includes communication circuitry **848** carried by securing member **710** and configured for at least one of sending one or more signal **850** to a personal computing device **852** and receiving one or more signal **854** from personal computing device **852**.

In an aspect, neural stimulation system **700** includes a sound source **856**, for delivering an auditory signal to the subject. Sound source **856** may be, for example, a speaker **858**. Sound source **856** may be configured (e.g., with appropriate electronic circuitry, not shown) to delivery an instruction **860** or alert **862** to the subject.

In an aspect, neural stimulation system **700** includes position sensor **864** for sensing the position of neural stimulator **706** with respect to the pinna of the subject. Position sensor **864** may detect the position of neural stimulator **706** with respect to the pinna by detecting electrical activity from a nerve, by detecting an image of the ear and determining the position based on landmarks in the image, or by detecting a temperature, pressure, or capacitive signal indicative of adequate contact of the stimulator with the ear, for example.

In an aspect, neural stimulation system **700** includes connector **866** for connecting the neural stimulator to a personal computing device. Connector **866** includes, for example, a jack or port for creating a wired (cable) connection with the personal computing device. In an aspect, neural stimulation system **700** includes user interface **867** for receiving input from the subject or presenting information to the subject. In an aspect, user interface **867** includes a small display, one or more indicator lights and simple user inputs, such as one or more buttons or dials for adjusting device setting and viewing and modifying system settings.

FIG. **8** illustrates a generalized form of circuitry-based systems as depicted in FIG. **7** and elsewhere herein. Although specific embodiments are described herein, those skilled in the art will appreciate that methods and systems as described herein can be implemented in various ways. Reference is made herein to various circuitry systems and subsystems (e.g., neural stimulation system **700** includes control/processing circuitry **846** in FIG. **7**, which may be considered to be control/processing circuitry. As shown generically in FIG. **8**, a system **870** includes a circuitry-based system **872**. Circuitry-based system **872**, which in some aspects is a computing device or computing subsystem, includes control/processing circuitry **874**, which includes any or all of digital and/or analog components **876**, one or more processor **878** (e.g., a microprocessor), and memory **880**, which may store one or more program module **882** and/or data **884**. In some aspects, control/processing circuitry provides for preliminary handling of data from one or more sensor **886**, transfer of data to remote device **896**, receipt of control signal from remote device **896**, and actuation of actuator **888**, which may be for example a neural stimulator (such as neural stimulator **706** as shown in FIG. **7**). Systems as described herein may receive signals from various sensors (e.g., sensor **886** depicted in FIG. **8**). System **870** may include other components as known to those skilled in the art, e.g., one or more power supply **890**, I/O structure **892**, clock, timer, data bus, etc. I/O structure **892** permits communication with various types of user interface devices (represented by user interface **894**, which may include one or more input devices such as a keyboard, button, switch, computer mouse, or touchscreen or one or more output devices such as screen, sound source, alphanumeric display, Braille display, etc.) and communication with various types of remote device **896**, e.g., remote system **216** in FIGS. **2A-2B**, which may have control/processing capability conferred by control/processing circuitry **898**.

In a general sense, the various embodiments described herein can be implemented, individually and/or collectively, by various types of electrical circuitry having a wide range of electrical components such as hardware, software, firmware, and/or virtually any combination thereof. Electrical circuitry (including control/processing circuitry **846** in FIG. **7**, for example) includes electrical circuitry having at least one discrete electrical circuit, electrical circuitry having at least one integrated circuit, electrical circuitry having at least one application specific integrated circuit, electrical circuitry forming a computing device configured by a computer program (e.g., a computer configured by a computer program which at least partially carries out processes and/or devices described herein, or a microprocessor configured by a computer program which at least partially carries out processes and/or devices described herein), electrical circuitry forming a memory device, which may include various types of memory (e.g., random access, flash, read only, etc.)), electrical circuitry forming a communications device (e.g., communication circuitry **848** in FIG. **7**) (e.g., a modem, communications switch, optical-electrical equipment, etc.), and/or any non-electrical analog thereto, such as optical or other analogs (e.g., graphene based circuitry). In an embodiment, the system is integrated in such a manner that the system operates as a unique system configured

specifically for function of the neural stimulation system described herein. In an embodiment, one or more associated computing devices of the system operate as specific use computers for purposes of the claimed system, and not general use computers. In an embodiment, one or more of the associated computing devices of the system are hard-wired with a specific ROM to instruct the one or more computing devices.

In a general sense, the various aspects described herein which can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, and/or any combination thereof can be viewed as being composed of various types of "electrical circuitry."

At least a portion of the devices and/or processes described herein can be integrated into a data processing system. A data processing system generally includes one or more of a system unit housing, a video display, memory such as volatile or non-volatile memory, processors such as microprocessors or digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices (e.g., a touch pad, a touch screen, an antenna, etc.), and/or control systems including feedback loops and control motors (e.g., feedback for sensing position and/or velocity; control motors for moving and/or adjusting components and/or quantities). A data processing system may be implemented utilizing suitable commercially available components, such as those typically found in data computing/communication and/or network computing/communication systems.

In various embodiments, methods as described herein may be performed according to instructions implementable in hardware, software, and/or firmware. Such instructions may be stored in non-transitory machine-readable data storage media, for example. The state of the art has progressed to the point where there is little distinction left between hardware, software, and/or firmware implementations of aspects of systems; the use of hardware, software, and/or firmware is generally (but not always, in that in certain contexts the choice between hardware and software can become significant) a design choice representing cost vs. efficiency tradeoffs. There are various vehicles by which processes and/or systems and/or other technologies described herein can be effected (e.g., hardware, software, and/or firmware), and that the preferred vehicle will vary with the context in which the processes and/or systems and/or other technologies are deployed. For example, if an implementer determines that speed and accuracy are paramount, the implementer may opt for a mainly hardware and/or firmware vehicle; alternatively, if flexibility is paramount, the implementer may opt for a mainly software implementation; or, yet again alternatively, the implementer may opt for some combination of hardware, software, and/or firmware in one or more machines, compositions of matter, and articles of manufacture. Hence, there are several possible vehicles by which the processes and/or devices and/or other technologies described herein may be effected, none of which is inherently superior to the other in that any vehicle to be utilized is a choice dependent upon the context in which the vehicle will be deployed and the specific concerns (e.g., speed, flexibility, or predictability) of the implementer, any of which may vary. Optical aspects of implementations will typically employ optically-oriented hardware, software, and or firmware.

In some implementations described herein, logic and similar implementations may include software or other control structures. Electrical circuitry, for example, may have one or more paths of electrical current constructed and arranged to implement various functions as described herein. In some implementations, one or more media may be configured to bear a device-detectable implementation when such media hold or transmit device detectable instructions operable to perform as described herein. In some variants, for example, implementations may include an update or modification of existing software or firmware, or of gate arrays or programmable hardware, such as by performing a reception of or a transmission of one or more instructions in relation to one or more operations described herein. Alternatively or additionally, in some variants, an implementation may include special-purpose hardware, software, firmware components, and/or general-purpose components executing or otherwise invoking special-purpose components.

Implementations may include executing a special-purpose instruction sequence or invoking circuitry for enabling, triggering, coordinating, requesting, or otherwise causing one or more occurrences of virtually any functional operations described herein. In some variants, operational or other logical descriptions herein may be expressed as source code and compiled or otherwise invoked as an executable instruction sequence. In some contexts, for example, implementations may be provided, in whole or in part, by source code, such as C++, or other code sequences. In other implementations, source or other code implementation, using commercially available and/or techniques in the art, may be compiled//implemented/translated/converted into a high-level descriptor language (e.g., initially implementing described technologies in C or C++ programming language and thereafter converting the programming language implementation into a logic-synthesizable language implementation, a hardware description language implementation, a hardware design simulation implementation, and/or other such similar mode(s) of expression). For example, some or all of a logical expression (e.g., computer programming language implementation) may be manifested as a Verilog-type hardware description (e.g., via Hardware Description Language (HDL) and/or Very High Speed Integrated Circuit Hardware Descriptor Language (VHDL)) or other circuitry model which may then be used to create a physical implementation having hardware (e.g., an Application Specific Integrated Circuit).

This detailed description sets forth various embodiments of devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In an embodiment, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, some aspects of the embodiments disclosed herein, in whole or in part, can be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of skill in the art in light of this disclosure. In addition, the mechanisms of

the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to non-transitory machine-readable data storage media such as a recordable type medium such as a floppy disk, a hard disk drive, a Compact Disc (CD), a Digital Video Disk (DVD), a digital tape, a computer memory, etc. A signal bearing medium may also include transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link (e.g., transmitter, receiver, transmission logic, reception logic, etc.) and so forth).

FIG. **9** is a flow diagram of a method **900** relating to use of a neural stimulation system as depicted in FIG. **7**. Here and elsewhere, method steps outlined with dashed lines represent steps that are included in some, but not all method aspects, and combinations of steps other than those specifically depicted in the figures are possible as would be known by those having ordinary skill in the relevant art. Method **900** includes sensing with a neural signal sensor a neural signal indicative of a physiological status of a subject, the neural signal sensor located in or on a portion of a body of the subject, as indicated at **902**; determining with signal analysis circuitry at least one parameter of the sensed neural signal, as indicated at **904**; and delivering a neural stimulus with a neural stimulation device worn on a pinna of the subject responsive to the sensed neural signal, wherein the neural stimulus is configured to modulate the activity of at least one sensory nerve fiber innervating at least a portion of the pinna of the subject, as indicated at **906**. In an aspect, the neural stimulus is of sufficient frequency and amplitude to modulate the activity of the at least one sensory nerve fiber innervating the at least a portion of the pinna of the subject. For example, in various aspects the neural stimulus has a frequency in the approximate range of 1 Hz-1000 Hz, 10 Hz-500 Hz, 30 Hz-40 Hz, 10 Hz-50 Hz, 10 Hz-80 Hz, 50 Hz-100 Hz, or 200-300 Hz. In an aspect, the stimulus has a sinusoidal waveform. In other aspects, the stimulus may have a triangular, rectangular, square, trapezoidal, or other waveform, delivered cyclically, with cycle frequencies in the ranges listed above. It will be appreciated that depending on the stimulus waveform or pulse shape, or envelope shape, a given stimulus may include higher or lower frequencies. The neural stimulus may be delivered according to programmed pattern, which may be stored in memory on the neural stimulation device or on a personal computing device or other remote device in communication with the neural stimulation device. In various aspects, the neural stimulus is delivered continuously, intermittently, and/or in a time-varying fashion. The neural stimulus may be a pulsed stimulus.

In an aspect, the neural stimulus is delivered with a neural stimulation device and/or neural stimulus configured to activate a cranial nerve, such as the vagus nerve, facial nerve, trigeminal nerve, or glossopharyngeal nerve. The neural stimulation device can be configured to stimulate a particular nerve by one or both of positioning the neural stimulator on at least a portion of a receptive field of the nerve of interest, and selecting the amplitude and other stimulus parameters (e.g. frequency, waveform, duration) of the stimulus delivered to activate the nerve fibers in the nerve of interest.

In an aspect, the method includes delivering the neural stimulus responsive to the at least one parameter of the sensed neural signal. The at least one parameter may include, for example, a frequency content of an electroencephalographic signal, an amplitude of an electroencephalographic signal, a rate of eye movement determined from an electrooculogram, or a gaze direction determined from an electrooculogram. In some aspects, such parameters are indicative of a brain-related disorder, or symptoms thereof. In an aspect, method **900** includes delivering the neural stimulus in response to detection of symptoms of a brain-related disorder (which may be, for example, any mental health disorder (e.g., psychological or psychiatric disorder), depression, post-traumatic stress disorder, seasonal affective disorder, anxiety, headache (e.g., primary headache, cluster headache, or migraine headache), or epilepsy). In an aspect, the method includes delivering the neural stimulus until symptoms of the brain-related disorder are no longer detected.

In an aspect, method **900** includes sensing at least one secondary signal with a secondary sensor. In an aspect, delivery of the neural stimulus may be started, stopped, or modulated in response to the secondary signal. The secondary signal may be a secondary neural signal (of the same or different type and sensed from the same or from a different location than the primary neural signal), or it may another type of physiological signal, an environmental signal, a location signal, or a signal from a motion sensor, for example. Such secondary signals may provide additional information relevant for determining whether the neural stimulus should be applied, assessing the subject's response to the neural stimulus, identifying appropriate time of delivery of the neural stimulus, etc. The secondary signal may include other types of secondary signal, e.g., as received by secondary signal input **800** in FIG. **7**. In an aspect, method **900** includes delivering at least one secondary stimulus to the subject in addition to the neural stimulus delivered with the neural stimulation device. The secondary stimulus may be any of various types of secondary stimulus, e.g., as delivered with secondary stimulator **818** as described in FIG. **7**. In various aspects, method **900** includes controlling the neural stimulation device with control circuitry located at least in part on the neural stimulation device, or with control circuitry located at least in part on a personal computing device in communication with the neural stimulation device worn on the pinna of the subject. In an aspect, method **900** includes sending a signal from the neural stimulation device worn on the pinna of the subject to a personal computing device or receiving a signal from a personal computing device at the neural stimulation device worn on the pinna of the subject. In an aspect, method **900** includes delivering an auditory instruction or an auditory alert to the subject with a sound source operatively connected to the neural stimulation device. In an aspect, method **900** includes sensing a position of the neural stimulation device relative to the pinna of subject with a position sensor operatively connected to the neural stimulation device. If the neural stimulation device is not positioned properly positioned, the auditory instruction or alert may remind the subject to correct the positioning of the neural stimulation device. Alternatively, or in addition, visual alerts can be provided to the subject, in the form of one or more blinking light, graphic, or a text message, delivered via an LED or other light emitting element, an alphanumeric display, a screen, or other display element on the neural stimulation device or on the personal computing device.

FIG. **10** depicts an embodiment of a wearable neural stimulation device **1000** that includes a vibratory mechanical stimulator **1002**. Vibratory mechanical stimulator **1002** is adapted to produce a vibratory stimulus of sufficient frequency and amplitude to modulate the activity of at least one mechanoreceptor with a receptive field on at least a portion of a pinna of a subject, and a securing member **710** configured to secure vibratory mechanical stimulator **1000** to the pinna. Securing member **710** is as described herein above. Vibratory mechanical stimulator **1002** is a vibratory stimulator, such as vibratory stimulator **732** described generally in connection with FIG. **7**. In various aspects, vibratory mechanical stimulator **1002** includes an electromechanical device **1004**, piezoelectric device **1006**, movable coil **1008**, electrostatic device **1010**, magnetostrictive device **1012**, isodynamic device **1014**, a MEMS device **1016**, and/or a stretchable electronic device **1018**.

In an aspect, neural stimulation device **1000** includes at least one sensor **1020**, which may be any of the various types of sensors described in connection with secondary sensor **750** in FIG. **7**, e.g., a physiological sensor **758**, a neural signal sensor **752**, an environmental sensor **780**, a motion sensor **794** or a location sensor **796**. In various aspects, neural stimulation device **1000** includes a secondary signal input **800**, secondary stimulator **818**, control circuitry **846** carried by securing member **710**, communication circuitry **848**, sound source **856**, position sensor **864**, and connector **866**, all of which have been discussed in connection with FIG. **7**.

FIG. **11** is a flow diagram of a method **1100** relating to use of a neural stimulation system as depicted in FIG. **10**. In an aspect, method **1100** includes delivering a vibratory mechanical stimulus to at least a portion of a pinna of a subject with a neural stimulation device worn on the pinna of the subject, wherein the vibratory mechanical stimulus is of sufficient frequency and amplitude to modulate the activity of at least one mechanoreceptor with a receptive field on the at least a portion of the pinna, as indicated at **1102**. In an aspect, method **1100** includes delivering the vibratory mechanical stimulus over a spatial extent of the pinna sufficient to modulate the activity of the at least one mechanoreceptor, as indicated at **1104**.

In an aspect, the vibratory mechanical stimulus has a waveform sufficient to modulate the activity of the at least one mechanoreceptor with a receptive field on the at least a portion of the pinna. For example, the vibratory mechanical stimulus may have a sinusoidal or other waveform. In some aspects, the vibratory mechanical stimulus is delivered according to programmed pattern, which may include delivering the vibratory mechanical stimulus either continuously or intermittently.

In an aspect, as indicated at **1106**, method **1100** includes sensing a signal with a sensor and controlling the delivery of the vibratory mechanical stimulus based at least in part on the sensed signal. The sensed signal may be any of the various types of signal sensed with sensor **1018** in FIG. **10**. In various aspects, controlling delivery of the vibratory mechanical stimulus based at least in part on the sensed signal includes modulating delivery of the neural stimulus in response to the sensed signal, or delivering the vibratory mechanical stimulus in response to the sensed signal. In an aspect, controlling the delivery of the vibratory mechanical stimulus based at least in part on the sensed signal includes initiating delivery of the vibratory mechanical stimulus in response to the sensed signal.

In an aspect, method **1100** includes receiving a signal from an input and controlling the delivery of the vibratory mechanical stimulus based at least in part on the received signal, as indicated at **1108**. The received signal may be e.g., any of the various types of input signals received at secondary signal input **800** in FIG. **10**.

In an aspect, method **1100** includes sensing at least one second sensed signal with a second sensor and controlling the delivery of the vibratory mechanical stimulus based at least in part on the second sensed signal, as indicated at **1110**.

In an aspect, method **1100** also includes delivering a secondary stimulus to the subject, as indicated at **1112**, which may include delivering a secondary stimulus with a secondary stimulator **818**, as described in connection with FIG. **7**.

As discussed in connection with method **900**, the vibratory mechanical stimulus can be delivered in response to detection of symptoms of a brain-related disorder, which may include, for example, a mental health disorder, depression, post-traumatic stress disorder, seasonal affective disorder, anxiety, headache, or epilepsy. In an aspect, method **1100** includes delivering the vibratory mechanical stimulus until symptoms of the brain-related disorder are no longer detected.

FIG. **12** depicts a neural stimulation system **1200** which includes a wearable neural stimulation device **1202** and personal computing device **1204**. Personal computing device **1204** may be packaged separately from wearable neural stimulation device **1202**, e.g., similar to the system depicted in FIGS. **2**A and **2**B. Wearable neural stimulation device **1202** includes neural stimulator **706**, which is adapted to produce a stimulus for activating at least one sensory nerve fiber innervating at least a portion of a pinna of a subject, securing member **710** configured to secure the neural stimulator to the pinna, control circuitry **1206** for controlling operation of neural stimulator **706**, and first communication circuitry **1208**. Neural stimulator **706** and securing member **710** are as described herein above in connection with FIG. **7**. Both control circuitry **1206** and first communication circuitry **1208** are incorporated into the wearable neural stimulation device **1202**. First communication circuitry **1208** is operatively connected to control circuitry **1206** and is configured for at least one of sending a signal **1210** to and receiving a signal **1212** from personal computing device **1204**. Other system components that may be included in or used in connection with wearable neural stimulation device **1202** include secondary signal input **800**, secondary stimulator **818**, sound source **856**, position sensor **864** and connector **866**, as described herein above in connection with FIG. **7**, and sensor **1018** as described herein above in connection with FIG. **10**. In an aspect, neural stimulation system **1200** includes user interface **1221**, including user input device **1222** which is used to receive an input from the subject or other user, and user output device **1223**. User input device **1222** may be any of various types of user input devices known to those of ordinary skill in the art, including but not limited to a button, keyboard, keypad, touchscreen, voice input, etc. In system **1200** and in other neural stimulation systems described herein, system components such as secondary signal input **800**, secondary stimulator **818**, sound source **856**, position sensor **864**, connector **866**, sensor **1018**, and user input device **1221** may in some cases be built into the wearable neural stimulation device (e.g., wearable neural stimulation device **1202**) and in some cases be packaged separately but used in combination with the wearable neural stimulation device. For example, sensors may be located on the subject's body at a location other than the ear, or in the vicinity of the subject

but not on the subject's body. In some cases, sensors may be implanted within the subject's body. Similarly, one or both of a secondary stimulator and a sound source can be located on the wearable neural stimulation device, on the subject's body distinct from the neural stimulation device, or in the vicinity of the subject but not on the subject's body.

Personal computing device **1202** includes a user interface **1214** for at least one of presenting information to and receiving information from a user, control circuitry **1216** operatively connected to user interface **1214**, and second communication circuitry **1218** configured for at least one of sending a signal to and receiving a signal from the first communication circuitry **1208** carried by the housing of the wearable neural stimulation device. In addition, personal computing device **1202** includes instructions **1220** that when executed on personal computing device **1204** cause personal computing device **1204** to perform at least one of sending signal **1212** to and receiving signal **1210** from wearable neural stimulation device **1202** via second communication circuitry **1218**.

Communication circuitry **1208** and communication circuitry **1218** provide for communication between wearable neural stimulation device **1202** and personal computing device **1204**. In addition, in some aspects one or both of communication circuitry **1208** and communication circuitry **1218** provide for communication of wearable neural stimulation device **1202** or personal computing device **1204**, respectively, with a remote system **1224**. In some aspects, communication circuitry **1208** and communication circuitry **1218** provide for wired communication between wearable neural stimulation device and personal computing device **1204**. Wired communication to wearable neural stimulation device may occur via connector **866**. Alternatively, or in addition, a wireless communication link may be established between wearable neural stimulation device **1202** and personal computing device **1204**, and/or between either wearable neural stimulation device **1202** or personal computing device **1204** and remote system **1224**. In various aspects, a wireless communication link includes at least one of a radio frequency, wireless network, cellular network, satellite, WiFi, BlueTooth, Wide Area Network, Local Area Network, or Body Area Network communication link. Various types of communication links are suitable for providing communication between two remote locations. Communication between locations remote from each other may take place over telecommunications networks, for example public or private Wide Area Network (WAN). In general, communication between remote locations is not considered to be suitably handled by technologies geared towards physically localized networks, e.g., Local Area Network (LAN) technologies operation at Layer 1/2 (such as the forms of Ethernet or WiFi). However, it will be appreciated that portions (but not the entirety) of communication networks used in remote communications may include technologies suitable for use in physically localized network, such as Ethernet or WiFi.

In an aspect, personal computing device **1204** is personal digital assistant **1226**, a personal entertainment device **1228**, a mobile phone **1230**, a laptop computer **1232**, a tablet personal computer **1234**, a wearable computing device **1236** (e.g., a fitness band, an item of clothing, attire, or eyewear incorporating computing capability), a networked computer **1238**, a computing system comprised of a cluster of processors **1240**, a computing system comprised of a cluster of servers **1242**, a workstation computer **1244**, and/or a desktop computer **1246**. In various aspects, personal computing device **1204** includes one or more of a portable computing device, a wearable computing device, a mobile computing device, and a thin client computing device, for example.

FIG. **13** depicts aspects of a system **1300** including personal computing device **1302**, for use in connection with neural stimulation system **1303**, which is a neural stimulation system such as described herein above. Personal computing device **1302** is as described generally in connection with FIG. **12**. In an aspect, personal computing device **1302** includes circuitry **1304** for receiving a neural activity signal **1306**, circuitry **1308** for determining a neural stimulus control signal **1310** based at least in part on neural activity signal **1306**, and circuitry **1312** for outputting neural stimulus control signal **1310** to neural stimulation device **1314**. In an aspect, neural activity signal **1306** is sensed by neural signal sensor **1315**, and is indicative of a physiological status of a subject. Neural activity signal **1306** may be an unprocessed neural signal, or neural activity signal **1306** may have been subjected to various types and amounts of signal processing, and/or analysis (including, but not limited to filtering, amplification, analog to digital conversion, signal averaging, conversion from time to frequency domain, feature extraction, and so forth). Neural activity signal **1306** may include neural activity sensed from one or more neural signal sensors **1315** (which may be electroencephalographic sensors or electrooculographic sensors, for example). Neural activity signal **1306** may include information derived from or associated with the sensed neural signal, and may include or be accompanied by additional information that identifies the type of signal, type of processing to which the signal has been subject, data formatting, device settings used during acquisition of the neural signal, etc. Neural signal sensor **1315** is a component of neural stimulation system **1303**, and may be a component of neural stimulation device **1314**, or used in association therewith, as described herein above. Neural stimulation device **1314** includes external neural stimulator **1316**, which is configured to be carried on a pinna of the subject. Neural stimulus control signal **1310** is configured to control delivery of a neural stimulus by external neural stimulator **1316**, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna.

Neural activity signal input **1304** (the circuitry for receiving neural activity signal **1306**) includes, for example, a headphone jack **1318**, data input **1320**, wireless receiver **1322**, or network connection **1324**. In various aspects neural activity signal input **1304** includes circuitry for receiving a signal from a body area network, a local area network, or a wide area network.

Neural stimulus control signal determination circuitry **1308** includes one or more of amplitude determination circuitry **1326** for determining a neural stimulus amplitude, frequency determination circuitry **1328** for determining a neural stimulus frequency, waveform determination circuitry **1330** for determining a neural stimulus waveform, pattern determination circuitry **1332** for determining a neural stimulus pattern, or duration determination circuitry **1333** for determining a neural stimulus duration. In an aspect, personal computing device **1302** includes data storage circuitry **1334** for storing data on the data storage device, including memory **1336** and circuitry for accessing data stored therein. Memory **1336** may contain stored preprogrammed stimulus patterns and waveforms as well as neural stimulus parameter values from which neural stimuli can be computed. In an aspect, system **1300** includes data storage circuitry **1334** for storing data on personal computing device **1302** representing neural stimulus control signal **1338**. In an aspect, system **1300** includes data storage circuitry **1334** for

storing data on personal computing device **1302** representing previous neural activity **1340**. In an aspect, neural activity prediction circuitry **1342** predicts a future neural activity signal based on a previous neural activity signal.

In an aspect, system **1300** includes secondary stimulus determination circuitry **1344** for determining a secondary stimulus based on neural activity signal **1306**. In an aspect, secondary stimulus determination circuitry **1344** determines the secondary stimulus control signal **1346** based on previous neural activity signal **1340**.

In an aspect, system **1300** includes reporting circuitry **1348** for providing a report **1350** to at least one recipient. Reporting circuitry **1348** may cause report **1350** to be provided via a user interface **1214** (as described in connection with FIG. **12**) or via a computing network (accessed via communication circuitry **1218**). In an aspect, report **1350** is provided to the subject using the neural stimulation device **1314**. In another aspect, report **1350** is provided to other parties, for example, a medical care provider, an insurance company, a service provider (e.g., a business or other entity that provides services related to the neural stimulation device or related to monitoring use of the neural stimulation device). In an aspect, report **1350** is provided to at least one social media contact (or 'friend'), or to a peer of the subject, e.g., via a social network. In an aspect, the recipient is a computing system, e.g. a computing system used for storing and/or processing healthcare information. In various aspects, anonymization circuitry **1352** is used to provide the report in anonymized form (e.g., with information identifying the subject removed therefrom). Reporting circuitry **1326** may include circuitry for including various information in report **1350**, e.g., information relating to one or more of neural activity signal **1306** or information derived therefrom, neural stimulus control signal **1310**, settings for neural stimulation device **1314** or personal computing device **1302**, stored neural activity data **1340**, secondary input signal **1354**, and secondary stimulus control signal **1346**. In an aspect, system **1300** includes secondary stimulus control signal output circuitry **1356** for delivering secondary stimulus control signal **1346** to secondary stimulator **1358**. Secondary stimulator **1358** can be any type of stimulator, for example such as secondary stimulator **818** described in connection with FIG. **7**.

In an aspect, system **1300** includes secondary signal input **1360** for receiving a secondary input signal **1354** at personal computing device **1302**. In an aspect, neural stimulus control signal determination circuitry is configured to determine neural stimulus control signal **1310** based at least in part on secondary input signal **1354**. Secondary input signal may be representative of a physiological parameter of the subject or an environmental parameter of the subject, and may include a signal sensed from a sensor on or associate with neural stimulation device **1314**, or a sensor in the environment of the subject, and/or parameters or values derived from such sensed signals. In an aspect, the secondary input signal is indicative of a user input provided by the subject. In an aspect, secondary input signal **1354** may be received via user input **1362** in user interface **1214**.

In an aspect, system **1300** includes circuitry for presenting a recommendation to the subject. The recommendation may be presented to the subject via user output **1364** of user interface **1214**, e.g., via audio output **1366** and/or graphical display **1368** or transmitted to neural stimulation device **1303** and presented via a user interface on neural stimulation device **1303**. In an aspect, system **1300** includes recommendation receiving circuitry **1370** for receiving recommendation **1372** at personal computing device **1302**.

For example, in an aspect recommendation receiving circuitry **1370** receives recommendation **1372** via a computing network. In various aspects, recommendation **1372** is received from a medical care provider, from an insurance company, a service provider, an advisor, a computation-based system (including, e.g. an artificial intelligence), or a social media source, for example. In various aspects, recommendation receiving circuitry **1370** is configured to receive recommendations from particular sources, e.g. by receiving along with the recommendation a code indicating the source of the recommendation (e.g., a specific medical care provider, a medical care provider as opposed to a social media source), and to recognize a source of the recommendation and respond differently depending upon the source of the recommendation. Recommendation receiving circuitry **1370** may be configured such that recommendations from more credible sources may presented to the subject more promptly or more prominently, whereas recommendations from undesirable sources may be blocked, for example. Recommendation **1372** may relate to a configuration of neural stimulus control signal **1319** or secondary stimulus control signal **1346**. In other aspects, recommendation **1372** relates to one or more of a consumer product, a service, a user experience, a user activity, or an organization that may be of interest to the subject, e.g., because the recommendations would enhance or be compatible with the effects of the neural stimulation received by the subject, or in some other manner relate to the neural stimulation or the condition which it is intended to treat. For example, the recommendation might be for software for storing, presenting, sharing, or reporting stimulation data or health data or for an organization that provides counseling to individuals with a particular condition. In an aspect, user input **1362** is configured to receive acceptance/rejection signal **1374** from the subject regarding acceptance or rejection of recommendation **1372**.

In an aspect, system **1300** includes patch or update receiving circuitry **1376** for receiving patch/update **1378** at personal computing device **1302**. Patch/update **1378** includes a software patch or update for software residing on personal computing device **1302** or neural stimulation device **1314** and may be received, for example, from the manufacturer of neural stimulation device **1314**, from a service provider, or the like. In an aspect, personal computing device **1302** includes update circuitry **1380** for applying the patch or update to software installed on personal computing device **1302** or to software installed on neural stimulation device **1314**, by sending update signal **1382** to neural stimulation system **1303**. In an aspect, update circuitry **1380** also provides for updating a configuration of at least one of the neural stimulation device and the personal computing device, the configuration relating to operation of the neural stimulation device. In an aspect, update circuitry **1380** can be configured to update the configuration of at least one of the neural stimulation device and the personal computing device based on historical data (e.g., as stored in memory **1336**). In another aspect, update circuitry **1380** is configured to update the configuration based on at least one instruction **1384**. In an aspect, instruction **1384** is received via user input **1362** of personal computing device **1302**. In another aspect, instruction **1384** is received from a computing network, (e.g., from a remote device or system, via a data input such as I/O **892** depicted in FIG. **8**). In various aspects, instruction **1384** is received from a medical care provider, an insurance company, or a service provider, for example.

In another aspect, update circuitry **1380** is configured to update the configuration of at least one of the neural stimu-

lation device and the personal computing device based on at least one recommendation **1372**. As discussed herein above, recommendation **1372** is received by recommendation receiving circuitry **1370**, and can be received from an advisor, from a computation-based system (e.g., an artificial intelligence, machine learning system, or search engine based on a data-driven technique), or from a social media source (for example, in various aspects, the recommendation is based on the at least one preference of at least one social media contact, peer, or role model of the subject). In addition, acceptance/rejection input **1374** is received from the subject by user interface **1214** regarding acceptance or rejection of the recommendation, and update circuitry **1380** updates the configuration responsive to acceptance of the recommendation by the subject (if the recommendation is rejected, no update is made in response to the recommendation). As an alternative, acceptance or rejection of the recommendation can be provided by a caregiver of the subject regarding received via either user interface **1214** or via a data input from a remote device or system. Update circuitry **1380** updates the configuration responsive to acceptance of the recommendation by the caregiver of the subject. In another aspect, update circuitry **1380** is configured to update the configuration of at least one of the neural stimulation device and the personal computing device based on an environmental parameter (based in a secondary input signal **1354** received at secondary signal input **1360**. In another aspect, update circuitry **1380** is configured to update the configuration of at least one of the neural stimulation device and the personal computing device automatically. For example, in an aspect, the configuration is updated automatically according to a schedule, for example when the time and/or date indicated by clock/timer **1386** matches an update time/date in schedule **1388** stored in memory **1336**.

In an aspect, neural activity signal input **1304** includes circuitry for receiving neural activity signal **1306** via a secure connection. In an aspect, neural control signal output **1312** includes circuitry for outputting neural stimulus control signal **1346** via a secure connection. The secure connection may include be provided through the use of an encrypted signal, for example.

In an aspect, system **1300** includes output circuitry **1390** for presenting information to the subject via user interface **1214**, including e.g., audio output **1366**, graphical display **1368**, alphanumeric display **1392**, touchscreen **1394**, or other user interface devices, as known to those of ordinary skill in the art.

In an aspect, system **1300** includes customization circuitry **1396**. Customization circuitry **1396** customizes for the subject one or both of the information, or the formatting of the information, that is presented to via user interface **1214**, based on user preferences, for example.

In an aspect, system **1300** includes authentication circuitry **1398** for receiving a credential **1400** showing that the subject is an authorized user. In an aspect, output circuitry **1390** presents information to the subject via user interface **1214** only following receipt of credential **1400** showing that the subject is an authorized user. In various aspects, authentication circuitry **1398** receives a password, a personal identification number, a biometric feature, or a card authentication, for example.

In an aspect, output circuitry **1390** includes output format circuitry **1402** for presenting the information to the subject via user interface **1214** in a graphical format that mimics the graphical format of an audio player, in a graphical format that mimics the graphical format of a mobile phone, or in any other graphical format that mimics the graphical format of a familiar user interface. This permits the subject to use the neural stimulation device discretely, and present to observers the impression that the personal computing device is functioning as a mobile phone or audio player rather than being used in connection with a neural stimulation device. In an aspect, output circuitry **1390** changes or discontinues the presenting of information to the subject via the user interface in response to an input signal **1404**. For example, output circuitry **1390** switches between a first graphical format and a second graphical format on user interface **1214** in response to input signal **1404**. For example, the first graphical format may present information relating to the neural stimulus, while the second graphical format may mimic the format of a mobile phone or audio player. In an aspect, input signal **1404** is a user input signal, received for example via user interface **1214**. In another aspect, input signal **1404** is a sensed environmental signal indicative of presence of another person (e.g., an audio input signal containing the detected voice of the other person, received via secondary input signal **1354**). In an aspect, input signal **1404** is indicative of a time (e.g., a signal received from clock/timer **1386** on personal computing device **1302**).

In an aspect, neural stimulus control signal determination circuitry **1308** modulates neural stimulus control signal **1310** in response to an override signal. For example, in an aspect override signal is input signal **1404** received via user input **1362**. In an aspect, override signal is secondary input signal **1354**, received via secondary signal input **1360**. In an aspect, the override signal originates from a sensor that senses a physiological parameter, such as heart rate. In the event that the physiological parameter indicates an unsafe condition (e.g., the heart rate is too high or too low), the neural stimulus control signal determination circuitry **1308** modulates neural stimulus control signal **1310** to discontinue production of the neural stimulus. For example, in various aspects, the override signal originates from a sensor responsive to sensing a presence of a person other than the subject in the vicinity of the subject or responsive to sensing that the external neural stimulator is not properly positioned on the pinna of the subject. In an aspect, neural stimulus control signal determination circuitry **1308** modulates neural stimulus control signal **1310** to discontinue production of the neural stimulus. In an aspect, neural stimulus control signal determination circuitry **1308** modulates neural stimulus control signal **1310** to change an intensity of the neural stimulus. In addition to modulating or discontinuing the neural stimulus in response to an override condition (e.g., physiological parameter indicative of an unsafe condition, improper positioning of the external neural stimulator, etc.), a notification may be sent to the subject and/or to a medical care provider or other party regarding the override condition, to prompt the recipient of the notification to take corrective action, or for inclusion of the information in the subject's medical records.

In an aspect, secondary signal input **1360** is adapted to receive a position signal indicative of a position of the external neural stimulator with respect to the pinna of the subject. In connection therewith, system **1300** may also include notification circuitry **1406** for delivering a notification to the subject indicating that the external neural stimulator should be repositioned. In an aspect, notification circuitry **1406** includes circuitry for delivering the notification via a graphical display **1368** of personal computing device **1302**. In an aspect, notification circuitry **1406** includes circuitry for delivering an auditory alert, either via audio output **1366** of personal computing device, or by generating an appropriate audio output signal **1408** for driving produc-

tion of the auditory alert by a sound source **1410** on neural stimulation device **1314**. In an aspect, notification circuitry **1406** includes circuitry for delivering a voice message (e.g., a preset message retrieved from memory **1336**). In a further aspect, notification circuitry **1406** includes circuitry for storing information indicating that stimulator **1316** is improperly positioned in a data storage location (e.g., memory **1336**) in personal computing device **1302**. In another aspect, notification circuitry **1406** provides for storing information indicating that stimulator **1316** is improperly positioned in a data storage location in neural stimulation device **1314** (e.g., by transmitting such information to neural stimulation device **1314**.

In an aspect, system **1300** includes circuitry for outputting an audio output signal, either via an audio output **1366** of personal computing device **1302** or via sound source **1410** of neural stimulation device **1314**, where the audio output signal drives delivery of sound to the ear of the subject via a sound source. In an aspect, output circuitry **1390** is used to output the audio output signal via audio output **1366** of the personal computing device. In an aspect, communication circuitry **1218** is used for transmitting audio output signal **1408** to a sound source **1410** on neural stimulation device **1314**. Alternatively, communication circuitry **1218** can be used to deliver an audio output signal to sound source distinct from the neural stimulation device (e.g., a sound source included in a device used by the subject, but not included in the neural stimulation device). In an aspect, output circuitry **1390** retrieves an audio signal from a data storage location (e.g., memory **1336**) on personal computing device **1302**, and generate audio output signal based on the retrieved audio signal. In another aspect, system **1300** includes audio receiver **1412** for receiving audio input signal **1414** from a telecommunication network. For example, in various aspects, audio input signal **1414** is a broadcast radio signal, a webcast audio signal, or a mobile phone signal.

In an aspect, system **1300** includes prioritization circuitry **1416** for prioritizing delivery of the neural stimulus control signal relative to the audio output signal (either audio output signal **1408** for delivery to sound source **1410**, and/or an audio output signal delivered via audio output **1366** on personal computing device **1302**). In an aspect, prioritization circuitry **1416** automatically discontinues outputting of the neural stimulus control signal **1310** and starts outputting of the audio output signal in response to receipt of audio input signal **1414**. In another aspect, prioritization circuitry **1416** automatically declines audio input signal **1414** if the neural stimulus is currently being delivered. In another aspect, prioritization circuitry **1416** provides for circuitry for outputting the audio output signal simultaneously with neural stimulus control signal **1310**. In another aspect prioritization circuitry **1416** provides for switching between outputting the audio output signal and outputting neural stimulus control signal **1346**. Switching may occur in response to a user input received via user input **1362**, or in response to sensor input received, for example, via secondary signal input **1360**. In an aspect, prioritization circuitry **1416** performs switching between outputting the audio output signal and outputting neural stimulus control signal **1310** according to a schedule (stored, e.g., in memory **1336**) in response to input from clock/timer **1386**. In an aspect, prioritization circuitry **1416** switches between outputting the audio output signal and outputting the neural stimulus control signal responsive to receipt of the audio input signal **1414** from a telecommunication network. Prioritization circuitry **1416** may be configured to give higher priority to outputting of the neural stimulus control signal than to outputting of the audio output signal, or to give higher priority to outputting of the audio output signal than to outputting of the neural stimulus control signal. The priority of the signals may be determined by the preference of the subject. For example, the subject may consider it a higher priority to receive a phone call via his or her mobile phone than to continue received of a neural stimulation, and therefore may configure system **1300** so that neural stimulation is discontinued when a phone call is received. Alternatively, the subject may prefer that a neural stimulation session not be interrupted, and may configure system **1300** such that no phone calls will be received while neural stimulation is taking place. In other aspects, the subject may provide an input at user interface **1214** (e.g., by pressing a button) to switch between receiving neural stimulation and listening to music, as preferred. In another aspect, system **1300** is configured to deliver neural stimulation in combination with music.

FIG. **14** is a flow diagram of a method **1450** relating to use of a system including a personal computing device, as illustrated in FIG. **13**. Method **1450** includes receiving a neural activity signal at a personal computing device, the neural activity signal indicative of a physiological status of a subject, as indicated at **1452**. In addition, method **1450** includes determining a neural stimulus control signal based at least in part on the neural activity signal, as indicated at **1454**, and outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, as indicated at **1456**. In an aspect, determining the neural stimulus control signal includes determining a stimulation pattern. In various aspect, method **1450** includes additional steps, relating to the system functions described in greater detail in connection with FIG. **13**. For example, in an aspect, method **1450** includes providing a report to at least one recipient, as indicated at **1458**. In an aspect, method **1450** includes determining a secondary stimulus control signal adapted to control delivery of a secondary stimulus to the subject, and delivering the secondary stimulus control signal to a secondary stimulator, as indicated at **1460**. For example, in an aspect, the secondary stimulator includes a game device, and the secondary stimulus control signal controls operation of the game device. In another aspect, the secondary stimulator includes computing system configured to deliver a virtual therapist experience, and the secondary stimulus control signal controls operation of the virtual therapist. In another aspect, the secondary stimulus includes an interactive activity delivered via a computing device, and the secondary stimulus control signal controls operation of the computing device.

In an aspect, method **1450** includes receiving a secondary input signal at the personal computing device and determining the neural stimulus control signal based at least in part on the secondary input signal, as indicated at **1462**. For example, in an aspect the secondary input signal is indicative of a user input provided spontaneously by subject. Other secondary input signals are described herein above.

In an aspect, method **1450** includes presenting a recommendation to the subject, as indicated at **1464**. Method **1450** may also include receiving the recommendation at the personal computing device, as described above in connection with FIG. **13**.

In an aspect, method **1450** includes receiving a patch or update at the personal computing device, the patch or update relating to operation of the neural stimulation device, as indicated at **1466**. In an aspect, the patch or update is for software installed on the personal computing device. In another aspect, the patch or update is for software installed on the neural stimulation device, in which case method **1450** may also include sending the patch or update to the neural stimulation device.

In an aspect, method **1450** includes updating a configuration of at least one of the neural stimulation device and the personal computing device, the configuration relating to operation of the neural stimulation device, as indicated at **1468**. As discussed above, the configuration is updated based on at least one instruction. In another aspect, the configuration is updated based on at least one recommendation, responsive to receipt of an input regarding acceptance of the recommendation by the subject or a caregiver of the subject.

In an aspect, method **1450** includes presenting information to the subject via a user interface, as indicated at **1470**. The method may also include changing or discontinuing the presenting of information to the subject via the user interface in response to an input signal. In an aspect, method **1450** includes modulating the neural stimulus control signal in response to an override signal, as indicated at **1472**.

In an aspect, method **1450** includes receiving a position signal indicative of the position of the external neural stimulator with respect to the pinna of the subject, as indicated at **1474**. Method **1450** may also include delivering a notification to the subject indicating that external neural stimulator should be repositioned. Other method aspects are discussed in connection with FIG. **13**.

FIG. **15** is a block diagram of a computer program product **1500** for implementing a method as described in connection with FIG. **14**. Computer program product **1500** includes a signal-bearing medium **1502** bearing one or more instructions for receiving a neural activity signal, the neural activity signal indicative of a physiological status of a subject; one or more instructions for determining a neural stimulus control signal based at least in part on the neural activity signal; and one or more instructions for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, as indicated at **1504**. Signal-bearing medium **1502** may be, for example, a computer-readable medium **1506**, a recordable medium **1508**, a non-transitory signal-bearing medium **1510**, or a communications medium **1512**, examples of which are described herein above.

FIG. **16** is a block diagram of a system **1600** including a personal computing device **1602** and external neural stimulator **1604**, which comprises a part of neural stimulation device **1606** and neural stimulation system **1608**. Personal computing device **1602** is as described generally in connection with FIG. **12**. In an aspect, a system **1600** includes personal computing device **1602** including physiological activity input circuitry **1610** for receiving a physiological activity signal **1612** at personal computing device **1062**. Physiological activity signal **1612** is sensed by physiological sensor **1614** in neural stimulation system **1608**, and is indicative of a physiological status of a subject. Physiological sensor **1614** can be any of various types of physiological sensors, e.g., as described in connection with physiological sensor **758** in FIG. **7**. In various aspects, physiological activity signal **1612** is representative of a heart rate (and in some cases heart rate rhythm variability), a blood pressure, perspiration, skin conductivity, respiration, pupil dilation, digestive tract activity, or piloerection. In some aspects, physiological activity signal **1612** is a neural activity signal, such as an electroencephalographic or electrooculographic signal. Physiological activity signal **1612** may be an electromyographic signal (indicative of muscle activity of the subject) or an electrocardiographic signal (indicative of cardiac activity of the subject). Physiological activity signal **1612** may be an unprocessed physiological signal, or physiological activity signal **1612** may have been subjected to various types and amounts of signal processing, and/or analysis (including, but not limited to filtering, amplification, analog to digital conversion, signal averaging, conversion from time to frequency domain, feature extraction, and so forth). Physiological activity signal **1612** may include activity sensed from one or more physiological sensors **1614**. Physiological activity signal **1612** may include information derived from or associated with the sensed physiological signal, and may include or be accompanied by additional information that identifies the type of signal, type of processing to which the signal has been subject, data formatting, device settings used during acquisition of the physiological signal, etc. Personal computing device **1602** also includes neural stimulus control signal determination circuitry **1616** for determining neural stimulus control signal **1618** based at least in part on physiological activity signal **1612**. Neural stimulus control signal **1618** is configured to control delivery of a neural stimulus by external neural stimulator **1604**. In an aspect, the neural stimulus is configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna. Personal computing device **1602** also includes neural stimulus control signal output circuitry **1620** for outputting neural stimulus control signal **1618** from personal computing device **1602** to neural stimulation device **1606**. Neural stimulation device **1606** includes external neural stimulator **1604** configured to be carried on a pinna of the subject. Personal computing device **1602** also includes output circuitry **1390** for presenting information to the subject via user interface **1364** (as described herein above in connection with FIG. **13**). Various elements of system **1600** are the same as like-numbered elements of the systems shown in FIG. **12** or **13**, and accordingly will not be discussed in detail again in connection with FIG. **16**. However, some components of system **1600** include different and/or additional features. For example, data storage circuitry **1334** is also adapted for storing physiological activity data **1622** representing physiological activity signal **1612** in memory **1336**. In an aspect, physiological activity prediction circuitry **1624** predicts a future physiological activity signal based on a previous physiological activity signal. In addition, neural stimulus control signal determination circuitry **1616** determines the neural stimulus based on a previous physiological activity signal. Secondary stimulus determination circuitry **1344** is adapted to determine the secondary stimulus based on physiological activity signal **1612** or a previous physiological activity signal (e.g., stored in memory **1336**). As noted above in connection with FIG. **13**, in an aspect, secondary input signal **1354** is a physiological signal. It will be appreciated that secondary input signal **1354** in this context will be a secondary physiological signal, and physiological activity signal **1612** will be a primary physiological signal. In an aspect, physiological activity input circuitry **1610** includes circuitry for receiving physi-

ological activity signal **1612** via a secure connection. In an aspect, neural stimulus control signal output **1620** includes circuitry for outputting neural stimulus control signal **1618** via a secure connection.

FIG. **17** is a flow diagram of a method **1700** relating to use of a system as depicted in FIG. **16**. In an aspect, method **1700** includes receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, as indicated at **1702**; determining a neural stimulus control signal based at least in part on the physiological activity signal, as indicated at **1704**; outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, as indicated at **1706**; and presenting information to the subject via a user interface, as indicated at **1708**. Other method aspects are discussed in connection with FIGS. **14** and **16**.

FIG. **18** is a block diagram of a computer program product **1800** for implementing a method as described in connection with FIG. **17**. Computer program product **1800** includes a signal-bearing medium **1802** bearing one or more instructions for receiving a physiological activity signal, the physiological activity signal indicative of a physiological status of a subject; one or more instructions for determining a neural stimulus control signal based at least in part on the physiological activity signal; one or more instructions for outputting the neural stimulus control signal to a neural stimulation device including an external neural stimulator configured to be carried on an ear of a subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna; and one or more instructions for presenting information to the subject via a user interface, as indicated at **1804**. Signal-bearing medium **1802** may be, for example, a computer-readable medium **1806**, a recordable medium **1808**, a non-transitory signal-bearing medium **1810**, or a communications medium **1812**, examples of which are described herein above.

FIG. **19** is a block diagram of a system **1900**. FIG. **19** is similar to the system depicted in FIGS. **13** and **16**, and like-numbered system components described in connection with these figures will not be described again in connection with FIG. **19**. In an aspect, system **1900** includes a personal computing device **1902** including physiological activity input circuitry **1610** for receiving a physiological activity signal at personal computing device **1902**, the physiological activity signal **1612** indicative of a physiological status of a subject. System **1900** also includes neural stimulus control signal determination circuitry **1616** for determining a neural stimulus control signal **1618** based at least in part on physiological activity signal **1612**. In addition, system **1900** includes neural stimulus control signal output circuitry **1620** for outputting neural stimulus control signal **1618** from personal computing device **1902** to neural stimulation device **1904**. Neural stimulation device **1904** includes external neural stimulator **1604** configured to be carried on a pinna of the subject, wherein neural stimulus control signal **1618** is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna. System **1900** also includes audio output circuitry **1908** for outputting an audio output signal **1910** via an audio output **1366** of personal computing device **1902**. In an aspect, system **1900** includes circuitry for delivering the audio output signal to sound source **1910** on neural stimulation device. In another aspect, system **1900** includes circuitry for delivering audio output signal **1910** to sound source **1912** that is distinct from neural stimulation device **1904**. For example, sound source **1912** may be a sound source in the environment of the subject but not on the neural stimulation device, including but not limited to a sound source on, built into, or associated with personal computing device **1902**. In an aspect, system **1900** includes data storage circuitry **1334** for retrieving stored audio signal **1914** from a data storage location (memory **1336**) on personal computing device **1902**. In an aspect, system **1900** includes audio receiver **1412** for receiving the audio input signal from telecommunication network **1918**. For example, in various aspects, the audio input signal is a broadcast radio signal **1920**, a webcast audio signal **1922**, or a mobile phone signal **1024**.

In an aspect, system **1900** includes prioritization circuitry **1416** which prioritizes between delivery of neural stimulus and delivery of the audio output signal, based upon system settings and/or preferences of the subject. For example, prioritization circuitry **1416** provides for automatically discontinuing outputting of the neural stimulus control signal and starting outputting of the audio output signal in response to receipt of the audio input signal, automatically declining the audio input signal if the neural stimulus is currently being delivered, or outputting the audio output signal simultaneously with the neural stimulus control signal. In other aspects, prioritization circuitry **1416** provides switching between outputting the audio output signal and outputting the neural stimulus control signal, for example in response to a user input or a sensor input, according to a schedule, or in response to receipt of an audio input signal (e.g., a phone call) from a telecommunication network. Depending on preference of the subject or other considerations, prioritization circuitry **1416** can be configured to give higher priority to outputting of the neural stimulus control signal than to outputting of the audio output signal, or to give higher priority to outputting of the audio output signal than to outputting of the neural stimulus control signal.

FIG. **20** is a flow diagram of a method **2000** relating to use of a system as depicted in FIG. **19**. In an aspect, method **2000** includes receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, as indicated at **2002**; determining a neural stimulus control signal based at least in part on the physiological activity signal, as indicated at **2004**; outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, as indicated at **2006**; and outputting an audio output signal via an audio output of the personal computing device, as indicated at **2008**. Other method aspects are discussed in connection with FIGS. **14** and **19**.

FIG. **21** is a block diagram of a computer program product **2100** for implementing a method as described in connection with FIG. **20**. Computer program product **2100** includes a signal-bearing medium **2102** bearing one or more instruc-

tions for receiving a physiological activity signal at a personal computing device, the physiological activity signal indicative of a physiological status of a subject, one or more instructions for determining a neural stimulus control signal based at least in part on the physiological activity signal, one or more instructions for outputting the neural stimulus control signal from the personal computing device to a neural stimulation device including an external neural stimulator configured to be carried on a pinna of the subject, wherein the neural stimulus control signal is configured to control delivery of a neural stimulus by the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating at least a portion of the pinna, and one or more instructions for outputting an audio output signal via an audio output of the personal computing device, as indicated at **2104**. Signal-bearing medium **2102** may be, for example, a computer-readable medium **2106**, a recordable medium **2108**, a non-transitory signal-bearing medium **2110**, or a communications medium **2112**, examples of which are described herein above.

FIG. **22** is a block diagram of a system **2200**, which includes a personal computing device **2202** for use in combination with a wearable mechanical stimulation device **2204**. FIG. **22** is similar to the systems depicted in FIGS. **13**, **16** and **19** and like-numbered system components described in connection with these figures will not be described again in connection with FIG. **22**. Personal computing device **2202** includes vibratory stimulus control signal determination circuitry **2206** for determining a vibratory stimulus control signal **2208**, and vibratory stimulus control signal output circuitry **2210** for outputting vibratory stimulus control signal **2208** to wearable mechanical stimulation device **2204**. Wearable mechanical stimulation device **2204** includes a vibratory mechanical stimulator **1002** configured to be carried on a pinna of a subject, wherein the vibratory stimulus control signal is configured to control delivery of a vibratory stimulus by the vibratory mechanical stimulator **1002**, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field on at least a portion of the pinna. In an aspect, wearable mechanical stimulation device **2204** is a wearable neural stimulation device **1000** of the type discussed in connection with FIG. **10**, and can be considered a variant of wearable neural stimulation device **1202** depicted and discussed in connection with FIG. **12**. In addition, in various aspects system **2200** includes additional components such as are included in neural stimulation system **1200** described in connection with FIGS. **7**, **10** and/or **12**, including, but not limited to, sensor **1018** for detecting input signal **1354**, user interface **1221**, position sensor **864**, secondary stimulator **818**, and sound source **856**. Personal computing device **2202** can be any of the various types of personal computing devices described in connection with FIG. **12**, for example, a personal digital assistant, a personal entertainment device, a mobile phone, a laptop computer, a table personal computer, a wearable computing device, a networked computer, a computing system comprised of a cluster of processors, a computing system comprised of a cluster of servers, a workstation computer, or a desktop computer. Data storage circuitry **1334** including memory **1336** on personal computing device **2202** can be used to store data, instructions, parameters, as described elsewhere herein, including but not limited to stimulation patterns **2212***a*, **2212***b*, and **2212***c* representing vibratory mechanical stimuli to be delivered under the control of vibratory stimulus control signal **2208**. In an aspect, vibratory stimulus control signal **2208** is configured to cause delivery of one of a plurality of pre-programmed stimulation patterns, e.g., selected from stimulation patterns **2212***a*, **2212***b*, and **2212***c* stored in memory **1336**. In an aspect, vibratory stimulus control signal **2208** is determined by vibratory stimulus control signal determination circuitry **2206**. In various aspects, vibratory stimulus control signal determination circuitry **2206** includes amplitude determination circuitry **2214**, frequency determination circuitry **2216**, waveform determination circuitry **2218**, pattern determination circuitry **2220**, or duration determination circuitry **2222** for determining various aspects of the vibratory stimulus control signal **2208**, which determines the mechanical stimulus delivered by vibratory mechanical stimulator **1002**. If position signal **2224** from position sensor **864** indicates that vibratory mechanical stimulator **1002** is not properly positioned on the ear of the subject, a notification is provided to the subject, e.g., via notification circuitry **1406**, instructing the subject to reposition vibratory mechanical stimulator **1002**.

FIG. **23** is a flow diagram of a method **2300** involving the use of a system as depicted in FIG. **22**. In an aspect, method **2300** includes determining a vibratory stimulus control signal with stimulation control circuitry in a personal computing device, as indicated at **2302**; and outputting the vibratory stimulus control signal from the personal computing device to a wearable mechanical stimulation device including a vibratory mechanical stimulator configured to be carried on a pinna of a subject, wherein the vibratory stimulus control signal is configured to control delivery of a vibratory stimulus by the vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field on at least a portion of the pinna, as indicated at **2304**.

FIG. **24** is a block diagram of a computer program product **2400** for implementing a method as described in connection with FIG. **23**. Computer program product **2400** includes a signal-bearing medium **2402** bearing one or more instructions for determining a vibratory stimulus control signal configured to control delivery of a vibratory stimulus by a vibratory mechanical stimulator, the vibratory stimulus configured to activate at least one mechanoreceptor with a receptive field on at least a portion of a pinna of a subject, and one or more instructions for outputting the vibratory stimulus control signal to a wearable mechanical stimulation device including the least one vibratory mechanical stimulator, as indicated at **2404**. Signal-bearing medium **2402** may be, for example, a computer-readable medium **2406**, a recordable medium **2408**, a non-transitory signal-bearing medium **2410**, or a communications medium **2412**, examples of which are described herein above.

In some aspects, wearable neural stimulation devices and systems as described herein above are used in combination with remote systems. For example, FIGS. **2**A and **2**B illustrate a neural stimulation system used in combination with remote system **26**, via communication network **218**. FIG. **12** depicts communication between wearable neural stimulation device **1202** and/or personal computing device **1204**, which form neural stimulation system **1200**, and remote system **1224**. In addition, as shown in FIG. **13**, information may be transmitted to personal computing device **1302** from a remote system, including, for example, recommendation **1372**, patch/update **1374**, or instruction **1384**. FIG. **25** provides greater detail regarding such a remote system **2500**. Remote system **2500** includes computing system **2502**. Computing system **2502** includes identification circuitry **2504** for receiving identifying information **2506** identifying at least one of a subject **2508** and a neural stimulation device **2510** associated with subject **2508**. Neural stimulation

device **2510** is a neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator **2512**. System **2502** includes recommendation circuitry **2520** for providing a recommendation **2522** relating to a treatment regimen to subject **2508**, where the treatment regimen includes delivery of a neural stimulus to the subject with external neural stimulator **2512**, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject. In an aspect, recommendation circuitry **2520** uses a database to generate recommendations for combinations of treatments in the treatment regimen, for example in a manner similar to that described in U.S. Pat. No. 7,801,686 granted Sep. 21, 2010 to Hyde et al.; U.S. Pat. No. 7,974,787 granted Jul. 5, 2011 to Hyde et al.; U.S. Pat. No. 8,876,688 granted Nov. 4, 2014 to Hyde et al.; U.S. Patent Publication 2009/0269329 to Hyde et al., dated Oct. 29, 2009; U.S. Patent Publication 2009/0271009 to Hyde et al. dated Oct. 29, 2009; and U.S. Patent Publication 2009/0271375 to Hyde et al. dated Oct. 29, 2009, each of which is incorporated herein by reference.

In various aspects, neural stimulation device **2510** is a neural stimulation device of any of the various types described herein, e.g., in connection with any of FIG. **7**, **10**, or **12**. In an aspect recommendation **2522** is sent to, and identifying information **2506** is received from, a local system **2524**. Local system **2524** includes neural stimulation device **2510** and other components at the location of subject **2508**, including but not limited to a secondary stimulator **2526**, at least one sensor **2528** (e.g., an environmental sensor **2530**, a physiological sensor **2532**, or other sensor as discussed herein above). In an aspect, local system **2524** includes personal computing device **2534**. Personal computing device **2534** may include, for example, at least one of a personal digital assistant, a personal entertainment device, a mobile phone, a laptop computer, a tablet personal computer, a wearable computing device, a networked computer, a workstation computer, and a desktop computer, as discussed herein above. In an aspect, recommendation **2522** is presented to subject **2508** via a user interface of personal computing device **2534**, for example, and acceptance or rejection of the recommendation entered via a user interface of personal computing device **2534** and transmitted as acceptance/rejection signal **2536** to remote computing system **2502**.

Secondary stimulator **2526**, sensor **2528**, and personal computing device **2534** are as described herein above, e.g., in connection with at least FIGS. **7** and **12**. Signals containing information, instructions, data, etc. may be sent between neural stimulation device **2510** and computing system **2502** directly, or information may be sent between computing system **2502** and personal computing device **2534**, and then between personal computing device **2534** and neural stimulation device **2510**. Transmission of signals (information, instructions, data, etc.) between computing system **2502** and local system **2524** may be via wired or wireless communication links, e.g., via computer or communication networks. In an aspect, computing system **2502** is part of a computing network from which it receives information **2536** from various parties and/or entities, including but not limited to social media **2540**, social media contacts **2542**, peers **2544**, or role models **2546** of subject **2508**, insurance companies, service providers (e.g., medical care providers or companies providing various health or wellness related services), and computation-based system associated with such service providers, for example.

Computing system **2502** includes one or more computing device, as described generally in connection with FIG. **8**. In an aspect, computing system **2502** includes update generation circuitry **2560** for generating patch/update **2562** which is sent to local system **2524**, for updating software on either personal computing device **2534** or neural stimulation device **2510**. In an aspect, computing system **2504** includes secondary stimulus determination circuitry **2564** for determining a secondary stimulus to be delivered in combination with the neural stimulus, e.g., by secondary stimulator **2526**. The secondary stimulus may be any of various types of stimuli, as described herein above. In an aspect, computing system **2502** includes data storage circuitry **2566**, which in various aspects stores information regarding, e.g., one or more stimulation patterns **2570**, subject response information **2572** received, e.g., from local system **2524**, treatment regimen information **2574**, or one or more report **2576**. In an aspect, report **2576** is generated by reporting circuitry **2578** and stored in data storage circuitry **2566** in addition to, or as an alternative to, providing report **2576** to a recipient.

FIG. **26** provides greater detail regarding several aspects of FIG. **25** of information handled by system **2500**, specifically information included in identifying information **2506**, recommendation **2522**, and treatment regimen information **2574**.

In various aspects, identifying information **2506** includes device information **2602** pertaining to the neural stimulation device **2510**, or subject information **2610** pertaining to the subject. Device information **2602** includes, for example, device type information **2604**, device serial number **2606**, or device inventory number **2608**). Subject information **2610** includes, for example, a name of the subject **2612**, a user name **2614** associated with the subject, an email address **2616** associated with the subject, a subject identification **2618** (e.g., identification number, code or the like), or biometric information **2620** associated with the subject. In various aspects, subject identification **2618** can be input by the subject via a user input, read with a bar-code or RFID reader, received with an RF receiver, etc.

Recommendation **2522** may include one or more recommendations for various aspects of device and system configuration for delivery of neural stimulation, and for one or more additional stimuli or experiences to be presented to or experienced by the subject in association with the neural stimulus. In various aspects, recommendation **2522** is for a configuration of the neural stimulus **2622** (e.g., stimulus amplitude **2624**, frequency **2626**, duration **2628**, waveform **2630**, or delivery pattern **2632**). In various aspects, recommendation **2522** is for a secondary stimulus **2632** to be delivered in association with the neural stimulus. In various aspects, secondary stimulus **2632** includes music, an auditory stimulus, a video stimulus, a tactile stimulus, a haptic stimulus, an olfactory stimulus, a pharmaceutical, a nutraceutical, a secondary neural stimulus, an experience (including, but not limited to a virtual reality experience, a game experience, a virtual therapist experience, an augmented reality experience, and/or an interactive experience). In various aspects, recommendation **2522** is for a product **2634**, a service **2636**, an activity **2638**, an experience **2640**, or an organization **2642**. The recommendation may be for multiple experiences. In an aspect, the recommendation specifies a pattern of delivery of the experience(s). It will be appreciated that not all secondary stimuli recommended for use in conjunction with a neural stimulus are delivered by the neural stimulation system. Recommendations (e.g., for a product, service, experience, or organization) can be presented to the subject via the personal computing device in

the form of a link to a relevant website, so that the subject may conveniently access the recommended product, service, experience, or organization, which the subject does, as desired.

Treatment regimen information **2574** includes, for example, neural stimulus information **2650** regarding the neural stimulus, secondary stimulus information **2652** regarding a secondary stimulus delivered in association with the neural stimulus, information **2654** regarding a secondary data signal, which may specifically include neural sensor signal information **2656**, physiological sensor signal information **2658**, environmental sensor signal information **2660**, motion sensor information **2662** or location sensor information **2664**.

FIG. **27** is a flow diagram of a method **2700** carried out in connection with a system as depicted in FIG. **25** for providing recommendations to a subject. In an aspect, a method **2700** includes receiving identifying information at a computing system (e.g., computing system **2502** in FIG. **25**), the identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator, as indicated at **2702**; and transmitting a recommendation relating to a treatment regimen from the computing system to a personal computing device used by the subject (e.g., personal computing device, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject, as indicated at **2704**.

In an aspect, receiving the identifying information at the computing system includes receiving information transmitted from the personal computing device. In an aspect, receiving the identifying information at the computing system includes receiving information transmitted via a computing network. In an aspect, receiving the identifying information at the computing system includes receiving information transmitted via a wireless network. In an aspect, providing the recommendation relating to the treatment regimen to the subject includes transmitting the recommendation to a personal computing device, e.g., via a computing network or a wireless network.

In an aspect, the recommendation is received at the computing system from a medical care provider. In another aspect, the recommendation is generated at the computing system, e.g., by recommendation circuitry **2520** as shown in FIG. **25**. The recommendation can be generated based on various types of information: for example, information regarding a response of the subject to a past treatment regimen (subject response information **2572** in FIG. **25**); information obtained via social media (e.g., information **2536** in FIG. **25**) which may include, for example, information regarding one or more preferences of one or more social media contacts, peers, or role models of the subject); information from an insurance company; or information from a service provider. In an aspect, generating the recommendation includes generating the recommendation with a computation-based system **2552** (e.g., an artificial intelligence, machine learning system, or search engine based on a data-driven technique). In an aspect, generating the recommendation includes generating the recommendation based on a predicted response of the subject to a treatment regimen.

In an aspect, method **2700** includes receiving information regarding whether the subject has accepted or rejected the recommendation. In an aspect, method **2700** includes receiving a credential showing that the subject is an authorized user of the personal computing device. For example, the credential may include a password, a PIN, a biometric feature, or a card authentication, and/or a credential showing that the personal computing device is an authorized device.

In an aspect, method **2700** includes storing at least one parameter of the neural stimulus in a data storage location associated with the computing system (e.g., with data storage circuitry **2566** of computing system **2502**).

In aspect, the recommendation relates to at least one parameter of the neural stimulus, for example, an amplitude, frequency, waveform, or duration of delivery of the neural stimulus, or stimulation pattern for delivery of the neural stimulus. The stimulation pattern may be, for example, a preprogrammed pattern, a continuous pattern, an intermittent pattern, a time-varying pattern, and/or a pulsed pattern. In an aspect, the recommendation specifies a selection of one of multiple stimulation patterns.

In an aspect, receiving the identifying information at the computing system includes receiving information transmitted from the personal computing device.

In an aspect, method **2700** includes transmitting a report relating to the treatment regimen to at least one recipient. In an aspect, the at least one recipient includes, for example, the subject, a caregiver of the subject, at least one social media contact of the subject, at least one peer of the subject, at least one medical care provider, or at least one insurance provider. In an aspect, the recipient is a computing system, e.g. a computing system used for storing and/or processing healthcare information. In some cases the report is anonymized, e.g., to preserve the privacy of the subject. The report may include demographic information pertaining to the subject, but not personal identifying information pertaining to the subject, for example. In an aspect, transmitting the report includes transmitting the report to the personal computing device. The report may include, for example, a neural stimulus control signal, a determined compliance of the subject with the treatment regimen, a determined efficacy of the treatment regimen, one or more system settings for controlling delivery of the neural stimulus, data retrieved from a data storage location associated with the computing system, and/or information regarding a secondary stimulus delivered in association with the neural stimulus. Compliance of the subject and/or efficacy of the treatment regimen may be determined by questioning the subject directly, by questioning another party, such as a caregiver, or by making a determination from measured physiological parameters of the subject.

In an aspect, method **2700** includes receiving a report relating to the treatment regimen from the personal computing device. In an aspect, method **2700** includes storing information relating to the treatment regimen in a data storage location associated with the computing system, e.g., treatment regimen information **2574** as described in connection with FIGS. **15** and **26**.

In an aspect, method **2700** includes receiving information at the computing system regarding a previously delivered treatment regimen. In addition, the method may include receiving information at the computing system regarding a response of subject to the previously delivered treatment regimen.

In an aspect, method **2700** includes sending a patch or update to a personal computing device from the computing system. The patch or update may be for software installed on the personal computing device, or for software installed on the external neural stimulator.

In an aspect, method **2700** includes generating an update for the configuration of the neural stimulus. This may be done based on a response of the subject to a previous treatment regimen, based on an environmental factor, or based on motion or location of the subject. In an aspect, the update is generated automatically e.g., when it is determined that an update is needed (based on a subject response or sensed environmental factor). In another aspect, the update is generated based upon acceptance of a recommendation for the update by the subject.

FIG. **28** is a block diagram of a computer program product **2800** for implementing a method as described in connection with FIG. **27**. Computer program product **2800** includes a signal-bearing medium **2802** bearing one or more instructions for receiving identifying information identifying at least one of a subject and a neural stimulation device associated with the subject, the neural stimulation device configured to be carried on an ear of a subject and including an external neural stimulator, and one or more instructions for providing a recommendation relating to a treatment regimen to the subject, the treatment regimen including delivery of a neural stimulus to the subject with the external neural stimulator, the neural stimulus configured to activate at least one sensory nerve fiber innervating skin on or in the vicinity of the ear of the subject, as indicated at **2804**. Signal-bearing medium **2802** may be, for example, a computer-readable medium **2806**, a recordable medium **2808**, a non-transitory signal-bearing medium **2810**, or a communications medium **2812**, examples of which are described herein above.

FIG. **29** depicts an embodiment of a system **2900** for delivering neural stimulation in combination with providing a therapeutic secondary stimulus. System **2900** includes securing member **400**, of the type depicted in FIGS. **4**A and **4**B, with an ear canal insert **416** including a heart rate sensor (not shown in FIG. **29**), and stimulating electrodes **414***a* and **414***b*, positioned to stimulate pinna **2902** of subject **2904**. System **2900** also includes mobile phone **2906**, configured with application software **2908**. Mobile phone **2906** and application software **2908** together form at least physiological activity input circuitry **2910**, secondary signal input **2912**, neural stimulus control signal determination circuitry **2914**, secondary stimulus determination circuitry **2916**, and reporting circuitry **2918**. Mobile phone **2906** along with application software **2908** form a personal computing device, which includes a variety of circuitry (not all of which is depicted in FIG. **29**), e.g. as depicted and described in connection with FIG. **16**.

Neural stimulus control signal determination circuitry **2914** is used to generate neural stimulus control signal **2920**, which drives delivery of a neural stimulus via electrodes **414***a* and **414***b*. Secondary stimulus determination circuitry **2916** is used to generate secondary stimulus control signal **2922**, which controls delivery of the therapeutic secondary stimulus while subject **2904** is receiving stimulation delivered to pinna **2902**. In the example of FIG. **29**, the therapeutic secondary stimulus is provided via digital media, in the form of a therapy application that provides cognitive training and therapy. The therapy application also performs mental health monitoring. In an aspect, the therapy application includes an interactive survey **2924** displayed on touchscreen **2926** of mobile phone **2906**. The survey asks subject **2904** questions designed, for example, to assess the subject's mental or emotional state ("Rate how you feel today"), identify factors contributing to or relating to the subject's mental or emotional state ("Did you sleep well last night?"), and guide the subject toward positive and/or constructive thought patterns ("What did you enjoy today?"). Subject **2904** provides responses (user input **2930**) to the queries via touchscreen **2926**, which are received by secondary signal input **2912**. In addition, or as an alternative, the therapy application may provide a therapeutic secondary stimulus that includes music or guided meditation, delivered via touchscreen **2926** and/or a speaker in ear canal insert **416**.

Heart rate **2932**, sensed with a heart rate sensor (for example an ECG sensor or pulse oximeter sensor) in ear canal insert **416**, is provided to physiological activity input circuitry **2910**. The subject's heart rate is monitored during delivery of neural stimulation in combination with the therapeutic secondary stimulus, to track the effect of the stimulation and therapy over time. Amount of heart rate variability and duration of heart variability and/or changes in heart rate variability over time may be monitored. Heart rate variability is an indicator of the balance between sympathetic and parasympathetic tone. Increased heart rate variability is associated with reduced inflammation and anxiety. In addition, the physiologic data can be coupled with how the subject interacts with the program. In an aspect, one or both of neural stimulus control signal **2920** and secondary stimulus control signal **2922** are modified (by neural stimulus control signal determination circuitry **2914** and secondary stimulus determination circuitry **2916**, respectively), in response to heart rate **2932** and user input **2930**. Physiological data regarding the subject's heart rate as well as data regarding interaction of subject **2904** with application software **2908** can be included in report **2934** which can be sent to the subject's medical care provider or psychologist via network **2936**. Detection of a heart rate indicative of an unsafe condition due to the neural stimulation results in discontinuation or modulation of stimulation, and transmittal of a notification to the subject's medical care provider.

FIG. **30** is a flow diagram of a method of controlling an ear stimulation device with a personal computing device. The ear stimulation device is a wearable neural stimulation device as described elsewhere herein (e.g. wearable ear stimulation device **202** controlled with personal computing device **208**, as depicted in FIGS. **2**A and **2**B), for delivering a stimulus to an ear of a user of the personal computing device to stimulate at least one nerve innervating the ear. In an aspect, the ear stimulation device includes an earpiece that incorporates a positioning element and a neural stimulator, various examples of which are described and depicted herein. In an aspect, the ear stimulation device is part of a system that is used for delivering sound (e.g., music), and the earpiece includes a speaker or other sound source. In an aspect, the system includes a pair of earpieces. In an aspect, only one of the earpieces includes a neural stimulator, but both earpieces include a speaker or other sound source. In another aspect, both earpieces include both neural stimulator and sound source. In another aspect, one earpiece includes a sound source and the other includes a neural stimulator. In an aspect, method **3000** in FIG. **30** includes capturing, with image capture circuitry on the personal computing device, via a user-facing camera associated with a personal computing device, an image of a user of the personal computing device, as indicated at **3002**; processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter as indicated at **3004**; and controlling, with neural stimulus control signal determination circuitry on the personal computing device, based at least in part on the at least one parameter, delivery of a stimulus to at least one nerve innervating an ear of the user with the ear stimulation device, as indicated at **3006**.

FIGS. **31-33** depict further aspects of the method of FIG. **30**, wherein steps **3002**, **3004**, and **3006** are as depicted and described in connection with FIG. **30**. As depicted in FIG. **31**, in further aspects of method **3100**, the at least one parameter is indicative of at least one emotion of the user **3102**, is indicative of a physiological condition of the user **3104**, is indicative of a medical condition of the user **3106**, is indicative of an identity of the user **3108**, is a heart rate of the user **3110**, is related to eye position of the user **3112**, is related to eye movement of the user **3114** of the user, or is indicative of a position of the earpiece with respect to the ear of the user **3116**. Various schemes for identifying or classifying emotions have been devised, and the meaning of the term, as used herein, is not tied to any specific scheme. Examples of emotions include, but are not limited to, e.g. depression, anxiety, agitation, happiness, sadness, excitement, fear, and anger. In various aspects, a physiological condition of the subject is indicative of a medical condition of the subject. Medical conditions of the subject, include, for example, muscle spasm, seizure, epilepsy (e.g., seizure, spasm, staring), drowsiness, lethargy, fatigue, pain, fever, hypertension (e.g., sweating, flushing), hypotension, or mental state.

Determining a parameter indicative of a position of the earpiece with respect to the ear of the user can include, for example, determining a distance of one or more portion of the earpiece with respect to various anatomical features of the ear, e.g., the ear canal, the tragus, the helix, the lobe, etc., to determine whether the earpiece is positioned on the appropriate portion of the pinna or inserted far enough into the ear canal, for example. In an aspect, method **3100** further includes delivering, under control of notification circuitry on the personal computing device, a notification to the user informing the user of the need to adjust a position of an earpiece of the ear stimulation device with respect to the ear of the user, as indicated at **3118**. In various aspects, delivering a notification includes delivering a text notification **3120**, delivering a visible notification **3122**, or delivering an audio notification **3124**. The notification can be specific (e.g., a text or audio notification instructing the user to "push the earpiece further into the ear canal" or "move the earpiece higher up on the pinna") or non-specific (e.g., a flashing light or beeping sound that indicates the need to reposition the earpiece without providing detail on how specifically it should be repositioned). In an aspect, delivering a notification includes delivering a directional notification **3126**. As used herein, the term "directional notification" refers a notification that provides information to the user regarding the direction of movement needed to move the earpiece to the proper position. For example, in an aspect, the notification includes a text or audio notification as described above, which instructs the user to "push the earpiece further into the ear canal" or "move the earpiece higher up on the pinna." In another aspect, the notification includes a tone that changes in pitch as the earpiece moves toward or away from the proper location, or a click or other pulsed sound that is repeated at a frequency that changes as the earpiece moves toward or away from the proper location. In an aspect, the tone can change (i.e. changing to another tone, or stopping entirely) when the earpiece is in the proper location.

The vagus innervation of the ears is not strictly symmetrical; for example, the right ear, unlike the left ear, is innervated by a branch of the vagus nerve that, when stimulated, influences heart rate. Accordingly, in some circumstances it may be preferred to stimulate the left, but not the right ear, to avoid affecting the heart rate of the user. Therefore, if the system includes two earpieces (e.g., for the purpose of delivering music or other audio to both the left and right ear), in an aspect, only one of the earpieces includes a neural stimulator. For example, the earpiece with the neural stimulator is then considered to be usable on the left ear, but not the right ear. In some aspects, the two earpieces are shaped differently such that one fits the left, but not the right ear and the other fits the right, but not the left ear. In other aspects, the two earpieces are shaped such that they fit on either ear. In such a situation, the two earpieces may be distinguished from each other based on shape or color, or by inclusion of indicia on the earpiece or associated cable, and the ear stimulation device control system. A method **3200** as outlined in FIG. **32**, which is a further variant of the method of FIG. **30**, can be used in connection with the ear stimulation device to ensure that the earpiece with the neural stimulator is used only with the ear with which it is considered to be usable. Method **3200**, includes at **3202** the following steps: processing the image, using the image processing circuitry, to determine (at **3202***a*) the presence of at least one earpiece of the ear stimulation device located at an ear of the user, as indicated at **3202***b*; the ear of the user at which the at least one earpiece is located, wherein the ear is selected from a right ear of the user and a left ear of the user, as indicated at **3202***c*, and at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with one of the left or the right ear of the user, as indicated at **3202***d*; determining, using application software on the personal computing device, the ear at which the earpiece is usable, based on the at least one attribute of the at least one earpiece **3202***e*; determining, using application software on the personal computing device, whether the ear at which the at least one earpiece is located is the ear at which the earpiece is usable **3202***f*; and, if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable, sending a control signal from the personal computing device to the ear stimulation device, under control of the neural stimulus control signal determination circuitry, to prevent delivery of a stimulus to the ear at which the earpiece is located via the earpiece, as indicated at **3202***g*. In a further aspect, method **3200** includes receiving, with handshake circuitry on the personal computing device, a handshake signal from ear stimulation device control circuitry associated with the ear stimulation device, as indicated at **3204**. This may include capturing the image of the user of the personal computing device responsive to receiving the handshake signal from the ear stimulation device control circuitry, as indicated at **3206**. In an aspect, method **3200** includes sending a handshake signal to the ear stimulation device control circuitry responsive to determining the presence of the at least one earpiece located at the ear of the user in the image, as indicated at **3208**.

FIG. **33** depicts method **3300**, providing further detail regarding the method of FIG. **32**, with step **3202** in FIG. **33** the same as in FIG. **32**. In an aspect, method **3300** includes delivering, under control of notification circuitry on the personal computing device, a notification to the user informing the user of the need to switch the earpiece to the other ear if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable, as indicated at **3302**. Delivering the notification to the user may include, for example, one or more of delivering a text notification, at **3304**, delivering a visible notification, at **3306**, or delivering an audio notification, at **3308**. In various aspects, determining the at least one attribute **3433** of the at least one earpiece includes determining a shape of the at least one earpiece, at **3310**, or determining a color of the at least one earpiece, at **3312**, for example. In an aspect, determining the at least one

attribute **3433** of the at least one earpiece includes determining the presence of an indicia on the at least one earpiece or an attachment to the at least one earpiece, as indicated at **3314**. In an aspect, the attachment to the at least one earpiece includes a cable connected to the at least one earpiece, as indicated at **3316**.

An alternative approach to addressing the usability of neural stimulation with the right ear versus the left ear is to include stimulation electrodes in both earpieces, but send a neural stimulus control signal to cause delivery of a neural stimulus only via one of the earpieces (e.g., the left ear). In an aspect, a neural stimulus control signal is sent to only one of the earpieces. In an aspect, this is done if separate neural stimulus control signal outputs are provided for the two earpieces. In another aspect, a neural stimulus control signal is sent to both earpieces, but causes delivery of stimulus via only one of the earpieces. This can be done, e.g., by including ear stimulation electrical circuitry in the two earpieces that produces a neural stimulus in response to different neural stimulus control signals. For example, the neural stimulus control signal can have one or more characteristics (e.g., frequency, polarity, activation code) that cause activation of ear stimulation device control circuitry in one but not the other of the two earpieces. It is assumed that it is known a priori that a particular earpiece (as identified by the attribute determined in the user image) will receive and be activated by the neural stimulus control signal.

FIG. **34** is a block diagram of an ear stimulation device control system **3400**. System **3400** includes a personal computing device **3402**; a user-facing camera **3404** associated with the personal computing device, image capture circuitry **3406**, image processing circuitry **3408**, and neural stimulus control signal determination circuitry **3410**. In various aspects, personal computing device **3402** is a phone, watch, wearable device, tablet computer, laptop computer, or desktop computer, for example.

Image capture circuitry **3406** is adapted to capture an image **3412** of a user of personal computing device **3402** from user-facing camera **3404**. In an aspect, user-facing camera is built into the personal computing device. In another aspect, user-facing camera **3404** is connected to personal computing device via either a wired or wireless connection. Image processing circuitry **3408** is configured to process image **3412**, using parameter determination module **3414**, to determine at least one parameter **3416**. Neural stimulus control signal determination circuitry **3410** is configured to control delivery of a stimulus to at least one nerve innervating an ear of the user with an ear stimulation device **3432**, based at least in part on the at least one parameter **3416**. In various aspects, parameter **3416** is indicative of one or more of at least one emotion of the user, a physiological condition of the user, an identity of the user, or a heart rate of the user. In an aspect, parameter **3416** is related to an eye position or eye movement of the user. In an aspect, parameter **3416** is indicative of a position of the earpiece with respect to the ear of the user

In an aspect, image processing circuitry **3408** includes earpiece location module **3418**, which is configured to process image **3412** to determine the presence **3435** of at least one earpiece **3419** of the ear stimulation device **3432** located at an ear of the user; the ear of the user at which the at least one earpiece is located, the ear selected from a right ear of the user and a left ear of the user; and at least one attribute **3433** of the at least one earpiece indicative of usability of the at least one earpiece **3419** with one of the left or the right ear of the user, as discussed herein above. Attribute **3433** may be, for example, an indicia **3421** used to indicate that the earpiece in question includes a neural stimulator, for example. In an aspect, neural stimulus control signal determination circuitry **3410** is configured (with earpiece location logic module **3420**) to determine the ear at which the earpiece is usable, based on the at least one attribute **3433** of the at least one earpiece; determine whether the ear at which the at least one earpiece is located is the ear at which the earpiece is usable; and if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable, send a control signal from the personal computing device to the ear stimulation device (neural stimulus control signal **3422** from neural stimulus control signal output **3424**) to prevent delivery of the stimulus to the a least one nerve innervating the ear of the user. As discussed herein above, in some circumstances it may be preferred to stimulate the left, but not the right ear, for example. Hence, in a system that includes two earpieces, the two earpieces may be distinguished from each other based on shape or color, or by inclusion of indicia on the earpiece or associated cable. In various aspects, indicia include any sort of markings detectable in the image via image processing. Indicia may include solid colored or patterned markings on an earpiece, or may include a characteristic of the earpiece itself (e.g., the color of the material of which the earpiece is made). Indicia may be detectable in the visible spectrum, or at other wavelengths. In some aspects, indicia may include text, alphanumeric markings, or symbols. The right and left ears of the user may be identified in user image **3412**, using image processing methods, e.g. as described in M. M. Fakhir et al., "Face Recognition Based on Features Measurement Technique," 2014 UKSim-AMSS 8th European Modelling Symposium, pp. 158-162; U.S. Patent Application Publication No. 2016/0026781 to Boczek et al.; and U.S. Patent Application Publication No. 2008/0285813 to Holm; each of which is incorporated herein by reference. In some aspects, the position of one or both ears with respect to the face is determined; in some aspects, the shape and/or features of one or both ears is determined.

In an aspect, ear stimulation device control system **3400** includes handshake circuitry **3426** adapted to receive a handshake signal **3428** from ear stimulation device control circuitry **3430** associated with the ear stimulation device **3432**. In an aspect, image capture circuitry **3406** is adapted to capture the image **3412** of the user of the personal computing device **3402** responsive to receiving the handshake signal **3428** from the ear stimulation device control circuitry **3430**. For example, in an aspect exchange of information between the ear stimulation device control system **3400** and ear stimulation device **3432** is initiated after user image **3412** has been captured and evaluated by image processing circuitry **3408**, and it has been determined, by earpiece location logic module **3420**, that the earpiece containing the ear stimulation device has been placed on the appropriate ear of the user. Alternatively, if two earpieces including ear stimulation devices are utilized, the handshake signal from each earpiece can include an earpiece identification code for identifying the earpiece. The earpiece identification code and indicia associated with a particular earpiece can be linked in a lookup table stored in data storage circuitry **3464**, for example.

In an aspect, the neural stimulus control signal determination circuitry **3410** is configured to send a handshake signal **3434** to ear stimulation device control circuitry **3430** responsive to determining the presence **3435** of the at least one earpiece located at the ear of the user in the image.

In an aspect, ear stimulation device control system includes output device **3440**, and notification circuitry **3442**,

which is adapted to provide a notification via output device **3440** instructing the user of to switch the earpiece to the other ear if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable. For example, output device **3440** may be part of user interface **3444**. In an aspect, output device is adapted to deliver a text notification **3446** to the user (e.g., output device includes an LED or LCD display, 7-segment display, or other alphanumeric display). In another aspect, output device **3440** is adapted to deliver a visible notification **3448** to the user, which may include a text display, as described previously, a graphic or symbol presented on a display, or a light that can be illuminated, flashed, etc. to attract the attention of the user. In an aspect, output device **3440** is adapted to deliver an audio notification **3450** to the user (e.g., output device **3440** includes a speaker, bell, buzzer, or other audio source for delivering one or both of a verbal notification or an alarm tone). User interface **3444** may also include one or more user input **3452**, of various types, e.g. as discussed elsewhere herein.

As noted above, image processing circuitry **3408** includes earpiece location module **3418**, which is configured to process image **3412** to determine at least one attribute **3433** of the at least one earpiece, where in an aspect the at least one attribute **3433** is indicative of usability of the at least one earpiece with one of the left or the right ear of the user. In addition, neural stimulus control signal determination circuitry **3410** is configured (with earpiece location logic module **3420**) to determine the ear at which the earpiece is usable, based on the at least one attribute of the at least one earpiece. In an aspect, the at least one attribute of the at least one earpiece includes a shape of the at least one earpiece, a color of the at least one earpiece, a presence of an indicia **3421** on the at least one earpiece or a presence of indicia **3421** on an attachment to the at least one earpiece, where, as noted above, the attachment to the at least one earpiece may be, for example, a cable connected to the at least one earpiece. For example, in a system in which only one of two earpieces includes a stimulating electrode, the cable connected to the earpiece with the electrode may include a pattern of light and dark stripes, while the cable connected to the other earpiece may be a solid color. In embodiments in which two earpieces including ear stimulation devices are used, neural stimulus control signal determination logic can send a neural stimulus control signal **3422** sufficient to activate only an earpiece that is usable with the ear upon which it is located, based on the output of earpiece location logic module **3420**.

In an aspect, image processing circuitry **3408** includes emotion determination module **3454**, which determines an emotion of the user from user image **3412**, based upon one or more parameter **3416**, e.g. from facial expression, for example using methods as described in Su, "A simple approach to facial expression recognition," Proceedings of the 2007 Int'l Conf on Computer Engineering and Applications, Queensland, Australia, 2007, pp. 456-461; U.S. Pat. No. 9,036,018 to Wang et al.; U.S. Pat. No. 8,488,023 to Bacivarov et al., and U.S. Patent Application Publication 2004/0207720 to Miyahara et al., each of which is incorporated herein by reference.

In an aspect, image processing circuitry **3408** includes physiological condition module **3456**, which determines a physiological condition of the user from user image **3412**, based upon one or more parameter **3416**. Physiological condition of the user can be inferred from eye movement, pupil dilation, heart rate, respiration rate, facial coloration, facial temperature, etc. A visible or IR image of the patient, obtained with a camera built into a personal computing device or operatively connected to the personal computing device can be used. Still or moving (video) image may be used. For example, video images of the subject may be analyzed to determine blood flow using Eulerian video magnification. Further data analysis may be used to determine blood pressure in the subject. See, e.g., Wu et al., ACM Trans. Graph. 31, 4, Article 65, July 2012; (available online at http://doi.acm.org/10.1145/2185520.2185561), which is incorporated herein by reference. An infrared camera may be used to measure corneal temperature (see e.g., Kessel et al., Investigative Opthalmology and Visual Science 51: 6593-6597, 2010 which is incorporated herein by reference). An infrared camera with a focal plane array detector, thermal sensitivity ≤0.09 degrees C. and an accuracy of 0.1 degrees C. is available from Fluke Corp., Everett, Wash. (see e.g., Fluke Ti25 Datasheet which is incorporated herein by reference).

Peripheral sympathetic responses can be detected through image analysis, as described in IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 56, NO. 2, FEBRUARY 2009 477, Imaging Facial Signs of Neurophysiological Responses, Dvijesh Shastri, Associate Member, IEEE, Arcangelo Merla, Member, IEEE, Panagiotis Tsiamyrtzis, and Ioannis Pavlidis, Senior Member, IEEE, which is incorporated herein by reference. For example, thermal imaging measurements from several different regions of the face provide indication of blood flow, sweat gland activation, and breathing, providing information similar to galvanic skin response. In various aspects, physiological condition module **3456** is used to determine one or more medical condition, including, for example, muscle spasm, seizure, epilepsy (e.g., seizure, spasm, staring), drowsiness, lethargy, fatigue, pain, fever, hypertension (e.g., sweating, flushing), hypotension, mental state

In an aspect, image processing circuitry **3408** includes identity determination module **3458**, which determines an identity of the user from user image **3412**, based upon one or more parameter **3416**. For example, systems and algorithms to obtain iris images, identify unique signatures and rapidly compare key features of iris images to a large database of iris images are described (see e.g., U.S. Pat. No. 5,572,596 issued to Wildes et al. on Nov. 5, 1996 and U.S. Pat. No. 4,641,349 issued to Flom et al. on Feb. 3, 1987 which are incorporated herein by reference). An iris scanning system which includes a near-infrared (approximately 700-900 nm) illumination source, a 1.3 megapixel camera and algorithms to analyze and compare iris images is available from Bayometric Inc., San Jose, Calif. (see e.g., the Specification Sheet: "Crossmatch Retinal Scan 2 Iris Scanner" which is incorporated herein by reference). In another aspect, facial recognition circuitry is used to determine the presence of the user through facial recognition, e.g., using approaches as described in Wheeler, Frederick W.; Weiss, R. L.; and Tu, Peter H., "Face Recognition at a Distance System for Surveillance Applications," Fourth IEEE International Conference on Biometrics: Theory Applications and Systems (BTAS), 2010 Page(s): 1-8 (DOI: 10.1109/BTAS.2010.5634523), and Moi Hoon Yap; Ugail, H.; Zwiggelaar, R.; Rajoub, B.; Doherty, V.; Appleyard, S.; and Hurdy, G., "A Short Review of Methods for Face Detection and Multifractal Analysis," International Conference on CyberWorlds, 2009. CW '09, Page(s): 231-236 (DOI: 10.1109/CW.2009.47), both of which are incorporated herein by reference. Biometric identification can also include recognition based on a variety of physiological or behavioral characteristics, such as fingerprints, voice, iris,

retina, hand geometry, handwriting, keystroke pattern, etc., e.g., as described in Kataria, A. N.; Adhyaru, D. M.; Sharma, A. K.; and Zaveri, T. H., "A Survey of Automated Biometric Authentication Techniques" Nirma University International Conference on Engineering (NUiCONE), 2013, Page(s): 1-6 (DOI: 10.1109/NUiCONE.2013.6780190), which is incorporated herein by reference. U.S. Pat. No. 8,229,178 issued Jul. 24, 2012 to Zhang et al., which is incorporated herein by reference, describes a method for acquiring a palm vein image with visible and infrared light and extracting features from the image for authentication of individual identity. Biometric identification can be based on imaging of the retina or iris, as described in U.S. Pat. No. 5,572,596 issued to Wildes et al. on Nov. 5, 1996 and U.S. Pat. No. 4,641,349 issued to Flom et al. on Feb. 3, 1987, each of which is incorporated herein by reference. Combinations of several types of identity signals can also be used (e.g., speech and video, as described in Aleksic, P. S. and Katsaggelos, A. K. "Audio-Visual Biometrics," Proceedings of the IEEE Volume: 94, Issue: 11, Page(s): 2025-2044, 2006 (DOI: 10.1109/JPROC.2006.886017), which is incorporated herein by reference).

In an aspect, image processing circuitry **3408** includes eye tracking module **3460**, which determines an eye position or eye movement from user image **3412**, based upon one or more parameter **3416**. For example, a gaze tracking system for monitoring eye position is available from Seeing Machines Inc., Tucson, Ariz. (see e.g., the Specification Sheet: "faceLAB™ 5 Specifications" which is incorporated herein by reference). Eye position, eye rotation, eye gaze position against screen, pupil diameter and eye vergence distance may be monitored. Eye rotation measurements of up to +/−45 degrees around the y-axis and +/−22 degrees around the x-axis are possible. Typical static accuracy of gaze direction measurement is 0.5-1 degree rotational error. Eye position can be sensed using a method and system as described in U.S. Pat. No. 8,808,195 to Tseng et al., which is incorporated herein by reference, or by other methods described herein or known to those skilled in the relevant art. Eye position may include static or fixed eye position/gaze direction or dynamic eye position/eye movement. In an aspect, eye tracking module **3460** detects pupil diameter. Pupil diameter can be measured, for example, by methods as described in U.S. Pat. No. 6,162,186 to Scinto et al., which is incorporated herein by reference.

Ear stimulation device control system **3400** may include various other components as described generally elsewhere herein, including, but not limited to, e.g., communication circuitry **3462**, data storage circuitry **3464**, and reporting circuitry **3466**. Similarly, ear stimulation device **3432** may include additional components, including but not limited to communication circuitry **3468** and stimulator driver circuitry **3470**. In addition, ear stimulation device **3432** may include or be used in combination with a securing member **3472**. In an aspect, the securing member includes or is a portion of an earpiece.

FIGS. **35**A and **35**B show examples of user interfaces used in connection with an ear stimulation device control system implemented on a personal computing device, and in particular illustrate ways in which processing of a user image captured with a user-facing camera is used in control of the ear stimulation device. In the example of FIG. **35**A, the personal computing device is a smart phone **3500** configured with application software that notifies the user of improper placement of the earpieces. Detection and notification is performed, e.g. as described in connection with FIGS. **30-34**. Delivery of text, visible, and audio notifications to the user (e.g., as in the method of FIG. **33**) are illustrated in FIG. **35**A. In the systems shown in FIGS. **35**A and **35**B, the ear stimulation device itself is not depicted, but it would be connected to smart phone **3500**, e.g. via an audio jack. Touchscreen **3502** of smart phone **3500** functions as a user interface (e.g., user interface **3444** in FIG. **34**). User image **3504**, captured with user-facing camera **3506** is displayed on touchscreen **3502**. Image analysis of user image **3504** is performed by image processing circuitry (e.g., image processing circuitry **3408** in FIG. **34**), to determine whether the earpiece including the ear stimulation device is positioned properly. In an aspect, proper positioning of the ear stimulation device means that the earpiece is located on the correct ear, and in some cases also means that the earpiece is located in the proper position on the ear. In the example of FIG. **35**A, earpieces **3508** and **3510** in user image **3504** are different colors, allowing the two earpieces to be distinguished. Alert symbol **3512** (an exclamation point in a circle) notifies the user of an alert message, which is delivered via alert text **3514** displayed on touchscreen **3502**. In this case, alert text **3514** provides the alert message "1. ALERT: STIMULATION BLOCKED! Switch stimulation earpiece to other ear to allow stimulator activation." An 'X' **3516** (or other marker) displayed next to user image **3504** indicates to the user that earpieces **3508** and **3510** are positioned incorrectly. An audible notification **3522** (e.g., a 'beep') delivered by speaker **3520** is also provided to attract the user's attention to the incorrectly positioned earpieces. A second user image **3524**, serving as an exemplar depicting correctly placed earpieces, is also presented on touchscreen **3502**. The colors of earpieces in image **3524** may be enhanced or highlighted in the image to emphasize the importance of placing an earpiece of a particular color at a particular ear. A check mark **3526** (or other marker) is used to indicate that second user image **3524** depicts correct earpiece position. Check mark **3526** may be animated, e.g. to switch from flashing to solid or change color from red to green when the user has switched the earpieces to the proper positions. Once the earpieces are properly positioned, the ear stimulation device control system, implemented with smart phone **3500**, controls the ear stimulation device to deliver a stimulus to the ear of the subject, as described elsewhere herein.

As described in connection with FIG. **34**, in an aspect ear stimulation device control system **3400** includes emotion determination module **3454**, physiological condition module **3456**, identity determination module **3458** and eye tracking module **3460**. These modules can be used to determine additional information about the user on which to base control of the ear stimulation device. In FIG. **35**B, touchscreen **3502** of smart phone **3500** functions as a user interface. User image **3504**, captured with user-facing camera **3506** is displayed on touchscreen **3502**. Image analysis of user image **3504** is performed by image processing circuitry **3408** as shown in FIG. **34**, to determine the identity of the user, and potentially also the emotion and physiological status of the user, as discussed herein above. After the identity of the user has been determined, user-specific information can be used to determine neural stimulation. For example, stimulus level settings that have been optimized for the user can be retrieved from memory and used to configure the ear stimulation device. In addition, the stimulus delivered with the stimulation device may be adjusted depending upon the mood or physiological status of the user.

In addition, in an aspect, application software on smart phone **3500** prompts the user to enter additional information regarding mood or other parameters, similar to application

software **2908** described in connection with FIG. **29**. In the example of FIG. **35**B, the mood of the subject may not be readily determined from the relatively neutral expression of the user in image **3504**. However, the application software may prompt the user to enter to enter information regarding mood or other feelings. For example, text prompt **3556** "Good morning, Anna! Are you tired today?" might be followed by additional questions, depending on the user's response, in order to determine how the user is feeling. The use of application software to assess the mood of the user is discussed in greater detail elsewhere herein.

As discussed herein above, in an aspect, image detection and analysis is used to detect improper placement of one or more earpieces on the ear(s) of a user of a personal computing device. In some aspects, it is desirable to detect quality of electrical contact between the ear and an electrode used for delivering electrical stimuli to or sensing electrical signals from the ear. FIG. **36** is a block diagram depicting neural stimulation system **3600**, which includes ear stimulation device **3602** and ear stimulation device control system **3604**. FIG. **36** depicts further aspects of a neural stimulation system **3600** including an ear stimulation device control system **3604**, used for controlling an ear stimulation device **3602** that delivers electrical stimuli via one or more electrodes **3606** and **3608**. Ear stimulation device control system **3604** determines whether the one or more electrodes **3606** and **3608** are in good electrical contact with the ear of the user and notifies the user of the status of electrodes **3606** and **3608** so that adjustments can be made, as needed. In addition, delivery of a stimulus via the electrode can be prevented if it is determined that there is not a good electrical contact between the electrode and the ear. Ear stimulation device control system **3604** includes a personal computing device **3610** configured to control delivery, via ear stimulation device **3602**, of a stimulus to at least one nerve innervating an ear of a user of personal computing device **3610**. Ear stimulation device **3602** includes at least one first electrode **3606**. Personal computing device **3610** includes electrical signal input circuitry **3612** adapted to receive an electrical signal **3614** indicative of electrical contact of the at least one first electrode **3606** with the ear of a user of the personal computing device **3610**. Personal computing device **3610** includes contact determination circuitry **3616** configured to determine whether the at least one first electrode **3606** is in good electrical contact with the ear of the user, and neural stimulus control signal determination circuitry **3620** configured to send a neural stimulus control signal **3622** from personal computing device **3610** to ear stimulation device **3602** to prevent delivery of the stimulus if the at least one first electrode **3606** is not in good electrical contact with the ear of the user. In addition, personal computing device **3610** includes notification circuitry **3622** configured to deliver a notification to the user relating to the status of the at least one first electrode **3606**. Personal computing device **3610** may be, for example, a phone, watch, wearable device, tablet computer, laptop computer, or desktop computer.

In an aspect, ear stimulation device control system **3604** includes handshake circuitry **3624** adapted to receive a handshake signal **3626** from ear stimulation device control circuitry **3628** associated with ear stimulation device **3602**. In an aspect, ear stimulation device control system **3604** includes test signal circuitry **3630** configured to deliver an electrical test signal **3632** via at least one second electrode **3608** of the at least one ear stimulation device **3602**, and detecting the electrical signal **3614** via the at least one first electrode **3606** responsive to electrical test signal **3632**. In an aspect, contact determination circuitry **3616** is configured to determine an electrical impedance between the at least one first electrode **3606** and the at least one second electrode **3608**. In an aspect, contact determination circuitry **3616** is configured to determine an amplitude of electrical signal **3614**. In an aspect, contact determination circuitry **3616** is configured to determine a signal-to-noise ratio of electrical signal **3614**. In an aspect, contact determination circuitry **3616** is configured to determine a phase shift or frequency content of the electrical signal **3614**. In various aspects, contact determination circuitry **3616** includes amplitude determination module **3634** for determining the amplitude of electrical signal **3614**, signal-to-noise ratio determination module **3636** for determining the signal-to-noise ratio of electrical signal **3614**, or phase shift/frequency content determination module **3638** for determining the phase shift or frequency content of electrical signal **3614**.

In an aspect, ear stimulation device **3602** includes earpiece **3640** which includes the at least one first electrode **3606**. In an aspect, notification circuitry **3622** is configured to instruct the user to reposition earpiece **3640**, replace at least a portion of the at least one first electrode **3606**, clean at least a portion of the at least one first electrode **3606**, moisten at least a portion of the at least one first electrode **3606**, or apply gel to at least a portion of the at least one first electrode **3606**. As discussed herein above, in various aspects, ear stimulation device **3602** includes or is used in connection with a securing member **3642**, and may include additional circuitry components as described elsewhere herein, e.g. communication circuitry **3644** and stimulator driver circuitry **3646**. In an aspect, notification circuitry **3622** is configured to deliver one or more of a text notification, a visible notification, or an audio notification. Neural stimulation system **3600** in various aspects includes other components as described elsewhere herein. For example, in various aspects personal computing device **3610** includes user interface **1214** including user input device **1362** and user output **1364**, including audio output **1366**, graphical display **1368**, alphanumeric display **1392**, or touchscreen **1394**, as depicted in and described in connection with FIG. **13**, for example. In various aspects, ear stimulation device control system includes neural stimulus control signal output **3424**, communication circuitry **3462**, data storage circuitry **3464**, as in connection with FIG. **34**. In various aspects, neural stimulation system **3600** includes one or more sensor **3650**, which may include, for example, a neural signal sensor, other physiological sensor, an environmental sensor, a motion sensor, a location sensor, of various types as described in connection with neural signal sensor **702** or secondary sensor **750** in FIG. **7**. In some aspects, neural stimulation system **3600** includes a secondary stimulator **818**, for example as described in connection with FIG. **7**. In some aspects, neural stimulation system **3600** includes a sound source **856**, e.g. as described in connection with FIG. **7**. Notification circuitry **3442** and reporting circuitry **3466** are as described in connection with FIG. **34**. Personal computing device **3610** is configured with application software **3650**, including but not limited to the various modules described specifically herein.

FIG. **37** depicted a method of controlling an ear stimulation device with a personal computing device, responsive to detection of contact between an electrode and the ear of the user, as described in connection with FIG. **36**. As noted above, the personal computing device may be, for example, a phone, watch, wearable device, tablet computer, laptop computer, or desktop computer. Method **3700** includes detecting at electrical signal input circuitry, via at least one

first electrode of an earpiece of an ear stimulation device, an electrical signal indicative of electrical contact of the at least one first electrode with the ear of a user of a personal computing device, wherein the at least one earpiece is operably connected to the personal computing device, and wherein the ear stimulation device is adapted to stimulate at least one nerve innervating the ear of the user of the personal computing device, as indicated at **3702**; determining, using contact determination circuitry on the personal computing device, whether the at least one first electrode is in good electrical contact with the ear of the user, as indicated at **3704**; if the at least one first electrode is not in good electrical contact with the ear of the user, sending a control signal from the personal computing device to the ear stimulation device, under control of neural stimulus control signal determination circuitry on the personal computing device, to prevent delivery via the earpiece of a stimulus to the ear at which the earpiece is located, as indicated at **3706**; and delivering, under control of notification circuitry on the personal computing device, a notification to the user relating to the status of the at least one first electrode, as indicated at **3708**.

Determining whether the at least one first electrode is in good electrical contact with the ear of the user can be performed by various methods, as discussed herein below. Good electrical contact can be defined by setting a threshold value for one or more measured parameter, such that contact is defined to be "good" if the measured parameter(s) are at or above the threshold value and "bad" if they are below the threshold parameter. In an aspect, determining whether the at least one first electrode is in good electrical contact includes providing a rating of the contact quality, e.g., "strong," "moderate," "usable but weak," "unusable," wherein any usable contact qualities are considered "good," but contacts that are not usable are considered "bad."

Further aspects and variants of method **3700** are depicted in FIGS. **38-39**. In these figures, steps **3702**, **3704**, **3706**, and **3708** are the same as in FIG. **37**.

FIG. **38** depicts a method **3800**, which includes further elaborations of the method of FIG. **37**. Steps **3702**, **3704**, **3706** and **3708** are as described in connection with FIG. **37**. In an aspect, method **3800** includes receiving, at handshake circuitry on the personal computing device, a handshake signal from ear stimulation device control circuitry associated with the ear stimulation device, as indicated at **3802**. In another aspect, method **3800** includes delivering, under control of test signal circuitry on the personal computing device, an electrical test signal via at least one second electrode of the at least one earpiece, and detecting the electrical signal via the at least one first electrode responsive to the electrical test signal, as indicated at **3804**. This may include, for example, determining an electrical impedance between the at least one first electrode and the at least one second electrode, as indicated at **3806**. In various aspects, determining whether the at least one first electrode is in good electrical contact with the ear of the user (at **3704**) includes determining an amplitude of the electrical signal, as indicated at **3808**, determining a signal-to-noise ratio of the electrical signal, as indicated at **3810**, or determining a phase shift or frequency content of the electrical signal, as indicated at **3812**.

FIG. **39** depicts a method **3900**, including further variants of the method shown in FIG. **37**, relating to delivering a notification to the user regarding the status of the at least one first electrode. In various aspects, delivering the notification to the user includes instructing the user to reposition the earpiece, as indicated at **3902**, instructing the user to replace at least a portion of the at least one first electrode, as indicated at **3904**, instructing the user to clean at least a portion of the at least one first electrode, as indicated at **3906**, instructing the user to moisten at least a portion of the at least one first electrode, as indicated at **3908**, or instructing the user to apply gel to at least a portion of the at least one first electrode, as indicated at **3910**. In other aspects, delivering the notification to the user includes delivering a text notification, as indicated at **3912**, delivering a visible notification, as indicated at **3914**, delivering an audio notification, as indicated at **3916**, or delivering a directional notification, at **3918**. Notifications can be delivered, for example, as described in connection with FIG. **31**, or as illustrated in FIG. **35**A. In another aspect, method **3900** includes delivering, under control of test signal circuitry on the personal computing device, an audio test signal via a sound source associated with the at least one earpiece, and determining proper placement of the at least one earpiece based upon audio feedback, as indicated at **3920**. In an aspect, audio feedback is determined from an audio signal detected from the earpiece, which will vary depending upon the placement of the earpiece, e.g. whether or not it is firmly seated within the ear canal. In an aspect, audio feedback is determined from the user, e.g. the user self-reporting of audio quality.

FIG. **40** illustrates a nerve stimulation system **4000** including ear stimulation device **4002** and personal computing device **4004**, which is configured personal computing device application **4006** for monitoring use of nerve stimulation system **4000** by a user. As in other examples presented herein, personal computing device **4004** may be, for example a phone, watch, wearable device, tablet computer, laptop computer, or desktop computer. Aspects of nerve stimulation system **4000** not described in detail in connection with FIG. **40** are generally as described in connection with other embodiment depicted and described herein.

Personal computing device application **4006** includes audio delivery module **4010**, mood assessment module **4012**, secondary factor input module **4014**, user control module **4016**, stimulator control module **4018**, and controller interface module **4020**. The various modules include application software operating in connection with personal computing device hardware and software (i.e. the personal computing device hardware is configured by the application software) to provide the module functionality. Personal computing device **4006** includes other hardware and software components as described elsewhere herein as well as conventional hardware and software components not specifically described herein. The term "module," as used herein, refers to application software operating on and used to configure personal computing device hardware to provide specialized circuitry functions of the device. In general, a module utilizes and in an aspect can be considered to incorporate both data storage circuitry and processing circuitry of the personal computing device.

Audio delivery module **4010** is adapted to control delivery of an audio signal from an audio signal source **4022** to an audio earpiece **4024** via an audio output **4026** of the personal computing device **4004**, the audio earpiece **4024** having associated therewith ear stimulation device **4002** configured to stimulate a nerve innervating the ear of the user. Audio signal source **4022** may be, for example an audio player application **4024**, a web radio application **4026**, a radio receiver **4028**, a telephone receiver **4030**, or a hearing aid **4031**.

Mood assessment module **4012** is adapted to receive mood-related input from the user via a first input structure

4032 associated with the personal computing device, and assess a mood of the user based at least in part upon the mood-related input. In an aspect, mood assessment module **4012** includes an ecological momentary assessment module **4034**. Ecological momentary assessment module **4034** includes application software on the person computing device that collects information about the user's behaviors and experiences from the user, by querying the user at intervals during the day as they go about their usual activities in their "natural environment" (as contrasted to self-reports of mood based on the user's recollections during a clinic visit, for example), e.g. as described generally in Shiffman et al., "Ecological Momentary Assessment," Annual Review of Clinical Psychology, Vol. 4:1-32, April 2008 (First Published Online Nov. 28, 2007), DOI: 10.1146/annurev.clinpsy.3.022806.091415, which is incorporated herein by reference. In some aspects, mood assessment module **4012** includes activity assessment module **4035**, which tracks and analyzes user activities involving use of the personal computing device (e.g. use of social media, web searches, speech patterns, typing patterns, including amount and/or type of use) to determine mood of the user. For example, in an aspect, activity assessment module **4035** analyzes typing patterns using, for example, techniques as described in U.S. Pat. No. 6,231,344 to Merzenich et al., U.S. Published Patent Application 2005/0084832 to Janssen et al., each of which is incorporated herein by reference. In an aspect, activity assessment module **4035** determines the timing of entry of instructions by the patient. In an aspect, it is not necessary to determine the specific instructions entered by the patient, but only to determine how often the patient is using the personal computing device, and/or how quickly the patient is entering instructions into the personal computing device. In other aspects, the specific instructions can be detected, e.g., to determine whether the patient is choosing to listen to music, play a game, send or read email, receive a phone call, or place a phone call. Sensing and processing of game controller signals, e.g., to determine reaction times, may be substantially as described in U.S. Pat. No. 5,913,310 to Brown, or U.S. Pat. No. 6,186,145 to Brown, both of which are incorporated herein by reference. It will be appreciated that while Brown describes a video game designed primarily for health care-related teaching purposes, the video game may be for entertainment purposes, and need not include an educational or medical component. In an aspect, activity assessment module **4035** is configured to process an audio signal (detected from a cell phone, for example) to determine a speech pattern of the patient. In an aspect, mood assessment module **4012** includes image processing module **4036** adapted to determine a mood of the user based on image analysis of an image of the user detected with a user-facing camera **4038** of the personal computing device **4004**, e.g., as discussed herein above. In various aspects, mood assessment module **4012** is adapted to receive mood-related input relating to depression, stress, or emotion, for example. First input structure **4032** of the personal computing device in various aspects includes a touch screen **4040**, a keyboard, or a microphone.

Secondary factor input module **4014** is adapted to receive at least one input relating to at least one secondary factor relating to the user via a second input structure **4050** associated with personal computing device **4004**. Secondary input structure **4050** of personal computing device **4004** includes at least one of a touch screen **4040**, a keyboard **4042**, a microphone **4044**, a device interface **4052**, a data input **4054**, USB port **4056**, a wireless interface **4058**, a serial port **4060**, and a parallel port **4062**. Touch screen **4040**, a keyboard **4042**, a microphone **4044**, are examples of components of a user interface **4064**, although it will be appreciated that input may be received by other types of user interface devices, as are known to those of skill in the art. Data input **4054**, USB port **4056**, wireless interface **4058**, serial port **4060**, and parallel port **4062** are examples of device interface **4052**; other device interfaces may be used as well. First input structure **4032**, second input structure **4050**, and third input structure **4066** may in some aspects be the same type of input structure, and indeed may be the same input structure. In other aspects, one or more of first input structure **4032**, second input structure **4050**, and third input structure **4066** are the same type of input structure, but are distinct input structures. In some aspects, first input structure **4032**, second input structure **4050**, and third input structure **4066**, are different types of input structures, and, in addition, are distinct input structures.

In an aspect, secondary factor input module **4014** is adapted to receive at least one input from the user, i.e., via user interface **4064**. In another aspect, secondary factor input module is adapted to receive at least one input from a sensor **4068**, e.g., via data input **4054** or another device interface. In another aspect, secondary factor input module **4014** is adapted to receive at least one input via a computing network **4070**.

User control module **4016** is adapted to receive at least one user control input via a third input structure **4066** of the personal computing device, the user control input for controlling user-controllable stimulation parameters of the ear stimulation device.

Stimulator control module **4018** is adapted to determine at least one stimulus control parameter based on at least one of the mood of the user, the at least one secondary factor, and the at least one user control input.

Controller interface module **4020** is used for communicating the at least one stimulus control parameter to a stimulator controller adapted to control the ear stimulation device responsive to the at least one stimulus control parameter.

In an aspect, stimulator control module **4018** is configured to coordinate delivery of the audio signal with delivery of at least one stimulus with ear stimulation device **4002**.

In an aspect, secondary factor input module **4014** is adapted to receive at least one input relating to an environmental condition of the user, for example, including at least one of a light level, a temperature, a humidity, a pollen count, a noise level, a day length, a precipitation, an air quality measure. In another aspect, secondary factor input module **4014** is adapted to receive at least one input relating to sleep pattern of the user. In another aspect, secondary factor input module **4014** is adapted to receive at least one input relating to medical history of the user. In another aspect, secondary factor input module **4014** is adapted to receive at least one input relating to an activity of the user, including, but not limited to a physical activity, a health-related activity, a recreational activity, a social activity, an employment activity, a purchasing activity, a mental activity, a spiritual activity, a media-related activity, an activity of daily life, an amount of activity, a duration of activity, a frequency of activity, a timing of activity, a calendar, a schedule, or a cost. In another aspect, secondary factor input module **4014** is adapted to receive at least one input relating to a diet of the user or an appetite of the user. An input relating to a secondary factor may include user input relating to the secondary factor, received for example, via user interface **4064**. In an aspect, secondary factor input module **4014** is adapted to receive at least one open ended comment

from the user, e.g. via text input **4074**. In another aspect, secondary factor input module **4014** is adapted to provide a drop down menu **4076** of selectable items and receive from the user a selection from the drop down menu. For example, in an aspect, the menu of selectable items includes topic areas for discussion with a medical care provider. In addition to text inputs or menus, various types of input elements may be utilized to receive input from the user, voice to text conversion, screen elements with clickable buttons or check-boxes that allow the user to select from multiple options, sliders that allow the user to increase or decrease a parameter value between minimum and maximum values, and various other types of input elements.

In an aspect, personal computing device application **4006** includes a recommendation delivery module **4078**, which is configured to present a recommendation to the user. For example, the recommendation can be presented to the user via user interface **4064**, or audio output **4026**, or sent to a remote device via device interface **4052**, computing network **4070**, or communication network **4080**. In an aspect, recommendation delivery module **4078** is adapted to receive the recommendation from a medical care provider, from an insurance company, a service provider, an advisor, a computation-based system, or a social media source. For example, in an aspect recommendation delivery module **4078** is adapted to receive a recommendation via computing network **4070**. For example, in an aspect the recommendation based on patients similar to the user. In an aspect, recommendation delivery module **4078** is adapted to generate the recommendation.

In an aspect, personal computing device application **4006** includes a correlation module **4082** configured to determine at least one correlation between the mood of the user and at least one of the at least one secondary factor and the at least one stimulus control parameter, and recommendation delivery module is configured to generate the recommendation based at least in part on the at least one correlation. For example, if it is determined that a particular secondary factor (e.g., rainy weather) is normally followed by a depressed mood in the user, if occurrence of the secondary factor is detected, a recommendation is generated for increasing stimulation. As another example, if a particular activity of the user is correlated with depression (for example, if the user reports being depressed after staying up late and not getting enough sleep, the recommendation might be to go to bed earlier).

In an aspect, recommendation delivery module **4078** is adapted to provide the recommendation to a medical care provider of the user. This can be done, for example, by sending the recommendation to a remote device used by the medical care provider, via computing network **4070**, communication network **4080**, device interface **4052**, or via user interface **4064**. Providing the recommendation to the medical care provider makes it possible for the medical care provider to discuss the recommendation with the user, or not, as deemed appropriate by the medical care provider, as well as to incorporate the recommendation into an overall treatment plan for the user.

In an aspect, recommendation delivery module **4078** is configured to generate the recommendation based on at least one of information regarding a response of the subject to a past treatment regimen, information obtained via social media, information regarding at least one preference of at least one social media contact of the subject, information regarding at least one preference of at least one peer of the subject, information regarding at least one preference of at least one role model of the subject, information from an insurance company, information from a service provider.

In an aspect, recommendation delivery module **4078** is configured to generate the recommendation with a computation-based system; for example, an artificial intelligence, a neural network, or a machine learning system. In an aspect, recommendation delivery module **4078** is configured to generate the recommendation based on a predicted response of the subject to a treatment regimen.

In another aspect, recommendation delivery module **4078** is configured to receive information regarding whether the subject has accepted or rejected the recommendation. In various aspects, recommendation delivery module **4078** is configured to present to the user a recommendation for a configuration of the neural stimulus, or a recommendation for a secondary stimulus to be delivered in association with the neural stimulus.

In an aspect, personal computing device application **4006** includes physiological data module **4084** adapted to receive at least one physiological data signal representing at least one physiological parameter of the user. In an aspect, physiological data module **4084** is adapted to receive the at least one physiological data signal from at least one sensor **4068**. In another aspect, physiological data module **4084** is adapted to receive the at least one physiological data signal from at least one computing network **4070**, or alternatively, via at least one communication network **4080**. In another aspect, physiological data module **4084** is adapted to receive the at least one physiological data signal from at least one remote sensing system **4086**. A remote sensing system may include one or more sensors in the environment of the user, including but not limited to cameras, motion sensors, pressure sensors, force sensors, infrared sensors, etc. In various aspects, physiological data module **4084** is adapted to receive the at least one physiological data signal from at least one of a blood pressure sensor, a heart rate sensor, a chemical sensor, a biosensor, a pH sensor, a blood oxygen sensor, a galvanic skin response sensor, an EEG sensor, an EMG sensor, an ECG sensor, a wearable item, an eye tracking system, an acoustic sensor, a motion sensor, a force transducer, or an activity sensor.

In an aspect, user control module **4016** is adapted to receive user input (e.g., via user interface **4064**) for controlling at least one of stimulus pulse amplitude, stimulus pulse duration, stimulus frequency, stimulus pulse pattern, and stimulus pulse envelope.

In an aspect, personal computing device application **4006** includes external control module **4088**, which is configured to receive an external control input for controlling at least one externally controllable stimulation parameter of the ear stimulation device. For example, in various aspects, external control module **4088** is configured to receive the external control input via computing network **4070** or communication network **4080**. In an aspect, external control module **4088** is configured to receive the external control input from an external party or entity. In an aspect, the external party or entity is a medical care provider. In other aspects, the external control input may be received from other external parties or entities, e.g., a family member, an insurance company, the device manufacturer, etc. The at least one externally controllable stimulation parameter includes, for example, at least one of stimulus pulse amplitude, stimulus pulse duration, stimulus frequency, stimulus pulse pattern, and stimulus pulse envelope. Externally controllable stimulation parameters may include preferred values for efficacy of treatment, including preferred values to be used in con-

nection with different patent conditions, or upper and lower limits for stimulus values, for purposes of patient safety or efficacy of treatment.

In another aspect, personal computing device application **4006** includes data transfer module **4090** for providing data relating to the user to an external party or entity. In an aspect, data transfer module **4090** is configured to provide the data to the external party or entity via computing network **4070**. In another aspect, data transfer module is configured to provide the data to the external party or entity via communication network **4080**. For example, the external party or entity may be a medical care provider, a family member, an insurance company, a service provider, a social media contact (or 'friend') of the subject, a peer of the subject, an advisor, a computation based system, a social media source, a device manufacturer, a merchant, an electronic medical record, a sensor network, or an additional program or application, for example. In an aspect, a sensor network includes or is part of a health diary platform, a smart home, or an internet of things.

In an aspect, stimulator control module **4018** is configured to determine the at least one stimulus control parameter **4034** by overriding the at least one user control input for controlling the at least one user-controllable stimulation parameter based on a medical-care provider control input. Alternatively, in another aspect, stimulator control module **4018** is configured to override a medical-care provider control input based on the at least one user control input for controlling the at least one user-controllable stimulation parameter. In yet another aspect, stimulator control module **4018** is configured to override the at least one user control input for controlling the at least one user-controllable stimulation parameter based on a computing system-generated stimulus control parameter. In another aspect, stimulator control module **4018** is configured to override a computing system-generated stimulus control parameter based on the at least one user control input for controlling the at least one user-controllable stimulation parameter. For example, stimulator control module **4018** is configured to determine the at least one stimulus control parameter to provide an initial setting of the ear stimulation device based on the at least one user-controllable stimulation parameter. In another aspect, stimulator control module **4018** is configured to determine the at least one stimulus control parameter to update a setting of the ear stimulation device based on the at least one user-controllable stimulation parameter.

FIG. **41** is a flow diagram of a method of controlling an ear stimulation device with a personal computing device. Method **4100** may be performed, for example, using a personal computing device configured with application software, as depicted and discussed in connection with FIG. **40**. Method **4100** includes receiving an audio signal at the personal computing device from an audio signal source, as indicated at **4102**; delivering the audio signal to an audio earpiece worn by a user via an audio output of the personal computing device, the audio earpiece having associated therewith an ear stimulation device configured to stimulate a nerve innervating the ear of the user, as indicated at **4104**; receiving with a mood assessment module, via a first input structure associated with the personal computing device, a mood-related input from the user, as indicated at **4106**; assessing, with the mood assessment module, a mood of the user based at least in part upon the mood-related input, as indicated at **4108**; receiving with a secondary factor input module, via a second input structure associated with the personal computing device, at least one input relating to at least one secondary factor relating to the user, as indicated at **4110**; receiving with a user control module, via a third input structure associated with the personal computing device, at least one user control input for controlling at least one user-controllable stimulation parameter of the ear stimulation device, as indicated at **4112**; determining, with a stimulator control module, at least one stimulus control parameter based on at least one of the mood of the user, the at least one secondary factor, and the at least one user control input, as indicated at **4114**; and communicating, with a controller interface module, at least one stimulus control parameter to a stimulator controller, the stimulator controller adapted to control the ear stimulation device responsive to the at least one stimulus control parameter, as indicated at **4116**.

Further aspects of the method shown in FIG. **41** are shown in FIGS. **42-47**.

For example, as shown in FIG. **42**, in various aspects of a method **4200**, receiving the audio signal at the personal computing device from the audio signal source includes receiving the audio signal from an audio player application, as indicated at **4202**; receiving the audio signal from a web radio application, as indicated at **4204**; receiving the audio signal from a radio receiver, as indicated at **4206**, receiving the audio signal from a telephone receiver, as indicated at **4208**, or receiving the audio signal from a hearing aid, as indicated at **4210**.

Receiving the mood-related input in various aspects includes receiving user input via an ecological momentary assessment module, as indicated at **4212**; receiving an image of the user with a user-facing camera of the personal computing device, and determining a mood of the user based on image analysis of the image of the user with image processing software of the mood assessment module, as indicated at **4214**. Mood assessment based on image analysis is discussed in greater detail herein above. Receiving the mood-related input may include receiving mood-related input relating to one or more of depression, as indicated at **4216**; stress, as indicated at **4218**; emotion, as indicated at **4220**; or a mental disorder, as indicated at **4222**. In an aspect, receiving the mood-related input via the first input structure includes receiving at least one input via a touch screen, a keyboard, or a microphone, as indicated at **4224**. In an aspect, method **4200** includes coordinating, with the stimulator control module, delivery of the audio signal with delivery of at least one stimulus with the ear stimulation device, as indicated at **4224**.

FIG. **43** provides further variants of the method of FIG. **41**, relating to receiving at least one input relating to at least one secondary factor relating to the user, at **4110**. In an aspect of method **4300**, receiving the at least one input relating to the at least one secondary factor includes receiving at least one input via at least one of a touch screen, a keyboard, a microphone, a device interface, a data input, a USB port, a wireless interface, a serial port, and a parallel port, as indicated at **4302**. In further aspects, receiving at least one input relating to at least one secondary factor relating to the user with the secondary factor input module includes receiving at least one input from the user, as indicated at **4304**; receiving at least one input from a sensor, as indicated at **4306**; or receiving at least one input via a computing network, as indicated at **4308**.

In another aspect, receiving at least one input relating to at least one secondary factor relating to the user with the secondary factor input module includes receiving at least one input relating to an environmental condition of the user, as indicated at **4310**. An environmental condition may include, for example, at least one of a light level, a tem-

perature, a humidity, a pollen count, a noise level, a day length, a precipitation, an air quality measure, as indicated at **4312**.

In other aspects, receiving at least one input relating to at least one secondary factor relating to the user with the secondary factor input module includes receiving at least one input relating to a sleep pattern of the user, as indicated at **4314**; a medical history of the user, as indicated at **4315**; a diet of the user, as indicated at **4316**; an appetite of the user, as indicated at **4318**; or an activity of the user, as indicated at **4320**. For example, receiving at least one input relating to an activity includes receiving at least one input relating to, e.g., a physical activity, a recreational activity, a social activity, an employment activity, a purchasing activity, a mental activity, a spiritual activity, a media-related activity, an activity of daily life, an amount of activity, a duration of activity, a frequency of activity, a timing of activity, a calendar, a schedule, or a cost, as indicated at **4322**.

In further aspect, receiving at least one input relating to at least one secondary factor relating to the user with the secondary factor input module includes receiving at least one open ended comment from the user, as indicated at **4324**. In other aspects, receiving at least one input relating to at least one secondary factor relating to the user with the secondary factor input module includes providing a drop down menu of selectable items and receiving from the user a selection from the drop down menu, as indicated at **4326**. For example, in an aspect, providing a drop down menu of selectable items includes providing a drop down menu of selectable topic areas for discussion with medical care provider, as indicated at **4328**.

As shown in FIG. **44**, in an aspect a method **4400** includes presenting a recommendation to the user with a recommendation delivery module, as indicated at **4402**. The recommendation may be received from a medical care provider, from an insurance company, a service provider, an advisor, a computation-based system, or a social media source, as indicated at **4404**, or from a computing network, as indicated at **4406**. In another aspect, method **4400** includes providing the recommendation to a medical care provider of the user with the recommendation delivery module, as indicated at **4408**. In a further aspect, method **4400** includes receiving, with the recommendation delivery module, information regarding whether the subject has accepted or rejected the recommendation, as indicated at **4410**.

In various aspects, presenting the recommendation includes presenting a recommendation for a configuration of the neural stimulus, as indicated at **4412**, or presenting a recommendation for a secondary stimulus to be delivered in association with the neural stimulus, as indicated at **4414**.

In an aspect, method **4400** includes delivering a recommendation based on patients similar to the user, as indicated at **4416**.

In an aspect, method **4400** includes generating the recommendation with the recommendation delivery module, as indicated at **4418**. For example, the method may include determining, with a correlation module, at least one correlation between the mood of the user and at least one of the at least one secondary factor and the at least one stimulus control parameter, and generating the recommendation with the recommendation delivery module based at least in part on the at least one correlation, as indicated at **4420**. In an aspect, the method includes generating the recommendation based on at least one of information regarding a response of the subject to a past treatment regimen, information obtained via social media, information regarding at least one preference of at least one social media contact of the subject, information regarding at least one preference of at least one peer of the subject, information regarding at least one preference of at least one role model of the subject, information from an insurance company, information from a service provider, as indicated at **4422**. In some aspects, the method includes generating the recommendation with a computation-based system, as indicated at **4424**, or generating the recommendation based on a predicted response of the subject to a treatment regimen, as indicated at **4426**.

FIG. **45** depicts aspects of a related method **4500**. In an aspect, method **4500** includes receiving, with a physiological data module, at least one physiological data signal representing at least one physiological parameter of the user, as indicated at **4502**. Receiving the at least one physiological data signal includes, for example, receiving the at least one physiological data signal from at least one sensor, as indicated at **4504**. In an aspect, the at least one sensor is located on the audio earpiece associated with the ear stimulation device, as indicated at **4506**. In an aspect, the audio earpiece having the ear stimulation device associated therewith is a first audio earpiece worn on a first ear of the subject, and wherein the at least one sensor is located on a second audio earpiece located on a second ear of the subject, as indicated at **4508**.

In an aspect, receiving the at least one physiological data signal includes receiving the at least one physiological data signal from at least one computing network, as indicated at **4510**, or from at least one remote sensing system, as indicated at **4512**. In various aspects, receiving the at least one physiological data signal includes receiving the at least one physiological data signal from at least one of a blood pressure sensor, a heart rate sensor, a chemical sensor, a biosensor, a pH sensor, a blood oxygen sensor, a galvanic skin response sensor, an EEG sensor, an EMG sensor, an ECG sensor, a wearable item, an eye tracking system, an acoustic sensor, a motion sensor, a force transducer, or an activity sensor, as indicated at **4514**.

In a further aspect, method **4500** includes providing data relating to the user to an external party or entity, as indicated at **4516**. In various aspects, providing the data to the external party or entity includes providing the data via a computing network, as indicated at **4518**, or providing the data via a communication network, as indicated at **4520**. In an aspect, providing the data to the external party or entity includes providing the data to a medical care provider, as indicated at **5422**. In various aspects, providing the data to the external party or entity includes providing the data to a family member, an insurance company, a service provider, a social media contact of the subject, a peer of the subject, an advisor, a computation based system, a social media source, a device manufacturer, a merchant, an electronic medical record, a sensor network, a program or an application, as indicated at **4524**.

FIG. **46** depicts further aspects of a method **4600**. In one aspect of method **4600**, receiving the at least one user control input for controlling the at least one user-controllable stimulation parameter includes receiving at least one user input for controlling at least one of stimulus pulse amplitude, stimulus pulse duration, stimulus frequency, stimulus pulse pattern, and stimulus pulse envelope, as indicated at **4602**.

In another aspect, method **4600** includes determining, with a correlation module, at least one correlation between the mood of the user and at least one of the at least one secondary factor and the at least one stimulus control parameter, as indicated at **4604**.

In another aspect, method **4600** includes receiving, with an external control module, an external control input for controlling at least one externally controllable stimulation parameter of the ear stimulation device, as indicated at **4606**. In various aspects, this includes receiving the external control input via a computing network or a communication network, as indicated at **4608**. In an aspect, receiving the external control input includes receiving the external control input from an external party or entity, as indicated at **4610**, for example, a medical care provider, as indicated at **4612**, or a family member, an insurance company, a service provider, a social media contact of the subject, a peer of the subject, an advisor, a computation based system, a social media source, a device manufacturer, a merchant, an electronic medical record, a sensor network, a program or an application, as indicated at **4614**. In various aspect, the at least one externally controllable stimulation parameter includes at least one of stimulus pulse amplitude, stimulus pulse duration, stimulus frequency, stimulus pulse pattern, and stimulus pulse envelope, as indicated at **4616**.

FIG. **47** depicts further aspects of a method **4700**, relating to determining the at least one stimulus control parameter. In an aspect, determining the at least one stimulus control parameter includes overriding the at least one user control input for controlling the at least one user-controllable stimulation parameter based on a medical-care provider control input, as indicated at **4702**. In another aspect, determining the at least one stimulus control parameter includes overriding a medical-care provider control input based on the at least one user control input for controlling the at least one user-controllable stimulation parameter, as indicated at **4704**. In yet another aspect, determining the at least one stimulus control parameter includes overriding the at least one user control input for controlling the at least one user-controllable stimulation parameter based on a computing system-generated stimulus control parameter, as indicated at **4706**. In still another aspect, determining the at least one stimulus control parameter includes overriding a computing system-generated stimulus control parameter based on the at least one user control input for controlling the at least one user-controllable stimulation parameter, as indicated at **4708**.

In an aspect, determining the at least one stimulus control parameter includes determining an initial setting of the ear stimulation device based on the at least one user-controllable stimulation parameter, as indicated at **4710**. In another aspect, determining the at least one stimulus control parameter includes updating a setting of the ear stimulation device based on the at least one user-controllable stimulation parameter, as indicated at **4712**.

The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely exemplary, and that in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected", or "operably coupled," to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being "operably couplable," to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components, and/or wirelessly interactable, and/or wirelessly interacting components, and/or logically interacting, and/or logically interactable components.

In some instances, one or more components may be referred to herein as "configured to," "configured by," "configurable to," "operable/operative to," "adapted/adaptable," "able to," "conformable/conformed to," etc. Those skilled in the art will recognize that such terms (e.g., "configured to") generally encompass active-state components and/or inactive-state components and/or standby-state components, unless context requires otherwise.

A personal computing device, as described herein, may include circuitry and other hardware components, provided, for example in the form of a custom board installed in the case of the personal computing device during or after manufacture, or in a separate package that may be operably connected to the personal computing device via one or more wired and/or wireless connection. Unless context dictates otherwise, as used herein, the term personal computing device is intended to encompass systems including circuitry and other hardware components packaged with the personal computing device and circuitry and other hardware components packaged separately but used in combination with the personal computing device.

While particular aspects of the present subject matter described herein have been shown and described, it will be apparent to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from the subject matter described herein and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of the subject matter described herein. It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to claims containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analo-

gous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that typically a disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms unless context dictates otherwise. For example, the phrase "A or B" will be typically understood to include the possibilities of "A" or "B" or "A and B."

With respect to the appended claims, those skilled in the art will appreciate that recited operations therein may generally be performed in any order. Also, although various operational flows are presented in a sequence(s), it should be understood that the various operations may be performed in other orders than those which are illustrated, or may be performed concurrently. Examples of such alternate orderings may include overlapping, interleaved, interrupted, reordered, incremental, preparatory, supplemental, simultaneous, reverse, or other variant orderings, unless context dictates otherwise. Furthermore, terms like "responsive to," "related to," or other past-tense adjectives are generally not intended to exclude such variants, unless context dictates otherwise.

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

The invention claimed is:

1. A method of controlling an ear stimulation device with a personal computing device, comprising:

capturing, with image capture circuitry on the personal computing device, via a user-facing camera associated with the personal computing device, an image of a user of the personal computing device;

processing the image, using image processing circuitry on the personal computing device, to determine at least one parameter; and

controlling, with neural stimulus control signal determination circuitry on the personal computing device, based at least in part on the at least one parameter, delivery of a stimulus to at least one nerve innervating a pinna of an ear of the user with the ear stimulation device,

wherein the stimulus includes as least one of a mechanical stimulus, electrical stimulus, magnetic stimulus, ultrasonic stimulus, optical stimulus, or chemical stimulus.

2. The method of claim **1**, wherein the image processing circuitry includes application software on the personal computing device.

3. The method of claim **1**, wherein the at least one parameter is an emotional parameter of the user.

4. The method of claim **1**, wherein the at least one parameter is a physiological parameter of the user.

5. The method of claim **1**, wherein the at least one parameter is a medical parameter of the user.

6. The method of claim **1**, wherein the at least one parameter is a biometric parameter indicative of an identity of the user.

7. The method of claim **1**, wherein the at least one parameter is a heart rate of the user.

8. The method of claim **1**, wherein the at least one parameter is an eye position or eye movement parameter of the user.

9. The method of claim **1**, wherein the at least one parameter is a distance of one or more portions of an earpiece of the ear stimulation device with respect to at least one anatomical feature of the ear of the user.

10. The method of claim **9**, including delivering, under control of notification circuitry on the personal computing device, a notification to the user informing the user of a need to adjust a position of the earpiece with respect to the ear of the user.

11. The method of claim **1**, wherein the personal computing device includes a phone, watch, wearable device, tablet computer, laptop computer, or desktop computer.

12. The method of method of claim **1**, including

processing the image, using the image processing circuitry, to determine

a presence of at least one earpiece of the ear stimulation device at the ear of the user, the ear selected from a right ear of the user and a left ear of the user; and

at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with the ear of the user at which the earpiece is located;

determining, using application software on the personal computing device, a target ear at which the at least one ear earpiece is usable, based on the at least one attribute of the at least one earpiece;

determining, using application software on the personal computing device, that the ear at which the at least one earpiece is located is not the target ear at which the at least one earpiece is usable; and

sending a control signal from the personal computing device to the ear stimulation device, under control of the neural stimulus control signal determination circuitry, to prevent delivery of a stimulus to the pinna of the ear at which the at least one earpiece is located via the at least one earpiece.

13. The method of claim **12**, including receiving, with handshake circuitry on the personal computing device, a handshake signal from ear stimulation device control circuitry associated with the ear stimulation device.

14. The method of claim **13**, including capturing the image of the user of the personal computing device responsive to receiving the handshake signal from the ear stimulation device control circuitry.

15. The method of claim **13**, including sending a handshake signal to the ear stimulation device control circuitry responsive to determining the presence of the at least one earpiece located at the ear of the user in the image.

16. The method of claim **12**, including delivering, under control of notification circuitry on the personal computing device, a notification to the user informing the user of a need to switch the at least one earpiece to the target ear if the ear at which the at least one earpiece is located is not the target ear at which the at least one earpiece is usable.

17. The method of claim 16, wherein delivering the notification to the user includes delivering a text notification.

18. The method of claim 16, wherein delivering the notification to the user includes delivering a visible notification.

19. The method of claim 16, wherein delivering the notification to the user includes delivering an audio notification.

20. The method of claim 12, wherein determining the at least one attribute of the at least one earpiece includes determining a shape of the at least one earpiece.

21. The method of claim 12, wherein determining the at least one attribute of the at least one earpiece includes determining a color of the at least one earpiece.

22. The method of claim 12, wherein determining the at least one attribute of the at least one earpiece includes determining a presence of an indicia on the at least one earpiece or an attachment to the at least one earpiece.

23. The method of claim 22, wherein the attachment to the at least one earpiece includes a cable connected to the at least one earpiece.

24. An ear stimulation device control system, comprising:

a personal computing device;

a user-facing camera associated with the personal computing device;

image capture circuitry adapted to capture an image of a user of the personal computing device from the user-facing camera;

image processing circuitry configured to process the image to determine at least one parameter; and

neural stimulus control signal determination circuitry configured to control delivery of a stimulus to at least one nerve innervating a pinna of an ear of the user with an ear stimulation device, based at least in part on the at least one parameter,

wherein the stimulus includes as least one of a mechanical stimulus, electrical stimulus, magnetic stimulus, ultrasonic stimulus, optical stimulus, or chemical stimulus.

25. The system of claim 24, wherein the at least one parameter is an emotional parameter of the user.

26. The system of claim 24, wherein the at least one parameter is a physiological parameter of the user.

27. The system of claim 24, wherein the at least one parameter is a biometric parameter indicative of an identity of the user.

28. The system of claim 24, wherein the at least one parameter is a heart rate of the user.

29. The system of claim 24, wherein the at least one parameter is an eye position or eye movement parameter of the user.

30. The system of claim 24, wherein the at least one parameter is a distance of one or more portions of an earpiece of the ear stimulation device with respect to at least one anatomical feature of the ear of the user.

31. The system of claim 24, wherein the personal computing device includes a phone, watch, wearable device, tablet computer, laptop computer, or desktop computer.

32. The system of claim 24, wherein the image processing circuitry includes an earpiece location module configured to process the image to determine

a presence of at least one earpiece of the ear stimulation device at the ear of the user, the ear selected from a right ear of the user and a left ear of the user; and

at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with the ear of the user at which the at least one earpiece is located; and

wherein the neural stimulus control signal determination circuitry is configured to

determine a target ear at which the earpiece is usable, based on the at least one attribute of the at least one earpiece;

determine that the ear at which the at least one earpiece is located is not the target ear at which the earpiece is usable; and if the ear at which the at least one earpiece is located is not the ear at which the earpiece is usable; and

send a control signal from the personal computing device to the ear stimulation device to prevent delivery of the stimulus to the at least one nerve innervating the pinna of the ear of the user.

33. The system of claim 32, including handshake circuitry adapted to receive a handshake signal from ear stimulation device control circuitry associated with the ear stimulation device.

34. The system of claim 33, wherein the image capture circuitry is adapted to capture the image of the user of the personal computing device responsive to receiving the handshake signal from the ear stimulation device control circuitry.

35. The system of claim 33, wherein the neural stimulus control signal determination circuitry is configured to send a handshake signal to the ear stimulation device control circuitry responsive to determining the presence of the at least one earpiece located at the ear of the user in the image.

36. The system of claim 32, including

an output device; and

notification circuitry adapted to provide a notification via the output device instructing the user to switch the at least one earpiece to the other ear if the ear at which the at least one earpiece is located is not the target ear at which the earpiece is usable.

37. The system of claim 36, wherein the output device is adapted to deliver a text notification to the user.

38. The system of claim 36, wherein the output device is adapted to deliver a visible notification to the user.

39. The system of claim 36, wherein the output device is adapted to deliver an audio notification to the user.

40. The system of claim 32, wherein the at least one attribute of the at least one earpiece includes a shape of the at least one earpiece.

41. The system of claim 32, wherein the at least one attribute of the at least one earpiece includes a color of the at least one earpiece.

42. The system of claim 32, wherein the at least one attribute of the at least one earpiece includes a presence of an indicia on the at least one earpiece or an attachment to the at least one earpiece.

43. The system of claim 42, wherein the attachment to the at least one earpiece includes a cable connected to the at least one earpiece.

44. An ear stimulation device control system, comprising:

a personal computing device;

a user-facing camera associated with the personal computing device;

image capture circuitry adapted to capture an image of a user of the personal computing device from the user-facing camera;

image processing circuitry configured to process the image to determine at least one parameter, wherein the image processing circuitry includes

an earpiece location module configured to process the image to determine

a presence of at least one earpiece of the ear stimulation device at the ear of the user, the ear selected from a right ear of the user and a left ear of the user; and

at least one attribute of the at least one earpiece indicative of usability of the at least one earpiece with the ear of the user at which the earpiece is located; and

neural stimulus control signal determination circuitry configured to control

delivery of a stimulus to at least one nerve innervating an ear of the user with an ear stimulation device, based at least in part on the at least one parameter,

wherein the neural stimulus control signal determination circuitry is configured to

determine a target ear at which the at least one earpiece is usable, based on the at least one attribute of the at least one earpiece;

determine that the ear at which the at least one earpiece is located is not the target ear at which the at least one earpiece is usable; and

send a control signal from the personal computing device to the ear stimulation device to prevent delivery of the stimulus to the a least one nerve innervating the ear of the user.

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